School of Health, Medicine and Life Sciences: A thesis submitted to the University of Hertfordshire in partial fulfilment of the requirement of the degree of Doctor of Philosophy

Paramedic Dynamic Risk Assessment related to Suspected Respiratory Disease in the context of SARS-CoV-2: A mixed-methods Study

Tim Millington

June 2025

Contents

Acknowledgements 1
List of abbreviations 2
Abstract 4
Chapter 1: Navigating this thesis 6
Chapter 2: Introduction 9
2.1 Background 9
2.2 Context 13
2.2.1 The paramedic role 13
2.2.2 Duty of care 14
2.2.3 Dynamic risk assessment 17
2.2.4 The COVID-19 pandemic 20
2.2.5 SARS-CoV-2 transmission and aerosol characteristics 25
2.2.6 Quantifying aerosols 29
2.2.7 Personal Protective Equipment guidance during the pandemic 32
2.2.8 Cardiac arrest resuscitation: Chest compressions and defibrillation 34
2.2.9 PPE guidelines – lack of clarity around AGPs 35
2.2.10 Personal Protective Equipment: Legal requirements of employers 37
2.3 Future pandemics 39
2.4 'PPE fatigue' and non-adherence to PPE protocols 40
2.5 Research Questions and Objectives 42
2.6 Aim 44
2.7 Significance of the study 44
2.7.1 The STOPGAP Study and Position of This Research 45
2.8 Summary 46
Chapter 3: Review of relevant literature 47
3.1 Literature Review 1 50
3.1.1 Paramedic experiences of delivering patient care using PPE during the COVID-19 pandemic and the factors that contribute to non-adherence 50
3.1.2 Implications to this thesis 59
3.2 Literature review 2 60
3.2.1 Title: Chest compressions and defibrillation as aerosol generating procedures. 60
3.2.2 Implications to this thesis 70
3.3 Literature Review 3 71
3.3.1 Title: Mask effectiveness during Cardiopulmonary Resuscitation (CPR) 71
3.3.2 Inclusion and Exclusion Criteria 74

3.3.3 Results 75
3.3.4 Discussion 77
3.3.5 Conclusion 88
3.3.6 Implications to this thesis 89
3.4 How do these reviews inform the dynamic risk assessment? 89
3.5 Summary 91
Chapter 4: Methodology 93
4.1: Introduction 93
4.2 Exploratory study design 94
4.3 Mixed-methods Research 95
4.3.1 Mixed-methods Research – Background in prehospital research 96
4.3.2 Mixed method versus multi-method research 97
4.3.3 Concepts in Mixed-methods Research 100
4.4 Paradigms and Worldviews 106
4.4.1 Positivism 109
4.4.2 Interpretivism and Constructivism 110
4.4.3 Pragmatism 114
4.5 Research Methods and Study Design 117
4.6 Workstream 1: *Insights into paramedics' experiences using personal protective equipment (PPE) during the COVID-19 pandemic.* 118
4.6.1 Overview 118
4.6.2 Research Design & Rationale 118
4.6.3 Sampling strategy and recruitment 119
4.6.4 Inclusion / Exclusion Criteria 122
4.6.5 Consent 123
4.6.6 Interview format 123
4.6.7 Follow up 125
4.6.8 Data storage and analysis 125
4.6.9 Participant Withdrawal 125
4.6.10 Evaluation of safety 126
4.6.11 Data and Quality Management 130
4.6.12 Reporting 130
4.6.13 Reflexive Thematic Analysis 130
4.6.14 Theoretical lenses 136
4.6.15 Other considered theoretical lenses 138
4.6.16 Workstream 1: Summary 144

4.7 Workstream 2: STOPGAP: Investigation of chest compressions and defibrillation as aerosol generating procedures. 145
4.7.1 Short summary of rationale and background 145
4.7.2 Workstream 2: Study Objectives 148
4.7.3 Investigational Plan 148
4.7.4 Locations 151
4.7.5 Procedures of observation 152
4.7.6 Operational sampling approach and eligibility criteria 153
4.7.7 Specialist Paramedics in Critical Care (SPCCs) 154
4.7.8 Equipment & Devices 156
4.7.9 Adverse Event Definitions 162
4.7.10 Data collected 162
4.7.11 Power calculation and sample size 162
4.7.12 Data Analysis 164
4.7.13 Research challenges 164
4.8 Ethical approval 167
4.8.1 Workstream 1 167
4.8.2 Workstream 2 167
4.9 Ethical issues 167
4.9.1 Workstream 1 167
4.9.2 Workstream 2 167
4.10 Summary 169
Chapter 5: Researcher positionality 171
5.1 Personal statement 171
5.2 Researcher beliefs 172
5.3 Positionality 173
5.3.1 Impact on the qualitative aspect of this study 175
5.3.2 Positionality: An observation from prehospital data collection 178
Chapter 6: Results 185
6.1 Introduction 185
6.2 Workstream 1 186
6.2.1 Theme 1: Communication 192
6.2.2 Theme 2: Patient care 198
6.2.3 Theme 3: Well-being 203
6.2.4 Theme 4: Guidelines 207
6.2.5 Theme 5: Factors motivating adherence 210

6.2.6 Theme 6: Thread of non-adherence 212
6.2.7 PPE fatigue 220
6.2.8 Workstream 1: Summary 221
6.3 Workstream 2 223
6.3.1 Overview of research activity 224
6.3.2 Case Study data 235
6.3.3 Chest compression data analysis 308
6.3.4 Defibrillation analysis 311
6.3.5 Workstream 2: Summary 313
6.4 Integration / Meta-inference generation 315
6.5 Summary 318
Chapter 7: Discussion 319
7.1 Introduction 319
7.2 Workstream 1: What are paramedics' experiences of delivering patient care using PPE during the COVID-19 pandemic? 321
7.2.1 Identity fusion 326
7.2.2 Moral Injury 330
7.3 Workstream 2: Do chest compressions and defibrillation delivered during active resuscitation of a patient in cardiac arrest generate aerosols and so pose a transmission risk to the rescuer? 332
7.3.1 Developments in wider literature 332
7.3.3 Workstream 2: Interpretation of the datasets 336
7.3.4 Challenges and limitations 341
7.4 Integration: Implications to dynamic risk assessment 346
7.5 Considerations for organisations and implications for clinical practice 358
7.5.1 Strengthening Paramedic Practice Through the Matrix Framework, and implications Future Pandemics 362
7.6.1 Specific recommendations 363
Chapter 8: Conclusion 365
References 367
Appendices 451
Appendix 1: STOPGAP Protocol 451
Appendix 2: Published .pdf of literature review 1 491
Appendix 3: Published .pdf of literature review 2 499
Appendix 4: Literature Review 2: Data Extraction Table 508
Appendix 5: Literature Review 1: Data Extraction table 509
Appendix 6: Protocol Workstream 1 510

Appendix 7: EC1A form 538
Appendix 8: EC3 'consent' form 553
Appendix 9: EC6 form 555
Appendix 10: University of Hertfordshire Ethics Approval Notification 558
Appendix 11: Interview guide 559
Appendix 12: Copy of completed IRAS form 563
Appendix 13: Abstract unpublished study 'Anthropogenic bioaerosol kinetics within a simulated ambulance environment: estimating potential exposure to SARS-CoV-2'. 599
Appendix 14: Yorkshire & The Humber – Leeds West Research Ethics Committee confirmation letter. 601
Appendix 15: Peer reviewed poster presentation 609
Appendix 16: Interview 2 transcription word document. 610
Appendix 17: Photograph of handwritten notes made during manual transcription of interview 2. 620
Appendix 18: Example of coding and node analysis taken from NVIVO[12™] 621
Appendix 19: Example of Theory-informed Code Grouping, using the Information – Motivation – Behaviour (IMB) theoretical lens (NVIVO[12] memo). 626
Appendix 20: Example of Node structure taken from NVIVO[12] 627
Appendix 21: Types of incidents attended by the research team, as per AMPDS descriptor. 628
Appendix 22: Pie Chart showing incidents as per AMPDS classification 629
Appendix 23: Chart showing reasons behind exclusion of calls coded as 'Cardiac Arrest'. . 630

Acknowledgements

Thanks to my academic supervisors Professor Julia Williams and Professor Rob Chilcott for their patience and guidance. Plus, a huge thank you to Ruth Fisher, Dale Gedge, and Joe Copson, all of whom have been valued supporters throughout the years.

I would like to acknowledge the effort and support of the critical care team at Yorkshire Ambulance Service, as well as the paramedics who kindly volunteered to participate in the interview process. Seeing them in action and listening to their accounts of the challenges they faced when working through the pandemic, delivered with such candour has truly been one of the privileges of my career.

The biggest, most heartfelt thank you must go to my family. To my wife, Gem, and wonderful daughters, Alice and Charlotte, I will always be forever grateful for their love, support, patience, outright dismissal of any talk of quitting, hugs when needed, and simply for being the lovely humans that they are. This feeling of gratitude is also expressed to my mum, Mel, Ian, Diane, Dave and Lesley, all of whom have supported me significantly and for which I am immensely grateful.

Without all of these lovely people in my life, this simply would not have been achievable. I am a privileged and lucky person. Thank you.

List of abbreviations

Abbreviation	Meaning
ACP	Advanced Clinical Practitioner
AGP	Aerosol generating procedure
AHP	Allied Health Professional
ALS	Advanced life support
BLS	Basic life support
BMJ	British Medical Journal
CBRNe	Chemical, biological, radiological, nuclear and explosive
CDC	Centres for Disease Control and Prevention
CET	Central European Time
CINAHL	Cumulated Index to Nursing and Allied Health Literature
CoP	College of Paramedics
CPR	Cardiopulmonary resuscitation
ECDA	Ethics Committee with Delegated Authority
ELPI	Electrical Low-Pressure Impactors
GI	Gastrointestinal
HART	Hazardous Area Response Teams
HCP	Healthcare professional
HCW	Healthcare worker
HCPC	The Health and Care Professions Council
HSE	Health and Safety Executive
IPC	Infection prevention and control
JRCALC	Joint Royal Colleges Ambulance Liaison Committee

NARU	National Ambulance Resilience Unit
NASIPCG	National Ambulance Service Infection Prevention & Control Group
NERVTAG	New and Emerging Respiratory Virus Threats Advisory Group
NHS	Nation Health Service
NHSE	National Health Service England
NICE	National Institute for Health and Care Excellence
NMC	Nursing and Midwifery Council
OHCA	Out-of-hospital-cardiac-arrest
ONS	Office for National Statistics
OPC	Optical particle counter
OSCE	Objective structured clinical examinations
PHE	Public Health England
PPE	Personal protective equipment
PPER	Personal protective equipment at work regulations
PPIE	Patient and public involvement and engagement
PRISMA-ScR	Preferred reporting items for systematic reviews and meta-analyses – for scoping reviews
REC	Research Ethics Committee
RCEM	Royal College of Emergency Medicine
RCN	Royal College of Nursing
RCUK	Resuscitation Council United Kingdom
ROSC	Return of spontaneous circulation
SARS-CoV-2	Severe acute respiratory syndrome coronavirus 2
tACP	Trainee Advanced Clinical Practitioner
UK	United Kingdom
WHO	World Health Organisation

Abstract

Following the outbreak of the COVID-19 pandemic, paramedics were required to adhere to strict PPE guidelines informed by limited evidence, largely derived from retrospective studies. This contributed to conflicting recommendations from healthcare bodies regarding resuscitation practices in cardiac arrest, with chest compressions and defibrillation generally considered low risk for aerosol generation, in contrast to airway interventions such as endotracheal intubation (Couper et al., 2020).

Before entering clinical settings, paramedics must rapidly balance the risk of harm to themselves against potential harm to patients should care be delayed. This dynamic risk assessment is complex, subjective and time-critical, and decisions to don PPE, and accept the associated delays, should be informed by evidence. However, limited data exists regarding aerosol generation during chest compressions, or the protection PPE affords rescuers, and little is known about paramedics' experiences of working in PPE or the factors influencing non-adherence.

This mixed-methods study addressed these gaps by combining semi-structured interviews exploring paramedics PPE experiences (n=16) with real-world measurement of aerosol generation during chest compressions and defibrillation in out-of-hospital cardiac arrest (n=18). Non-adherence was posited as being linked to professional identity theory, including identity fusion and moral injury, shaped by societal expectations and crisis narratives such as 'clap for heroes'. Aerosol data were inconclusive but suggested elevated airway aerosol levels during resuscitation, indicating a potential transmission risk to rescuers.

This thesis makes an original contribution to knowledge by integrating real-world, prehospital aerosol measurement with qualitative analysis of paramedic decision-making under uncertainty. By empirically examining resuscitation-associated aerosol exposure in operational ambulance settings and theorising how professional identity and contextual pressures influence dynamic risk assessment and PPE adherence, the study advances understanding of how risk is negotiated in time critical prehospital care.

It further introduces the concept of the ‘blue mist’ to describe time-critical cognitive narrowing in emergency settings, providing an evidence-informed foundation for future guidance, education and respiratory PPE design in ambulance services.

Chapter 1: Navigating this thesis

The following chapter contextualises the aim of this thesis, which, as the title suggests, was to inform the paramedic dynamic risk assessment in the context of the respiratory disease COVID-19. This was achieved through a discussion that focused on the impact of the COVID-19 pandemic and its associated implications for paramedic practice. Paramedics were required to adhere to protocols mandating the use of respiratory Personal Protective Equipment (PPE). The infection prevention and control measures were specifically designed to protect patients and healthcare workers and to contain the spread of the disease. Paramedics assess risk prior to delivering patient care as they approach the scene and then continually throughout the care episode. The introduction of PPE directly affected the paramedic dynamic risk assessment by potentially delaying time-critical interventions associated with its application. The following chapter outlines the concept of paramedic dynamic risk assessment, discussing the potential legal and professional ramifications that influence paramedics when required to perform these risk assessments. The resulting formulation of two research questions informed the literature reviews and the subsequent methodological choices forming this research. To assist the reader in navigating this mixed-methods model and to provide a visual reference guide of the structure and processes therein, a flow chart has been developed (see Figure 1.1).

I have also included a timeline of key events to help the reader contextualise the major stages of the research alongside the wider progression of the COVID-19 pandemic (see Table 1.1).

The quantitative component of this thesis forms part of the wider STOPGAP (**ST**udy **O**f Cardiopulmonary **P**rocedures thought to **G**enerate **A**erosol **P**articles) project, a multi-procedural research initiative investigating aerosol generation during resuscitation in the context of COVID-19. This doctoral research focuses on the prehospital measurement of aerosols during chest compressions and defibrillation, integrated with an independent qualitative workstream exploring paramedic decision-making and PPE use (see section 2.7.1).

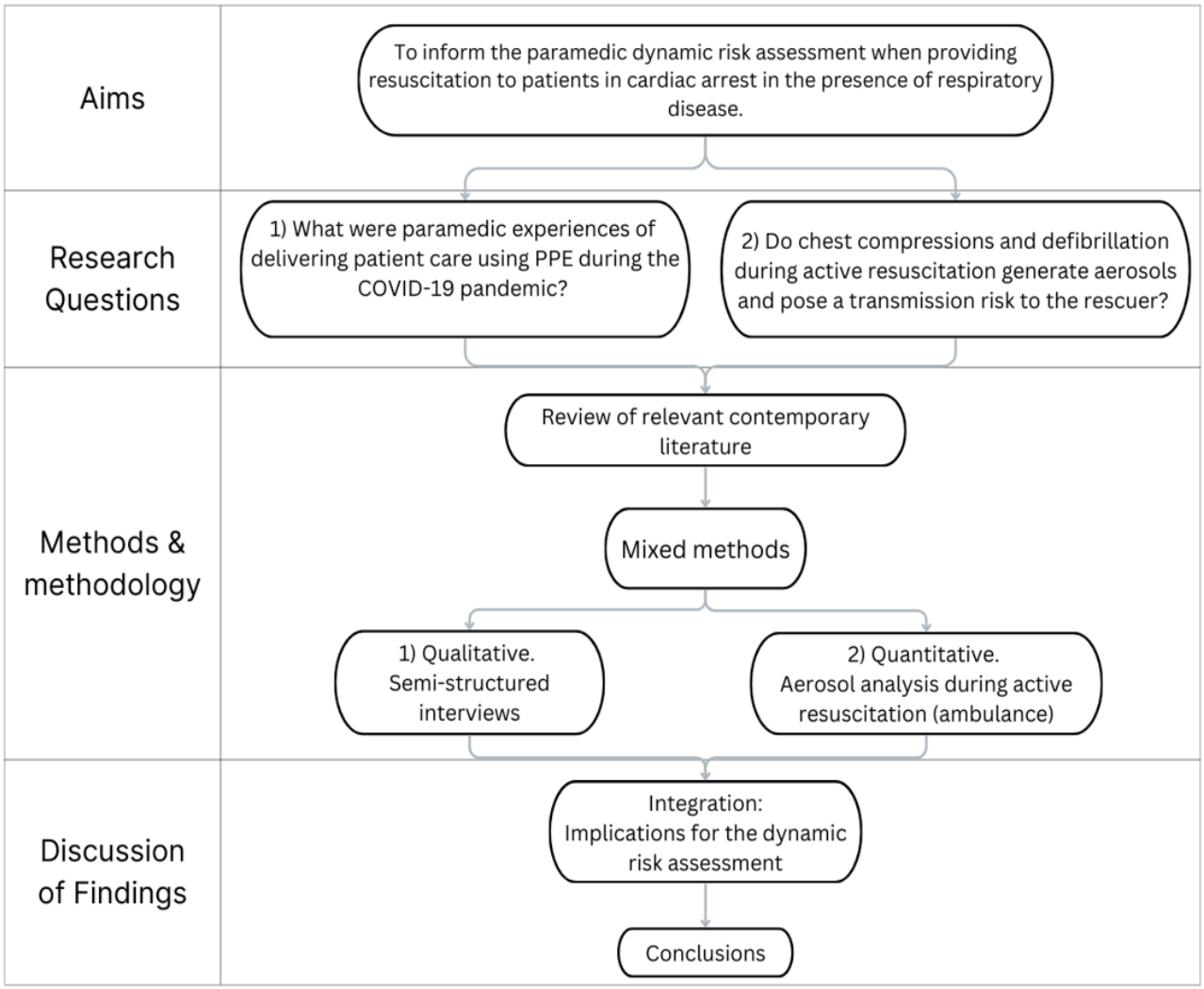


Figure 1.1 Flow chart outlining the various components and how they present and inform this thesis.

Table 1.1 Timeline of pandemic phases and research activity

COVID-19 Milestones	Research Milestones (STOPGAP / Thesis)
December 2019 – First cluster of pneumonia cases reported in Wuhan, China	
January 2020 – WHO declares a Public Health Emergency of International Concern ***March 2020*** - WHO declares global pandemic; UK enters first national lockdown UK Government issues first 'work from home and avoid unnecessary contact' advice. First Thursday pm, doorstep 'Clap for Carers'. ***July 2020*** - Face coverings required in indoor public places, 2m distancing rule relaxed to 1m. ***August 2020*** – "Eat Out to Help Out" introduced ***September 2020*** – Launch of NHS COVID-19 app for contact tracing across England and Wales ***December 2020*** – First UK COVID-19 vaccination administered	***Spring / Summer 2020*** - Concept for STOPGAP study developed in response to emerging COVID-19 risk to paramedics ***December 2020*** - Recruited to STOPGAP
Spring 2021 – Wave 2 - Alpha variant ***Summer 2021*** – Wave 3 - Delta variant ***Winter 2021*** – Wave 4 - Omicron variant	***March 2021*** – First day of PhD program. ***July 2021*** – First PPIE meeting; stakeholder feedback informs protocol refinement
February 2022 – 'Living with COVID' strategy launched; most UK restrictions lifted	***May 2022*** – UH ECDA ethics approval granted for qualitative workstream. May–Dec 2022 – Paramedic interviews conducted
2023 – COVID-19 enters endemic management phase; ongoing variant surveillance	***May 2022*** – NHS Leeds West REC approval (Ref 22/YH/0145) for Quantitative workstream (STOPGAP). ***June 2023–September 2023*** – Aerosol data collection during out-of-hospital cardiac arrests (STOPGAP) & second PPIE meeting.
2024 – Ongoing vaccine booster programmes and NHS recovery measures	***2024*** – Data analysis, integration, and meta-inference generation
-	***June 2025*** – Thesis submitted for viva examination

Chapter 2: Introduction

2.1 Background

On the 11th of March 2020, the World Health Organisation (WHO) declared a pandemic in response to the highly contagious respiratory coronavirus named 'severe acute respiratory syndrome coronavirus two', also called SARS-CoV-2. SARS-CoV-2 causes the respiratory disease COVID-19, transmitted through respiratory droplets and bioaerosols and associated with prominent levels of morbidity and mortality in certain patient populations (Oboza et al., 2023; Booth et al., 2021). Healthcare professionals (HCPs), including paramedics, were instructed to wear personal protective equipment (PPE) throughout this period within their professional work environment, and advice continues to advocate for higher levels of PPE when in the presence of aerosol generating procedures (AGPs) if COVID-19 is suspected.

A paucity of evidence exists to support or refute the classification of chest compressions or defibrillation as aerosol-generating procedures (AGPs), with the limited data available suggestive of risk, however inconclusive in its findings (Couper et al., 2020). It has been highlighted how the release of conflicting guidelines regarding appropriate levels of PPE when in the presence of suspected COVID-19 patients, issued throughout the pandemic, led to ethical and medicolegal dilemmas particularly pertinent to rescuers tasked with responding to patients in cardiac arrest (Arimany-Manso et al., 2020; Zhou et al., 2023; Payne & Peache, 2021). Adherence to enhanced PPE protocols delayed and disrupted lifesaving interventions and procedures described within the Resuscitation Council of the United Kingdom's (RCUK) chain of survival (Nolan et al., 2006). However, omitting or reducing PPE puts rescuers at risk of disease transmission and the potentially catastrophic consequences thereafter. It has been reported how patients' chances of a positive prognosis following an out-of-hospital cardiac arrest (OHCA) diminished during the COVID-19 pandemic, with the delays associated with donning and doffing of PPE thought to have contributed (Bielski et al., 2021). The process of donning (putting on) and doffing

(removing) personal protective equipment (PPE) is essential for protecting healthcare workers, including paramedics, from infectious diseases such as COVID-19. However, these procedures are time-consuming and must be carried out with precision to prevent contamination (World Health Organisation, 2020). In emergency settings, the additional time taken to don PPE inevitably delays time-critical interventions, particularly in life-threatening scenarios where minutes may determine outcomes (Smith et al., 2021). This delay can affect the timely administration of life-saving procedures such as airway management, chest compressions, or defibrillation. Further to this, doffing PPE after patient contact can be an intricate process that requires careful adherence to protocol to avoid self-contamination, adding to the mental and operational burden faced by paramedics who might not have access to the resources afforded to secondary care colleagues due to the working in the varied prehospital environment (Tran et al., 2020). While necessary, these infection control measures have challenged paramedics to balance self-protection with the urgency of patient care during the pandemic.

Even with stricter PPE measures in place, HCPs were subject to persistently elevated infection rates. Moreover, both mortality and post-COVID complications were reported at significantly higher rates among HCPs compared to the wider population (Kursumovic et al., 2020; Nguyen et al., 2020; Dempsey et al., 2024; Key et al., 2020).

> '*WHO estimates that between 80,000 and 180,000 health and care workers could have died from COVID-19 in the period between January 2020 to May 2021'*
>
> World Health Organisation (2021).

Literature repeatedly highlights the urgent need for further research to quantify aerosols generated by chest compressions and defibrillation (Couper et al., 2020; Brown et al., 2020). While studies have

examined healthcare professionals' general experiences of working in the new and challenging clinical environments associated with COVID-19 patients, there is limited data on the specific impact of personal protective equipment (PPE) on paramedics. Furthermore, no literature has been identified that investigates the perspectives of paramedics in England or Scotland through interviews (Chen et al., 2021; [1]Chen et al., 2021; Hoernke et al., 2021; Rees et al., 2021). Clarity regarding AGPs in resuscitation, alongside a deeper understanding of the impact of PPE on healthcare workers, will increase the limited literature regarding this matter and help to inform any future healthcare strategies, thereby acting to protect HCPs, who continue to remain disproportionately at risk from contagious respiratory diseases.

The origins of SARS-CoV-2 are believed to be zoonotic. As the global population increases, it is suggested that humans will continue to encroach on animal habitats, raising the likelihood of future pandemics (Hao et al., 2022; Shanks et al., 2022, 1WHO 2021). The effects of the COVID-19 pandemic are still evident within healthcare. Healthcare professionals attending to patients in cardiac arrest who require resuscitative procedures, particularly chest compressions and defibrillation, are crucial to any first aid response and emergency ambulance service delivery. Dynamic risk assessment is essential for the safe and effective provision of care. This term is commonly used in paramedic training and education and involves evaluating and balancing the risks presented to both the rescuer and the patient within any given clinical setting. The use of personal protective equipment (PPE) as a mitigating strategy offers protection to the wearer; however, it can have implications for patient care. This results in time delays associated with donning PPE, which invariably affect the rapid delivery of time-critical interventions. Thus, the decision to don PPE or not is a significant factor in the considerations associated with dynamic risk assessment.

Ambulance services, like any employer, are duty and legally bound to ensure their staff remain adequately protected when performing the role for which they have been employed. Furthermore, these

employees must be appropriately informed as to the risks threatening their health and safety by the tasks that the employer expects them to be exposed to. The reliability of the information provided is critical if they are to be able to make informed decisions as to whether to continue and proceed with a given course of action or abstain. The significance of this information cannot be underestimated both for the HCP and patients, literally being, in certain instances, a matter of life and death. Should the balance of risk be unacceptable and persistent, an individual might be persuaded to consider alternative employment if they were to deem the risk to themselves or their family as too great.

With that in mind, the purpose of this thesis is to explore the components that inform the paramedic dynamic risk assessment when this group of ambulance clinicians are tasked with delivering time-critical interventions associated with resuscitation when in the suspected presence of contagious respiratory disease, as was the case throughout the COVID-19 pandemic. To do this effectively, one must both ascertain whether specific procedures of resuscitation present a potential transmission risk to the rescuer tasked with their delivery, as well as also understand the key factors that motivate rescuers to not adhere to a prescribed PPE policy, and so hence the mixed-methods study design utilised within this thesis. This approach enabled analysis of real-time aerosol data collected at the scene of out-of-hospital cardiac arrests whilst allowing for exploration of the personal views of paramedics who have worked in the prehospital setting, delivering patient care when wearing PPE during the COVID-19 pandemic. Having a focus on their non-adherence behaviours, provided a mechanism to harness insight into the thought processes behind this decision, enabling a better understanding as to whether these decisions were driven by a considered appreciation of risk or if, in fact, they were more instinctive and driven through an emotive and reflex-like response to fellow humans in their time of need. The intention is that this approach would act to illuminate a previously under researched concept of dynamic risk assessment in this context whilst also contributing to the limited literature on the matter.

2.2 Context

To provide context to this research, this section will outline the paramedic role, their responsibilities when faced with risk, and the implications of dynamic risk assessment in the context of the COVID-19 pandemic.

2.2.1 The paramedic role

Paramedics make up one of the fourteen Allied Health Professionals (AHPs). Regulated by the Health and Care Professions Council (HCPC), they are highly skilled professionals and play an important role in the delivery of contemporary healthcare. Traditionally, the role of the paramedic involved responding to emergency calls in ambulance service vehicles to provide prehospital care. However, the nature of the role has evolved dramatically since its conception, due in part to organisational response to the increased pressures seen across health and social care. The varied nature of emergency prehospital work allows paramedics to develop knowledge and skills that can be effectively applied in other healthcare settings (Eaton et al., 2018; Reeve et al., 2008). The expansion of the paramedic role has driven the development of enhanced and advanced practice positions aligned with the 'four pillars' set out in Health Education England's (HEE) Multi-professional Framework for Advanced Clinical Practice in England (HEE, 2017). These four pillars—clinical practice, leadership and management, education, and research—provide the foundational structure for advanced practice across professions. They are also reflected in the College of Paramedics' (CoP) Career Framework for Paramedics, which was most recently updated in its fifth edition (CoP, 2023) and further supported by contemporary academic discussions (Leary, 2022). This evolution of the profession means paramedics now operate in a variety of clinical and non-clinical roles, spanning all four pillars throughout the entire health and social care system and beyond. As educated and highly skilled healthcare professionals, paramedics deliver evidence-based clinical care that involves independent decision-making and autonomous practice.

2.2.2 Duty of care

The nature of prehospital work dictates that the elimination of all risks is an impossibility (Alacahan et al., 2023; Bitan & Jaffe, 2017). The Joint Royal Colleges Ambulance Liaison Committee (JRCALC) guidance issued to all UK paramedics describes how they must negotiate a delicate balance between taking appropriate actions to mitigate their own personal risk whilst also being willing to accept an element of risk to themselves in order to deliver effective, and importantly, timely patient care (JRCALC 2023). Precisely defining an acceptable level of risk in emergency situations or high-risk settings is immensely challenging, with it frequently being an evolving and dynamic process, dependent on re-evaluation of changing circumstances as they occur. Understanding the medicolegal and ethical implications and considerations is imperative when constructing one's own dynamic risk assessment and review of the perceived risks. One must consider and understand expectations of their role legally, but also in terms of their respective professional body. These considerations will include whether the employer has taken adequate steps to ensure the safety of their staff, plus whether the paramedic has offered a reasonable duty of care to the patient. This is done alongside consideration of 'the right to life', in which it is described how paramedics must take adequate steps to preserve life at all times.

In terms of caring for critically unwell patients with respiratory disease, the considerations a paramedic might make will involve whether the equipment that has been provided to them affords them adequate protection. If the application of the relevant piece of equipment is associated with a delay to time critical patient care, they must then consider whether this delay is justifiable. In other words, they must appraise the evidence and assess whether the required procedure that is necessary for effective patient care poses a significant enough threat to themselves in terms of transmission risk. These, along with other key elements for consideration, have been summarised in JRCALC (2023) Duty of care guidance, whereby a summary is offered of the requirements of paramedics and the suggested mitigating steps they should take when faced with risk in their course of the duties (see Table 2.1).

Table 2.1 'Duty of Care - Aide Memoire' taken from JRCALC (2023)

Duty of Care Requirement		Steps to Take	Explanation
Duty of Care to Staff	Take all reasonable and practical steps to keep employees safe.	Perform approved activities and apply the controls specified in procedures. Ensure there is a generic risk assessment already in place. Ensure you are trained and competent to undertake the activity. Ensure the minimum equipment mandated by procedures is available and used (including your Personal Protective Equipment (PPE).	These are statutory duties under the Health and Safety at Work Act 1974 and associated regulatory provisions. These steps will help ensure you have a safe system of work. Most of these provisions should already be established prior to the incident.
Duty of Care to the Patient	Provide a reasonable standard of care without any unreasonable delay.	Undertake a dynamic risk assessment and determine the action you need to take as quickly as possible. Continually review the position and deliver care as soon as possible. If you need specialist support, make sure you request it as soon as possible.	This is an established duty at common law. It is a positive duty of the ambulance service to provide a reasonable standard of care without unreasonable delay. This duty is unique to healthcare professionals. The police and fire services have duties to the public at large, but their duty to individual patients is largely discretionary (Kent v Griffith [2001] QB 36).
Article 2 Right to Life	Take steps to protect people from harm which may lead to loss of life.	Take steps to protect people from harm which may lead to loss of life.	Take steps to protect people from harm which may lead to loss of life.
Risk Assess the Activity	Assess the risks for both staff and patients.	Supplement the pre-existing generic risk assessment with a dynamic risk assessment at the scene considering the situation and hazards. Mitigate the risks as best you can. The risk to patients must be included in that assessment. Regularly review the risk assessment.	If the activity is likely to result in death or serious injury to you or a member of your team despite the controls, do not commit. Statutory health and safety obligations provide justification for the temporary delay in care. If the risk of death or serious injury to you or your team can be mitigated by a safe system of work, making the likelihood low but accepting some residual risk, you must avoid unreasonable delay in committing and providing emergency care. For complex or major incidents, ambulance commanders are responsible for balancing these principles.

Expanding on some of the concepts featured within Table 2.1; 'Duty of care' refers to the ethical, professional, and legal obligations that exist to safeguard standards of care and patient safety. This is applicable to clinicians employed by an ambulance service in two ways, firstly, there are expectations that an individual clinician takes appropriate measures to ensure their own personal safety and that of their team; secondly, expectations exist that an individual clinician provides a reasonable standard of care to the patient they are responsible for (Robinson, 2022; [1]Royal College of Nursing (RCN), 2023; Chartered Society of Physiotherapists, 2020; JRCALC 2023).

The case in law of 'Kent v Griffiths' (2001) found that NHS ambulance services have a positive legal duty to provide reasonable standards of patient care that avoid prolonged delays. 'Bolam v Friern Hospital Management Committee' (1957) defined a reasonable standard of care as being that expected and supported as being reasonable following review by a body of similarly qualified medical professionals. Ambulance clinicians, specifically paramedics and nurses, have standards of proficiency outlined by their appropriate professional bodies (HCPC 2023, NMC 2018). Additionally, ambulance services find themselves in a position where delays in care might potentially need to be defended from a liability standpoint. Failure to justify delays in care could potentially see ambulance services charged with negligence as was the case in 'Kent v Griffiths' (2001). Being cognisant of the uncertainty and angst that existed at the time of the declaration of the COVID-19 pandemic, which shall be described in more detail later in the chapter, the dilemma faced by paramedics is alluded to in the following direct quotation.

> '*If the activity is likely to result in death or serious injury to you or a member of your team despite the controls, do not commit. Statutory health and safety obligations provide justification for the temporary delay in care. If the risk of death or serious injury to you or your team can be mitigated*

by a safe system of work, making the likelihood low but accepting some residual risk, you must avoid unreasonable delay in committing and providing emergency care.' (National Ambulance Resilience Unit (NARU); The Duty of Care for Ambulance Responders, 2021)

2.2.3 Dynamic risk assessment

When it comes to risk assessment in the prehospital setting, dynamic risk assessment is used to establish scene safety. It is a term familiar to paramedics and a practice routinely conducted in prehospital care. Typically, during paramedic practice education, assessment of risk in this fashion is introduced as part of 'objective structured clinical examinations' (OSCEs). Prior to their qualification, as part of their training, paramedic students would be encouraged to ask the question, 'Is the scene safe to proceed?' before commencing simulated patient scenarios. They would potentially fail the assessment should they not ask this question from the offset, as they could have risked their safety. Classic examples might include a simulated OSCE setting involving an electrocuted patient whereby the live wire is still in proximity to the patient or a chemical incident in which a toxic substance was present. This training intends to embed the principle of dynamic risk assessment to help safeguard the aspirant paramedic's safety as they embark on their careers (Stafford, 2023; Klein & Tadi, 2023; Scottish Ambulance Service (SAS) 2015).

The recommended process by the National Ambulance Resilience Unit (NARU) Command and Control guidance provides a formal structure to this assessment for use at larger scale incidents involving multiple casualties. Dynamic risk assessments are required wherever risk is present and thus are a requirement during all patient care episodes, including those where nosocomial transmission of respiratory disease might exist. Paramedics must undertake appropriate, rapid assessment of these risks when arriving at all incidents which they attend, and when the scene is deemed unsafe, they will

then be expected to take appropriate actions to mitigate the presenting risk and yet continue to provide the best patient care they are able (JRCALC 2023).

The roots of these principles lie within industries outside of healthcare, with dynamic risk assessment first documented in firefighting and aviation. The process can be described as a framework to aid emergency responders' decision-making, and its use encourages continuous assessment of risks, with the taking of appropriate countermeasures to mitigate said risk. The origins of this lie in the naturalistic decision-making paradigm (NDM), its development being an evolution of the recognition-primed decision-making model (Ashbury & Jacobs, 2014). The NDM is described as a framework, or process, in which individuals draw upon their previous lived experience in order to make decisions when presented with complex situations (Orasanu, 2001). The advancing developments in prehospital care, alongside the multi-agency approach to major incident response, led to the use of dynamic risk assessment becoming embedded within ambulance service response mechanisms to major incident management.

Dynamic risk assessment refers to a particular circumstance or environment that, by definition, will be actively evolving or changing, hence the inclusion of dynamism (Pilbery, et al 2019). Prehospital, the evolving nature of emergencies is common; one might suggest it to be a daily occurrence. The cognitive processes behind risk assessment must balance the perceived benefit of proceeding with a targeted course of action versus the risk to those tasked with its delivery. The concept of dynamism refers to the environment or situation and not the risk itself (Ashbury & Jacobs, 2014). Figure 2.1 shows the dynamic risk assessment tool recommended for major incident response commanders used by the National Ambulance Resilience Unit (NARU). This process is also featured in JRCALC guidance for paramedics. This system aligns the principles held within the recognition-primed decision-making methodology and the dynamic management of risk framework (Ashbury & Jacobs, 2014).

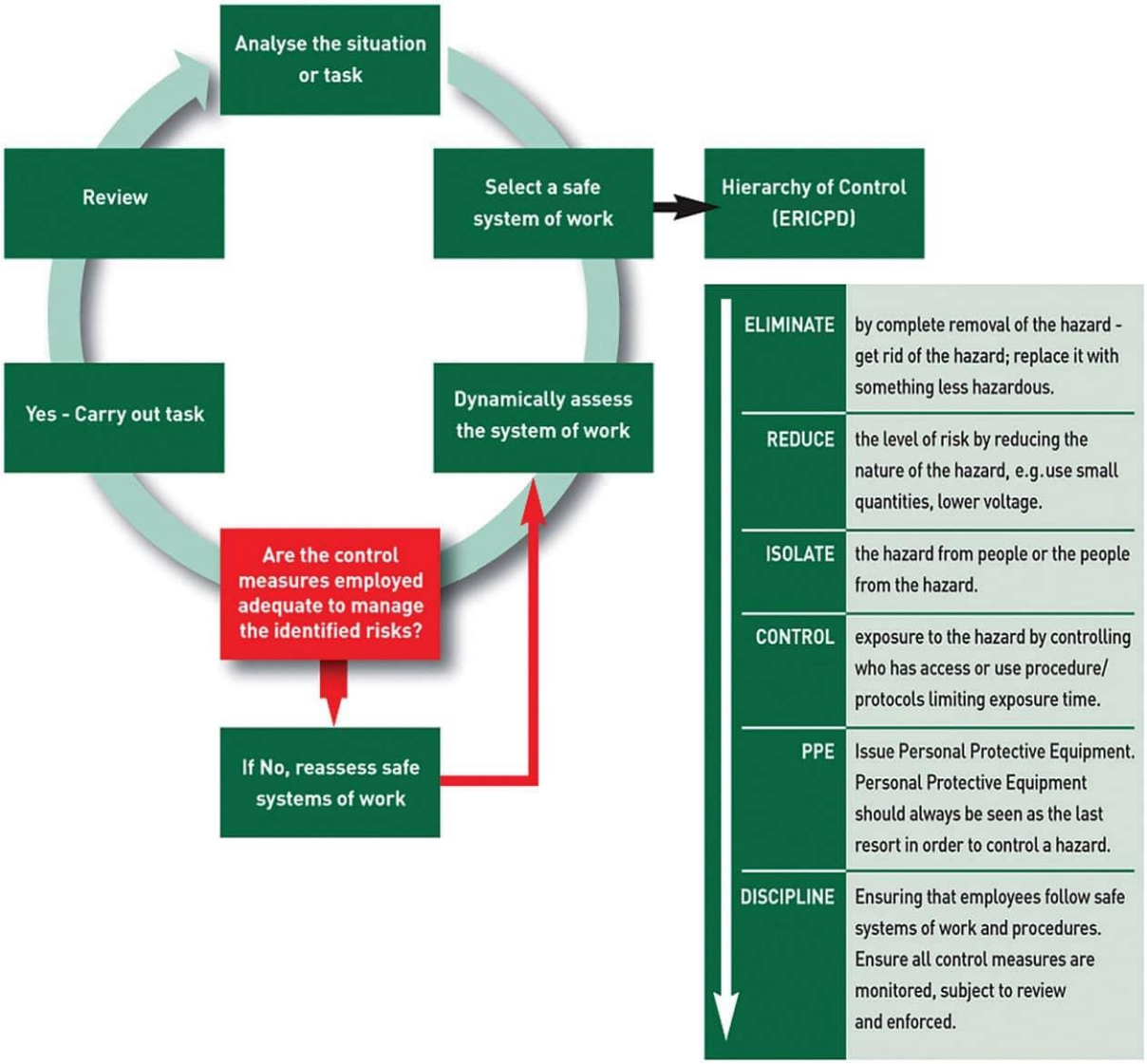


Figure 2.1 Dynamic risk assessment in NARU command and control guidance (2015)

An important consideration regarding dynamic risk assessment is that it should not be relied upon in isolation but should instead form part of a broader risk assessment process. Employers, such as ambulance services, have a duty to conduct suitable predictive risk assessment evaluations for activities they expect their staff to perform. Once employers have carried out risk analyses, they are legally required to implement suitably proportionate protective measures to enable their staff to perform

their duties effectively. If employers fail to meet this legal requirement, they could find themselves liable for legal prosecution.

2.2.4 The COVID-19 pandemic

On the 31st of December 2019, the World Health Organisation (WHO) was notified regarding the emergence of pneumonia of unknown aetiology within Wuhan City, Hubei province, China. Epidemiological data highlighted two of the three earliest cases linked to a Huanan wild animal and seafood market (Holmes et al., 2021). By the 31st of January 2020, Chinese authorities reported forty-four cases, eleven of which had become seriously ill, requiring ventilatory support (WHO, 2020). The causal agent was subsequently identified as a novel coronavirus, later named SARS-CoV-2.

A pandemic was declared by the WHO on the 11th of March 2020; case numbers subsequently increased rapidly (WHO, 2020). As of 1151Hrs CET, on the 25th of January 2025, there have been 777,310,393 reported cases globally, with 7,083,246 deaths attributed to SARS-CoV-2. Furthermore, 1 in 8 deaths in England and Wales are thought to be COVID-19-related up to July 2022 (WHO Coronavirus Dashboard 2025, Raleigh 2022).

Infection of host cells by SARS-CoV-2 virus results in the respiratory disease COVID-19 (full name; Coronavirus disease 2019). Symptomology of COVID-19 has been highly varied since the declaration of the pandemic, with patient presentations ranging from asymptomatic to severe, potentially fatal disease requiring critical care ventilatory support (Alene et al., 2021; Booth et al., 2021). Mild symptoms frequently include fever, rhinorrhoea, cough, dyspnoea, gastrointestinal (GI) disturbances or headaches. Severe illness can lead to multi-organ failure and be fatal, particularly in the presence of certain predisposing risk factors such as comorbidities, sex, and ethnicity (BMJ, 2020). Most frequently, patients

report a combination of fever, cough, taste or smell disturbances and dyspnoea; however, variants of coronavirus emerge, creating a variety of new symptoms affecting bodily systems outside the cardiorespiratory; a summary of those reported is in Table 2.2.

Table 2.2 Table showing description and prevalence of the signs and symptoms of COVID-19.

Clinical signs	Prevalence / further information	Source(s)
Fever	Prevalence of 77%, 44% in milder cases, and 89% prevalence in hospitalised patients.	Xie et al., 2020, Guan et al., 2020
Cough	68% prevalence. Dry more so than productive. May persist for extended periods.	Song et al., 2021, Xie et al., 2020
Dyspnoea / tachypnoea	Prevalence 38%. Median onset between 5 – 8 days. Wheeze was noted in 17% of cases.	Xie et al., 2020, BMJ Best Practice, 2022, Grant et al. 2020
Altered taste and/or smell	Anosmia/hyposmia: 55% prevalence. Ageusia / dysgeusia: 41% prevalence. 13 – 73% first symptom of COVID-19.	Esselli et al., 2021, Dos Santos et al., 2021
Headache	Twice as prevalent in COVID-19 versus other viral infections. 25% overall prevalence. A common symptom of the Omicron variant.	Mutiawati et al., 2020, ZOE, 2021
Sore throat	16% prevalence. Common Delta and Omicron variant symptoms.	Xie et al., 2020, ZOE, 2021
Rhinorrhoea	8% prevalence. Common Delta and Omicron variant symptoms.	Grant et al., 2020, ZOE, 2021
Fatigue	Present in 30% +/- malaise, it may be prolonged. Common Omicron variant symptom.	Xie et al., 2020, ZOE, 2021
Myalgia	Myalgia 17%, Arthralgia 11% prevalence	Grant et al., 2020
Sneezing	Common Delta and Omicron variant symptoms.	ZOE, 2021
GI upset	20% prevalence. Symptom breakdown: Reduced appetite 22.3%, diarrhoea 2.4%, nausea and vomiting 9%, abdominal pain 6.2%.	Tariq et al., 2020
Dizziness	11% prevalence	Grant et al., 2020
Eye irritation	11% prevalence. Symptom breakdown: Dry eye 16%, tearing 12.8%, pain 9.6%, discharge 8.8%.	Nasri et al., 2021
Neurological symptoms	Delirium prevalence: 24.3%. 28% in adults >65 years. Confusion prevalence is 11%, anxiety 15.2%, depression 16%, insomnia 23.9%.	Grant et al., 2020, Shao et al., 2021
Audio-vestibular	Hearing loss 7.6%, tinnitus 14.8%, vertigo 7.2%	Almufarrij et al., 2021

Chest pain	7% prevalence	Grant et al., 2020
Haemoptysis	2% prevalence	Grant et al., 2020
Tachycardia	Unknown prevalence and can also be a sign of SARS	BMJ, 2022
Cutaneous symptoms	Pooled prevalence 5.7%, viral exanthem 4.2%, maculopapular 3.8%, vesiculobullous lesions 1.7%	Bandhala et al., 2020, Kashetsky et al., 2021
Oral lesions	Ulcers of varying aetiology: prevalence 36.3%	Erbas et al., 2022
Lower UTI symptoms	Scrotal pain/swelling, urinary retention, and symptoms of UTI are among documented findings.	Creta et al., 2021
Arrhythmia / pain	Cardiac injury prevalence in hospitalised patients ~13 – 41%	Friedrich et al., 2021, Clerkin et al., 2020

Infection with SARS-COV-2 led to the emergence of post-COVID syndrome, commonly referred to as 'long COVID', a poorly understood yet debilitating and protracted secondary syndrome of COVID-19 (Iqbal 2021). As of the 2nd of January 2022, the ONS found that 2.1% of the population of the United Kingdom had self-reported having suffered from the effects of 'long COVID'. The most frequently reported symptoms of post-COVID syndrome were fatigue (50% prevalence), dyspnoea (37%), loss of smell (37%) and taste (28%) (ONS 2022). Data regarding demographic prevalence found that specific populations, notably healthcare workers, were subject to disproportionately high transmission rates of COVID-19. They were found to have ten times that of the general population in the UK (see Figure 2.2) (Nguyen et al. 2020). This subsequently resulted in increased incidences of long COVID compared to non-healthcare workers (British Medical Association (BMA) 2022).

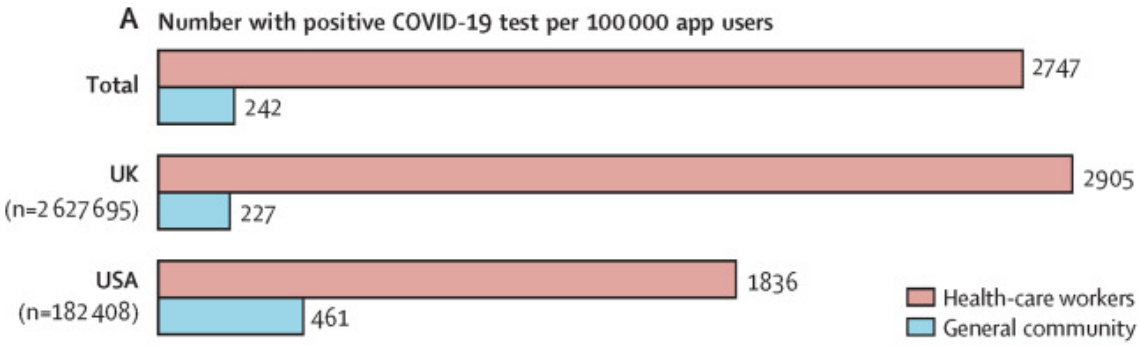


Figure 2.2 Comparison of COVID-19 infection rates taken from Nguyen et al 2020.

The COVID-19 pandemic had a dramatic impact on health outcomes in the United Kingdom and is believed to have contributed to a change in the overall health profile in England (Raleigh, 2022). Healthcare providers were inadequately prepared in terms of the speed and capacity needed to respond to the significant volume of patients and the nature of their presentations, particularly at the onset of the pandemic (BMA, 2023; Stavropulou et al., 2022). Data from the ONS specifically examining mortality in England and Wales between March 2020 and April 2021 revealed that COVID-19 was the nation's leading cause of death, accounting for one in five of all recorded deaths in England (Raleigh, 2022).

To counter rising transmission rates, strict public health guidance was implemented by governments in many countries, including the UK. These measures included restricted travel and 'lockdown' orders issued to the public, mandating that individuals remain at home, an instruction thought to have negatively impacted those in need. This assumption is supported by data showing that, during lockdown periods, a third more people died at home compared to previous years in England (Burton et al., 2022; Raleigh, 2022). These observations align with Rashid et al.'s (2020) findings regarding out-of-hospital cardiac arrest (OHCA) data, where they reported a significant increase in OHCAs in England during this period. Meyerowirz-Katz et al. (2021) urged caution, however, before conclusively linking government

interventions aimed at reducing viral transmission with increased deaths in the community. They highlighted the many challenges associated with untangling the causal implications of public health measures imposed on a vast and varied population, which was simultaneously being served by a stretched healthcare system during a pandemic involving a highly transmissible and potentially fatal pathogen. What is certain, however, is that the pandemic exacerbated health inequalities, sharply highlighting disparities between socio-economic groups, with life expectancies declining more sharply and death rates 2.6 times higher in the most deprived areas of England (Raleigh, 2022).

2.2.5 SARS-CoV-2 transmission and aerosol characteristics

After considerable debate in the initial stages of the COVID-19 pandemic, SARS-CoV-2 transmission was eventually described as airborne through respiratory droplets, bioaerosols and fomites (Fink et al. 2020, [2]WHO 2021). Aside from imposed isolation and social distancing measures, paramedics and other ambulance service healthcare professionals were mandated to adhere to strict protocols regarding infection control that involved the introduction of respiratory personal protective equipment (PPE), particularly when in the proximity of medical procedures thought to be aerosol generating procedures (AGPs) (Leong et al., 2020)—Table 2.3 lists medical procedures thought to generate aerosols according to the World Health Organisations list in 2021.

Table 2.3 World Health Organisation list of aerosol-generating procedures (WHO 2021)

Medical	**Dental**
Tracheal intubation	Any procedure involving spray-generating equipment e.g., three-way air/water spray and dental cleaning
Non-invasive ventilation (bilevel positive airway pressure/continuous positive airway pressure)	Tooth polishing
Tracheotomy	Periodontal treatment using ultrasonic scaler
Cardiopulmonary resuscitation (CPR)	Procedures involving high- or low-speed handpieces
Manual ventilation before intubation	Direct or indirect restoration and polishing
Bronchoscopy	Cementation of crowns or bridges
Sputum induction using nebulised hypertonic saline	Mechanical endodontic treatment
Autopsy procedures	Surgical tooth extractions and implant placement

At the onset of the pandemic, these definitions of medical procedures thought to be aerosol generating within literature were derived from theoretical hypotheses rather than evidence-based quantification. Transmission risk was assumed to be associated with the forces of pressurised air or medical gases causing the aerosolisation of virus-containing moisture situated within infected airways (Klompas et al., 2021).

Expelled respiratory particles take the form of aerosols or droplets, terms that are based on the respiratory particle size and aerodynamic characteristics. The smallest expelled respiratory particles

measure nanometres compared to the substantially larger particles that can be recordable in magnitudes as large as millimetres (Leung, 2021; Gralton, 2011; Fennelly, 2020; Johnson, 2010). In Respiratory aerosol particles have been previously defined as being under five micrometres. Particles that are over five micrometres in size were then referred to as droplets. Droplets suggested as much larger and heavier than aerosols, are assumed to follow a ballistic trajectory.

In contrast, aerosols can remain suspended in the air, akin to smoke, or spray from a deodorant can, governed by chemical and physical processes. It has since been suggested in more contemporary literature, through advances in aerosol-measuring technology, that this dichotomy used to describe aerosols and droplets with a seemingly arbitrary size cut-off could be over-simplistic. It has more recently been described how particle sizes of magnitudes up to 100 μm can demonstrate aerosolisation properties and remain suspended in the air for up to 5 seconds (Drossinos et al., 2021). SARS-CoV-2 virus particles measure approximately 0.1 μm, with aerosol particles of approximately 5 μm able to convey these virions (Bar-On et al., 2020; Lee, 2020; Wang et al., 2021). These measurements and characteristics have important implications when making risk evaluation decisions around appropriate levels of PPE.

Humans create respiratory particles, both droplets and aerosols, through the turbulence of exhaled air passing over moist, mucous-lined epithelial cells that make up the tracts of the airways. This air force, generated through activities such as coughing, sneezing, singing, or simply breathing, liberates aerosol particles that are then exhaled, leaving the confines of the airway and entering the more expansive atmosphere (Edwards et al., 2021). Once aerosolised, particles are then subject to the environmental effects of temperature and humidity, which can further alter their size and aerodynamic properties, as does the speed at which they leave the airway (Drossinos et al., 2021; Klompas et al., 2021). Physiological conditions that alter the surface tension and viscoelasticity of the mucous-lined airways

can increase the propensity for respiratory particle generation; hence, surfactant properties play a crucial role. Surfactants within the lungs are chemical complexes comprising proteins and phospholipids and act to reduce surface tension where air meets the pulmonary liquids to enable the process of respiration (Bernhard, 2016). Factors such as age, weight, diet, and the presence of infection (notably COVID-19) can change lung surfactant properties and lead to a greater propensity to produce droplets and aerosols (Edwards et al., 2021; Yin et al., 2021; Leung, 2021).

Bioaerosols present a particular threat of transmission due to their propensity to remain suspended in the air for prolonged periods, a characteristic that potentiates disease transmission over long distances within a multiphase, turbulent gas cloud. This proposed model suggests that exhaled particles exist in a mixture within ambient air carried forward through the force and momentum of expiratory activities (Leong et al., 2016; Bischoff et al., 2013). These particles would be subject to influences both environmentally and within the turbulent gas cloud, including humidity and temperature, so providing larger droplets conditions in which to travel more considerable distances than would be expected from a simple ballistic trajectory as they are subject to environmental influence.

Successful transmission of a virus, therefore, is dependent on a multitude of factors that include the susceptibility of the host, the type of virus involved, viral load, and the environmental conditions present, such as temperature, pH or humidity. These determinants also include the level of contagiousness of the host as well as the susceptibility of the recipient. It is postulated that aerosol deposition within the lower respiratory tract is more associated with disease transmission (Spicknall et al., 2010; Leong, 2021). The propensity for viral transmission depends upon its stability when subjected to environmental stress. This is influenced by various characteristics of its composition, including the makeup of its viral envelope, internal proteins, and capsid (Bajimaya et al., 2017; Mateu et al., 2013; Saha et al., 2014).

Bioaerosols, as their name suggests, originate from biological sources. Examples are wide-ranging and complex and originate from any living organism. This might be active viruses or bacteria, dust-containing dried insect excreta, organic carbon aerosols, or pollen (Lindsley et al., 2017). Anthropogenic aerosols are those that are produced because of human activities. They are a term that can be used to refer to aerosols produced through agriculture or the combustion of fuels, for example. Atmospheric aerosols are made up of various particles, dust being one such example. The constituents of atmospheric aerosols include bioaerosol and anthropogenic aerosols, dust (size range ~0.5–10µm), smoke (~50 nm–1µm), sea salt, and even volcanic ash dependent on the surrounding environmental characteristics (Pan, 2015). Exhaled cigarette smoke, as an example, has a particle size range smaller than that of exhaled bioaerosols, with particles with the ultrafine size range typically smaller than 1µm. Being able to differentiate bioaerosols from environmental aerosols through knowledge of their properties and characteristics is particularly important when attempting to interpret and evaluate aerosol data and determine the aerosol generating propensity of procedures in the context of disease transmission.

2.2.6 Quantifying aerosols

Measuring aerosols is challenging for a variety of reasons. Their small size and complex composition present significant barriers. These factors make it difficult to differentiate one aerosol source from another. In a domestic setting, the composition of aerosol particles can originate from numerous sources, such as cooking, cleaning, dust, the exhalation activities of either human or animal occupants, outdoor air pollution, and pet dander. Various tools and mechanisms exist for sampling and quantification; the Optical Particle Counters (OPC) used in this project are discussed in greater detail in Chapter 4. Other tools for quantifying aerosols include Electrical Low-Pressure Impactors, gravimetric sampling, and bioaerosol samplers.

2.2.6.1 Optical particle counters

OPCs use optical light scattering techniques to enable particle detection. This method involves passing particles within air samples over a light source, typically a laser beam. The light source then becomes scattered as particles pass over this light source. The amount of scattered light is proportional to the size of the particle and enables the estimation of particle sizes and numbers. Although useful in indoor and environmental studies, enabling real-time data to be monitored, their limitations lie in their ability to distinguish between biological and non-biological aerosols (Bezantakos et al., 2020). The Alphasense® OPC-N3 (Alphasense® Ltd., Essex, UK) used within the prehospital element of this study utilised a diode laser at a 658 nm wavelength as the light source to measure particle-induced light scattering. This device collects data in 24 bins, each corresponding to a particular particle size. Preferred for the prehospital element due to being lightweight, small, and easily portable.

2.2.6.2 Dekati® HR- Electrical Low-Pressure Impactor (ELP®I+).

This sophisticated instrument measures particles' size distribution and concentration by inducing an electric charge to particles as they enter the device through a sampling port. These are then passed over a series of stages or 'bins'. Each bin collects/detects particles of a specific size ranging from 0.06 µm to 10 µm. The Dekati® ELPI®+ (Electrical Low-Pressure Impactor; Dekati® Ltd., Finland) was originally planned to be used during the prehospital element of this thesis; however, although it offers some portability through its design, the device was too large and heavy when tested to be used during the prehospital data collection.

2.2.6.3 Gravimetric Sampling

This method of measuring airborne particulate mass concentration utilises a technique in which air samples are drawn over a filter that collects any circulating particulates. It has previously been used in studies investigating coal dust in relation to Australian workers' susceptibility to pneumoconiosis. Although providing a direct measurement of particle mass, it does not offer real-time data and requires laboratory analysis, positioning it as a more time-consuming technique when compared to optical methods (Belle, 2019; O'Connor et al., 2014; Huang et al., 2021).

2.2.6.4 Bioaerosol Samplers

This mechanism involves using specialised devices to collect and analyse biological particles present in the air. Air samples are drawn over a medium that captures any free-floating biological matter, which is then cultured and reviewed microscopically or molecularly. Samplers of this kind take a variety of forms and include ‘impinges’ and ‘impactors’. So named ‘impinges’ act to trap free floating biological matter in the air within a liquid medium, whereas ‘impactors’ deposit the biological matter onto a solid surface to enable analysis. It is a technique widely used within microbiological and environmental health studies and provides insight into air quality; however, despite providing a robust mechanism to identify the circulating bioaerosol through culture growth correctly, it does not provide any real-time analysis of particle numbers. The use of a laboratory in which to conduct the analysis again is a timely endeavour (Guo et al., 2024).

2.2.7 Personal Protective Equipment guidance during the pandemic

Personal Protective Equipment (PPE), in all its guises, is designed to offer protection to the wearer; regarding respiratory PPE specifically, it is designed to reduce the risk of transmission of infectious diseases by providing a physical barrier between the wearer and the pathogen (Chugtai et al., 2020; Higginson et al., 2020). Before the COVID-19 pandemic, PPE in ambulance services typically involved protection from the elements such as high visibility clothing and helmets. Basic provisions to contribute to infection prevention and control measures included disposable gloves and, less commonly, aprons with little or no exposure to respiratory protection. Higher levels of PPE, particularly respiratory PPE, were reserved for the more specialist paramedics who made up the Hazardous Area Response teams (HART). This respiratory PPE was issued to assist with elements of their role that involved responding to and supporting incidents where hazardous materials (termed HazMat) or chemical, biological, radiological, nuclear and explosives (CBRNe) might be present. The 'HazMat' element required HART paramedics to perform inter-facility transportation of patients suspected, or confirmed as, having any high-risk infectious disease, such as Ebola, and so led to them being utilised in the initial stages of COVID-19 (NARU, 2023; NHSE, 2020).

PPE use in healthcare contributes to wider infection, prevention, and control strategies to reduce nosocomial infection. It has significant importance during the initial stages of a pandemic, pending the development of alternative protective strategies such as vaccination programs, and is recommended to be used in conjunction with other preventative and control measures to optimise PPE effectiveness, such as social distancing, hand hygiene and cough etiquette (Chugtai et al., 2020; WHO, 2020).

Guidance developed and issued by the WHO for healthcare professionals in response to COVID-19, mirrored by the UK government's early advice, recommended the use of medical masks, gowns,

disposable gloves, and eye protection when caring for suspected or confirmed COVID-19 patients. An increased level of PPE was advised when healthcare workers were in the presence of AGPs being performed on a suspected or confirmed COVID-19 patient. In this instance, they advised respiratory (N95 or Filtered Face Piece (FFP) 2 masks, standard or equivalent, gown, gloves, eye protection and apron (Public Health England (PHE) 2020, WHO 2020) (see Figure 2.3).

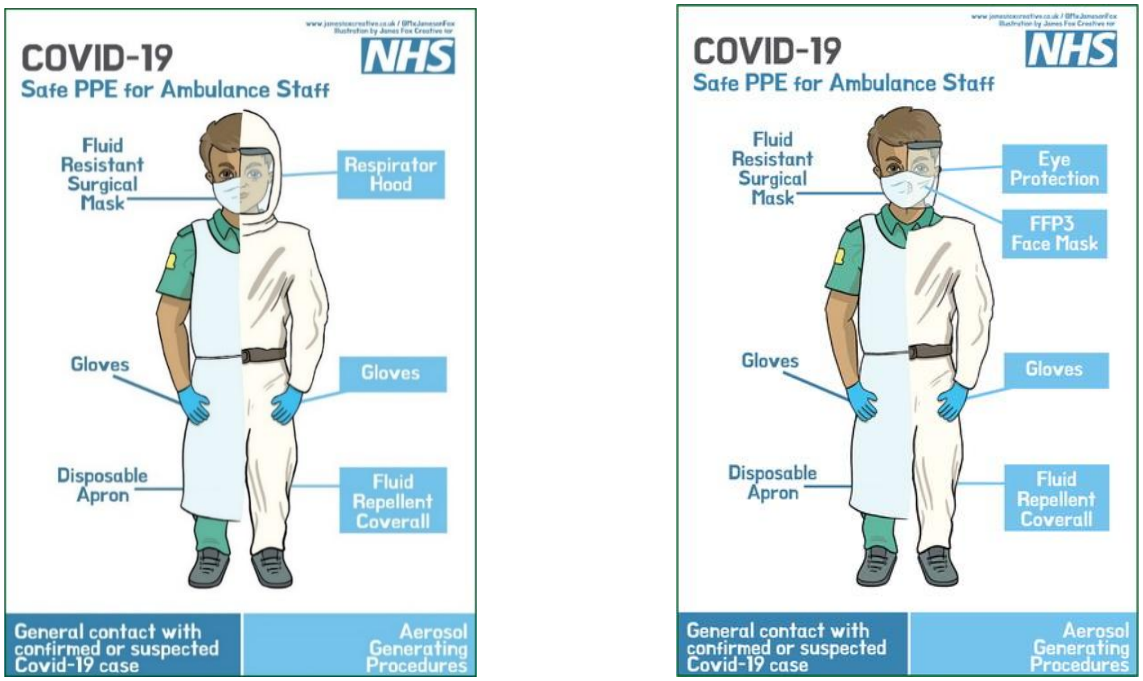


Figure 2.3 PPE guidance issued to ambulance service personnel during general patient contact (level 2, depicted on the left side of the image) and when in the presence of aerosol generating procedures (level 3, depicted on the right side of the image). Shared with kind permission granted from the author, James Fox Neville.

N95 is a name provided by the United States of America's National Institute for Occupational Safety and Health (NIOSH). This organisation provides standards for which respirators must meet, and classifications are differentiated by their level of oil resistance, 'N' representing 'non-oil', meaning it is not for use in the presence of oil. N95 describes a non-oil respirator that filters 95% of particles. The

European classification uses the Filtering Face Piece (FFP) system. These respirators must meet the European Standard EN 149:2001 standards, which defines FFP2 masks as those that filter 94% of particles and FFP3 masks 99%.

2.2.8 Cardiac arrest resuscitation: Chest compressions and defibrillation

A cardiac arrest is a time-critical emergency and refers to the event in which the heart stops pumping blood effectively (British Heart Foundation, 2023). This results in an inability to maintain a blood pressure compatible with life and will prove fatal if not rectified quickly. Cardiac arrest survival is dependent on early and effective cardiopulmonary resuscitation (CPR) (Olasveengen et al., 2021; Soar et al., 2021). Basic life support (BLS) describes the delivery of rapid, sequential interventions conceptualised within the 'chain of survival' (Nolan et al., 2006). Chest compressions and defibrillation play crucial roles in CPR, with CPR placed fundamentally within BLS algorithms. Alongside the administration of chest compressions, the rescuer should deliver 'rescue breaths', also termed assisted ventilations (Olasveengen et al., 2021; Soar et al., 2021).

Chest compressions require the rescuer to physically apply repeated, controlled, rhythmical external pressure to a patient's sternum. The intended action is to affect intrathoracic pressure in such a way as to manually assist blood flow and sustain end-organ perfusion, therefore temporarily mimicking the actions of the heart to provide time for more definitive treatment to be administered (Harris et al., 2018; Leong et al., 2020; Soar et al. 2021,). Defibrillation involves an electrical current being passed through the thoracic cavity, acting on the heart to terminate; in the instance of cardiac arrest, ventricular dysrhythmias that, if ignored, would prove fatal. When done promptly, defibrillation has been proven to be a highly effective, life-saving intervention (Goyal et al., 2020; Nolan et al., 2006).

2.2.9 PPE guidelines – lack of clarity around AGPs

Uncertainty regarding PPE guidance arose about which procedures of resuscitation should be considered aerosol generating. Evidence regarding chest compressions and defibrillation, specifically as AGPs, is scant, with the limited data available being inconclusive due in part to the multifaceted nature of resuscitative efforts, meaning making any specific conclusions as to the source of transmission during resuscitation is difficult (Couper et al., 2020). This lack of evidence led to conflicting guidelines from various professional bodies regarding recommended levels of PPE, which then created ethical and medicolegal questions regarding healthcare professionals' responsibilities when responding to patients in cardiac arrest (Cheruku et al., 2020; Payne & Peache, 2021; Perkins et al., 2020). Adherence to enhanced PPE protocols meant the process of donning PPE delayed the rescuer administering lifesaving interventions to patients; however, non-adherence to higher levels of PPE might put rescuers at risk of infection from a potentially life-threatening respiratory disease. Literature exists that demonstrates how delays in response to OHCA patients during COVID-19 might have contributed to adverse clinical effectiveness and affected patient outcomes, as seen through increased OHCA rates throughout this period (Hodkinson, 2022; Ryapan et al., 2022; Masuda et al., 2022).

Healthcare professionals' COVID-19 infection rates remained high despite enhanced PPE protocols, and tragically, mortality was found to be disproportionately high among healthcare professionals when compared to the general population (Key et al. 2020, Haji et al. 2020). Literature repeatedly highlighted the urgent need for further research to quantify aerosols generated by compressions and defibrillation (Couper et al., 2020). Confusion in PPE guidance, directed to healthcare professionals responding to patients in cardiac arrest, arose due to inconsistencies in nomenclature. As stated in Table 3, cardiopulmonary resuscitation (CPR) was highlighted as an aerosol generating procedure by the WHO, a sentiment echoed in early guidance issued by the Resuscitation Council UK (RCUK) (2020).

Cardiopulmonary Resuscitation (CPR) traditionally refers to the delivery of chest compressions and assisted ventilations via mouth-to-mouth or bag-valve-mask ventilation. Guidelines were adapted to encourage compression-only CPR due to the reluctance of laypeople to perform assisted ventilations. This reluctance is suspected to have been born from either a lack of understanding of the techniques involved or a fear of disease transmission through mouth-to-mouth ventilation (Taniguchi et al., 2007), a fear exacerbated by the pandemic (Bray, 2020). Advanced Life Support (ALS) builds on BLS by introducing more invasive interventions, such as intravenous medications and advanced airway management, in addition to BLS procedures such as chest compressions and assisted ventilation. Literature can use CPR as a term to refer to either chest compressions, BLS or ALS. This ambiguity of language regarding CPR led to difficulty in drawing specific conclusions regarding chest compressions as a possible AGP.

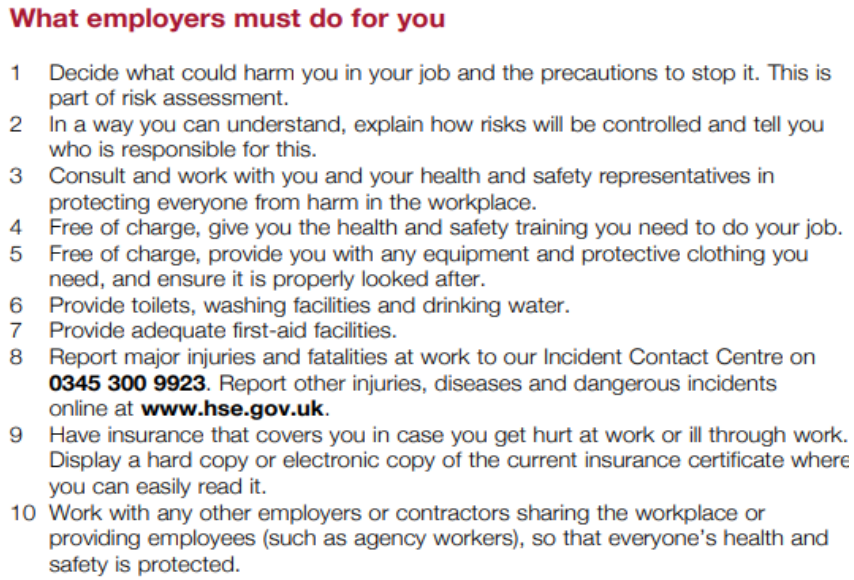
Public Health England's (PHE) early guidance during the first wave of COVID-19, issued to healthcare professionals, recommended higher levels of PPE to be worn when undertaking or in the proximity of aerosol generating procedures (PHE 2020). Chest compressions and defibrillation were notable omissions from their list of AGPs. This was based on the New and Emerging Respiratory Virus Threats Advisory Group (NERVTAGs) statement on CPR as an AGP. The report stated that whilst chest compressions creating aerosol might be possible, it should be seen as a low-risk event in the same way that expiration and cough were (NERVTAG 2020). RCUK, a committee of healthcare professionals and 'national experts in resuscitation' (RCUK 2024), as per their website, issued a statement that highlighted their concerns on PHE's stance not to include chest compressions on the list of AGPs. The below direct quote from their then-president provides insight into the confusion facing healthcare professionals that existed at this time. The RCUK went on to issue PPE guidance that went against the recommendations from PHE and NERVTAG, seeing RCUK advocating for higher levels of PPE when administering chest compressions.

'*We are deeply concerned by Public Health England (PHE)'s continued insistence on designating chest compressions as non-Aerosol Generating Procedures (AGPs). The clinical reality is that chest compressions produce excretions from a patient's nose and mouth. As such, irrespective of whether this is via aerosol or droplet or both, this poses a demonstrable risk to Healthcare Professionals (HCPs).*'

Professor Jonathan Wyllie, RCUK president ([1]RCUK 2020).

2.2.10 Personal Protective Equipment: Legal requirements of employers

The primary piece of legislation that sets out an employer's health and safety obligation to their employees and that of the wider public is the Health and Safety Act 1974 (Health and Safety Executive (HSE) 2023). The pertinent details held within this legislation include the following summary leaflet (Figure 2.4) issued for employee awareness, published by the HSE.



What employers must do for you

1 Decide what could harm you in your job and the precautions to stop it. This is part of risk assessment.
2 In a way you can understand, explain how risks will be controlled and tell you who is responsible for this.
3 Consult and work with you and your health and safety representatives in protecting everyone from harm in the workplace.
4 Free of charge, give you the health and safety training you need to do your job.
5 Free of charge, provide you with any equipment and protective clothing you need, and ensure it is properly looked after.
6 Provide toilets, washing facilities and drinking water.
7 Provide adequate first-aid facilities.
8 Report major injuries and fatalities at work to our Incident Contact Centre on **0345 300 9923**. Report other injuries, diseases and dangerous incidents online at **www.hse.gov.uk**.
9 Have insurance that covers you in case you get hurt at work or ill through work. Display a hard copy or electronic copy of the current insurance certificate where you can easily read it.
10 Work with any other employers or contractors sharing the workplace or providing employees (such as agency workers), so that everyone's health and safety is protected.

Figure 2.4 Section taken from Page 1 of a 20-page Health and Safety at Work - employee information leaflet issued by the Health and Safety Executive summarising the pertinent details of employer's responsibilities to their staff (HSE 2009).

PPE features separately as part of the Personal Protective Equipment at Work Regulations (PPER) Act of 1992, in which PPE was defined as being '*all equipment (including clothing affording protection against the weather) which is intended to be worn or held by a person at work and which protects the person against one or more risks to that person's health or safety, and any addition or accessory designed to meet that* objective' (PPER 1992). The 1992 Act has since been amended through the release of the Personal Protective Equipment at Work (Amendment) Regulations Act of 2022. The original definition of PPE remains valid within this amended legislation. The 2022 act, like its predecessor, highlights how employers have a duty to conduct risk assessments about the activities of their employees and respond appropriately to mitigate any identified risk. The 2022 Act states that when a risk assessment has deemed PPE necessary, employers should provide protective equipment at no cost to the employee (HSE 2022).

Strategies to mitigate risk are included in a hierarchy of controls suggested for employers in which PPE features as a final resort. Recommended actions to implement before using PPE include the following: '*elimination*' through removal of the offending hazard, '*substitution*' through replacing the hazard with an alternative, '*engineering controls'* that involve isolating people from the hazard, and '*administrative controls'* that involve adapting systems of working to mitigate the threat posed by the risk (HSE 2023).

The guidance provided by HSE to employers suggests that the risk of contaminated air can be caused by hazardous dust, mist, or gas. Whilst there is no direct reference to respiratory pathogens, viruses or words of that ilk, PPE at Work Regulations 1992 Regulation 4 states how employers, namely healthcare organisations, should provide appropriate PPE wherever employees' health and safety are at risk and the risk cannot be controlled through other measures (PPE at Work Regulations amended 2022). It describes how respiratory protective equipment should be both 'adequate' and 'suitable'. Where adequate refers to consideration as to whether the PPE is correct for the hazard and reduces the risk of exposure to a level to assure the wearer's health. Suitability focuses on whether the PPE is correct for the wearer, the task, and the risk.

2.3 Future pandemics

SARS-CoV-2 is thought to be zoonotic in its origin (Vilcek 2020). Epidemiological data taken in December 2019 showed that 55% of reported SARS-CoV-2 cases were found to have had some degree of first-hand contact with the wild animal markets of Wuhan, particularly the market at Huanan. Early case data strongly suggested the Huanan market as the epicentre; however, further relevant literature advised caution in making definitive claims due to various biases, including sampling bias. However, the significant spike in mortality attributed to pneumonia recorded within the Hubei Province, where the Huanan market is located, specifically towards the end of January 2020, with multiple patients

confirming their attendance to the market area, supports the claim that patient zero originated at this site. These data suggest that SARS-CoV-2 had started to spread within the general population of Wuhan during the first week of January 2020 (Holmes et al. 2021, WHO 2021). By the 1st of January 2020, only 8.6% of cases reported having had any contact with the animal markets, suggesting that the disease's person-to-person transmission had begun around the middle of December 2020 (Li et al. 2020).

The origins of SARS-COV-2, being zoonotic, are not unique to this virion. As populations grow, anthropogenic and ecological activities further entwine, increasing contact between humans and wildlife. Circumstances such as this are thought to have contributed to the majority of new pathogens, and examples include Lyme disease, HIV, malaria, and Ebola (Bardhan et al 2023). The likelihood of this phenomenon repeating is thought to increase as human populations grow and so encroach further into animal habitats, thereby increasing the probability of future pandemics. This fact, considered alongside the global impact of COVID-19, has likely contributed to pandemics now being featured on the HM Government National Risk Register (2023). This document describes the reasonable, worst-case scenario regarding future pandemics. It highlights them being respiratory likely in nature, and so the need to wear PPE remains omnipresent in healthcare environments.

2.4 'PPE fatigue' and non-adherence to PPE protocols

PPE fatigue is a relatively contemporary term adopted as part of the Royal College of Emergency Medicine's (RCEM) safety flash card, designed to help protect healthcare workers from nosocomial infection. This organisation created a poster as a visual reminder to staff to maintain exacting standards regarding personal protection (RCEM, 2020) (see Figure 2.5). The term subsequently featured in various online articles, however, lacks a clear definition within the reviewed literature. The flashcard was later

withdrawn as the pandemic progressed and infection control measures moved away from PPE to focus on hand hygiene and vaccination programs.



Figure 2.5 Royal College of Emergency Medicine (RCEM) Safety Flash card (RCEM, 2020).

The use of the word fatigue suggests forgetfulness or carelessness through tiredness. Literature investigating healthcare workers' adherence to PPE echoes this sentiment, describing forgetfulness and carelessness as major contributors to non-compliance (Neves et al., 2011; Yildiz et al., 2020). Increased workloads directly impact healthcare workers' reported fatigue levels (Chapman et al., 2017). Houghton et al. (2020) found that nursing staff described unrealistic workloads as detrimental to infection prevention and control guidelines adherence.

Several reasons have been captured within qualitative literature regarding non-adherence to PPE protocols, literature that predominately captured perspectives of hospital-based nursing staff, with no

ambulance personnel insight, on this matter, identified through the utilised search strategy. Discomfort, supply, and ability to deliver quality patient care were frequently cited as causes for non-compliance (Li et al., 2020; Silverberg et al., 2021; Yildiz et al., 2020). Health workers who found PPE particularly uncomfortable understandably chose to wear it for shorter time periods (Li et al., 2020). One might say admirably, but worryingly nevertheless, health workers have reported choosing not to use PPE, particularly masks, if they felt it made their patients feel stigmatised or frightened (Houghton et al., 2020). This could be, in part, due to individuals' views of personal risk of disease. The perception of risk has been deemed a key aspect of PPE compliance, with concern regarding protecting family members as a motivating factor (Neves et al., 2020). Conversely, knowledge gaps or a lack of belief in PPE effectiveness led to increased levels of non-adherence (Haji et al. 2020, Houghton et al. 2020). Ultimately, behaviour, particularly in healthcare settings, can be habitual; in Vietnam, 56.4% of HCPs reported finding changes from their old working methods too challenging. This challenge was born from the ease with which they reverted to these old methods, seemingly becoming engrained, instinctive and habitual (Tien et al., 2021). Finally, interesting points were raised regarding the cultural influence within organisations, with staff who saw colleagues maintaining high standards or who felt supported by managers more likely to maintain adherence to PPE policy (Houghton et al., 2020).

2.5 Research Questions and Objectives

Research Question 1:

What are paramedics' experiences of delivering patient care using PPE during the COVID-19 pandemic?

This was achieved via qualitative methods using semi-structured interviews and had two objectives.

Objectives:

i) To examine factors that contribute to paramedic non-adherence to PPE protocols.

ii) To explore how paramedics define PPE fatigue.

Research Question 2:

Do chest compressions and defibrillation delivered during active resuscitation of a patient in cardiac arrest generate aerosols and so pose a transmission risk to the rescuer?

This was conducted using quantitative methods with human subjects in the prehospital setting, with one objective.

Objective:

i) To determine whether chest compressions and defibrillation, delivered during active resuscitation of a patient in cardiac arrest, generate aerosols that may pose a transmission risk to rescuers.

Point of note: The College of Paramedics and the University of Hertfordshire funded and supported this research. The original study design involved recruiting three paramedic researchers to focus on six procedures of resuscitation aerosol-generating propensity. Each researcher was assigned two key procedures involved in the resuscitation of patients in cardiac arrest. These included chest compressions and defibrillation, which are included in this thesis. The other four procedures were bag valve mask ventilation, suctioning, supraglottic airway insertion and endotracheal tube insertion. This will be elaborated on further within Chapter 4.

2.6 Aim

The research questions informed the aim of this thesis, which is to explore and inform the paramedic dynamic risk assessment when applied in the context of delivering resuscitative care to patients in cardiac arrest at scenes where respiratory disease was suspected.

2.7 Significance of the study

It has been demonstrated that patients faced worse outcomes from OHCA after COVID-19. Literature shows fewer OHCA patients achieved a return of spontaneous circulation (ROSC), which was associated with poorer neurological outcomes for those who did during the pandemic (Squizzato et al., 2021). Without a deeper understanding of the aspects highlighted within this work, healthcare workers and the public continue to be exposed to the increased risk posed by current and future contagious diseases, both through the transmission of disease due to inadequate protection and through associated delays in providing life-saving interventions due to the time taken to don PPE. The present uncertainty allows healthcare workers' physical and mental health to suffer, with sources of anxiety in this demographic repeatedly linked to the confusion around methods of protection and guidelines (Flateau et al., 2021; Key et al., 2020; Muharraq, 2021; Wahed et al., 2020).

This study was anticipated to yield data that will contribute to the evidence base to support development in patient and healthcare worker safety. Understanding sources of resuscitative aerosols, the effectiveness of chosen PPE, and gaining insight into behaviours of paramedics when using PPE could lead to tailored, evidence-based guidance, that protects both rescuers and patients and informs infection prevention and control strategies of the future.

2.7.1 The STOPGAP Study and Position of This Research

The quantitative work presented within this thesis was undertaken as part of the wider STOPGAP study (**ST**udy **O**f **C**ardiopulmonary **P**rocedures thought to **G**enerate **A**erosol **P**articles). STOPGAP was designed to investigate aerosol generation during six specific procedures of resuscitation (the full protocol is provided in Appendix 1). The original STOPGAP protocol described three sequential components: a prehospital arm, a critical care arm, and a laboratory simulation arm. The intention was that aerosol data collected in prehospital settings and during controlled critical care procedures would inform the laboratory simulation, enabling a more precise characterisation of aerosol behaviour under controlled conditions. However, the critical care arm did not ultimately progress. As a result, the programme adapted its design and implemented an Emergency Department (ED) arm alongside the prehospital component, ensuring that aerosol measurement could still be undertaken for the planned procedural set. The overarching aim of the programme was to address the uncertainty surrounding aerosol-generating procedures and to inform infection-prevention policy during the COVID-19 pandemic.

This thesis formed part of the prehospital component of STOPGAP. Specifically, it presents the quantitative aerosol-measurement of two of the six procedures of resuscitation for which the author was recruited to lead; these being chest compression and defibrillation, undertaken during out-of-hospital cardiac arrests. These data were combined with an independent and complementary qualitative workstream led solely by the author, that explored paramedics' experiences and PPE-related decision-making during the pandemic. Both of these elements fed into discussion around the paramedic dynamic risk assessment in the context of contagious respiratory disease.

The author was one of a team of three involved in the development and implementation of the STOPGAP protocol, leading on all areas relating to CPR and defibrillation. For the quantitative workstream, the author contributed to the ethics governance, study design, data collection / delivery and analysis. For the qualitative workstream which ran independently to STOPGAP, the author was the sole researcher with responsibility for design, recruitment, data collection, analysis and interpretation.

By integrating these two workstreams, this thesis represents the practitioner-centred element of STOPGAP. It provides both quantitative and qualitative insights into how paramedics interpreted and acted upon risk when responding to suspected respiratory disease, forming the basis for the meta-inferences presented later in the thesis.

2.8 Summary

This chapter introduces the concept of paramedic dynamic risk assessment and the various professional, legal, and ethical considerations that guide decisions related to risk and patient care in a prehospital setting. The COVID-19 pandemic and the subsequent introduction of PPE added an additional layer of complexity in delivering prehospital patient care. Questions emerged regarding the evidence base that informed the strict guidance mandating the routine use of respiratory PPE in different forms within the prehospital environment, particularly when attending to patients in cardiac arrest. This decision was pragmatic, based on a lack of evidence to protect both rescuers and patients. There is little understanding of paramedics' experiences while wearing PPE in this context. To address these knowledge gaps, this thesis poses two research questions that initiate two lines of inquiry using a mixed-methods study design. These questions were formulated to achieve the aim of ultimately informing the paramedic dynamic risk assessment in this situation.

Chapter 3: Review of relevant literature

The opening chapter of this thesis introduced the paramedic dynamic risk assessment, respiratory personal protective equipment, and the impact on paramedic practice due to the COVID-19 pandemic. In this chapter, the two research questions of the thesis informed two literature reviews. These included all relevant, contemporary literature identified using a pre-defined search strategy. Given that two research questions were presented in Chapter One, it was decided that two separate literature reviews would best address them. Notably, two of the literature reviews conducted as part of this thesis have undergone peer review and been published in the Journal of Paramedic Practice, both of which are included in this chapter (and the appendices; Appendix 2 and Appendix 3) as they were published.

Following the completion of the first two literature reviews, a subsequent review was conducted to explore the effectiveness of masks during cardiopulmonary resuscitation, an issue that emerged as pertinent during the initial reviews. This third review was considered potentially valuable to the discussion, which is why it was included.

The literature included across the three reviews was diverse in both methodological design and investigative focus, reflecting the early and evolving nature of this particular research area. In light of this, a formal quality appraisal tool was not used. This decision was based on recognising that, in contexts where literature is limited and highly varied, traditional quality assessment tools may inadvertently exclude studies that offer valuable insights despite not aligning with conventional methodological criteria. Rather than applying a rigid scoring framework, each study was assessed on its relevance to the research question, population focus, methodological approach, and potential contribution to the understanding of the topic. This relevance-based approach allowed for a more inclusive and context-sensitive synthesis, particularly important in under-researched areas. It is also consistent with guidance

from scoping review methodology, which supports flexible appraisal strategies where the priority is to map the breadth and nature of available evidence (Levac et al., 2010; Peters et al., 2015). Transparency in selection and evaluation was maintained by documenting clear inclusion and exclusion criteria. Furthermore, none of the reviews were presented as being systematic in nature, and the approach taken was made explicit throughout. While the absence of a formal quality appraisal tool is acknowledged as a potential limitation, it was a considered and contextually appropriate decision. Tools such as the Quality Assessment with Diverse Studies (QuADS) reflect an increasing recognition that diverse forms of evidence require tailored approaches in their appraisal (Harrison et al., 2021).

Four key databases were used a part of these literature reviews; MEDLINE, CINAHL, PubMed and the Cochrane Library, chosen to ensure comprehensive coverage of biomedical, allied health, and evidence-synthesis literature relevant to paramedic practice, PPE, infection prevention and control and aerosol-related risk. Their selection was driven by both methodological appropriateness and the specific knowledge gaps relating to the paramedic dynamic risk assessment. Together they offered a balanced approach to identifying biomedical, behavioural, and procedural, evidence relevant, or transferable, to paramedic practice.

- MEDLINE: Selected as a principal biomedical database, indexing high-quality peer-reviewed literature relating to respiratory disease, PPE effectiveness, aerosol science, and cardiac arrest resuscitation, internationally recognised as the foundation for systematic review searching.
- CINAHL: Included to ensure robust capture of research involving allied health professionals, specifically paramedics, but also similar professions in other healthcare settings where comparisons might be drawn. It was especially important for Review 1, which explored experiences of PPE use and non-adherence. Qualitative evidence relating to workforce behaviour, communication barriers, and psychosocial determinants of risk is often indexed in CINAHL but not consistently captured in biomedical databases (Hoernke et al., 2021; Rees et al., 2021).

- PUBMED: Complemented MEDLINE by ensuring retrieval of in-press, early-release and COVID-19-specific studies. During the pandemic, a substantial volume of emerging evidence—particularly mechanistic aerosol studies, early CPR-related reports, and PPE investigations—appeared first in PubMed (Cheng et al., 2021).
- Cochrane Library: Used to identify existing systematic reviews related to PPE effectiveness, IPC interventions, CPR, and aerosol-generating procedures. Although formal systematic reviews on COVID-19 AGPs were limited in the early stages of the pandemic, Cochrane acted as an important source for identifying pre-existing syntheses on masks, respiratory protection, and resuscitation practices (Verbeek et al., 2020).

All literature searches for the three reviews were undertaken between March and August 2022, with updated searches conducted in 2023 and 2024 to capture emerging COVID-19–related PPE and aerosol evidence. Key papers identified during these later searches, for example, Shrimpton et al. (2024), are incorporated within the Discussion chapter, where they informed the content therein. The reviews presented in this chapter are therefore reproduced in the form in which they were originally conducted and prepared for publication, reflecting the evidence base available at that time. Their purpose is to demonstrate the methodological rationale that shaped the design of this study, rather than to provide a continually updated synthesis of the evolving pandemic literature. This approach maintains the integrity of the original review processes while ensuring that the thesis as a whole reflects the current state of knowledge.

3.1 Literature Review 1

3.1.1 Paramedic experiences of delivering patient care using PPE during the COVID-19 pandemic and the factors that contribute to non-adherence.

(Accepted for publication on 25th August 2022. Journal of Paramedic Practice. Volume 14. Number 10.

Title: 'Experiences of personal protective equipment and reasons for non-compliance' see Appendix 2).

Data extraction table viewable via Appendix 5.

Experiences of personal protective equipment and reasons for non-compliance

Timothy Ian Millington (Corresponding Author), Emergency Medicine Advanced Clinical Practitioner, Rotherham NHS Foundation Trust; and Paramedic Researcher, University of Hertfordshire; Robert P Chilcott, Head of Toxicology; University of Hertfordshire; Julia Williams, Professor of Paramedic Science and Associate Dean—Research; University of Hertfordshire, UK.
Email: Timothy.millington@nhs.net

Abstract

Background: The COVID-19 pandemic created challenges in prehospital care. Paramedics have been required to adhere to strict protocols regarding infection control and the use of personal protective equipment (PPE). These protocols have evolved as the pandemic progressed. Understanding the experiences of paramedics in using PPE and their reasons behind not adhering to recommended guidelines should improve the limited evidence base and assist healthcare organisations to form tailored PPE guidance, enabling better protection of paramedics. Aim: This study aimed to analyse evidence on paramedics' experiences of using PPE and explore the reasons behind non-compliance to inform PPE policies. Methods: Searches of five key databases identified papers relating to frontline practitioners' experiences of using PPE; frontline was defined as working in patient-facing roles in prehospital, emergency department or critical care settings. Articles were then subject to thematic analysis as part of this narrative review. Results: Three themes emerged: physical and emotional wellbeing; impact on patient care and clinical effectiveness; and PPE fatigue. The evidence explores health professionals' experiences of working in this difficult environment but very little data exist regarding the impact of PPE, specifically on UK paramedics or their reasons for not adhering to PPE protocols. Conclusion: PPE affects wearers in a variety of ways. Factors behind non-adherence are multifactorial. A paucity of literature exists regarding paramedics' experiences of using PPE.

Key words
● Personal and protective equipment (PPE) ● Paramedicine ● Experiences ● Protocols ● COVID-19 ● Pandemic

Accepted for publication: 25 August 2022

COVID-19, the respiratory disease caused by SARS-CoV-2, led to the World Health Organization (WHO) declaring a pandemic in March 2020 (WHO, 2022). COVID-19 has a variety of symptoms, which have changed as the virus mutated and understanding of the disease deepened. Significant mortality has been seen in particular demographic groups. Many patients are asymptomatic, compounding difficulties in infection control and prevention of disease transmission (Atzrodt et al, 2020; Fink et al, 2020).

Health professionals are still required to adhere to strict protocols regarding the use of personal protective equipment (PPE), particularly when in proximity to medical procedures thought to generate aerosols. This is because SARS-CoV-2 is primarily transmitted through respiratory particles in the form of droplets, aerosols or fomites (Leong et al, 2020).

Infection control guidelines have been variable and contradictory in some instances. It remains recommended that PPE be worn when caring for patients to provide a protective barrier, shielding the wearer from exposure with external contaminants. Level 2 PPE was initially recommended for use with all patients regardless of COVID-19 status, with level 3 PPE reserved for use in patients who were suspected of or had been confirmed as being COVID-19 positive (*Figure 1*).

Studies have explored health professionals' general experiences of working during the pandemic and highlights the new challenges COVID-19 has presented; however, very little research has explored the impact of PPE on prehospital care or paramedics specifically (Chen et al, 2021a; Hoernke et al, 2021; Rees et al, 2021).

A deeper understanding of how the wearing of PPE impacts paramedics, with a focus on their reasons when they might not adhere to PPE policies, would improve the limited data that are available and help inform healthcare strategies in

© 2022 MA Healthcare Ltd

the future. Contemporary literature on this matter would provide healthcare organisations with tools to create evidence-based PPE guidance. The overall result would be better protection for health professionals who continue to be at risk from coronavirus and any other transmissible, potentially lethal, pathogens.

Aim

The aim of this review is to investigate paramedics' experiences of using PPE in order to better understand factors contributing to their non-adherence of PPE policy.

A preliminary literature search highlighted a dearth of evidence on this so the population was expanded to explore frontline health professionals' experiences of using PPE. Frontline was defined as working in patient-facing roles in critical care units, emergency departments or ambulance services.

Prehospital care poses its own set of unique challenges. However it was felt there were enough similarities with other frontline specialities to warrant their inclusion in this study to address the lack of paramedic-specific literature.

Methods

After a preliminary literature search identified a paucity of literature specifically involving paramedic or prehospital health workers' experiences when using PPE, an adapted literature search exploring frontline health professionals' perspectives was conducted. This involved the use of key words and phrases, boolean operators and MeSH terminology relevant to the topic.

Four databases were searched (*Table 1*): PubMed, CINAHL, Cochrane and Medline. Key search terms included combinations of 'PPE', 'Mask*', 'protective equipment', 'COVID-19', 'SARS-CoV-2', 'corona*', 'healthcare', 'workers', 'professionals', 'frontline', 'ambulance', 'emergency', 'critical care' and 'intensive'.

All literature obtained using the search terms and exclusion criteria below were then subject to title and abstract review to identify papers of relevance. These then underwent further screening by a solo researcher. Duplicates and foreign language papers without a readily available translation were excluded. Appropriate papers were subject to full text review and thematic analysis. Relevant papers were included as part of the review with relevance defined as articles that specifically discussed either experiences of frontline health professionals with PPE or health professionals' non-compliance with PPE. No date parameters were set.

Inclusion criteria

- English language or readily available translation
- Any discussion regarding paramedic, emergency department or critical care health workers' experiences of PPE
- Any focus on non-adherence to PPE in settings related to the frontline.

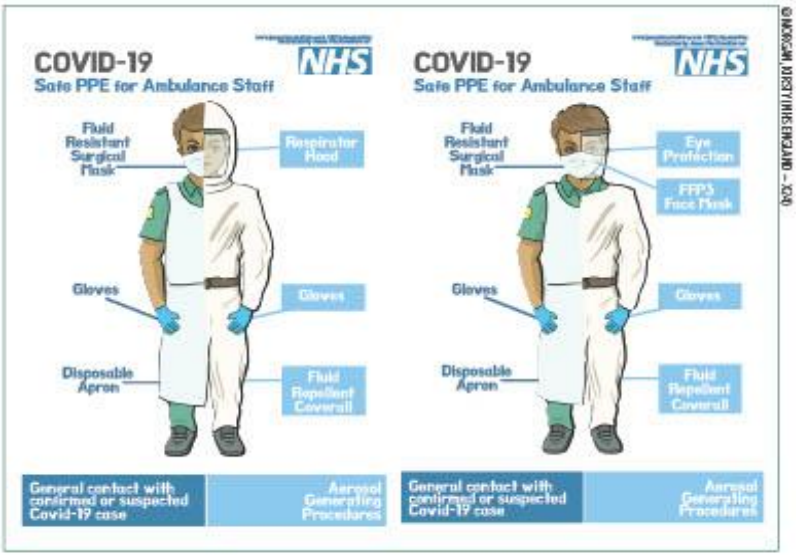


Figure 1. Recommended PPE from East Midlands Ambulance Service NHS Trust issued at the start of the pandemic

Exclusion criteria

- No English language version available
- No discussion regarding paramedic, emergency department or critical care health workers' experiences of PPE
- No focus on non-adherence to PPE in settings related to the frontline.

Results

Thirty-one papers of interest met the inclusion criteria and were included in the review (*Figure 2*; *Table 1*). Systematic literature searching principles were used that were aligned to Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) (Tricco et al, 2018).

Literature that focused on the proposed line of inquiry highlighted in the research questions was analysed, namely frontline health workers' experiences of wearing PPE when caring for patients, with a lens on the reasons behind non-adherence. This enabled identification of themes to be identified to structure the discussion.

Discussion

PPE is vital to counter the transmission of infectious diseases. The image of frontline health professionals caring for COVID-19 patients wearing enhanced PPE has become arguably one of the defining images of the pandemic.

© 2022 MA Healthcare Ltd

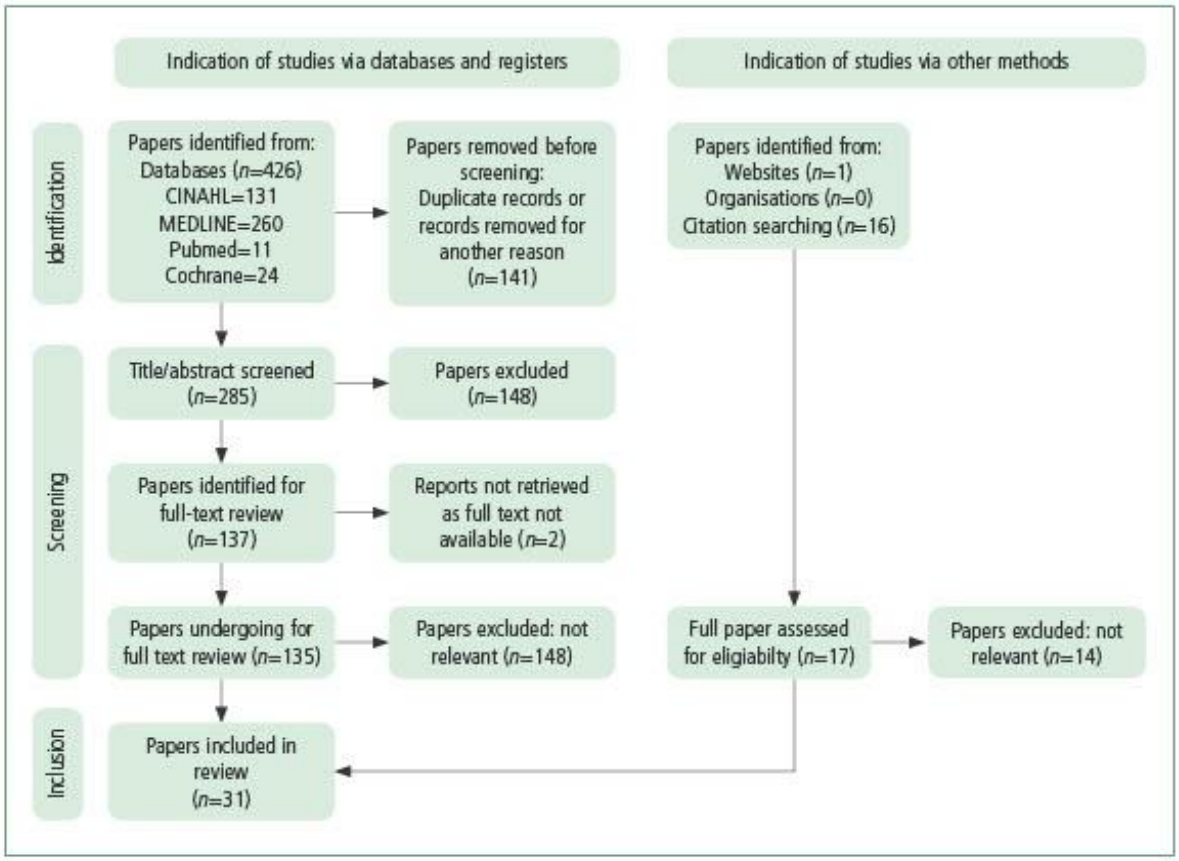


Figure 2. PRISMA diagram of search strategy

Table 1. Results yielded from searches

Source	Results
CINAHL plus	131
Medline	260
PubMed	11
Cochrane	24
Citation searches	16

The use of PPE is not without consequence, however. Themes were identified following review of the literature regarding its effect on physical and emotional wellbeing as well as the impact wearing PPE can have on patient care and clinical effectiveness (*Figure 3*).

Theme 1. Physical and emotional wellbeing

Hoernke et al's (2021) qualitative study investigating frontline healthcare workers' experiences of PPE, perhaps the most relevant article that exists in relation to the clinical questions, offers valuable insight. Data obtained through their semistructured interviews were collected at three stages during the first wave of the COVID-19 pandemic and illustrated the views of health professionals based within the UK. Interview findings were then triangulated with policy and media review literature. The authors grouped their findings into three key themes: 'PPE guidance', 'PPE supply' and 'challenges in care delivery'. Frontline health professionals included in the study had a variety of secondary and primary care roles; however, the sample consisted of predominately doctors based in critical care departments and the perspectives of prehospital health professionals were not captured.

Hoernke et al (2021) found that a lack of clear, consistent PPE guidance resulted in feelings of confusion and mistrust in policies. This ultimately led to health professionals losing confidence in PPE effectiveness. Concern regarding PPE reuse and procurement issues led to health professionals becoming distressed and anxious about passing infection on to family members. Adjectives such as terrified, angry and upset were all associated with health professionals' concerns regarding the lack of PPE available (Gordon et al, 2021).

© 2024 MA Healthcare Ltd

This negative tone towards PPE was echoed in prehospital care. Rees et al (2021) found Welsh paramedics were concerned over being issued inappropriate PPE and confusing guidelines raising anxiety among prehospital staff. Rees et al (2021) used evolved grounded theory to explore Welsh paramedics' experiences in providing care during the pandemic, gaining a broad insight into their experiences over this period. They captured paramedics' feelings of increased anxiety regarding the quality of the PPE being issued and being overwhelmed by numerous changes to clinical guidelines or PPE protocols. However, Rees et al's (2021) study did not focus on PPE's impact but gathered a more general view of pandemic prehospital working.

The sentiment of health professionals who feared infecting loved ones was frequently cited within other qualitative research that explored the experiences of health professionals working in patient-facing roles during the COVID-19 pandemic. Indeed, this was repeatedly highlighted as a key factor influencing an individual's adherence to PPE guidance (Abdel Wahed et al, 2020; Key et al, 2020; Al Muharraq, 2021; Flateau et al, 2021).

More than half of the health professionals questioned in a review of PPE used in Turkish hospitals reported that wearing PPE was associated with increased incidences of sleep disturbance and feelings of being overwhelmed. Stress and anxiety brought on by donning PPE were hypothesised to be a cause of these symptoms and thought to contribute to the high levels of burnout seen in frontline healthcare professionals (Alrawashdeh et al, 2021; Çiriş Yildiz et al, 2022). Çiriş Yildiz et al's (2022) evaluation of PPE's effects on the wearer included 27 paramedics (4.5% of the overall sample).

Gordon et al (2021) captured similar findings in their qualitative study through interviews with critical care nursing staff. Participants attributed anxiety and sleep disturbances to prolonged PPE use, a finding aligned with Swaminathan et al's (2022) survey of hospital-based doctors and nurses, which found PPE was linked to anxiety, depression and somnolence. Their single-centre, cross-sectional study assessed mental and physical wellbeing, using a visual analogue scale, found significant scores of ≥7 or more were reported by 27.8% of respondents regarding PPE-associated anxiety, 19.5% concerning PPE-related depression and 40.3% regarding PPE-attributed somnolence.

The use of enhanced PPE creates practical obstacles to performing simple yet essential tasks such as taking regular toilet breaks, eating or drinking fluids (Paiano et al, 2020; Vindrola-Padros et al, 2020). This is confounded when supply issues cause additional pressures, pushing the wearer to prolong item use because supplies are limited.

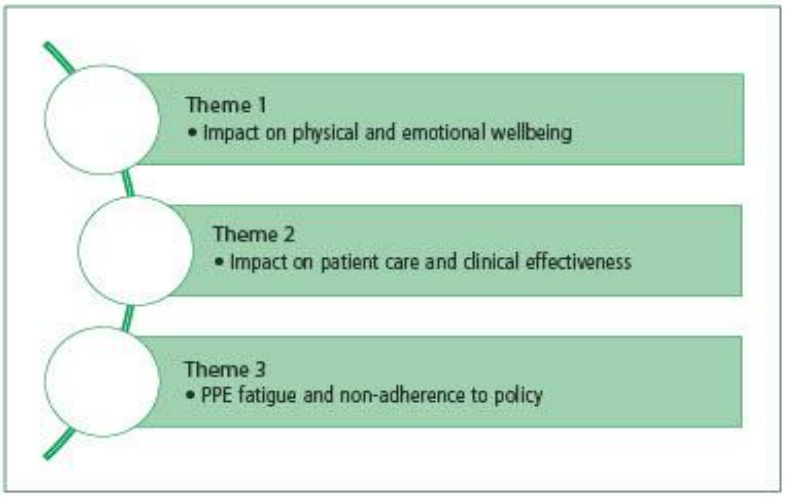


Figure 3. Summary of themes arising from the literature review

The introduction of additional plastic layers on top of clothing, such as hoods and double gowns, can lead to overheating when performing physically demanding tasks such as chest compressions. The PPE used while caring for COVID-19 patients has been reported to have twice the evaporative resistance of scrubs alone, and this is postulated to increase more than tenfold when used in conjunction with sealed head and neck hoods. Prolonged use and physical activity lead to overheating (Messeri et al, 2021).

Health professionals who were fasting during Ramadan reported feeling particularly anxious and vulnerable to adverse events when wearing PPE (Vindrola-Padros et al, 2020). The combination of overheating and restricted oral intake puts health professionals at risk of developing symptoms of dehydration, including headaches, light-headedness and even syncope.

Further adverse effects reported included dyspnoea, hyperthermia and exacerbations of gastrointestinal and skin conditions (Chen et al, 2021a; Gordon et al, 2021; Hoernke et al, 2021; Li et al, 2021).

It has been reported that hospital-based health professionals preferred full-body disposable gowns to plastic aprons because of their perceived breathability (Swaminathan et al, 2022).

Additionally, a survey of hospital-based health professionals in Wuhan, China, found that immediately on doffing PPE, significant numbers reported symptoms of palpitations (27.3%), chest discomfort and shortness of breath (33.0%) or nausea or vomiting (16.8%) (Xia et al, 2020).

The weight and bulky nature of PPE, particularly eye protection and certain respirators, can have

© 2022 MA Healthcare Ltd

implications for the wearer's physical health. Headaches attributed to the tight bands required to maintain an effective seal when using face masks, respirators and goggles have been reported (Chen et al, 2021b). Skin was particularly vulnerable to the adverse effects of prolonged PPE use. Pressure damage to the skin and soft tissues of the face, nose and ears was a common area of concern and frequently reported by health professionals, particularly on social media platforms, after extended periods of PPE use (Coyer et al, 2020).

Retro-auricular pain was reported in 81.8% of 297 health professionals surveyed regarding their PPE experiences in Wuhan (Xia et al, 2020). The effects over time of sweating, pressure and overheating can lead to dermatological conditions such as dermatitis, pruritus, acne, friction burns, dry skin, skin indentation and rashes, with male health professionals more prone to skin erosion than their female counterparts (Xia et al, 2020; Yuan et al, 2021).

Variation in levels of discomfort experienced by health professionals has been found when comparing them by role as well as by sex, with hospital doctors and GPs reporting PPE wearing to be more uncomfortable than other groups of health professionals; prehospital perspectives were not included in this survey (Messeri et al, 2021).

Theme 2. Patient care and clinical effectiveness

The widespread adoption of enhanced PPE across all healthcare settings created barriers to the delivery of patient care (Hoernke et al, 2021). Health professionals reported significant impedance in clinical performance. Examples obtained through qualitative means described several issues.

The application and removal of PPE delayed timely patient care. Double-gloving hindered the identification of subtle signs involved when performing a detailed patient examination, for example when palpating pulses or identifying veins for intravenous cannulation.

Additionally, communication, both verbal and non-verbal, was detrimentally impacted when eye protection fogged, and masks and respirators impeded this (Hoernke et al, 2021). These findings were underpinned by Montgomery et al (2021) and Monzani et al (2020), who conducted qualitative research into critical care staff and paediatric emergency physicians respectively. The detrimental impact of PPE on patient examination and interactions were reiterated, described by Monzani et al (2020) as the biggest challenge facing clinicians.

PPE use impeded teamwork when attempting to identify roles, particularly seniority, during time-critical procedures such as intubation. Fogging of eye protection was highlighted as a common complaint within the literature (Wang et al, 2020; Xia et al, 2020; Swaminathan et al, 2022).

Additionally, PPE reduced manual dexterity, resulting in difficulties when attempting procedures requiring several members of staff, such as proning or rolling patients in critical care units. Health professionals described experiencing diminished senses (Montgomery et al, 2021).

Similarly, Messeri et al (2021), noted prolonged use of headgear was linked to statistically significant impairment of cognitive reasoning.

The nature of respiratory disease requires patients as well as staff to adhere to strict PPE protocols, limiting the ability of clinicians to gauge visual clues as to patients' condition from the end of the bed (Montgomery et al, 2021).

Rao et al (2021) investigated the experiences of health professionals in the US including five paramedics, and found less time was spent with patients to minimise the workers' risks of exposure of COVID-19.

Considering these points alongside the physician's concerns raised in Monzani et al's (2020) study regarding PPE leading to increased framing bias when formulating potential differential diagnoses, as well as Hoernke et al (2021) finding that junior staff were less likely to seek senior advice when in enhanced PPE because they were unable to leave isolation bays, one can envisage how the use of PPE creates an environment ripe for potential diagnostic errors and patient mismanagement.

Communication between patients and health professionals, particularly building the rapport that is crucial for effective care, became depersonalised by the introduction of PPE and was a source of significant frustration to caregivers (Malik et al, 2021; Rao et al, 2021; Shurlock et al, 2021).

Hoernke et al (2021) reported that health professionals felt they were viewed as intimidating to patients when donned in PPE. This was particularly the case with patients who usually rely on lip reading because of a hearing impairment. Similarly, interactions could be disorientating for delirious patients, who previously might have been comforted through non-verbal communication techniques such as hand-holding or facial expressions.

Rao et al (2021) went further by describing a stripping away of a key principle of patient care, namely human interaction, highlighting health professionals' frustrations at not being able to convey empathy or compassion because of PPE blocking their usual means of expressing this. Care would become more paternalistic, with patients often not being involved in discussions regarding

© 2022 MA Healthcare Ltd

their treatment options. Concerningly, health professionals have reported overcoming these frustrations, particularly when breaking bad news, by removing their masks (Rao et al, 2021).

Theme 3. PPE fatigue and non-adherence to PPE protocols

PPE fatigue is a contemporary term coined by the Royal College of Emergency Medicine (RCEM) throughout the initial stages of the pandemic in their safety flash card, which has subsequently been withdrawn. This was designed to help protect health professionals from infection through a visual reminder to maintain high standards regarding personal protection.

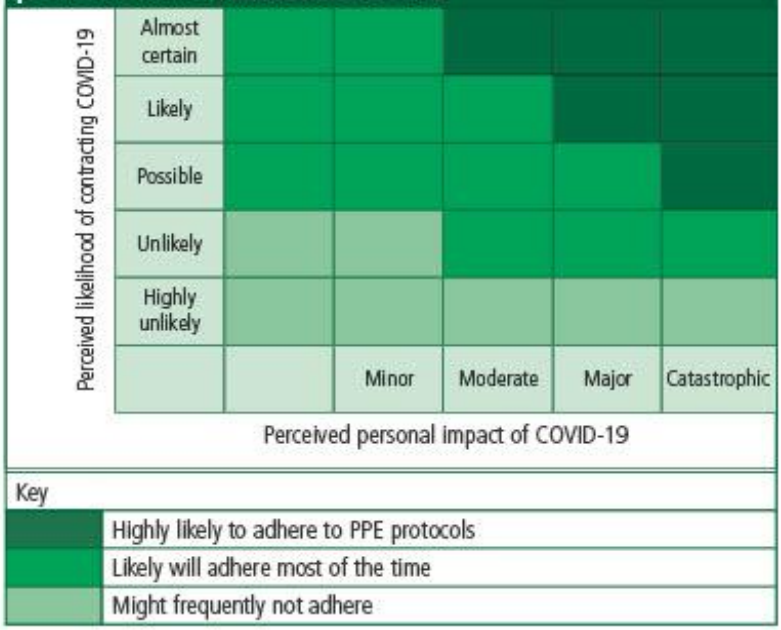
The term subsequently featured on various online articles but is not clearly defined in the reviewed literature. While there is no formal definition of PPE fatigue in the literature, the use of the word 'fatigue' suggests forgetfulness or carelessness through tiredness. The literature investigating health professionals' adherence to PPE echoes this, describing both forgetfulness and carelessness as major contributors to practitioner non-compliance (Neves et al, 2011; Çiriş Yildiz et al, 2022). Increased workloads directly impact health professional fatigue (Chapman et al, 2017). Nursing staff have described how unrealistic workloads had detrimental impacts on adherence to infection control guidelines (Houghton et al, 2020).

Various reasons have been captured within qualitative literature regarding non-adherence to PPE protocols. The literature identified through the search strategy in the present study predominately captured perspectives of hospital-based nursing staff. Discomfort, supply issues and effects on the ability to deliver good-quality patient care were frequently cited as causes for non-compliance (Li et al, 2021, Silverberg et al, 2021, Çiriş Yildiz et al, 2022). Health professionals who found PPE particularly uncomfortable, understandably, chose to wear it for shorter time periods (Li et al, 2021). Health professionals have reported choosing not to use PPE, particularly masks, if they felt it made their patients feel stigmatised or frightened (Houghton et al, 2020).

This could stem in part from an individual's view of personal risk. Perception of risk has been deemed a key aspect in PPE compliance, with concern regarding the protection of family members being a motivating factor (Neves et al, 2011).

Risk matrices are used within NHS organisations to illustrate, identify and evaluate risk. A proposed matrix regarding health professionals' assessment of their own risk regarding COVID-19 and their probability to adhere to PPE guidelines was generated by the lead author, giving consideration to the points raised within this review (*Table 2*).

Table 2. Proposed risk matrix relevant to health professionals' adherence to PPE



Using tools such as this during performance reviews could enable health professionals with a low personal perception of their own risk to be identified and aid delivery of more targeted educational programmes.

The concepts on which the matrix is based are supported by evidence (albeit limited) showing that non-adherence to PPE can arise from knowledge gaps or a lack of belief in its effectiveness (Haji et al, 2020; Houghton et al, 2020).

Ultimately, behaviour—particularly in healthcare settings—can be habitual. In a Vietnamese study, more than half of health professionals sampled reported finding modifications to their methods of working because of COVID-19 too difficult to maintain in the long term (Tien et al, 2021).

Finally, this review identified points regarding cultural influences within organisations, with staff who saw colleagues repeatedly maintaining high standards or who felt supported by managers more likely to maintain adherence to PPE policy (Houghton et al, 2020).

Conclusion

There is a clear paucity of literature specifically exploring the experiences of UK paramedics when using PPE. No evidence was found relating to this population or the reasons behind non-adherence. Looking more broadly to include other frontline health professionals shows there is a dearth of evidence on this matter.

© 2022 MA Healthcare Ltd

Key Points

- Healthcare workers found their physical and mental wellbeing affected by the use of personal protective equipment (PPE)
- PPE acted as a barrier to effective communication, impeding both verbal and non-verbal communication
- Healthcare workers suspect patient care to be negatively impacted by PPE
- An individual's perception of their own risk could influence their likelihood of adherence to PPE guidelines

Understanding the experiences of practitioners working in other healthcare settings can help to illustrate paramedics' experiences working in this new, challenging environment. However, the unique nature of prehospital healthcare means that, to properly understand how PPE has impacted paramedics, further research is required.

There is no current formal understanding of non-adherence to PPE policies, particularly regarding paramedics. The limited literature available consists of anecdotal reports and hypotheses that are not evidence-based.

Common themes emerged on analysis of broader contextual data showing PPE to affect both caregiver and care recipient negatively, causing detriment to their physical and emotional health as well as to the quality of care provided.

Further research is needed to explore paramedics' experiences of non-adherence specifically to fill the existing gaps in knowledge on this topic. JPP

Conflict of interest: None.

References

Abdel Wahed WY, Hefzy EM, Ahmed MI, Hamed NS. Assessment of knowledge, attitudes, and perception of health care workers regarding COVID-19, a cross-sectional study from Egypt. J Community Health. 2020;45(6):1242–1251. https://doi.org/10.1007/s10900-020-00882-0

Al Muharraq EH. The psychological impact of coronavirus disease 2019 on nurses in Saudi Arabia and their coping strategies. SAGE Open Nurs. 2021;7:1–10. https://doi.org/10.1177/23779608211011322

Alrawashdeh HM, Al-Tammemi AB, Alzawahreh MK et al. Occupational burnout and job satisfaction among physicians in times of COVID-19 crisis: a convergent parallel mixed-method study. BMC Public Health. 2021;21(1):811. https://doi.org/10.1186/s12889-021-10897-4

Atzrodt CL, Maknojia I, McCarthy RDP et al. A guide to COVID-19: a global pandemic caused by the novel coronavirus SARS-CoV-2. FEBS J. 2020;287(17):3633–3650. https://doi.org/10.1111/febs.15375

Chapman HJ, Veras-Estévez BA, Pomeranz JL, Pérez-Then EN, Marcelino B, Lauzardo M. Perceived barriers to adherence to tuberculosis infection control measures among health care workers in the Dominican Republic. MEDICC Rev. 2017;19(1):16–22. https://doi.org/10.37757/MR2017.V19.N1.4

Chen CH, Yang PH, Kuo FL, Yeh IJ, Su CY. Experience of 2003 SARS has a negative psychological impact on healthcare workers in the COVID-19 pandemic: a cross-sectional study. Sao Paulo Med J. 2021a;139(1):65–71. https://doi.org/10.1590/1516-3180.2020.0516.r1.10122020

Chen F, Zang Y, Liu Y, Wang X, Lin X. Dispatched nurses' experience of wearing full gear personal protective equipment to care for COVID-19 patients in China—a descriptive qualitative study. J Clin Nurs. 2021b;30(13–14):2001–2014. https://doi.org/10.1111/jocn.15753

Çiriş Yildiz C, Ulaşli Kaban H, Tanriverdi FŞ. COVID-19 pandemic and personal protective equipment: Evaluation of equipment comfort and user attitude. Arch Environ Occup Health. 2022;77(1):1–8. https://doi.org/10.1080/19338244.2020.1828247

Coyer F, Coleman K, Hocking K, Leong T, Levido A, Barakat-Johnson M. Maintaining skin health and integrity for staff wearing personal protective equipment for prolonged periods: a practical tip sheet. Wound Practice and Research. 2020;28(2):75–83. https://doi.org/10.33235/wpr.28.2.75-83

Fink JB, Ehrmann S, Li J et al. Reducing aerosol-related risk of transmission in the era of COVID-19: an interim guidance endorsed by the International Society of Aerosols in Medicine. J Aerosol Med Pulm Drug Deliv. 2020;33(6):300–304. https://doi.org/10.1089/jamp.2020.1615

Flateau C, Noël C, Bonnafoux A, Fuentes E, de Pontfarcy A, Diamantis S. Psychological impact of the SARS-CoV-2 outbreak on the staff of a French hospital. Infect Dis Now. 2021;51(2):187–193. https://doi.org/10.1016/j.idnow.2021.01.007

Gordon JM, Magbee T, Yoder LH. The experiences of critical care nurses caring for patients with COVID-19 during the 2020 pandemic: a qualitative study. Appl Nurs Res. 2021;59:151418. https://doi.org/10.1016/j.apnr.2021.151418

Haji JY, Subramaniam A, Kumar P, Ramanathan K, Rajamani A. State of personal protective equipment practice in Indian intensive care units amidst COVID-19 pandemic: a nationwide survey. Indian J Crit Care Med. 2020;24(9):809–816. https://doi.

CPD Reflection Questions

- Reflecting on times you may have experienced non-adherence to personal protective equipment (PPE) guidelines, what factors do you feel contributed to this?
- From your understanding of the transmission of respiratory disease, how does PPE protect both you and the patient?
- Thinking more broadly, COVID-19 aside, what are your feelings regarding PPE use in the future? Does it have a place in protecting health workers and patients from other contagious diseases?

© 2022 MA Healthcare Ltd

org/10.5005/jp-journals-10071-23550

Hoernke K, Djellouli N, Andrews L et al. Frontline healthcare workers' experiences with personal protective equipment during the COVID-19 pandemic in the UK: a rapid qualitative appraisal. BMJ Open. 2021;11(1):e046199. https://doi.org/10.1136/bmjopen-2020-046199

Houghton C, Meskell P, Delaney H et al. Barriers and facilitators to healthcare workers' adherence with infection prevention and control (IPC) guidelines for respiratory infectious diseases: a rapid qualitative evidence synthesis. Cochrane Database Syst Rev. 2020;4(4):CD013582. https://doi.org/10.1002/14651858.CD013582

Key T, Mathai NJ, Venkatesan AS, Farnell D, Mohanty K. Personal protective equipment during the COVID-19 crisis: a snapshot and recommendations from the frontline of a university teaching hospital. Bone Jt Open. 2020;1(5):131–136. https://doi.org/10.1302/2633-1462.15.BJO-2020-0027.R1

Leong YC, Cheskes S, Drennan IR, Buick JE, Latchmansingh RG, Verbeek PR. Clinical considerations for out-of-hospital cardiac arrest management during COVID-19. Resusc Plus. 2020;4:100027. https://doi.org/10.1016/j.resplu.2020.100027

Li F, Jiang T, Shi T et al. Factors that affect the duration of wearing disposable personal protective equipment by healthcare professionals in Wuhan during treatment of COVID-19 patients: an epidemiological study. Nurs Health Sci. 2021;23(1):245–254. https://doi.org/10.1111/nhs.12814

Malik M, Peirce J, Wert MV, Wood C, Burhanullah H, Swartz K. Psychological first aid well-being support rounds for frontline healthcare workers during COVID-19. Front Psychiatry. 2021;12:669009. https://doi.org/10.3389/fpsyt.2021.669009

Messeri A, Bonafede M, Pietrafesa E et al. A web survey to evaluate the thermal stress associated with personal protective equipment among healthcare workers during the Covid-19 pandemic in Italy. Int J Environ Res Public Health. 2021;18(8):3861. https://doi.org/10.3390/ijerph18083861

Montgomery CM, Humphreys S, McCulloch C, Docherty AB, Sturdy S, Pattison N. Critical care work during COVID-19: a qualitative study of staff experiences in the UK. BMJ Open. 2021;11(5):e048124. https://doi.org/10.1136/bmjopen-2020-048124

Monzani A, Ragazzoni L, Della Corte F, Rabbone I, Franc JM. COVID-19 pandemic: perspective from Italian pediatric emergency physicians. Disaster Med Public Health Prep. 2020;14(5):648–651. https://doi.org/10.1017/dmp.2020.198

Neves HC, Souza AC, Medeiros M, Munari DB, Ribeiro LC, Tipple AF. Safety of nursing staff and determinants of adherence to personal protective equipment. Rev Lat Am Enfermagem. 2011;19(2):354–361. https://doi.org/10.1590/S0104-11692011000200018

Paiano M, Jaques AE, Nacamura PAB, Salci MA, Radovanovic CAT, Carreira L. Mental health of healthcare professionals in China during the new coronavirus pandemic: an integrative review. Rev Bras Enferm. 2020;73(suppl 2):e20200338. https://doi.org/10.1590/0034-7167-2020-0338

Rao H, Mancini D, Tong A et al. Frontline interdisciplinary clinician perspectives on caring for patients with COVID-19: a qualitative study. BMJ Open. 2021;11(5):e048712. https://doi.org/10.1136/bmjopen-2021-048712

Rees N, Smythe L, Hogan C, Williams J. Paramedic experiences of providing care in Wales (UK) during the 2020 COVID-19 pandemic (PECC-19): a qualitative study using evolved grounded theory. BMJ Open. 2021;11(6):e048677. https://doi.org/10.1136/bmjopen-2021-048677

Shurlock J, Rudd J, Jeanes A et al. Communication in the intensive care unit during COVID-19: early experience with the Nightingale Communication Method. Int J Qual Health Care. 2021;33(1):mzaa162. https://doi.org/10.1093/intqhc/mzaa162

Silverberg SL, Puchalski Ritchie LM, Gobat N, Murthy S. COVID-19 infection prevention and control procedures and institutional trust: perceptions of Canadian intensive care and emergency department nurses. Can J Anaesth. 2021;68(8):1165–1175. https://doi.org/10.1007/s12630-021-02028-9

Swaminathan R, Mukundadura BP, Prasad S. Impact of enhanced personal protective equipment on the physical and mental well-being of healthcare workers during COVID-19. Postgrad Med J. 2022;98(1157):231–233. https://doi.org/10.1136/postgradmedj-2020-139150

Tien TQ, Tuyet-Hanh TT, Linh TNQ, Hai Phuc H, Van Nhu H. Knowledge, attitudes, and practices regarding COVID-19 prevention among Vietnamese healthcare workers in 2020. Health Serv Insights. 2021;14:11786329211019225. https://doi.org/10.1177/11786329211019225

Tricco AC, Lillie E, Zarin W et al. PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. Ann Int Med. 2018;169(7):P467–473

Vindrola-Padros C, Andrews L, Dowrick A et al. Perceptions and experiences of healthcare workers during the COVID-19 pandemic in the UK. BMJ Open. 2020;10(11):e040503. https://doi.org/10.1136/bmjopen-2020-040503

Wang H, Liu Y, Hu K et al. Healthcare workers' stress when caring for COVID-19 patients: an altruistic perspective. Nurs Ethics. 2020; 27(7):1490–1500. https://doi.org/10.1177/0969733020934146

World Health Organization. Coronavirus disease (COVID-19) pandemic. 2022. https://www.who.int/europe/emergencies/situations/covid-19 (accessed 21 September 2022)

Xia W, Fu L, Liao H, Yang C, Guo H, Bian Z. The physical and psychological effects of personal protective equipment on health care workers in Wuhan, China: a cross-sectional survey study. J Emerg Nurs. 2020;46(6):791–801.e7. https://doi.org/10.1016/j.jen.2020.08.004

Yuan N, Yang WX, Lu JL, Lv ZH. Investigation of adverse reactions in healthcare personnel working in level 3 barrier protection PPE to treat COVID-19. Postgrad Med J. 2021;97(1148):351–354. https://doi.org/10.1136/postgradmedj-2020-137854

Write for IPP

International Paramedic Practice (IPP) is our quarterly online publication targeted at Paramedics around the world. Write to us with your ideas and discuss with the editor how your article might be published in the next issue of IPP.



PARAMEDIC PRACTICE CPD

jpp@markallengroup.com

© 2022 MA Healthcare Ltd

3.1.2 Implications to this thesis

The findings from this literature review support the qualitative aspect of this thesis, which investigates how paramedics conduct dynamic risk assessments regarding PPE usage in relation to respiratory pathogens, especially COVID-19. There is a lack of research focused on paramedics specifically, emphasising the need for a deeper understanding of adherence behaviours and the factors that influence these risk assessments made daily by paramedics and the wider prehospital clinical workforce. This gap reflects the scientific uncertainty about whether certain resuscitation techniques—especially chest compressions and defibrillation—are considered aerosol generating procedures. The following section presents a published scoping review that examines the scarce and often contradictory evidence on this subject. This review directly informs the quantitative part of this thesis, aiming to assess aerosol production during resuscitation, and underscores the need for empirical data to support safe and effective PPE decision-making during cardiac arrest management.

3.2 Literature review 2

3.2.1 Title: Chest compressions and defibrillation as aerosol generating procedures.

Accepted for publication 15th July 2022. Journal of Paramedic Practice. Volume 15. Number 4. Title: *'Chest compressions and defibrillation as aerosol generating procedures*' (Appendix 3). The peer reviewed publication appears verbatim within the proceeding pages. Data extraction table included, please see Appendix 4.

(As a reminder to the reader and for transparency: This research was funded and supported by the College of Paramedics and the University of Hertfordshire. The original study design involved the recruitment of three paramedic researchers to focus on six procedures of resuscitation aerosol generating propensity. Each research was assigned two procedures each. The procedures that were required to be investigated included chest compressions and defibrillation which featured in this thesis, as well as bag valve mask ventilation, suctioning, supraglottic airway insertion and endotracheal tube insertion.)

Chest compressions and defibrillation as aerosol-generating procedures

Timothy Ian Millington, Consultant Paramedic, Yorkshire Ambulance Service NHS Trust, Wakefield, UK; University of Hertfordshire, Hatfield, UK; **Robert P Chilcott**, Head of Toxicology, University of Hertfordshire, Hatfield, UK; **Julia Williams**, Professor of Paramedic Science; Associate Dean – Research; University of Hertfordshire, Hatfield, UK. **Email:** Timothy.millington@nhs.net

Abstract

SARS-CoV-2 is a highly contagious respiratory pathogen associated with significant mortality in certain patient populations. Patients may be asymptomatic, which causes problems regarding infection control and prevention. Health professionals are required to adhere to strict protocols regarding infection control and personal protective equipment (PPE), particularly when engaging in resuscitation activities thought to be aerosol-generating procedures (AGPs). While adherence to enhanced PPE protocols can delay life-saving interventions, non-adherence may put responders at risk. The aim of this scoping literature review was to establish if chest compressions and defibrillation should be classified as AGPs. Following application of systematic literature search criteria, a limited selection of studies was identified in relation to chest compressions and defibrillation as AGPs. An assumption that endotracheal intubation posed a high risk of nosocomial transmission was noted. Emerging evidence suggests that endotracheal intubation produces fewer aerosol particles than coughing so could be classed as a low-risk-procedure. Because of the lack of adequate prospective studies investigating chest compressions and defibrillation as AGPs, there is a clear need to perform further, well-controlled studies to better understand the aerosol-generating potential of chest compressions and defibrillation.

Key words

● Chest compressions ● Defibrillation ● Aerosols ● Aerosol-generating procedures ● COVID-19 ● SARS-CoV-2 ● Cardiopulmonary resuscitation ● Transmission ● Nosocomial

Accepted for publication: 15 July 2022

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) belongs to a family of highly contagious respiratory coronaviruses and is associated with high levels of mortality in certain patient populations (Chandrasekharan et al, 2020; Cheruku et al, 2020). Disease presentation, in the form of COVID-19, typically involves cough, pyrexia and dyspnoea; however, symptomology may be highly variable, with asymptomatic patients creating problems regarding infection control and prevention (Atzrodt et al, 2020; Fink et al, 2020). A pandemic was declared by the World Health Organization (WHO) in March 2020 and the resulting global disruption remains ongoing (Kalita et al, 2022). As of 7 July 2022, COVID-19 has been responsible for over 6.8 million deaths worldwide (WHO, 2023).

It is postulated that COVID-19's route of transmission is through respiratory droplets, bioaerosols and fomites (Fink et al, 2020). As a result, health professionals are required to adhere to strict protocols regarding infection control and personal protective equipment (PPE), particularly when in proximity to medical activities thought to be aerosol-generating procedures (AGPs) (Leong et al, 2020). During the early stages of the pandemic, advice issued regarding appropriate levels of PPE was inconsistent (Hoernke et al, 2021).

Definitions of AGPs are often derived from theoretical hypotheses rather than evidence-based quantification, with transmission risk thought to be associated with forced air aerosolising virus-containing moisture within infected airways (Klompas et al, 2021).

Cardiac arrest survival depends upon the effective delivery of rapid, sequential interventions, conceptualised as the chain of survival (Nolan et al, 2006). Basic life support and defibrillation play crucial roles within this approach. Timely administration of chest compressions is promoted in both basic and advanced life support algorithms (Olasveengen et al, 2021; Soar et al, 2021). The intent is to mimic the actions of the heart, affecting intrathoracic pressure in such a way as to manually assist blood flow and sustain some level of end-

© 2023 MA Healthcare Ltd

Downloaded from magonlinelibrary.com by 147.197.131.099 on March 2, 2025.

organ perfusion (Harris et al, 2018; Leong et al, 2020; Soar et al, 2021). Defibrillation concerns the application of an electrical current that acts on the heart to terminate ventricular dysrhythmias not consistent with a perfusing blood pressure. When done promptly, both chest compressions and defibrillation can contribute to survival after cardiac arrest (Nolan et al, 2006; Goyal et al, 2023).

Evidence regarding chest compressions and defibrillation specifically regarding whether they are AGPs is scant, with the limited data available inconclusive. This is partly because the multifaceted nature of resuscitative efforts means drawing specific conclusions is difficult (Couper at al, 2020). Furthermore, there are significant ethical considerations regarding conducting research in this area.

This paucity of literature has led to conflicting guidelines from various professional bodies regarding appropriate levels of PPE required when responding to patients in cardiac arrest, raising ethical and medico-legal questions regarding health professionals' responsibilities (Cheruku et al, 2020; Payne and Peache, 2021; Perkins et al, 2021).

The application of PPE with adherence to enhanced PPE protocols will delay the delivery of life-saving interventions; however, deciding not to use PPE potentially puts the rescuer at risk. COVID-19 infection rates among health professionals remain high despite enhanced PPE protocols and mortality is disproportionately high among health workers compared to the general population (Key et al, 2020; Haji et al, 2020). Clarity regarding AGPs in resuscitation will improve the limited literature regarding this matter and help to inform future healthcare strategies, better protecting health professionals who continue to remain at risk of COVID-19.

Clinical questions

This review aimed to answer the following questions:

- Should chest compressions be classified as an AGP?
- Should defibrillation be classified as an AGP?

Methodology

Scoping reviews offer flexibility when reviewing literature that spans multiple, diverse methodologies and allow a broad overview of a topic to be created. As such, they have been described as an appropriate alternative to traditional systematic reviews when tackling limited evidence obtained using differing methodologies (Peterson et al, 2017; Munn et al, 2018).

A literature search was performed using systematic principles aligned to Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) (Tricco et al, 2018). Five key databases were searched: PubMed, Cumulative Index to Nursing and Allied Health Literature (CINAHL), SCOPUS, the Cochrane Library and MEDLINE. Key search terms included combinations of 'AGP', 'aerosol', 'droplet', 'bioaerosol', 'defib*', 'CPR', 'resus*', 'compression', 'transm*', 'COVID*', 'SARS', 'coronavirus', 'ebola' and 'airborne'. Boolean operators and MeSH terminology were also used.

Identified articles were subject to title and abstract analysis to obtain relevant papers and were screened using inclusion and exclusion criteria. Duplicates and foreign language papers without a translation into English were excluded. The remaining papers then underwent full text review. Relevant papers were included as part of the review with relevance defined as articles that specifically discussed either chest compressions or defibrillation as a source of transmission of disease or potential AGP. Grey literature and searches of reference lists also highlighted papers of interest and were again included for full-text review. Following full analysis, findings were chartered in a table with common findings and themes were colour-coded. All of this was undertaken by a solo researcher.

Inclusion criteria

The following were considered regarding inclusion:

- Any time: no date restrictions were applied after a pilot literature search found research was scarce
- In the English language or with a translation readily available
- Any discussion regarding chest compressions or defibrillation as potential AGPs
- Focus on nosocomial transmission of respiratory disease during resuscitation.

Exclusion criteria

The following exclusion criteria were applied:

- No readily available English language version
- No discussion regarding chest compression or defibrillation as AGP
- No focus on nosocomial transmission.

Results

The search strategy identified 13 papers specifically discussing chest compressions or defibrillation as possible AGPs/sources of nosocomial infection (*Figure 1*). Literature dates ranged from 2004 to 2021 and were predominately retrospective in nature. Only two prospective papers were identified.

© 2023 MA Healthcare Ltd

Downloaded from magonlinelibrary.com by 147.197.131.099 on March 2, 2025.

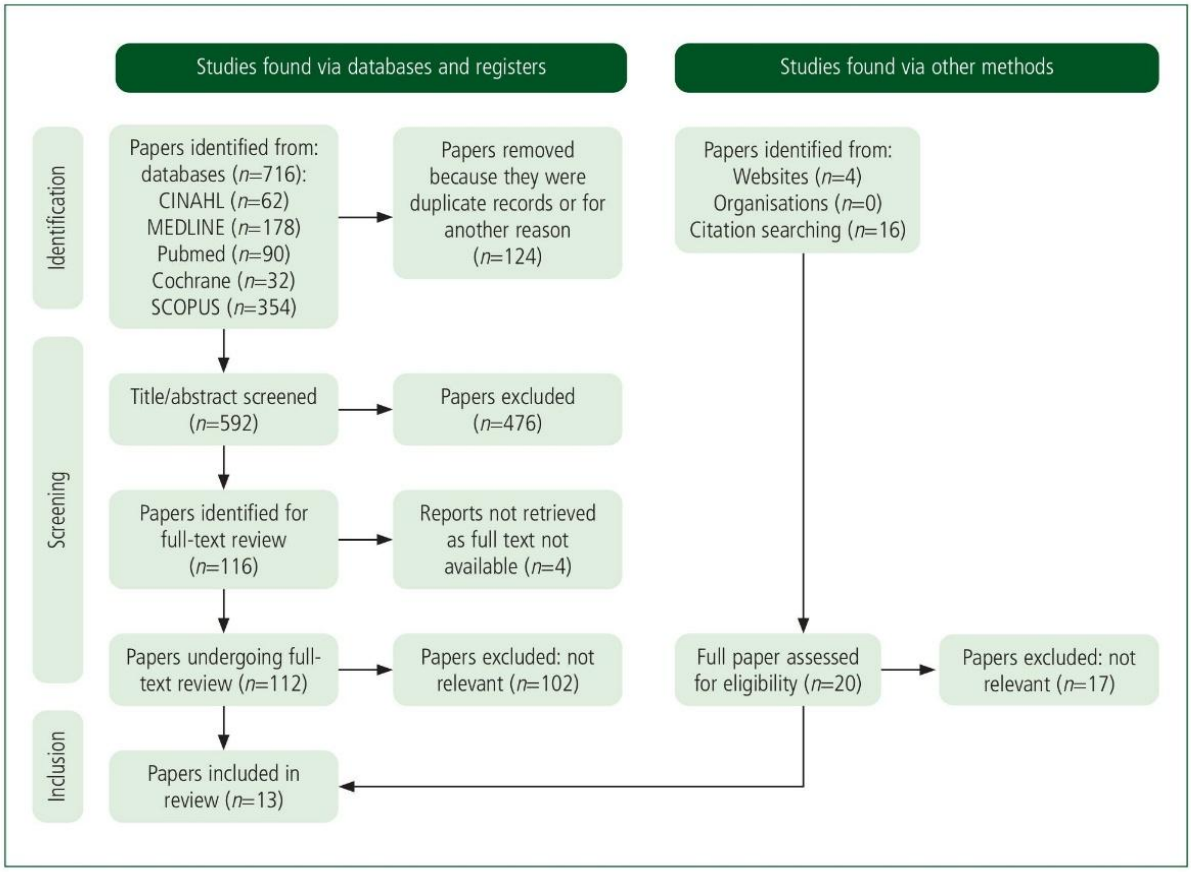


Figure 1. PRISMA–ScR search results (Tricco et al, 2018)

Evidence identified through the search criteria consisted of case reviews, retrospective cohort studies and systematic reviews (*Table 1*).

Case study and retrospective cohort study data showed that SARS-CoV-2 was not the first coronavirus to present a threat to health workers treating critically ill patients. Similar concerns regarding nosocomial transmission during resuscitation were raised during SARS and Middle East respiratory syndrome (MERS) outbreaks in Canada and Saudi Arabia respectively (Christian et al, 2004; Loeb et al, 2004; Raboud et al, 2010; Nam et al, 2017). Similarly, in an outbreak of severe fever with thrombocytopenia syndrome (not caused by a coronavirus) in South Korea, four out of seven health professionals involved in cardiopulmonary resuscitation (CPR), wearing varying levels of PPE, subsequently contracted the disease (Kim et al, 2015).

The search identified three notable systematic reviews, which were included in this review. A consistent finding across all three was that chest compressions and defibrillation were thought to pose a low risk of transmission of respiratory disease compared to the perceived higher risk procedure of endotracheal intubation (Tran et al, 2012; Brown and Chan, 2020; Couper et al, 2020).

Prospective studies used animal or cadaver models to investigate chest compressions and defibrillation as potential AGPs. A pilot study by Hsu et al (2021a) involved induced cardiac arrest in three Yorkshire swine which then underwent chest compressions and defibrillation while attached to an aerosol analyser. No difference was seen in the level of aerosols generated by chest compressions alone, but significantly larger aerosols were observed immediately after chest compressions were initiated following defibrillation. The limitations of the study design are apparent, particularly with regards to sample size and anatomical differences between pigs and humans. The authors also conceded they had neglected to measure humidity, temperature and air flow, all of which are known to influence aerosol dispersion. Furthermore, the equipment used by Hsu et al (2021a) measured aerosols with particles that measured <10µm, therefore not gaining an understanding of aerosols with larger particles that might be created.

© 2023 MA Healthcare Ltd

Downloaded from magonlinelibrary.com by 147.197.131.099 on March 2, 2025.

Table 1. Results yielded from searches

Author (year) Country	Methodology	Results/outcomes	Chest compressions as an AGP	Defibrillation as an AGP
Loeb et al (2004) Canada	Retrospective cohort study	Three nurses performed chest compressions on SARS patients; none contracted the disease	Low risk	Low risk
Brown and Chan (2020) UK	Literature review	Limited evidence included in the review. Transmission potentially from compressions	Inconclusive	Not investigated
Chalumeau et al (2005) France	Case study	Transmission of Panton-Valentine leukocidin-producing *Staphylococcus aureus* during resuscitation of child to one health professional	Inconclusive	Not investigated
Christian et al (2004) Canada	Case report	One of nine health professionals infected with SARS during resuscitation attempt	Inconclusive: suspected	Not investigated
Liu et al (2009) China	Case control study	Chest compressions associated with increased risk (33%) of health professional SARS infection	Strongly suspected	Not discussed
Raboud et al (2010) Canada	Retrospective cohort study	Twenty-six of 697 health professionals investigated were infected during resuscitation of SARS patients	Potentially high risk	Potentially high risk
Tran et al (2012) Canada	Systematic review	Reviewed evidence of very low quality following GRADE. Intubation associated with transmission. Findings not generalisable	Low risk	Low risk
Kim et al (2015) Korea	Case study	Four out of seven health professionals involved in CPR of patient with severe fever with thrombocytopenia syndrome.	Inconclusive: suspected	Inconclusive; suspected
Nam et al (2017) Korea	Case study	Health professional contraction of MERS during CPR. Exact route of transmission unclear	CPR high risk	Not discussed
Couper et al (2020) UK	Systematic review	Evidence was lacking but significant caution is advised when drawing conclusions	Inconclusive: suspected	Inconclusive: suspected
Jackson et al (2020) UK	Rapid systematic review	89% of literature classified CPR as an AGP, 5% as possibly AGP and 7% as not an AGP	Inconclusive: suspected	Inconclusive: suspected
Ott et al (2020) Germany	Simulation	Chest compression shown as AGP in a mannequin and cadaver model	High risk	Not investigated
Hsu et al (2021a) US	Pilot study: simulated animal model	Chest compressions following defibrillation created increased aerosols. Compressions alone did not	Compressions alone not AGP	Compressions plus defibrillation AGP

Key: evidence for an AGP: green: in favour; red: against; grey: not investigated; pink: inconclusive; blue: inconclusive but suspected AGP
AGP: aerosol-generating procedure; CPR: cardiopulmonary resuscitation; GRADE: Grading of Recommendations, Assessment, Development and Evaluation; MERS: Middle East respiratory syndrome; SARS: severe acute respiratory syndrome

Ott et al (2020) concluded that chest compressions were a potential AGP from using ultraviolet-sensitive detergent in their mannequin and cadaver simulation models. Their study design involved filling the lungs and airways of mannequins and cadavers with nebulised detergent, then using periodic, ultraviolet-sensitive photography to track aerosol dispersion during chest compressions. This methodology meant aerosol distribution could be estimated; however, size and quantity were not measurable. Limitations were cited as an inability to translate aerosol

© 2023 MA Healthcare Ltd

Downloaded from magonlinelibrary.com by 147.197.131.099 on March 2, 2025.

dispersion into risk of infection, likely because of the inability to quantify aerosol volume or mass, as well as man-made aerosols not being truly representative of what might be seen in real life.

Ambiguity of language

Inconsistencies regarding terminology, specifically regarding CPR, were noted.

CPR traditionally comprises chest compressions and assisted ventilations, either via mouth-to-mouth or bag-valve mask ventilations. Guidelines have been adapted to encourage compression-only CPR due to the reluctance of lay people to perform assisted ventilations. Partly due to a lack of understanding of the techniques involved or, more notably, fear of disease transmission through mouth-to-mouth ventilation (Taniguchi et al, 2007)—a fear exacerbated through the pandemic (Bray, 2020).

This ambiguity of language regarding CPR seen throughout the literature meant it was difficult to draw specific conclusions regarding chest compressions as a possible AGP.

Discussion

This review of the limited literature has demonstrated a pressing need for clarity to better understand aerosol production during resuscitation procedures. There was a paucity of evidence regarding chest compressions and defibrillation as potential AGPs, with no study offering definitive, conclusive findings. This dearth of evidence has led to contradictory guidelines being produced, with documented confusion among health professionals and reported feelings of mistrust in policies. The effect is that health professionals could potentially not be complying with PPE guidelines, putting themselves and others at risk (Cheruku et al, 2020; Houghton et al, 2020; Payne and Peache, 2021; Perkins et al, 2021).

Retrospective evidence analysed within this review suggests the risk of contracting respiratory disease through chest compressions and defibrillation is low. However, data contributing to this viewpoint have been demonstrated to be of poor quality in various systematic reviews, with caution repeatedly urged within the literature should one wish to draw definitive conclusions.

Uncertainty has arisen because of the multiple confounding variables and significant biases associated with retrospective data. Resuscitation of patients in cardiac events inevitably involves multiple procedures performed simultaneously, which means that case review data cannot be used to pinpoint the specific point of nosocomial transmission.

A general assumption exists within literature that nosocomial transmission in a resuscitative attempt originates from being in close proximity to the airway, with transmission often presumed to be a result of endotracheal intubation, which is perceived as a high-risk procedure (Tran et al, 2012; Brown and Chan, 2020; Couper et al, 2020).

Emerging literature casts doubt on the validity of this assumption. Recently published quantitative studies have shown elective intubation to produce very few aerosols—significantly fewer than coughing (Brown et al, 2021). Similar findings have been demonstrated during insertion and removal of supraglottic airways (Shrimpton et al, 2021). These findings have led to calls for reviews of which procedures should be defined as an AGP. When considering these findings in relation to prehospital working, a point of consideration in both studies is the environment in which the investigated intervention occurred.

Both Brown et al (2021) and Shrimpton et al (2021) investigated aerosol production in the controlled environment of hospital theatres. Routine practice would involve prior assessment and grading of airways. Similarly, patients would be fully anaesthetised, making no respiratory effort and kept nil by mouth before the procedure. In the case of Shrimpton et al (2021), patients with difficult airways were excluded from the study. These safety and screening measures would not be afforded to the prehospital rescuer. Prehospital patients do not present fully anaesthetised so could potentially make a respiratory effort at any moment, further complicating matters. As such, this is an area that would benefit from further investigation.

No studies were identified that had attempted to record real-time aerosol data during active emergency resuscitation in human subjects and very little data exist investigating size, volume or distribution of aerosols generated by these procedures. The two prospective studies identified via the search strategy suggest chest compressions and defibrillation are potential AGPs. However, both were subject to significant limitations. Although innovative in their study design, the use of small sample sizes impacted their findings. Methodological techniques that were not reflective of true resuscitative events meant that generalised conclusions were impossible. Both studies conceded this point, highlighting the need for further research (Ott et al, 2020; Hsu et al, 2021a).

With no definitive, evidence-based answer regarding defibrillation or chest compressions being aerosol generating or, more importantly, whether these procedures pose a risk of transmission of respiratory disease to health professionals, one must consider their respective risk in relation to the nature of respiratory viral transmission and aerosol production.

© 2023 MA Healthcare Ltd

Downloaded from magonlinelibrary.com by 147.197.131.099 on March 2, 2025.

Respiratory aerosol particles and droplets have historically been defined as being under 5 µm and droplets exceeding this are arbitrarily cut off. Droplets follow a ballistic trajectory whereas aerosols remain suspended in the air, akin to smoke. It has since emerged, through advances in aerosol-measuring technology, that this might be over simplistic. Particles of up to 100 µm have been found to remain suspended in air for up to 5 seconds. SARS-CoV-2 measures approximately 0.1 µm, with aerosol particles of under 5 µm or more able to carry virions (Bar-On et al, 2020; Lee, 2020; Wang et al, 2021). These measurements have implications when considering what appropriate levels of PPE would be.

People create respiratory particles, both droplets and aerosols, through the turbulence of exhaled air passing over moist, mucous-lined airways. This air force liberates aerosols that are then exhaled, coughed or sneezed from the airway (Edwards et al, 2021). Once aerosolised, particles are then subject to the effects of temperature and humidity, which can further alter their size and aerodynamic properties, as does the speed at which they leave the airway (Drossinos et al, 2021; Klompas et al, 2021).

Physiological conditions that alter the surface tension and viscoelasticity of the mucous-lined airways can increase the propensity for respiratory particle generation, in which surfactant properties play a crucial role. Factors such as age, weight, diet and COVID-19 infection can change lung surfactant properties and lead to a greater production of droplets and aerosols (Edwards et al, 2021). The force of compressing a patient's chest to manually affect intrathoracic pressure, as seen during chest compressions, has been demonstrated to create an expiratory passive tidal volume as high as 45.8 ml (McDannold et al, 2018). Similarly, defibrillation causes a violent muscular contraction. One can thus see how chest compressions or defibrillation might lead to production of respiratory aerosols and be a risk factor in the transmission of respiratory disease.

On 28 September 2021, Public Health England (PHE) released its updated interpretation of the New and Emerging Respiratory Virus Threats Advisory Group (NERVTAG) review, examining the evidence regarding chest compressions and defibrillation as AGPs. This was reviewed on 14 April 2022 but later withdrawn in May 2022. Within this document PHE published the following quote from NERVTAG:

'It is biologically plausible that chest compressions could generate an aerosol, but only in the same way that an exhalation breath would do. No other mechanism exists to generate an aerosol other than compressing the chest and an expiration breath, much like a cough, is not currently recognised as a high-risk event or an AGP.' (PHE, 2022)

Table 2. World Health Organization list of aerosol-generating procedures

Medical	Dental
Tracheal intubation	Any procedure involving spray-generating equipment e.g. three-way air/water spray and dental cleaning
Non-invasive ventilation (bilevel positive airway pressure/continuous positive airway pressure)	Tooth polishing
Tracheotomy	Periodontal treatment using ultrasonic scaler
Cardiopulmonary resuscitation	Procedures involving high- or low-speed handpieces
Manual ventilation before intubation	Direct or indirect restoration and polishing
Bronchoscopy	Cementation of crowns or bridges
Sputum induction using nebulised hypertonic saline	Mechanical endodontic treatment
Autopsy procedures	Surgical tooth extractions and implant placement

Source: World Health Organization (2021)

This is caveated with a suggestion that health organisations may wish to use higher levels of PPE for staff tasked with the delivery of chest compressions. PHE has since been replaced by the UK Health Security Agency and Office for Health Improvement and Disparities. More recently, NHS England (NHSE) published a rapid review of AGPs in June 2022, in which chest compressions or defibrillation are not mentioned (NHSE, 2022). Interestingly the Resuscitation Council UK (RCUK) advised members of the public to not delay chest compressions on out-of-hospital cardiac arrest patients. Both RCUK and the Royal College of Nursing (RCN) advocate higher levels of PPE (FFP3 masks or respirators) for health care workers performing chest compressions for suspected or confirmed COVID-19 (RCUK, 2022; RCN, 2023). The RCN takes a different stance with regards to how it advises its members when faced with cardiac arrest patients outside of hospital.

'…conduct a risk assessment and use their professional judgement to decide whether or not to provide Basic Life Support CPR; taking

© 2023 MA Healthcare Ltd

Downloaded from magonlinelibrary.com by 147.197.131.099 on March 2, 2025.

Key Points

- There is very limited evidence available regarding chest compressions and defibrillation as potential aerosol-generating procedures (AGPs)
- Health organisations disagree over whether chest compressions are AGPs
- Evidence suggests the physiological mechanism involved in both chest compression and defibrillation could plausibly increase respiratory aerosols
- There is urgent need for future studies investigating procedures of resuscitation as AGPs

> ***into consideration the individual needing CPR, the current situation, the environment and their own safety, local policy, and any knowledge of the individual.' (RCN, 2023)***

Similarly, the American Heart Association (Hsu et al, 2021b), in an attempt to address rising mortality rates seen in patients experiencing an out-of-hospital cardiac arrest, recommend there be no delay in compression or defibrillation in regions where vaccinations have been widely distributed. This is in contrast to the WHO's (2021) stance; CPR remains on its list of AGPs, alongside tracheal intubation, manual ventilation and non-invasive ventilation. *Table 2* shows the WHO's (2021) full list of AGPs.

Without formal quantification of aerosols during real-time resuscitation with a focus on chest compressions and defibrillation specifically, disagreement and debate regarding the most appropriate course of action will remain.

Conclusions

The evidence base regarding chest compressions and defibrillation as possible AGPs is highly limited and subject to multiple confounding factors and biases. Literature suggests chest compressions and defibrillation to be of low risk of transmission of respiratory diseases. This is partly because, during a cardiac arrest, these procedures occur simultaneously to the perceived high-risk procedures associated with airway management.

Literature repeatedly theorises the origin of nosocomial transmission during a resuscitation attempt to be airway management procedures, specifically endotracheal intubation. Emerging evidence in controlled hospital settings suggests elective intubation and supraglottic airway insertion might not be as high risk as initially thought, generating fewer aerosols than coughing (Brown et al, 2021; Klompas et al, 2021; Shrimpton et al, 2021).

It is a recommendation from this review that urgent research is carried out to establish which procedures of resuscitation generate aerosols, with clarity required regarding chest compressions and defibrillation, specifically to reassure rescuers and benefit patients in cardiac arrest. JPP

Conflict of interest: The author is part of a trial entitled STOPGAP: STudy Of cardioPulmonary resuscitation activities thought to Generate Aerosol Particles.

Data sharing: Data are available from the author upon reasonable request.

Funding: No funding was received for this work.

References

Atzrodt CL, Maknojia I, McCarthy RDP et al. A guide to COVID-19: a global pandemic caused by the novel coronavirus SARS-CoV-2. FEBS J. 2020;287(17):3633–3650. https://doi.org/10.1111/febs.15375

Bar-On YM, Flamholz A, Phillips R, Milo R. Science forum: SARS-CoV-2 (COVID-19) by the numbers. Elife. 2020;9:e57309. https://doi.org/10.7554/eLife.57309

Bray J. Bystander CPR in the COVID-19 pandemic. Resus Plus. 2020. https://doi.org/10.1016/j.resplu.2020.100041

Brown E, Chan LM. Should chest compressions be considered an aerosol-generating procedure? A literature review in response to recent guidelines on personal protective equipment for patients with suspected COVID-19. Clin Med (Lond). 2020; 20(5):e154–e159. https://doi.org/10.7861/clinmed.2020-0258

Brown J, Gregson FKA, Shrimpton A et al. A quantitative evaluation of aerosol generation during tracheal intubation and extubation. Anaesthesia. 2021;76(2):174–181. https://doi.org/10.1111/anae.15292

Chalumeau M, Bidet P, Lina G et al. Transmission of Panton-Valentine leukocidin-producing Staphylococcus aureus to a physician during resuscitation of a child. Clin Infect Dis. 2005;41(3):e29–30. https://doi.org/10.1086/431762

CPD Reflection Questions

- Considering the size of aerosol particles discussed in this review, what are the implications with respect to personal protective equipment?
- Which procedures of resuscitation do you feel pose the greatest risk and why?
- Given current knowledge, do you feel chest compressions should be considered an aerosol-generating procedure? What is your rationale?

© 2023 MA Healthcare Ltd

Downloaded from magonlinelibrary.com by 147.197.131.099 on March 2, 2025.

Chandrasekharan P, Vento M, Trevisanuto D et al. Neonatal resuscitation and postresuscitation care of infants born to mothers with suspected or confirmed SARS-CoV-2 infection. Am J Perinatol. 2020;37(8):813–824. https://doi.org/10.1055/s-0040-1709688

Cheruku S, Dave S, Goff K et al. Cardiopulmonary resuscitation in intensive care unit patients with coronavirus disease 2019. J Cardiothorac Vasc Anesth. 2020;34(10):2595–2603. https://doi.org/10.1053/j.jvca.2020.06.008

Christian MD, Loutfy M, McDonald LC et al. Possible SARS coronavirus transmission during cardiopulmonary resuscitation. Emerg Infect Dis. 2004;10(2):287–293. https://doi.org/10.3201/eid1002.030700

Couper K, Taylor-Phillips S, Grove A et al. COVID-19 in cardiac arrest and infection risk to rescuers: a systematic review. Resuscitation. 2020;151:59–66. https://doi.org/10.1016/j.resuscitation.2020.04.022

Drossinos Y, Weber TP, Stilianakis NI. Droplets and aerosols: an artificial dichotomy in respiratory virus transmission. Health Sci Rep. 2021;4(2):e275. https://doi.org/10.1002/hsr2.275

Edwards DA, Ausiello D, Salzman J et al. Exhaled aerosol increases with COVID-19 infection, age, and obesity. Proc Natl Acad Sci U S A. 2021;118(8):e2021830118. https://doi.org/10.1073/pnas.2021830118. Erratum in: Proc Natl Acad Sci U S A. 2021;118(27)

Fink JB, Ehrmann S, Li J et al. Reducing aerosol-related risk of transmission in the era of COVID-19: an interim guidance endorsed by the international society of aerosols in medicine. J Aerosol Med Pulm Drug Deliv. 2020;33(6):300–304. https://doi.org/10.1089/jamp.2020.1615

Goyal A, Chhabra L, Sciammarella JC et al. Defibrillation. Treasure Island (FL): StatPearls Publishing. 2023. https://www.ncbi.nlm.nih.gov/books/NBK499899/ (accessed 8 March 2023)

Haji JY, Subramaniam A, Kumar P, Ramanathan K, Rajamani A. State of personal protective equipment practice in Indian intensive care units amidst COVID-19 pandemic: a nationwide survey. Indian J Crit Care Med. 2020;24(9):809–816. https://doi.org/10.5005/jp-journals-10071-23550

Harris AW, Kudenchuk PJ. Cardiopulmonary resuscitation: the science behind the hands. Heart. 2018;104(13):1056–1061. https://doi.org/10.1136/heartjnl-2017-312696

Hoernke K, Djellouli N, Andrews L et al. Frontline healthcare workers' experiences with personal protective equipment during the COVID-19 pandemic in the UK: a rapid qualitative appraisal. BMJ Open. 2021;11(1):e046199. https://doi.org/10.1136/bmjopen-2020-046199

Houghton C, Meskell P, Delaney H et al. Barriers and facilitators to healthcare workers' adherence with infection prevention and control (IPC) guidelines for respiratory infectious diseases: a rapid qualitative evidence synthesis. Cochrane Database Syst Rev. 2020;4(4):CD013582. https://doi.org/10.1002/14651858.CD013582

Hsu CH, Tiba MH, Boehman AL et al. Aerosol generation during chest compression and defibrillation in a swine cardiac arrest model. Resuscitation. 2021a;159:28–34. https://doi.org/10.1016/j.resuscitation.2020.12.004

Hsu A, Sasson C, Kudenchuk PJ et al. 2021 interim guidance to health care providers for basic and advanced cardiac life support in adults, children, and neonates with suspected or confirmed COVID-19. Circ Cardiovasc Qual Outcomes. 2021b;14(10):e008396. https://doi.org/10.1161/CIRCOUTCOMES.121.008396

Jackson T, Deibert D, Wyatt G et al. Classification of aerosol-generating procedures: a rapid systematic review. BMJ Open Respir Res. 2020;7(1):e000730. https://doi.org/10.1136/bmjresp-2020-000730

Kalita S, Gogoi B, Khaund G et al. Optimizing airway surgery in COVID 19 era. Indian J Otolaryngol Head Neck Surg. 2022; 74(suppl 2):3370–3377. https://doi.org/10.1007/s12070-020-02326-6

Key T, Mathai NJ, Venkatesan AS, Farnell D, Mohanty K. Personal protective equipment during the COVID-19 crisis: a snapshot and recommendations from the frontline of a university teaching hospital. Bone Jt Open. 2020;1(5):131–136. https://doi.org/10.1302/2633-1462.15.BJO-2020-0027.R1

Kim WY, Choi W, Park SW et al. Nosocomial transmission of severe fever with thrombocytopenia syndrome in Korea. Clin Infect Dis. 2015;60(11):1681–1683. https://doi.org/10.1093/cid/civ128

Klompas M, Baker M, Rhee C. What is an aerosol-generating procedure? JAMA Surg. 2021;156(2):113–114. https://doi.org/10.1001/jamasurg.2020.6643

Laue M, Kauter A, Hoffmann T, Möller L, Michel J, Nitsche A. Morphometry of SARS-CoV and SARS-CoV-2 particles in ultrathin plastic sections of infected Vero cell cultures. Sci Rep. 2021;11(1):3515. https://doi.org/10.1038/s41598-021-82852-7

Lee BU. Minimum sizes of respiratory particles carrying SARS-CoV-2 and the possibility of aerosol generation. Int J Environ Res Public Health. 2020;17(19):6960. https://doi.org/10.3390/ijerph17196960. Erratum in: Int J Environ Res Public Health. 2021;18(22)

Liu E, Tang F, Fang LQ et al. Risk factors for SARS infection among hospital healthcare workers in Beijing: a case control study. Trop Med Int Health 2009;14(suppl 1):52–59

Leong YC, Cheskes S, Drennan IR, Buick JE, Latchmansingh RG, Verbeek PR. Clinical considerations for out-of-hospital cardiac arrest management during COVID-19. Resusc Plus. 2020;4: 100027. https://doi.org/10.1016/j.resplu.2020.100027

Loeb M, McGeer A, Henry B et al. SARS among critical care nurses, Toronto. Emerg Infect Dis. 2004;10(2):251–255. https://doi.org/10.3201/eid1002.030838

McDannold R, Bobrow BJ, Chikani V, Silver A, Spaite DW, Vadeboncoeur T. Quantification of ventilation volumes produced by compressions during emergency department cardiopulmonary resuscitation. Am J Emerg Med. 2018;36(9):1640–1644. https://doi.org/10.1016/j.ajem.2018.06.057

Munn Z, Peters MDJ, Stern C, Tufanaru C, McArthur A, Aromataris E. Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. BMC Med Res Methodol. 2018;18(1):143. https://doi.org/10.1186/s12874-018-0611-x

NHS England. A rapid review of aerosol generating procedures (AGPs). A rapid review of aerosol generating procedures (AGPs). 2022. https://tinyurl.com/mry9trkj (accessed 24 March 2023)

Nam HS, Yeon MY, Park JW, Hong JY, Son JW. Healthcare worker infected with Middle East Respiratory Syndrome during cardiopulmonary resuscitation in Korea, 2015. Epidemiol Health. 2017;39:e2017052. https://doi.org/10.4178/epih.e2017052

Nolan J, Soar J, Eikeland H. The chain of survival. Resuscitation. 2006;71(3):270–271. https://doi.org/10.1016/j.resuscitation.2006.09.001

Olasveengen TM, Semeraro F, Ristagno G et al. European Resuscitation Council Guidelines 2021: basic life support. Resuscitation. 2021;161:98–114. https://doi.org/10.1016/j.resuscitation.2021.02.009

Ott M, Milazzo A, Liebau S, Jaki C, Schilling T, Krohn A, Heymer J. Exploration of strategies to reduce aerosol-spread during chest compressions: a simulation and cadaver model. Resuscitation. 2020;152:192–198. https://doi.org/10.1016/j.resuscitation.2020.05.012

Payne D, Peache M. Aerosol-generating procedures in home care. Br J Community Nurs. 2021;26(2):76–80. https://doi.org/10.12968/bjcn.2021.26.2.76

© 2023 MA Healthcare Ltd

Downloaded from magonlinelibrary.com by 147.197.131.099 on March 2, 2025.

Perkins J, Hamilton M, Canniff C et al. Resuscitation during the pandemic: optional obligation? Or supererogation? Clin Ethics. 2021;16(2):74–80. https://doi.org/10.1177/1477750920946684

Peterson J, Pearce PF, Ferguson LA, Langford CA. Understanding scoping reviews: definition, purpose, and process. J Am Assoc Nurse Pract. 2017;29(1):12–16. https://doi.org/10.1002/2327-6924.12380

Public Health England. PHE statement regarding NERVTAG review and consensus on cardiopulmonary resuscitation as an aerosol generating procedure (AGP). 2022. https://tinyurl.com/yhaesxn3 (accessed 8 March 2023)

Raboud J, Shigayeva A, McGeer A et al. Risk factors for SARS transmission from patients requiring intubation: a multicentre investigation in Toronto, Canada. PLoS One. 2010;5(5):e10717. https://doi.org/10.1371/journal.pone.0010717

Resuscitation Council UK. Guidance: COVID-19. 2022. https://www.resus.org.uk/library/additional-guidance/ (accessed 24 March 2023)

Royal College of Nursing. Personal protective equipment (PPE) and COVID-19. 2023. https://tinyurl.com/3v77nwu5 (accessed 24 March 2023)

Shrimpton AJ, Gregson FKA, Brown JM et al. A quantitative evaluation of aerosol generation during supraglottic airway insertion and removal. Anaesthesia. 2021;76(12):1577–1584. https://doi.org/10.1111/anae.15542

Soar J, Böttiger BW, Carli P et al. European Resuscitation Council Guidelines 2021: adult advanced life support. Resuscitation. 2021;161:115–151. https://doi.org/10.1016/j.resuscitation. 2021.02.010. Erratum in: Resuscitation. 2021;167:105–106

Taniguchi T, Omi W, Inaba H. Attitudes toward the performance of bystander cardiopulmonary resuscitation in Japan. Resuscitation. 2007;75(1):82–87

Tran K, Cimon K, Severn M, Pessoa-Silva CL, Conly J. Aerosol generating procedures and risk of transmission of acute respiratory infections to healthcare workers: a systematic review. PLoS One. 2012;7(4):e35797. https://doi.org/10.1371/journal.pone.0035797

Tricco AC, Lillie E, Zarin W et al. PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. Ann Intern Med. 2018;169(7):467–473. https://doi.org/10.7326/M18-0850

Wang CC, Prather KA, Sznitman J et al. Airborne transmission of respiratory viruses. Science. 2021;373(6558):eabd9149. https://doi.org/10.1126/science.abd9149

World Health Organization. Infection prevention and control during health care when coronavirus disease (COVID-19) is suspected or confirmed. Interim guidance. 2021. https://tinyurl.com/27rsya3k (8 March 2023

World Health Organization. WHO Coronavirus (COVID-19) Dashboard. 2023. https://covid19.who.int/ (8 March 2023)

© 2023 MA Healthcare Ltd

Downloaded from magonlinelibrary.com by 147.197.131.099 on March 2, 2025.

3.2.2 Implications to this thesis

Having conducted this literature review, it supports the need for further study about chest compressions and defibrillation as possible AGPs. The dearth of quantitative evidence in this regard at the point of conducting the review had only been addressed via retrospective case studies or low fidelity simulation, using porcine or mannikin models, neither conclusive, with all suggestive of the potential risk associated with chest compressions. Both animal and manikin methods were considered for use in this thesis. However, it was strongly felt that the evidence base demanded an attempt to capture real-time aerosol data during an active resuscitation. Various methods were considered and explored, several of which were presented to patient and public involvement and engagement (PPIE) groups. Several of these methods were later abandoned for a host of reasons that will be discussed in more depth later in the thesis (section 4.7.14). It is noteworthy that since this literature review was completed, developments have emerged in this field towards the latter part of 2022, specifically referring to a study conducted by Shrimpton et al. (2024). This study quantified aerosols during active resuscitation through novel means. These more contemporary studies are part of the discussion of the findings; however, as they did not inform the study design, they have not been featured as part of this literature review but do feature in more depth within Chapter 7 (section 7.3.1).

These two literature reviews also raise a point of interest concerning the protection afforded by masks used by healthcare workers during chest compressions. Therefore, an additional literature review is being conducted to inform the integration of workstreams one and two in the discussion.

3.3 Literature Review 3

3.3.1 Title: Mask effectiveness during Cardiopulmonary Resuscitation (CPR)

The COVID-19 pandemic has brought into sharp focus healthcare organisations' practices and responsibilities regarding health and safety relating to infection control and prevention. Throughout the pandemic, it was recommended that healthcare workers (HCWs) use level 3 personal protective equipment (PPE) for procedures thought to be aerosol generating. Level 3 PPE consists of disposable gloves, a fluid-repellent outer garment, typically a long-sleeved apron or gown, a higher level facial covering such as a Filtering Face Piece mask (also known as an FFP3 mask) or powered respirator hood, and eye protection or face shield (note eye protection nor face shields are not required when using a powered respirator) (UK Health Security Agency, 2022).

This advice was withdrawn by the UK Health Security Agency on the 10th of May 2022, replaced by a notice signposting organisations to the Association of Ambulance Chief Executives (AACE) position statement created on the 14th of April 2022. This document recommends level 3 PPE when respiratory infection is suspected or confirmed and aerosol generating procedures are likely required, per the following direct quote…

> '*Level 3 PPE must be worn following dynamic risk assessment:*
>
> - *…for all known or suspected respiratory infectious patients where AGPs are required –i.e., witnessed arrest where patient history can be clinically assessed.*
> - *…when undertaking AGPs or AGP is predicted to be required and there is an unacceptable risk of transmission of an infection following rigorous application of the hierarchy of controls i.e., known cardiac arrest where patients' respiratory infectious status is unknown*' (National Ambulance Service Infection Prevention & Control Group, (NASIPCG) 2022).

The Resuscitation Council UK (RCUK) echoes this sentiment for healthcare workers attending patients in cardiac arrest, providing a rationale due to the uncertainty around chest compressions as an aerosol generating procedure that existed at that time (RCUK 2022). Guidance like this presented front-line ambulance staff with a moral and ethical predicament. This arose because paramedics are rarely party to patients' 'respiratory infectious status' (as referred to by NASIPCG) prior to their arrival on the scene when attending emergencies and the delays attributed to donning higher levels of PPE. The nature of time-critical emergencies means, as the name suggests, that time is of the essence. In relation to patients who have suffered a cardiac arrest, details about their medical history are usually obtained during the act of their attempted resuscitation. Ambulance staff would, therefore, face the dilemma - should they don higher levels of PPE, protecting themselves from a potentially fatal or debilitating respiratory infection, thereby opting to delay lifesaving treatment, or instead, choose a lower standard of PPE that could be donned in a timelier fashion, or perhaps even omit it all together, an act that would almost certainly put their personal health and safety at risk for the benefit of the patient.

A dynamic risk assessment is a process by which a rescuer or care provider continually assesses the hazards and balances the risk associated with a course of action with the benefit offered to the patient. The formal dynamic risk assessment process outlined in paramedic guidance produced by NARU is typically reserved for a dynamic and evolving scene that might involve multiple patients, such as that of a major incident. Following these processes in this regard enables the rescuer to make considered choice as to the most appropriate actions to take (NARU 2015). To do this effectively, the rescuer must understand the risk and know where it lies. To inform decision-making regarding PPE and the inevitable delays this might have to the delivery of chest compressions, it is essential that rescuers are assured that higher levels of PPE, which take longer to don, offer better protection and so can trust the evidence to justify their actions. With that in mind, a further literature review was conducted to answer the following question:

- ‘Does performing chest compressions reduce mask effectiveness when worn by paramedics required to deliver resuscitation to patients who have experienced an out-of-hospital cardiac arrest?’

Three databases were searched: MEDLINE, Cumulative Index to Nursing and Allied Health Literature (CINAHL) PLUS, and PUBMED. The search terms and Boolean operators used are illustrated in Tables 3.1 and 3.2.

Table 3.1 MEDLINE and CINAHL Plus search terms and results

Search	Term	Result
1	PPE or personal protective equipment or mask*	154395
2	Effectiveness or efficacy or effective or safety or protection	4747506
3	CPR or cardiopulmonary resuscitation or resuscitation or chest compressions or cardiac arrest	182681
4	1 AND 2 AND 3	929

Table 3.2 PUBMED search terms and results

Search	Term	Result
1	PPE or personal protective equipment or mask*	1442
2	Effectiveness or efficacy or effective or safety or protection	122345
3	CPR or cardiopulmonary resuscitation or resuscitation or chest compressions or cardiac arrest	188
4	1 AND 2 AND 3	45

3.3.2 Inclusion and Exclusion Criteria

3.3.2.1 Inclusion criteria

- English language or English translation readily available.
- any discussion regarding chest compressions' impact on PPE effectiveness. This was expanded to include any discussion around PPE effectiveness in a clinical setting due to the dearth of evidence regarding chest compressions.
- Studies of any age were included, with no date restrictions applied.

3.3.2.2 Exclusion criteria

- No readily available English language version.
- Duplicated record.
- No discussion regarding chest compressions' impact on PPE effectiveness.

Application of the search criteria resulted in 460 articles, which were then subject to title and abstract review. Three hundred ninety-six were then discarded either following the application of the inclusion and exclusion criteria. Sixty-four articles went on to undergo full-text review by a solo researcher. Literature was also obtained through citation and alternative media searches, which yielded fourteen papers. This meant a total of seventy-eight articles received a full-text review. Following a full-text review for appropriateness, eighteen papers were subsequently included in the review (see Fig. 3.1).

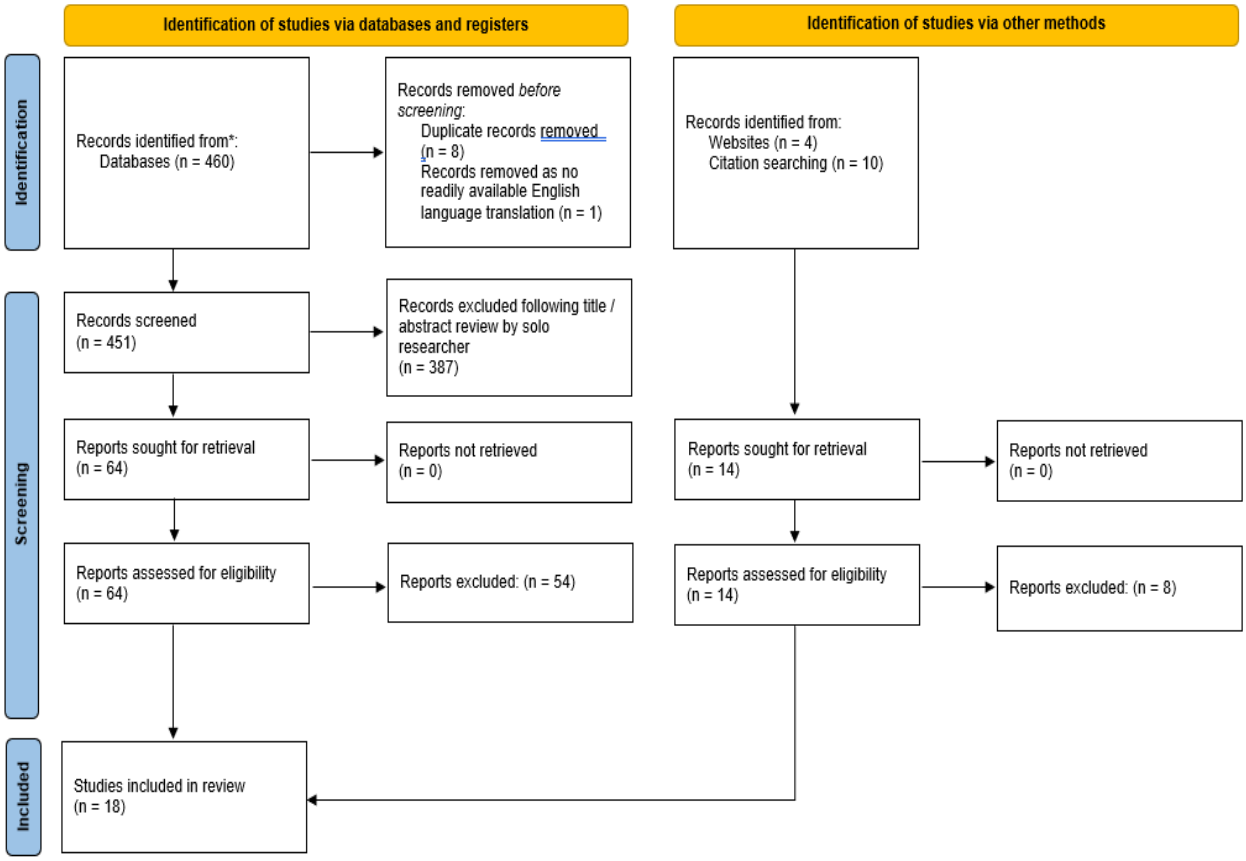


Figure 3.1 PRISMA diagram outlining the screening process for eligible papers.

3.3.3 Results

The search strategy yielded six prospective papers that specifically investigated the effectiveness of various face masks when HCWs performed chest compressions. It also highlighted two retrospective papers that looked at nosocomial transmission of respiratory disease during resuscitation of patients who were in cardiac arrest (summarised in Table 3.3). When the inclusion criteria were broadened to include papers that investigated the protective effect of PPE in clinical settings without reference to chest compressions or CPR, five prospective and five further studies, including two literature reviews, were identified and included to add to the richness of discussion. This undertaking enabled the exploration of evidence that included some documented narrative of clinical activities, aside from chest

compressions, that were thought to have compromised seal patency in various facemasks and contributed to the broader discussion.

Table 3.3 Summarising prospective evidence regarding PPE effectiveness.

Lead author/year	Title	Included CPR?	Type of mask	Findings
Barros 2021	Effectiveness of EHMRs vs N95 FFR During Simulated Resuscitation: A Nonrandomized Controlled Trial	Yes	N95 FFR, reusable EHMRs	FFR fit during CPR is poor, and EHMRs provide a superior fit
Goto 2021	The protective effect of tight-fitting PAPRs during chest compressions	Yes	Tight-fitting PAPRs	The tight-fitting PAPR did not provide adequate protection
Sietsema 2022	Simulated workplace protection factor study of a quarter-facepiece elastomeric respirator	Yes	Quarter facepiece EHMRs	A quarter-facepiece respirator is an effective option for HCW protection during a pandemic or similar situations.
Hwang 2020	N95 filtering facepiece respirators do not reliably afford respiratory protection during chest compression: A simulation study	Yes	N95	The fit-tested N95 respirator provided inadequate protection against respiratory infections during chest compression.
Park 2021	Are loose-fitting PAPRs safe during chest compression? A simulation study	Yes	Loose-fitting PAPRs	Sufficient respiratory protection by PAPRs during chest compression
Shin 2017	Comparing the protective performances of 3 types of N95 FFRs during chest compressions	Yes	cup-type, fold-type, and valve-type respirator	Chest compressions can affect the protective performance of respirators
MacIntyre 2017	The efficacy of medical masks and respirators against respiratory infection in HCWs	No	N95, medical masks.	Respirators provide superior protection vs masks against droplet infections.
Radonovich 2019	N95 Respirators vs Medical Masks for Preventing Influenza Among HealthCare Personnel: A RCT	No	N95, medical masks.	There was no significant difference between N95 and medical masks
Cummings 2021	Risk Factors for Healthcare Personnel Infection with Endemic Coronaviruses (HKU1, OC43, NL63, 229E): Results from the ResPECT	No	N95, medical masks	There are no conclusions regarding the relative effectiveness of N95 versus medical masks for AGP.
Green 2012	Effectiveness of selected surgical masks in arresting vegetative cells and endospores when worn by simulated contagious patients	No	Five commercially available surgical masks	Supports surgical mask use in infection prevention/cough etiquette
Loeb 2009	Surgical Mask vs N95 Respirator for Preventing Influenza Among HCWs: A Randomized Trial	No	Surgical masks, N95	Surgical masks, compared with N95 respirators, resulted in similar rates of HCW influenza.

List of featured abbreviations within Table 3.3:

EHMRs = Elastomeric half-mask respirators

FFR = Filtering facepiece respirator

ResPECT = Respiratory Protection Effectiveness Clinical Trial

HCWs = Healthcare workers

RCT = Randomised controlled trial

PAPRs = Powered air-purifying respirators

3.3.4 Discussion

3.3.4.1 Prospective data

Prospective data utilised various methodologies. Barros et al. (2021) recruited HCWs, including doctors, advanced practice clinicians, and nurses, as part of their nonrandomised, controlled trial. Their design assigned participants either reusable, elastomeric half-mask respirators (EHMR) with P100 filters or an N95 filtering facepiece respirator (FFR) before them being required to perform chest compressions on a mannequin. Denatonium benzoate was then aerosolised into a hood, placed over the participant's head, and testing would be stopped once participants reported its detection or 2 minutes had passed, as would be done when performing routine fit testing. Various models of N95 were used as part of the study. Their results found EMHR to have a superior fit, with FFR described as being of poor fit in comparison. The real-world design was a particular strength of the study; however, the lack of blinding, plus the subjective nature of a participant-led detection model of aerosol, were notable limitations (Barros et al., 2021).

Goto et al. (2021) measured the simulated workplace protection factor (SWPF) for powered air-purifying respirators (PAPRs). SWPF indicates how much protection the respirator provides when in a simulated work environment. It is the ratio calculated by measuring the particles outside and inside the respirator

and is often used in research to assess the effectiveness of facemasks (Sietsema et al., 2022; Goto et al., 2021). Participants performed chest compressions on a mannequin, and the SWPF was recorded throughout. An investigator observed them to ensure the appropriate rate and depth of compressions throughout, with participants not allowed to adjust the mask. Protective failure was recorded when the SWPF dropped below a value of 500. It was found that the movement associated with delivering chest compressions loosened the seal between the wearer's face and the mask, leading to inadequate protection and a high failure rate of 73% (equating to 32 out of 54 people). Interestingly, the first session of CPR recorded much higher failure rates than the third session. The authors postulated that this observation might be due to fatigue. This was despite the participants being independently observed for technique during their delivery of chest compressions. An alternative explanation might be that this was a learned behaviour or countermeasure of the experimental equipment design, whereby participants adjusted their posture to prevent the more erratic movements of their heads that might have been seen during the first attempt. A particular strength of this study, when compared to Barros et al. (2021), is how this design removed the subjective nature of aerosol detection in favour of objective, quantifiable aerosol analysis. Limitations of the study included simulated research not truly reflecting scenarios seen in real life; for example, continuous chest compressions were performed from the start; in reality, chest compressions would be performed at a rate of thirty to two until a definitive airway is in situ as is guidance. Furthermore, as is the case in these situations, the HCW will often count aloud to inform their colleague when it is time to ventilate the patient. This was not part of this simulated exercise. It is a point for consideration that speaking out loud could further compromise the seal between the face and mask and is an additional facial movement that might compromise the seal (Goto et al., 2021).

Like Goto et al. (2021), Park et al. (2020) used SWPF to assess the protective effects of loose-fitting PAPRs during chest compressions. Park et al. (2020) found them safe in a simulated environment within an emergency department. Different measures of success or failure were seen when comparing the two

study designs. In Park's study, an SWPF of less than 250 was deemed a failure. However, Goto et al. (2021) had their failure criteria as an SWPF of less than 500. Notably, this did not necessarily detract from the outcome as the median SWPF in the Park et al. (2020) study was over 15000, meaning participants would've passed either failure definition.

Sietsema et al. (2022) explored the protection offered to HCWs by using a quarter-facepiece elastomeric respirator; again, the technique of calculating the SWPF was used. In this instance, the study design required participants to perform various simulated clinical tasks for 30 minutes; one of these tasks included 90 seconds of CPR, namely chest compressions. Each activity was alternated with a minute of normal breathing and repeated three times. The authors concluded the quarter-facepiece reusable elastometric respirator to be capable of a fit comparable to that of a half-piece respirator whilst offering the added benefit of being less bulky around the wearer's face, being reusable, and generally more comfortable than the larger alternative (Sietsema et al., 2022). A criticism of this design was the choice to perform chest compressions for 90 seconds. Typically, HCWs deliver compressions in 2-minute cycles, as per recommended guidance, before being advised to switch roles to avoid fatigue that can compromise chest compression depth and effectiveness. Therefore, considering guidance and nationally agreed standard practice, testing for 120 seconds would have better reflected actual practice.

Following the MERS outbreak in 2015, Hwang et al. (2017) investigated the effectiveness of N95 respirators when performing chest compressions in participants who only partially passed their fit testing using a device that measured fit factor (FF). They found that chest compressions led to inadequate protection, even if fit testing was passed, highlighting how sweat further compromises the seal of these masks. Average FF dropped from 185 to 135, dropping to below 100 in a third of participants. A notable observation from this study centred around how the standard fit testing process

involved very mild movements of the head and neck and was certainly not representative of movements that were seen during day-to-day clinical practice, particularly not in line with what one would expect to see of a healthcare worker when administering chest compressions. Similar limitations as to those seen in Goto et al (2021) were highlighted in this study. These were based around how the simulated laboratory setting did not reflect real practice. The author again focused on continuous chest compressions only and not the thirty-to-two model. In real-world settings, the performance of movements associated with the varied procedures of resuscitation might lead to different outcomes (Hwang et al., 2017).

The trend emerged of poor-performing N95 respirators during chest compressions and was seen again in two of three N95 filtering facepiece respirators tested in the Shin et al. (2017) study. They found a decrease in the acceptable performance rate of both the cup-type and valve-type masks. This led to them concluding that vigorous movements, as seen with those associated with CPR, affect N95 filtering face piece performance. This contradicts the conclusions made in the McIntyre et al. (2017) study that pooled data from two randomised controlled trials. Rates of droplet-transmitted infections and laboratory-confirmed bacterial colonisation were compared in participants wearing medical (also termed surgical) masks, targeted use of N95 respirators and continuous use of N95 respirators. The continuous use of N95 in clinical settings was associated with fewer infections and provided superior protection from droplet transmission. It is noteworthy, however, that it is not stated what activities the wearers undertook during the four-week study period, meaning it is impossible to draw definitive conclusions in relation to chest compressions specifically and the influence they might have on mask effectiveness from this study alone.

Medical masks demonstrated comparable performance to N95 respirators when incidence rates of laboratory-confirmed influenza were recorded in a cluster-randomised pragmatic effectiveness study

by Radonovich et al. (2019). Over 4000 participants were given either a surgical mask or an N95 respirator, and the incidence of influenza infections was recorded over 4 years. Within the study, Emergency Departments did feature as one of the clinical settings that hosted the trial, which targeted working environments with perceived high levels of respiratory infections. However, the focus was outpatient settings with no mention of chest compressions or CPR. Limitations of this study primarily involve the inability of the researcher to monitor non-adherence to PPE in various settings. Although worthy of review and scrutiny within this literature review with the prescribed inclusion criteria, it did not offer any evidence to neither confirm nor deny the risk of performing chest compressions on mask effectiveness.

Cummings et al. (2021) were similar in design to Radonovich et al. (2019), with a large number of participants featured over a prolonged period of time. Their method utilised a post-hoc-sub-analysis to estimate the odds of endemic coronavirus infections. It observed the effect of N95 and medical masks with a caveat that during aerosol generating procedures, participants should opt out of the study design and instead follow local policy. As a result, no conclusions could be drawn about chest compressions. However, it identified that N95 could be safer at protecting wearers against endemic coronavirus than standard medical masks, although this finding was not statistically significant.

Surgical masks performed favourably in Green et al. (2012) dated study exploring arrestence of endospores and vegetative cells. This had several notable limitations, primarily because it was a simulated, lab-based study that lacked transferability. An earlier study by Loeb et al. (2009) similarly found surgical masks favourable, reporting nurses who wore surgical masks to have similar incidences of influenza as those who wore N95 respirators throughout the influenza season of 2008-2009. This study featured nurses working within an Emergency Department and other care settings, tasked with caring for patients with febrile respiratory illness so involved data from a real-world setting. It is

noteworthy however that chest compressions nor CPR are specifically mentioned within the paper and a limitation involved the inability to audit compliance to study protocols in nurses within this Emergency Department cohort (Loeb et al, 2009).

2.3.4.2 Further relevant data

Further data were identified in various forms, as shown in Tables 3.4 and 3.5. These included observational cohort studies, literature reviews, questionnaires, and case studies and provided conflicted findings. The bulk of this data was retrospective literature, identified through the search strategy, which suggested mask-wearing offered a suspected level of protection to the wearer from respiratory disease however, no conclusive evidence was presented, aside from the suspicion of correlation between mask-wearing and infection rates (Lier et al., 2021; Haiko et al., 2021; Seto et al., 2003).

Table 3.4 Further relevant data summary

Lead author / Date	Title	Method	Findings	CPR featured?
Lier 2021	High class filtering facepiece (FFP) are fundamental and effective in protection of emergency healthcare workers: an observational cohort study in a German community	retrospective observational cohort study design	Mandatory protection using FFP2/FFP3 is effective and efficient protection against SARS-CoV-2	No
Ghazali 2020	Feedback to Prepare EMS Teams to Manage Infected Patients with COVID-19: A Case Series	Retrospective observational study	Appropriate PPE was utilized for all the 391 emergencies, of which 81 patients were confirmed COVID-19 with zero transmission to HCWs	Yes
Haiko 2021	A retrospective survey study of paramedic students' exposure to SARS-CoV-2, participation in the COVID-19 pandemic response, and health-related quality of life	Retrospective, descriptive, cross-sectional study	No students tested positive for COVID-19 during their placements despite some being present for AGPs with inadequate PPE.	No
Seto 2003	Effectiveness of precautions against droplets and contact in prevention of nosocomial transmission of severe acute respiratory syndrome (SARS).	Retrospective questionnaire	None of the 69 staff became infected when adopting all four measures of masks, gown, gloves and hand washing.	No
Christian 2004	Possible SARS coronavirus transmission during cardiopulmonary resuscitation	Case study	Viral load thought to have overwhelmed non–fit-tested N95 disposable respirators during CPR.	Yes

Table 3.5 Secondary data / literature reviews

Lead author / Date	Title	Method	Findings	CPR featured?
Smith 2016	Effectiveness of N95 respirators versus surgical masks in protecting healthcare workers from acute respiratory infection: a systematic review and meta-analysis	Systematic literature review	Insufficient data to conclude whether N95 respirators offered superior protection versus surgical masks in clinical settings	No
Jefferson 2023	Physical interventions to interrupt or reduce the spread of respiratory viruses	Retrospective literature review	It is uncertain whether wearing masks or N95/P2 respirators helps to slow the spread of respiratory viruses.	No

Lier et al. (2021) compared emergency service (EMS) workers' infection rates against hospital workers, predominately based within an intensive care unit (ICU) in Germany. The authors made the logical assumption that working on a unit within a hospital ward could be described as a more controlled working environment than the prehospital EMS worker's daily working environment. This assumption is partly due to ICU healthcare workers having access to patients' COVID-19 status before contact and generally experiencing a less chaotic working environment overall. These factors were thought to lend themselves to a presumed lower risk of exposure to SARS-CoV-2 for this demographic. Interestingly, the presumed higher-risk environment did not translate to higher nosocomial infection rates in EMS workers, with comparably low SARS-CoV-2 infections seen across all investigated groups. This finding led to the authors reiterating the mandatory requirement for higher levels of PPE (FFP2 or 3) as a seemingly effective and relatively efficient strategy to protect EMS workers. Low overall incidence rates of COVID-19 (1.01 %), seen within the geographical study area, were cited by the authors as a notable limitation. Furthermore, concluding higher levels of PPE as effective through this chosen methodology negates to factor in the additional infection control practices that were in place at the time of the research. For example, the policy at the time recommended such additional measures as social distancing, hand hygiene, cough etiquette and psycho-social contributors that all may have affected individual behaviours and reduced transmission routes, both inside and outside the workplace.

Ghazali et al. (2020) demonstrated, through four brief case studies, the risk of nosocomial transmission posed to healthcare workers when caring for COVID-19 patients in various settings. Particularly pertinent to this project was a case that included members of a prehospital resuscitation team that responded to a patient in cardiac arrest who was subsequently confirmed as being COVID-19 positive at post-mortem testing. Two of the resuscitation team then went on to develop COVID-19 shortly after the event. Only a physician who performed the intubation was documented as wearing any, be it minimal, PPE whatsoever. As part of the discussion, the authors stated how compliance with the infection control and PPE rules is essential to protect staff from nosocomial infection. Although this sentiment is difficult to challenge, caution must be taken before drawing definitive conclusions from studies such as this. Similar limitations apply to this study as those seen in Lier et al. (2021). These events captured within the case studies occurred at a time of high circulating respiratory virus within the general population; therefore, although it was highly likely that responding to a COVID-19-positive patient in cardiac arrest without adequate PPE was the source of infection within the resuscitation team, it cannot be assumed. It is unclear what other activities the infected team members were tasked with in and around this time nor what activities they undertook outside of the workplace. They might have had several other patient contacts with possible COVID-19 patients or been in social gatherings with an asymptomatic associate.

Haiko et al. (2021) findings present an argument against the assumption made by Ghazali et al. (2020) that being the risk of nosocomial transmission posed by rescuer involvement in resuscitation. Their 2021 study investigated the experiences of student paramedics in Oslo via a questionnaire. They found that six students who participated in the study were involved in aerosol generating procedures with what the participants felt, in their assessment, was inadequate PPE (an example was given as this being due to a cardiac arrest occurring unexpectedly). Furthermore, one student reportedly had issues obtaining PPE

due to insufficient supply. Despite these reports, none of the 109 participants who enrolled in the study tested positive for COVID-19 or at least had a positive test when symptomatic. It is noteworthy that no tests were carried out on asymptomatic individuals, and the sample was only taken for participants during the first five months of the pandemic. Haiko et al. (2021) reiterated the importance of considering how transmission of COVID-19 can occur socially and is not necessarily a result of the failure of PPE. Recall bias must also be considered when interpreting these results.

Questionnaires were also employed in a similar study conducted during the SARS outbreak by Seto et al. in 2003, which aimed to investigate nosocomial transmission in Hong Kong hospitals during this period. The study defined exposure as being within 3 feet of a confirmed positive patient, and staff members who developed symptoms two to seven days later were included, reflecting the incubation period consistent with the Centres for Disease Control and Prevention (CDC) definition (CDC, 2005). None of the 69 staff who adopted all four infection control and prevention measures became infected. The specific measures focused on the use of gloves, various types of masks including paper, surgical, or N95, gowns or aprons, and essential handwashing. Among the 13 positive cases, it was noted that 12 involved staff in a medical ward who were not wearing masks in the vicinity of suspected SARS patients. Notably, the only confirmed case of nosocomial transmission within an Emergency Department (ED) involved a nurse who reported wearing three of the four protective measures examined in this project—namely, a paper mask, gloves, and practising handwashing. Seto et al. (2003) suggested that SARS infection was not airborne, detailing their rationale based on the significant reduction in infection rates with surgical and N95 masks. Moreover, nearly a third of uninfected healthcare workers did not wear masks while performing their duties. This correlation is difficult to comprehend from the data presented in this dated study, a finding that arguably requires further investigation.

Christian et al. (2004) presented a case study describing the care provided to a SARS-positive patient, focusing on a resuscitation attempt. Although Christian et al. (2004) describes their case study as exploring a potential 'cluster' of nosocomial SARS-CoV transmission, in fact, when delving into the specific details of the event, rather than a cluster, only one ICU nurse directly involved in the resuscitation attempt tested positive for SARS-CoV as per the WHO criteria for SARS-CoV infection. Notably, a nurse who administered chest compressions also exhibited fever symptoms but later provided an indeterminate test result. The particular nurse with a positive test was involved in intravenous cannulation of the patient's foot and also applied ECG leads. Both nurses reportedly wore significant levels of PPE during the resuscitation, being described as having worn safety glasses, a protective gown, gloves, a face shield, shoe and hair covers, and an N95 respirator. Notably, the nurse who tested positive had little direct contact with any other SARS-CoV positive patients in the 48 hours preceding this encounter and developed symptoms seven days after the resuscitation attempt, a timeline which the author believes suggests that this interaction was the source of their infection transmission. Christian et al. (2004) postulated that transmission occurred either through an aerosolised virus overwhelming the N95 respirator or an unrecognised PPE breach during resuscitation. As with all retrospective data, limitations centre around bias, specifically recall and observer bias.

Two literature reviews were identified through the search strategy employed within this review (Jefferson et al., 2023; Smith et al., 2016). Jefferson et al. (2023), in their robust, Cochrane-published systematic review, found only five papers that reviewed the effectiveness of N95 respirators; it also included three papers that were not identified through the search strategy employed within this literature review. These three case-control studies found N95 respirators to be an effective measure against nosocomial transmission (Teleman et al., 2004; Seto et al., 2003; Liu et al., 2009). Overall, however, Jefferson's review reported N95 respirators as being non-inferior to surgical masks while also being expensive and uncomfortable for the wearer.

The second literature review identified through the search strategy was by Smith et al. (2016), who conducted a systematic review and meta-analysis comparing the effectiveness of N95 respirators with surgical masks. They found that the N95 performed more favourably than surgical masks in twenty-three surrogate exposures or laboratory-based studies. These tests focused on filter penetration, face seal leakage, and total inward leakage. However, when reviewing transmission rates in hospital workers wearing both masks, Smith et al. (2016) found the performance of N95 to be comparable with surgical masks, with no reported significant difference. The authors explain this difference by considering the importance of comfort and mask fit in relation to mask effectiveness, particularly when wearing masks for prolonged periods. Uncomfortable masks, as one might expect, then lead users to adjust the fitting in an attempt to alleviate the discomfort. This could detrimentally affect seal patency, which explains the varying results observed in more comfortable and less prolonged lab settings compared to potentially less comfortable, often extended, real-world environments encountered during shift work. Furthermore, none of the papers featured in Smith et al. (2016) systematic literature review specifically regarded CPR, resuscitation, or chest compressions as contributory factors to mask ineffectiveness, and neither phrase was mentioned in the review as a focus of consideration.

3.3.5 Conclusion

This literature review investigated whether chest compressions influence the protection offered to the wearer by facemasks. The impact of chest compressions on N95 and PAPR mask effectiveness was reported as detrimental to the protection they afforded the wearer by the majority of papers featured within the review (Hwang et al., 2020; Barros et al., 2021; Goto et al., 2021). However, not all papers reported CPR affecting protection, with some finding that certain mask types offered the wearer adequate protection during chest compressions (Park et al., 2021; Sietsema, 2022; Barros et al., 2021).

Notably, in these instances, investigated masks were of differing types to those worn by front-line paramedics in the UK. The reasons behind the reduced protection offered by certain mask types were multifactorial. Seal patency was thought to be affected by the movements associated with administering chest compressions. Perspiration due to exertion was also believed to be a factor, as was user adjustment due to discomfort or mask irritation; findings were seen in wider literature (Rammohan et al., 2020; Hoernke et al., 2021).

3.3.6 Implications to this thesis

This literature review revealed how variability in performance was recorded by a variety of masks when the wearer was required to perform chest compressions. Most of the masks featured were negatively impacted by this action; however, it is important to note that this cannot be said for all masks. No literature was identified that focused on commonly used respirators by UK ambulance services. In the context of the paramedic dynamic risk assessment, this is significant; if a paramedic chooses to delay their delivery of patient care, they need to be assured that the evidence supports their decision and that the mask they don will provide protection for the task they wish to perform.

3.4 How do these reviews inform the dynamic risk assessment?

The paramedic dynamic risk assessment involves a rapid evaluation of risk. This assessment balances the risk presented to the rescuer and the patient and considers the implications of any risk mitigation strategy. This whole process will often be a split-second decision. In the presence of respiratory disease, this balance involves the decision to wear adequate PPE. This will inevitably take time and impact the rapid delivery of patient care. To effectively perform this balancing act, the paramedic must have confidence that any recommendation or guideline is based on reliable data and that any equipment they

might call upon is adequately tested in clinical settings aligned to their daily practice. One must then consider their motivations and influences. Personal motivations, for example, might include implications for their health or that of a family member should they contract any disease. It is key, therefore, that paramedics can trust the guidance they are given.

There was a dearth of evidence in relation to all three areas relevant to the research objectives proposed by this thesis, with a persistent desire expressed in the relevant literature for further study in each respective area. Paramedic experiences of wearing PPE have not been robustly explored or captured within the literature identified through the search strategy utilised within this literature review. The limited evidence focused on the broader healthcare system rather than the ambulance setting. Therefore, understanding their motivations behind adherence (or not) to PPE protocols remained uncertain. Similarly, regarding resuscitation procedures being aerosol generating, the evidence base on this matter appeared equally limited. Guidelines have been previously issued that were based on small numbers of minimal, retrospective studies subject to various biases. Guidelines and recommendations exist that are contradictory in this regard due to this lack of definitive evidence.

Finally, the FFP3 masks used by ambulance services in the UK have not been scrutinised regarding the protection they offer when the wearer is tasked with prolonged delivery of chest compressions, as might occur routinely in prehospital settings throughout the UK. The literature review suggests that similar masks present an issue with seal patency. It is apparent that PPE has been designed for use within the controlled environment of hospital settings, where an abundance of staff can be summoned quickly and are shielded from the elements, unlike their prehospital colleagues. Therefore, it is correct that the research questions in this thesis scrutinise both the need for PPE and its effectiveness in the prehospital arena. If paramedics feel vulnerable to nosocomial infection, they have the right to know that the PPE they choose to don will protect them. Similarly, this involves an assumption that paramedics feel

vulnerable in this regard and want PPE. The evidence in this regard is scant, hence the need for this thesis. Whenever a paramedic decides to don PPE, there will be a vulnerable patient whose care might be delayed. This must not be done in vain; any decision should be evidence-based and effective, leading to safer practice.

3.5 Summary

This chapter, structured around three literature reviews, explored key areas relevant to paramedic practice and the use of PPE in the context of respiratory disease. Together, these reviews establish the evidence base and inform the rationale for this thesis.

The first review, published and peer-reviewed, sought to explore paramedic experiences with PPE during the COVID-19 pandemic. It revealed a dearth of evidence but showed how operational and behavioural challenges influence non-adherence and identified contextual factors present in healthcare settings aside from ambulance services. The second review, also published, examined the classification of chest compressions and defibrillation as aerosol-generating procedures (AGPs). Again, a paucity of literature was identified, with the few limited studies available drawing attention to inconsistencies across guidance and underscoring the clinical and ethical tensions paramedics face when balancing infection risk with life-saving interventions.

After completing these two reviews, a gap was identified regarding the role of mask effectiveness during cardiopulmonary resuscitation (CPR), prompting a third unpublished review. This final review focuses on the comparative efficacy of different mask types during CPR, contributing important insight into the protective capabilities of PPE in resuscitation scenarios. Together,

these three reviews contribute a multi-layered understanding of the clinical, operational, and evidence-based complexities that shape paramedic decision-making when donning PPE. They also reveal a limited but emerging evidence base, marked by ambiguity in guidance and challenges in real-world application.

The findings from this chapter directly inform the development of the mixed-methods study presented in the next chapter. The reviews helped to identify gaps in current knowledge and underlined the need to explore how paramedics make dynamic risk assessments in the field when faced with respiratory pathogens. The following chapter outlines the design, rationale, and implementation of the mixed-methods approach used to investigate these issues in greater depth, combining qualitative and quantitative perspectives to explore PPE decision-making in paramedic practice comprehensively.

As alluded to earlier in this chapter, during the completion of this thesis, emerging evidence relevant to this topic was published. Importantly, these did not inform the methodological choices and will therefore be considered alongside the findings of this thesis within the discussion chapter (Chapter 7).

Chapter 4: Methodology

4.1: Introduction

This chapter aims to outline the rationale of the chosen methods and demonstrate how their respective philosophical underpinnings have contributed to addressing the research questions and objectives. A pragmatic, mixed-methods, exploratory study design was employed, utilising qualitative and quantitative lines of inquiry. The findings of each were then integrated into the discussion. Each research question was addressed by an independent workstream. These were as follows:

Workstream one:

This addressed research question one;

'What are paramedics' experiences of delivering patient care using PPE during the COVID-19 pandemic?'.

This was done through a qualitative investigation that explored paramedics' experiences of using PPE.

Workstream two:

This addressed research question two;

'Do chest compressions and defibrillation delivered during active resuscitation of a patient in cardiac arrest generate aerosols and so pose a transmission risk to the rescuer? '.

This was done through a quantitative investigation of aerosols produced by chest compressions and defibrillation during active resuscitation of patients in cardiac arrest.

4.2 Exploratory study design

Research exploring novel phenomena or topics with limited data, as identified in this field, is well-suited to an exploratory study design. A comprehensive literature review of the contemporary evidence base sought to answer the clinical questions presented by this project and highlighted a significant lack of evidence across all aspects. Exploratory research is described in the literature as a helpful method that can illuminate previously poorly understood phenomena (Hunter et al., 2019). Although multiple definitions of exploratory research exist, these are typically context dependent. Essentially, as the name suggests, exploratory research generally entails discovering something that has not yet been captured or observed. Words like exploratory or 'exploration' may conjure images of daring explorers as they venture into space, the Arctic, or the deep sea. Similarly, research of this nature inevitably carries a less dramatic element of risk as one attempts to chart a course into the unknown and shed light on otherwise undiscovered topics (Elman et al., 2020).

An exploratory study design offers several key advantages, such as providing in-depth insights into under-researched topics. However, it also has limitations, particularly in generalisability, as the findings may not apply to larger, more diverse populations (Hallingberg et al., 2018). Exploratory research illuminates areas of study with limited evidence that require further examination or have been previously neglected. Pertaining to this thesis, paramedics, as a population, have seldom been featured as the main focus in literature exploring PPE experiences. To the best of the author's knowledge, no literature has been found that investigates paramedics' non-adherence behaviours in this context. Likewise, concerning the quantitative aspect of this thesis, at the time of designing the study, a significant lack of evidence, apart from retrospective case studies, was found in investigating chest compressions and defibrillation as resuscitation procedures capable of generating aerosols during real-time resuscitation. By adopting an exploratory research design in this case, it was anticipated that the findings or themes generated would inform future lines of enquiry and serve as a catalyst for further investigation.

It is crucial to comprehend that exploratory research is limited in its generalisability or transferability. Both terms refer to the applicability of findings to groups beyond those studied (Guba et al., 1982). Generalisability is more commonly associated with quantitative research, while transferability typically relates to qualitative research. In mixed-methods research, both terms can be significant. Exploratory research generally does not provide either (Drisko, 2024). However, the transferability of qualitative research is nuanced and can occur through a theoretical co-production of concepts and ideas between the reader and the author. This might be accomplished by documenting detailed, contextualised accounts regarding the study setting and participants. By doing so, rich contextual information regarding aspects such as the author's rationale behind decision-making, the inclusion of theoretical frameworks, or the depth of integration can enhance a project's potential for broader transferability. By concentrating on contextualisation and theoretical engagement, exploratory research can indeed produce insights that offer valuable perspectives and contribute to the development of transferable findings regarding similar populations or settings (Stalmeijer et al., 2024; Munthe-Kaas et al., 2020; McLeod, 2024). Therefore, although exploratory research may not typically be transferable, dominant themes can emerge following reflexive thematic analysis, with the transferability of these findings being circumstance dependent. This means their application to the entire paramedic profession could be made, provided the reader exercises a degree of cautionary scrutiny when doing so. The emerging themes provide insights unique to the participants in this study during the COVID-19 pandemic; thus, attention must be devoted to the study demographics. However, it does offer opportunities for future lines of inquiry.

4.3 Mixed-methods Research

Literature exploring challenges faced by those attempting to measure quality in healthcare highlights the requirement for qualitative and quantitative metrics to provide a more holistic assessment. Both techniques are, therefore, required to triangulate findings and better understand the appropriateness of proposed clinical actions (Hanefield et al., 2017). In a review of ambulance response times, the need for

a broad, holistic measure of effectiveness was echoed, arguing that focussing on one quantitative metric, typically response times in ambulance services, would lead to 'tunnel vision' and 'myopia' when informing ambulance strategy. In this regard, tunnel vision was described by Wankhade (2011). In this context, it inferred how an organisation focused on only one facet would be unable to instigate meaningful change due to its focus being narrowed and fixed on delivering only one element. Myopia refers to pursuing short-term deliverables at the detriment of longer-term solutions, such as reducing staff numbers. For example, this might provide short-term cost savings, but longer-term productivity and quality will inevitably be impacted (Wankhade, 2011).

Mixed-methods research unifies qualitative and quantitative methods, allowing for a comprehensive approach to addressing distinct research questions within a single study (Creswell & Clarke, 2011). In a general sense, quantitative methods are particularly well-suited to research questions that focus on quantifiable data and measurable variables, typically framed as closed questions that can be answered definitively, such as 'Do chest compressions create aerosols?'. These methods are ideal for exploring relationships between variables and establishing patterns within large populations. On the other hand, qualitative methods are better positioned to address open-ended research questions that delve into the complexities of human experiences, behaviours, and motivations, such as 'Why do some paramedics not adhere to PPE policy?' (O'Cathain, et al, 2009).

4.3.1 Mixed-methods Research – Background in prehospital research

The origins of mixed-method research can be traced back to the work of Campbell and Fiske (1959), who documented the intercorrelation of their findings while employing more than one method of inquiry in their published social science research, as referenced by Blummer et al. (2014). This represents the first formal recorded publication on mixed-methods research, where the authors utilised triangulation

of multiple datasets to explain variance, thereby validating their results and disproving artefact as a source (Manzoor, 2021). Bouchard (1976) subsequently endorsed the technique of triangulating results from multiple sources as a valid process to provide researchers with assurance regarding the validity of their results. Over recent decades, the application of mixed-methods in research has become increasingly prevalent across various disciplines, particularly within the realms of social science and human sciences (Creswell & Clark, 2011; Onwuegbuzie et al., 2022).

Approaching the turn of the twenty-first century, literature described the lack of prehospital research as a notable impediment to advancement in this area (Cooke & Wilson, 1999; Moscati, 2002). Over the past two decades, research activity has increased in the prehospital field, thought to be due, in part, to prehospital researchers' utilisation of this mixed-method approach to research. Explanations as to why this approach has been seemingly embraced so readily by prehospital researchers have been thought to be due to the flexibility it offers the researcher, and so through its adaptability, mixed-methods research lends itself to the challenging, dynamic nature of the prehospital environment (Siriwardena & Whitley, 2022; McManamny et al., 2023).

4.3.2 Mixed method versus multi-method research

The literature is ambiguous and debated regarding terminology associated with mixed-methods, particularly with regard to how best to define studies that contain both quantitative and qualitative elements. No one universal definition of mixed methods exists (Gutterman et al., 2023; Whitley et al., 2020). This chapter addresses the variances seen within research and the terminology used in mixed-methods research.

Research that combines qualitative and quantitative aspects is traditionally referred to as mixed-methods research, while the term 'multi-method' is reserved for studies that employ more than one form of the same method, such as multiple qualitative methods or more than one form of quantitative method (notably, these are not mixed in this multi-method definition). For instance, a project that utilises two qualitative methods, such as semi-structured interviews and focus groups, might be described as multi-method. Although research employing more than one quantitative method would also fall under this multi-method umbrella, this is rarely observed (Mik-Meyer, 2020).

Creswell (2015) describes mixed-methods research as that which utilises and, importantly, integrates both qualitative and quantitative data and their underpinning research philosophies to formulate more rounded conclusions that draw upon the strengths of each contributory data set. This mixing, or integrating, of two forms of data is fundamentally part of Creswell's core principles of mixed-methods research. The combining and merging of two differing data sets can occur sequentially, whereby the findings of the first go on to shape the structure of the second line of inquiry or be achieved simultaneously by conducting two lines of enquiry alongside each other, then embedding their findings within each other. This simultaneous method is referred to as a convergent parallel design. It enables researchers to better understand a particular topic through the merger of multiple datasets obtained via quantitative and qualitative means (Creswell & Clark, 2011). This definition offered by Cresswell (2015) was supported by Teddlie & Tashakkori (2010), who similarly described mixed-methods as a process that utilised both quantitative and qualitative data collection techniques with analysis either sequentially, whereby one method fed into the author or in parallel whereby findings could be merged. Again, findings were then integrated.

Martha et al. (2007) referenced Morse (2003) in their description of multi-method research, in which it was described how multi-method research is born from two or more individual projects which then, in

combination, form one more extensive project that addressed an overarching research question through triangulation of the findings. Each aspect, or arm, could potentially be a stand-alone project and could be conducted in isolation from the other, with each arm designed to either answer the primary clinical question or any secondary sub-questions (Martha et al., 2007). Put more simply, multi-methods studies must include more than one method and so utilise two or more (hence 'multiple' or 'multi') research methods. These methods can be all quantitative or all qualitative in origin. Confusingly, in certain forums, the term multi-method has also been used to describe study designs that include both qualitative and quantitative lines of inquiry, going against the definitions put forward by Creswell (2015) and Gutterman et al. (2023) (Morse, 2003; Mills et al., 2010). This ambiguity in language is addressed by Hesse-Biber (2010), who offers an amended definition of multi-methods inquiry, describing it as a combination of two or more methods, be these either qualitative or quantitative, but crucially not both. The combination of both qualitative and quantitative methods whose results are integrated, or 'mixed' is Hesse-Biber's (2010) definition of a mixed-methods study design, a definition which echoes those put forward by both Creswell (2011) and Teddlie & Tashakkori (2010). This is encapsulated in the below quote from Gutterman et al. (2023).

> '*Mixed-methods research is distinguished from multimethod research, which could involve two or more quantitative methods or two or more qualitative methods. The integration of both qualitative and quantitative approaches is the defining characteristic of mixed-methods research.*'
>
> (Gutterman et al. (2023).

These sentiments captured within this quote are echoed in Whitley et al.'s (2020) article examining mixed-methods research, again underscoring the integration of qualitative and quantitative elements as

a key contributing factor in this context. Fetters & Molina-Azorin (2016), both editors of the Journal of Mixed-methods Research, provided further clarity on this debate. They reiterated Creswell's definition and characterised mixed-methods research as a category or subset of multi-methods research. They acknowledged the necessity of preserving both terms due to the distinct challenges posed by each, particularly those encountered when integrating qualitative and quantitative research methods, as this may present philosophical and theoretical dilemmas.

Mixed-methods transcend the mere use of multiple methods and instead delve into an area that offers the chance to explore datasets through integration, enriching the depth of interpretation. Although this integration may not be deemed essential for a study to be classified as mixed-methods in certain literature, its presence in the study design is a hallmark of high-quality research (O'Cathain et al., 2009; Siriwardene & Whitley, 2022; Whitley et al., 2020). The enhanced richness of findings that can be achieved through the process of integration can be achieved by blending approaches and concepts at multiple levels. This may encompass the mixing of methods, methodologies, or worldviews in order to foster a more rounded or detailed discussion and, therefore, uncover otherwise unnoticed phenomena (Green, 2015).

4.3.3 Concepts in Mixed-methods Research

As discussed, utilising both qualitative and quantitative methods within research can increase the opportunity to identify otherwise undetected phenomena. Integrating the data streams via triangulation is crucial in identifying these richer findings. These designs can be either fixed (also termed structured) or emergent (Creswell & Clark, 2022; Tashakkori & Newman, 2010). Fixed or structured mixed-methods study design, as its name suggests, involves the use of quantitative and qualitative data collection that is predetermined during the planning process of the research proposal and then implemented as the

plan dictates as the study progresses. Emergent study design in mixed-methods, rather than being predetermined, instead arises as the research unfolds. This typically evolves as a study progresses and arises due to the observation that an additional, alternative research method would add to the proposed findings (Creswell et al., 2010; Cresswell & Clarke, 2022). Although these are relatively fixed, utilising either form of mixed-methods is less of a dichotomy and more of a spectrum or continuum, as was the case in this project.

The development of clinical practice encourages reflective practice to further develop clinical knowledge through learning from previous experiences. The author has previous experience with Rolfe et al. (2001). The reflective model informs reflective practice when reviewing clinical cases. It is based upon three simple questions that encourage critical reflection and provide the process of reflection with a basic structure. Questions that this model asks include 'What? So What? Now What?' and are expanded in Figure 4.1.

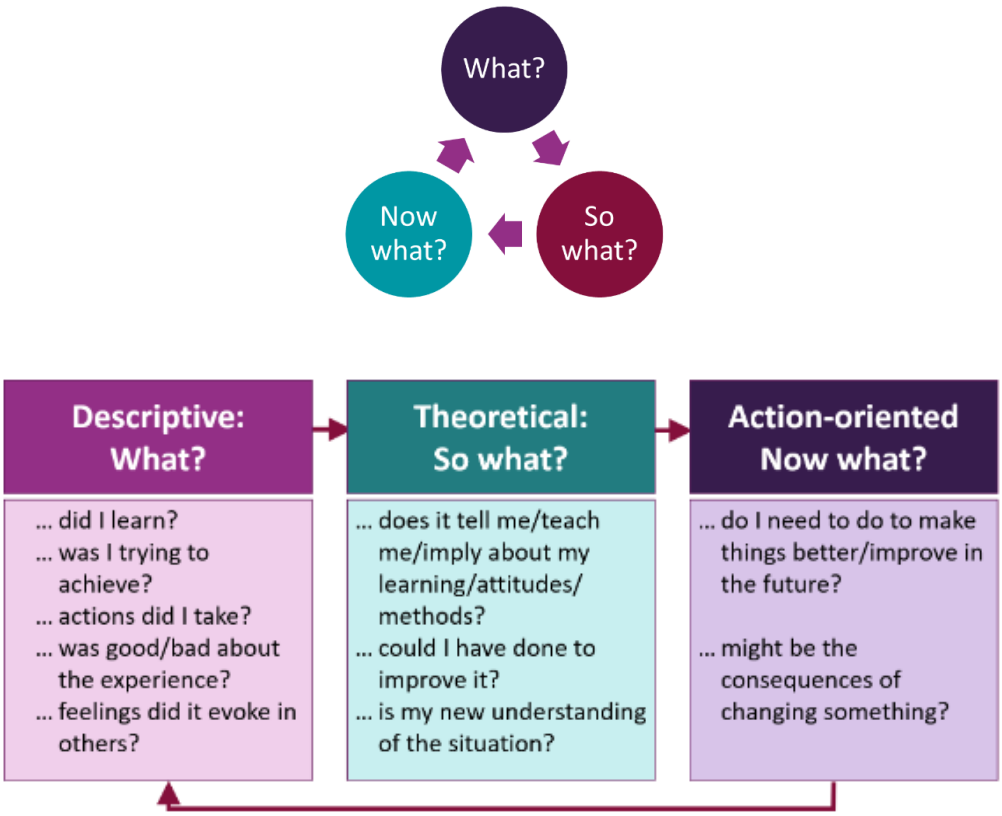


Figure 4.2 Rolfe et al (2001), Reflective model, taken from an online publication by the University of Hull, 2024

The use of the Rolfe et al. (2001) reflective model is a practice that has become embedded in my thinking outside of the clinical setting and informed the rationale for using emergent mixed-methods for the chosen study design. The original STOPGAP research proposal, to which the research team was recruited, questioned whether resuscitation procedures create respiratory aerosols. By developing the protocol for this aspect of the study, a question presented itself: assuming the findings were positive, meaning resuscitative procedures produced aerosols, would this fact be enough for paramedics to adhere to PPE guidelines, or might other factors influence them? This subsequent question formed the 'So what? Now What?' element of the Rolfe et al. (2001) reflective model. Using this tool led to the development of an emergent, mixed-methods study design to address this quandary.

4.3.3.1 Integration versus Triangulation

The term "triangulation" has been critiqued in contemporary mixed-methods research, with some cautionary notes suggesting its avoidance in specific contexts. Historically, the term originates from the field of navigation, where it referred to using two geographical points to identify a single 'true' point; this concept was then adapted to research (Teddlie & Tashakkori, 2003; Fetters & Molina-Azorin, 2016). Initially, triangulation was employed in research to enhance the rigor and reliability of findings by cross-checking results from different methods or sources. However, recent research has argued that its application has become too narrow and restrictive for modern mixed-methods research, where the integration of qualitative and quantitative data is viewed as more flexible and dynamic. Integration can occur at any stage of the research process, from the design phase to data analysis, and can inform decisions related to sampling, research philosophies, or overall study structure. As such, the term "triangulation" is increasingly regarded as less appropriate for describing these broader integration strategies (Gutterman et al., 2023; Whitley et al., 2020).

The two workstreams of the study design focussed on information that would contribute to the dynamic risk assessment made by paramedics and the application of PPE before proceeding to care for patients with suspected respiratory disease in cardiac arrest. The knowledge of whether the procedures associated with resuscitation created more circulating aerosol is a core element of this decision-making process. Additionally, one would wish to understand whether their prescribed PPE would provide adequate protection. The qualitative aspect of this study design was designed to explore these aspects and other factors that might inform paramedic adherence and non-adherence to recommended PPE guidelines.

4.3.3.2 Integration within this thesis

Integration within this thesis occurred during the initial analysis of the results and in more depth within the discussion of chapter six. The two workstreams were reviewed and discussed initially as individual, stand-alone projects, and meta-inferences were created as part of their integration element within the discussion. Meta-inferences are findings that form a narrative from the considerations of all aspects that make up a mixed method. Their purpose is to create a deeper understanding of a field of study than that would be achieved by the individual element alone (Whitley et al., 2020; Younas et al., 2023). Cross references were made by tabling each component's pertinent findings as part of the findings captured within Chapter 6, then discussed in more depth in the following discussion that featured within Chapter 7.

4.3.3.3 Convergent parallel design

A convergent parallel mixed-methods design was chosen for this study and is an example of mixed-methods research that involves the merging of both quantitative and qualitative data. In convergent parallel study design, these differing lines of enquiry are conducted simultaneously, with their initial analysis being conducted independently. These individual components then feed into the discussion, where the findings were amalgamated through integration and so provide a broader depth of acquired knowledge to inform the discussion and address the aim (Creswell et al., 2010; Creswell & Clarke, 2022; Schoonenboom & Johnson, 2017).

There is some overlap between the definitions of convergent parallel design and that of multiphase mixed method design. Both are widely used in healthcare. Multiphase refers to multiple projects carried out over time, where findings are linked together. These projects might be qualitative, quantitative, and mixed-methods, and the content of one line of inquiry would contribute to and inform the content of the

next. This was rejected in favour of convergent parallel design due to time and resource restraints (Creswell et al., 2010).

Alternative mixed-method strategies include explanatory sequential and exploratory sequential designs. Explanatory design prioritises quantitative inquiry first, which is interpreted, and then the following qualitative phase attempts to explain the initial quantitative findings. The reverse can be said for exploratory sequential designs – whereby qualitative inquiry precedes quantitative data collection (Creswell & Clarke, 2022; Schoonenboom & Johnson, 2017). About this project, both sequential designs were considered but rejected for various reasons. However, a sequential design requires more time and resources than a convergent parallel design than was available, which is a common and recognised challenge in mixed-methods research. This was ultimately the key driver behind the decision not to use a sequential method (Creswell et al., 2010). It could be argued that an explanatory sequential design would be of benefit, whereby a quantitative investigation conducted first would attempt to establish whether or not aerosols were produced by resuscitation, then the resulting data presented to paramedics, and their views explored through qualitative interviews regarding PPE and the implications to their practice in light of the context of the quantitative findings. This was dismissed simply based on the protracted length of time associated with sequential designs and the additional time needed to seek ethical approval for the quantitative aspect. The length of time required was significant for the prehospital aerosol investigation due to the complexities of conducting research during COVID-19 in healthcare settings with patients in cardiac arrest. Meaning a sequential method was not a viable option.

4.3.3.4 Meta-inferences

Meta-inferences refer to the process in which mixed-methods researchers amalgamate insights harvested from both qualitative and quantitative data sets to build a more comprehensive understanding

of a research question. This process goes beyond simply integrating the results; it requires researchers to critically examine how the two types of data complement each other, providing a more nuanced and well-rounded interpretation (Whitley, 2020). Meta-inferences are vital for enriching the findings of a study by allowing the integration of different perspectives and also act to enhance the validity of any conclusions (Tashakkori & Teddlie, 2010). Whitley (2020) suggests this approach fosters a deeper understanding by ensuring that both qualitative and quantitative methods are not just combined, but carefully synthesised, drawing on the strengths of both elements. The act of synthesising these different strands of data can reveal patterns or insights that might not be possible through one method alone (Creswell & Clark, 2022). Achieving meaningful meta-inferences requires careful attention to the design and implementation of both qualitative and quantitative components, ensuring that the integration is both valid and significant (Bryman, 2006). By doing so, mixed-methods research can offer a holistic view of complex phenomena, expanding on the limitations of using either approach in isolation (Johnson & Onwuegbuzie, 2004).

4.4 Paradigms and Worldviews

Research paradigms, or research philosophies as they can also be referred to, are described in the literature as theoretical frameworks that guide and assist researchers with conceptualising knowledge and selecting the most appropriate methods to answer their research questions. Put more succinctly, a research philosophy is a belief regarding a specific way to collect data (Bajpal, 2011; Tsung, 2016). Any researcher is an individual, and as such, will bring their own set of beliefs to any given project, formed from their own, lived experiences. This is termed their worldview, as described by Creswell (2011). Worldviews involve the researchers' philosophical assumptions and will inevitably influence their chosen study design and interpretation of results, whether consciously or not. As such, a researcher's set of experiences and basic beliefs will inform and guide their chosen line of inquiry.

In research terminology, the terms research paradigms and world views are intricately linked and have been used interchangeably in specific contexts within the literature; however, subtle differences exist between the two (Mertens, 2012). Research paradigms act to group together the researcher's ontological, epistemological, and methodological preferences and to conceptualise the researchers' beliefs to inform their study design and chosen methods. 'Paradigm' was a term first used in a research context by Thomas Kuhn (1962) where it was used to describe the shared values and beliefs of a group of specialists. Creswell and Clarke (2011) describe their preference for a worldview over a paradigm in this context as it is more generalisable and applicable to all researchers. That is to say it does not infer to a specific specialism nor is it linked to any specific discipline. It is suggested in literature that researchers with opposing worldviews cannot communicate with each other effectively due to the fundamental differences held in their view of reality and so methodology (Kuhn 1962; Mertens 2012). This stance has led to the term 'paradigm wars' being used to describe this conflict between quantitative and qualitative researchers, centred around criticism of the small sample sizes and subjectivity attributed to qualitative research (Given 2017), an interesting concept regarding mixed-methods research.

Widely used worldviews, or paradigms, within contemporary research that are associated with mixed-methods research include post-positivism, constructivism, interpretivism and pragmatism, all of which shall be explored in more depth (Allemang et al., 2021). Philosophical frameworks are recommended in order to better understand where and how philosophy is situated within a mixed-methods study design (Creswell, 2011). Creswell advised using an adaptation of Crotty (1998) to ascertain the position of a relevant philosophy within mixed-methods study design during the developmental phase, advocating the use of the processes described in Figure 4.2.

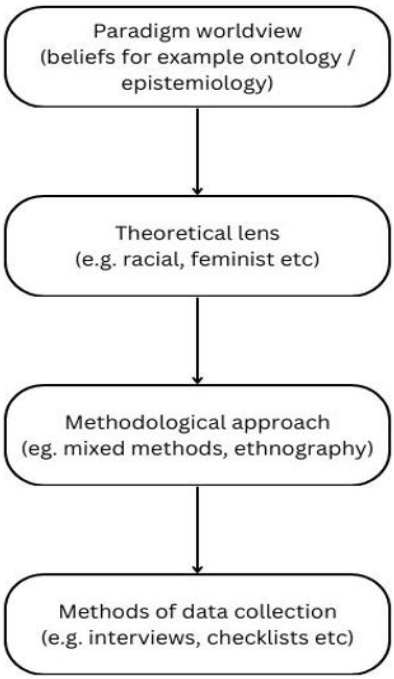


Figure 4.2 Crotty's adapted model used by Creswell (2011), recommending where research paradigms should be included to inform decisions around appropriate methods of data collection.

Although the recommendations from Crotty (1998) and broader literature act to ensure underlying philosophical principles are embedded within and inform the chosen methodology and methods, this proposed framework lacks the fluidity or malleability that certain prehospital researchers might require to adapt their research design to meet the dynamic demands of their working environment. Teddlie & Tashakkori (2012) described methodological eclecticism as being about mixed-methods researchers selectively utilising appropriate creative techniques to investigate a particular phenomenon of interest. An important detail in their description of methodological eclecticism in mixed-methods research centres around how the researcher might intuitively select an appropriate technique based on how a study evolves. This concept contrasts with that outlined by the apparently more rigidly structured processes articulated by Crotty (1998) in Figure 3.3. Furthermore, Teddlie and Tashakkori (2012) highlighted the concept of paradigm pluralism. This begins the move away from the fixed viewpoint that only one paradigm, or assumptions associated with that paradigm, will fit a singular, specific method,

and it also rejects the assumptions that paradigms must always be in opposition. Indeed, multiple paradigms have been associated with mixed-methods studies (Maxwell & Mittapalli, 2010; Greene, 2007; Mertens et al., 2010). Pragmatism as a paradigm has been suggested as a philosophical framework suited to mixed-methods research, as it assumes that no one method should be labelled as appropriate for any given viewpoint. Instead, pragmatism encourages researchers to choose the most appropriate method to answer their research question (Mertens, 2012). This contemporary approach, offering flexibility when tackling any given topic, is crucial to be able to deliver effective mixed-methods research and is of relevance within this pragmatic, mixed-methods research. Adaptability and flexibility were crucial skills required to overcome the challenges presented throughout planning and data collection.

Mixed-methods research, however, is more than simply including an element of qualitative and an element of quantitative research. In order to gain a complete understanding of both elements, an appreciation of the associated research paradigm is essential. Without this understanding of both qualitative and quantitative research paradigms, the depth of analysis of these studies will be limited (Wilding, 2019; Given, 2017). Although pragmatism was the paradigm of choice for this thesis, various other paradigms were considered. The factors that informed those considerations are outlined in the following sections.

4.4.1 Positivism

As a research paradigm, positivism dates back to the late 18th and early 19th centuries, as shown by the work of William Whewell and Auguste Comte (Johnson, 2010). It has evolved from its original form (Bourdeau, 2018). It is rooted fundamentally within quantitative research. Positivism, at its core, centres upon the belief that knowledge is factual and, as such, can be, and indeed must be, measured to be

deemed trustworthy. Its ontological stance is typically universalism, in that only one actual reality exists with an epistemological preference towards the quantifiable, measurable data that, in turn, lend themselves to statistical analyses. Positivism is objective and not subject to the observer's influence; it is free from assumptions, culture, and personal beliefs. It directly opposes interpretivism, a paradigm associated with qualitative research. The intention is that objectivity helps to remove or reduce bias (Siriwardena & Whitley, 2022).

Post-positivism is a contemporary paradigm and adaptation of positivism, founded in 1975 by Bhaskar. Over recent decades, it has frequently replaced positivism in healthcare research. A common ontological stance associated with post-positivism is critical realism. Critical realists state that there is one independent reality, but our understanding of it is imperfect. This combination of post-positivism and critical realism alludes to the fact that all observations can be fallible and subject to error; as such, critical realists might be said to be critical of the ability to be certain (Cruickshank, 2012). This conjectural view and acceptance of error comes from understanding the limitations and ultimate fallibility of human endeavour, i.e., there is a limit to human understanding of the world (Teddlie & Tashakkori, 2010).

Postpositivism was considered a potentially appropriate paradigm for the quantitative elements of the proposed study design. However, it lacked the subjectivity required to adequately explore the lived experiences of paramedics as part of the qualitative line of inquiry.

4.4.2 Interpretivism and Constructivism

In juxtaposition to the objective nature of positivism, both interpretivism and constructivism share a subjective understanding of reality, but their epistemological focuses differ significantly. Interpretivism

is primarily concerned with understanding how individuals experience, interpret, and give meaning to their reality. Researchers adopting an interpretivist approach focus on how people make sense of their experiences and the meanings they attach to them within specific contexts, be they social, cultural, or historical. Having an ontological stance of relativism, asserts that multiple realities exist, each shaped by individual perceptions and lived experiences. In interpretivist research, the emphasis is placed on uncovering the meanings behind human actions and interactions, assuming that reality is constructed through social engagement and cannot be understood without considering individuals' personal viewpoints (Creswell & Clarke, 2011; Siriwardena & Whitley, 2022).

On the other hand, constructivism also aligns with relativist ontology but extends the focus to how individuals actively construct their understanding of reality. Unlike interpretivism, which emphasises interpreting reality, constructivism is concerned with how knowledge is actively created through experiences, reflections, and social interactions. This paradigm asserts that individuals do not passively receive knowledge; rather, they engage in an active process of constructing their own understanding of the world. Therefore, constructivism is more focused on the process of knowledge creation and so views individuals as agents who shape their own unique perceptions and understandings through interacting with their environment and others. This makes constructivism more centred on the individual's agency in forming their own view of reality (Schwandt, 2000; Siriwardena & Whitley, 2022).

Both paradigms reject the idea of a single, objective truth, emphasising the subjectivity of reality. However, while interpretivism seeks to understand the interpretations individuals place on their reality, constructivism delves deeper into the active construction of that reality. These distinctions are significant when considering their application to mixed-methods research, as the paradigms provide complementary insights but with different emphases on the processes of meaning-making and knowledge construction.

This becomes particularly relevant when considering the paramedic dynamic risk assessment process. In their daily practice, paramedics constantly assess the risks they encounter during medical interventions, including decisions related to PPE use. Their dynamic risk assessments rely heavily on their lived experiences, context, and knowledge of the situation at hand. Under an interpretivist lens, researchers would focus on understanding how paramedics interpret the risks and the subjective factors influencing their decisions around PPE adherence—what meaning they attach to these actions, and how these are shaped by their experiences in diverse contexts (e.g., the urgency of the situation, the severity of the patient's condition, or prior exposure to risk). This focus on subjective experience helps illuminate how paramedics make sense of their actions in real time, particularly in high-stress, rapidly evolving medical emergencies.

From a constructivist perspective, the focus shifts slightly to how paramedics actively construct their risk assessment and PPE decisions. In this approach, paramedics' understanding of safety and adherence to PPE guidelines is seen as an ongoing process shaped by their interactions with colleagues, evolving medical protocols, and their own past experiences. Rather than passively adopting PPE practices, paramedics are viewed as agents who actively build and adapt their knowledge of safety procedures through reflection and active learning throughout their career. This active construction of knowledge influences how they assess risks and make decisions in dynamic situations, highlighting their agency in determining how best to manage both patient care and their own safety.

However, while these insights are valuable in understanding the subjective and active processes behind paramedics' decisions, the constructivist approach could also present limitations in integrating quantitative data, such as aerosol quantification during chest compressions. The purely subjective and individualistic focus of constructivism would mean it would be difficult to incorporate the objective measurements necessary for assessing such risks. In contrast, interpretivism would allow for more

detailed exploration of how individual paramedics perceive and manage risk based on their experiences, yet it might still face challenges in translating those insights into measurable data for assessing the risks associated with PPE use during resuscitation procedures.

In this study, the interpretivist approach was considered highly relevant for investigating paramedics' experiences with personal protective equipment (PPE) because it allowed for a deep exploration of the meanings they attach to their use of PPE, as well as the factors influencing non-adherence. This approach could capture the subjective experiences and interpretations that guide paramedic behaviour in real-world settings. However, while constructivism also held promise in examining how paramedics actively construct their realities around PPE usage, its focus on the active process of knowledge construction might have been too centred on individual agency and subjective realities. This would have potentially limited its ability to integrate the quantitative data required for the aerosol quantification within this thesis.

Although both paradigms could contribute to a rich understanding of paramedics' experiences, adopting a purely constructivist approach would have posed challenges in integrating the objective measurements necessary for the quantitative components. This is a crucial consideration when attempting to balance qualitative insights with quantitative measures, as each paradigm provides valuable but distinct lenses for addressing different aspects of the research problem. The paramedic dynamic risk assessment adds a layer of complexity to this, as it requires an understanding of both subjective and objective factors, demanding an integrated approach that can counterbalance the interpretive aspects with the quantitative measurement necessary for assessing safety and effectiveness in the use of PPE.

4.4.3 Pragmatism

Pragmatism as a research paradigm, or philosophy, has existed since 1870, becoming prevalent in contemporary healthcare research. Key 'classical' pragmatists included John Dewey, Sanders Peirce, and William James. Neo-pragmatists, also called 'post-Deweyan' pragmatists, later followed these, such as Richard Bernstein or Richard Rorty. Dewy argued that the construction of knowledge was through the interaction of humans with their environment (Biesta et al., 2003). Pragmatism refers to a world view that, through thoughtful inquiry, utilises a 'what works best' mindset, fundamentally based on the premise of action over inaction, in order to address a specific research question through the most appropriate methods (Morgan, 2014; Kaushik et al., 2019; Siriwardena & Whitley, 2022). Likened to an architect's designs being influenced by the materials available to them, pragmatic research allows researchers to adopt a combination of techniques, paradigms, or philosophies that might potentially be viewed as conflicting historically, such as positivism and interpretivism and so lends itself well to mixed-methods research and is commonly associated paradigm of this form of research as a result (Creswell & Clarke 2011, University of Nottingham 2022).

Criticisms historically centred upon a lack of clear epistemological and ontological underpinnings, leading it to be described less as a paradigm and more as a philosophical tool to enable the researcher to gain valuable insight into other paradigms (Biesta, 2010; Johnson & Onwuegbuzie, 2004). This view has been challenged in more contemporary literature, where pragmatism is seen as a paradigm in its own right (Creswell & Clarke, 2022; Allemang et al., 2021). However, this has been challenged by Hampson et al. (2023), suggesting that the pragmatic stance should lie within an aparadigmatic worldview and so be a paradigm that focuses on achieving results. Johnson & Onwuegbuzie (2004) argue that taking a pragmatic, or pluralist, position in mixed-methods research can help to facilitate effective communication, particularly between paradigm purists. This pragmatic approach is illustrated in Tashakkori & Newman 2010, which clearly outlines and defines mixed method research.

'Mixed-methods researchers are pragmatic, collect both narrative and numerical data, employ both structured and emergent designs, analyse their data both via statistical and content analysis, and make meta-inferences as answers to their research questions by integrating the inferences gleaned from their qualitative and quantitative findings.' (Tashakkori & Newman 2010).

Morgan (2007, as cited in Creswell et al. 2010) endorsed using pragmatism in mixed-methods research. Its use within mixed-methods research allows researchers to bridge tensions between opposing world views or paradigms. It facilitates the creation of innovative ideas through adopting a dialectical stance (Creswell et al., 2010). The use of pragmatism within this project enabled the amalgamation of opposing world views or lenses that have been traditionally associated with quantitative and qualitative methods to give a broader understanding of aerosol production and personal protective equipment. It is noteworthy that although pragmatism has been reported as lending itself well to mixed-method research, it is not essential to conduct all mixed-methods research through a pragmatic paradigm. Instead, pragmatists' pragmatically', or for reasons of practicality, choose a method, or combination of methods, that best advances real-world problems pertaining to their chosen area of research. The increasing application of pragmatism within healthcare research has led to it being described as a highly relevant paradigm in relation to prehospital research, enabling the production of highly valued research through the utilisation of the most appropriate methods (Siriwardena & Whitley, 2022). Pragmatism, as a paradigm, afforded the researcher the flexibility required to adapt or amend the method to meet the dynamic landscape associated with the delivery of front-line healthcare during the COVID-19 pandemic.

Adopting the pragmatist paradigm informed the design and delivery of the workstreams within this research in various ways. As described, pragmatists prioritise practical, real-world solutions and

embrace flexibility regarding the choice of methods to address the research questions best. Specifically, relating to this thesis, regarding aerosol quantification, the methods involved with data collection required some adjustment and amendment to meet the practical barriers associated with the dynamic and varied prehospital locations anticipated to be faced when accessing out-of-hospital cardiac arrest patients. It was initially planned to use a Dekati® ELPI®+ (Electrical Low-Pressure Impactor). As described in Chapter 1, these portable devices are highly effective at measuring particle size distribution and concentrations. However, issues arose during simulated sessions designed to recreate scenes that might be encountered when attending prehospital scenes. The device and associated parts were heavy, somewhat noisy, and cumbersome to manoeuvre, particularly problematic when climbing stairs, being one such example. As such, it did not lend itself well when attempting to gain timely access to participants and rapid initiation of data collection. Therefore, Alphasense® Optical Particle Counters (OPC) were chosen for their lightweight design, lack of sound generation, and rapid activation speed. This decision to balance scientific rigour with practical considerations might be said to epitomise pragmatism in action. The ELPI®+ offered more precise data in the laboratory setting, however its weight and noise [presented two notable issues. Firstly, it might have compromised patient care during data collection, and secondly, it's weight would mean accessing specific locations in a timely fashion would have been problematic. Therefor the decision to switch to the more portable Alphasense® OPC ensured the study remained methodologically sound while also still being feasible which is a core principle of pragmatic research.

Similarly, pragmatism also informed methodological choices involved within the qualitative workstream. The core principle behind the research question that explored paramedic experiences, with a focus on non-adherence, directly addressed a real-world issue. The study design prioritised understanding behaviour in practical contexts. Rather than assuming that non-adherence is related to compliance, the research sought to contextualise non-adherence through experience-based explanations. The digital

interview format preserved rich qualitative data while ensuring that participation in the research was accessible and convenient for paramedics. This approach enabled access to participants from across the whole of the UK. Rather than rigidly following traditional interview formats, this methodological decision enabled adaptation and so promoted a 'what works best' approach, a hallmark of the pragmatist paradigm. One example included allowing participants to be interviewed with only their audio being recorded, as was taken up in one such instance. Not providing this option would have meant one less participant would have been recruited along with any insight they would have offered. A further key aspect that demonstrated pragmatism's influence on this workstream was the decision to switch from automated transcription software to manual transcription. This decision was made to ensure that critical nuances in language were preserved and is discussed in more depth later in the chapter. To summarise this point, regional dialect led to transcribing errors and sarcastic inferences were lost via the automated transcription route. This was recognised after the first interview, and so a shift to manual transcription was made to ensure this detail was captured.

4.5 Research Methods and Study Design

The next section details the two individual workstreams and the methods used in this mixed-methods investigation.

4.6 Workstream 1: *Insights into paramedics' experiences using personal protective equipment (PPE) during the COVID-19 pandemic.*

4.6.1 Overview

This element of the thesis was designed to investigate patient-facing paramedics' experiences of using PPE during the COVID-19 pandemic. This was done to shed light on their lived experiences with the intention to better understand factors contributing to their non-adherence to PPE policy. To ensure ethical standards were met, the full protocol and all relevant ethical documentation were completed in accordance with the requirements for research involving human participants. These documents were submitted and reviewed by the University of Hertfordshire's ethics committee (protocol number: HSK/PGT/UH/04962). The relevant documentation included the EC1A, EC3, and EC6 forms, all of which were scrutinised and approved by the committee. The relevant documentation is included in the appendices of this thesis: Protocol; Appendix 6, EC1A form; Appendix 7, EC3; Appendix 8, EC6; Appendix 9, University of Hertfordshire Health, Science, Engineering and Technology ECDA Ethics Approval Notification; Appendix 10.

4.6.2 Research Design & Rationale

Semi-structured interviews were utilised as part of an exploratory design to capture the perspectives of paramedics, with the intention to investigate their experiences of using PPE when delivering patient care in the prehospital environment. Focus was given to their views regarding causes of non-adherence to PPE guidelines. An exploratory approach was an appropriate research design in order to explore phenomena within healthcare in which there exists little or no, understanding, as was the case in this regard (Hunter et al., 2019). Semi-structured interviews are widely accepted within literature as an appropriate research tool in qualitative research, particularly when collecting new exploratory data and

enabling experiences, thoughts, and perceptions to be explored in adequate depth whilst also allowing for any novel, unanticipated themes or concepts that arose to be further discussed (DeJonckheere et al., 2019).

4.6.3 Sampling strategy and recruitment

This sampling and recruitment strategy was designed to prioritise depth, contextual relevance, and experiential insight over representativeness or theoretical saturation, consistent with the exploratory aims of the study. A purposive sample was designed to target a minimum of ten participants. Ten is an arbitrary target based on similar research that focussed on the experiences of healthcare workers outside of the ambulance sector. Saturation was never a target of this exploratory research. Saturation as a concept is somewhat controversial in this regard, with certain facets of literature stipulating qualitative research should, in fact, strive to achieve saturation if it wishes to be deemed of adequate quality, with those that do not lack the necessary rigour (Francis et al., 2010; Morse 2015). Definitions and implications of saturation link closely to transferability and generalisability, with origins lying in grounded theory. In the case of theoretical saturation, this describes a point in which no new themes emerge from the data (Rahimi et al 2024). Although a useful tool in specific circumstances, its necessity and validity have been questioned in other areas within the wider literature, with it instead postulated that it is a subjective measure and one might never know definitively that all themes have been identified, a stance taken within the context of this thesis (Corbin et al 2015, Tight 2023).

The participant recruitment campaign involved a promotional campaign having been pre-approved by the University of Hertfordshire's ethic committee. This was done through the College of Paramedics' website and Paramedic Insight magazine, initially. After two months, it was recognised that the response from this approach alone was insufficient, so the recruitment campaign was further expanded to include the use of the social media platform, which was the then named 'Twitter™' platform, now rebranded as

'X®.' As an additional incentive, a certificate was created and offered to successful participants. This acknowledged the participants' contribution to paramedic research. No additional incentives were offered.

The study design had been created with a purposive sampling strategy in mind, tailored to target one specific group of professionals, namely, patient-facing paramedics working in NHS ambulance services. Purposive sampling is commonly used in research as it ensures the inclusion of participants ideally positioned to provide contextually rich information (Vasileiou et al., 2018). Paramedics were the preferred participants for this line of inquiry for several reasons. Primarily this was due to the dearth of research involving this group of professionals that was in existence, as found following a thorough and comprehensive review of contemporary literature, (see Chapter 2). No papers were identified that specifically focussed on the PPE experiences of paramedics; neither were data identified that explored non-adherence to PPE protocols in this population. Literature was identified whereby paramedics were interviewed, but these studies were broader in their aims and focussed on the general experiences of paramedics when working during the COVID-19 pandemic. It was observed that the content therein inevitably led to an element of discussion around PPE as part of this research. However, it was observed that this discussion was limited and lacked the depth sought within this study design. The content featured procurement issues and focussed on paramedics' anxieties around supply chain issues. PPE was not a primary focus of the research, and the discussion did not explore non-adherence behaviours nor how its introduction into standard paramedic practice impacted patient care (Rees et al., 2021). Front-line healthcare workers were interviewed as part of a rapid qualitative appraisal study conducted by Hoernke et al. (2021); however, following appraisal of the paper, it was noted the sample did not feature paramedics, with emergency department and critical care staff as the primary focus, specifically, nurses and doctors.

A further benefit of the sampling strategy was noted when considering the researcher's previous experience as a practising, advanced-level paramedic in both the in-hospital and prehospital setting. This clinical experience provided a unique contextual understanding of the challenges faced by paramedics and the pressures they had and continued to endure when working throughout the COVID-19 pandemic. It was anticipated that participants, or interviewees, might be required to recall distressing memories, particularly as the focus of the discussion would centre around the delivery of emergency care to patients during the COVID-19 pandemic, during which many people died, including ambulance service members of staff, and immense pressures were put on healthcare workers of the time. This appreciation and awareness assisted in establishing rapport during interviews through a demonstration of empathy regarding the challenges faced by paramedics. Allowing a more sensitive, empathetic approach to the interview process than might be offered should a non-healthcare worker be positioned as the lead interviewer (Dejonckheere et al., 2019).

A further benefit involved the fact that paramedics, as a population, were more accessible to the researcher. One could argue that because of this fact, the sample could be described as a convenience sample. This advantageous practical element meant the sample was more convenient to the researcher and so technically had the defined traits of a convenience sample (Galloway, 2005). However, the inclusion and exclusion criteria were designed in such a way as to ensure the sampling strategy was purposive in nature. Purposive samples intentionally select participants 'based on their ability to elucidate a specific theme, concept or phenomenon' (Robinson, 2014). Paramedics were excluded if they had not achieved a minimum exposure to patient-facing clinical care of six months. Therefore, although the sample could be described as having elements of convenience, it remained a purposive sampling strategy. Participant screening and enrolment occurred prior to the interview process with a pre-defined set of inclusion and exclusion criteria.

Following receipt of a signed consent form from participants, semi-structured interviews were scheduled and held remotely over Microsoft (MS) Teams®. These were designed to be no longer than one hour in duration. MS teams was chosen as it had been approved for use in research by the University of Hertfordshire and mitigated for any potential, unexpected changes to guidelines with respect to face-to-face meetings as had been seen in the months prior to planning, due to increased COVID-19 transmission rates within the general population. It also allowed for recording of audio and visual data, as well as safe storage on the University of Hertfordshire's OneDrive®. All research will be conducted by a solo paramedic researcher.

4.6.4 Inclusion / Exclusion Criteria

Inclusion / Exclusion criteria were applied to applicants who wished to be part of the study. These were defined as follows...

4.6.4.1 Inclusion Criteria

- National Health Service (NHS) Health and Care Professions Council (HCPC) registered paramedics based in the United Kingdom (UK).
- Must have worked from at least the 11th of March 2020, then for at least 6 months thereafter. (Note that the 11th of March 2020 was the date the World Health Organisation (WHO) declared COVID-19 a pandemic).
- Must have been working in a patient-facing role at this time.
- Must have been required to wear PPE in the care of patients as part of their role.

4.6.4.2 Exclusion Criteria

- Not an NHS paramedic
- Worked for less than 6 months following 11th of March 2020.
- Not in a patient-facing role
- Not required to wear PPE in the care of patients.

4.6.5 Consent

Eligible participants were issued with a participant information leaflet (PIL) and consent declaration prior to data collection (Appendix 8). A requirement that these be read and signed prior to the commencement of interviews was mandated. These were then stored on coded files on the University of Hertfordshire's secure Microsoft OneDrive® as per the University's research data management recommendations.

4.6.6 Interview format

The primary research method utilised semi-structured interviews. A flexible script was created to guide the flow of the discussion following a thorough review of contemporary literature (Appendix 11). This comprised open questions divided into themes that had been identified following the literature review (see section 3.1, Chapter 3).

Themes included...

i) General experiences of PPE

ii) PPE's impact on patient care

iii) The physical and mental health implications of PPE

iv) Non-adherence with PPE guidelines

v) Service improvement, i.e. with hindsight, what could have been done better?

vi) Defining PPE fatigue

Semi-structured interviews are widely accepted within the literature as an appropriate research tool in qualitative research, particularly when collecting new exploratory data and enable experiences, thoughts, and perceptions to be explored take (DeJonckheere et al., 2019). Questions were structured in such a way as to allow for the development of any emerging perspectives or themes. It was planned that not every question would be asked; however, it had been created to act as an aide memoir to the interviewer should it be necessary. Each theme was covered as part of all interviews to ensure an element of standardisation. This format enabled a flexible approach to data collection, obtained directly from the source, namely the paramedic participants that met the predetermined inclusion and exclusion criteria. The script was created following a review of current literature consisting of open questions divided into themes.

Interviews were held via Microsoft Teams®, allowing for the recording of audio-visual data; participants were able to request audio-only recording should they desire and were encouraged to raise this as their preference prior to the interview. This occurred in one case. The use of Microsoft Teams® ensured COVID-19 guideline compliance as, at the time of planning, restrictions were in a dynamic state of flux, and future restrictions could not be ruled out at the time of designing the protocol.

4.6.7 Follow up

No specific follow-up of participants was planned. Contact details in the form of a university email address were provided to all participants, with advice that this channel of communication would remain open throughout the course of the doctoral program. This enabled participants to remain updated as to the progress of the research or decide to withdraw, should they desire. Participants were informed that the option to withdraw had a deadline to allow for data capture and progression of data analysis.

4.6.8 Data storage and analysis

Audiovisual recordings were uploaded directly to coded files on the University of Hertfordshire's secure, cloud-operated, OneDrive®. These data were further encrypted using the inbuilt encryption feature in WinZip®, as recommended by the Research and Scholarly Communications team at the University of Hertfordshire. Video footage was transcribed by the solo, lead researcher manually and anonymised within three days of recording. Video files were then permanently deleted. The process of transcription involved typing up the interview dialogue verbatim. The only adjustment was the removal of any identifying information that might have been described, for example, names, precise locations, etc. The transcribed data were then coded to identify themes using NVIVO® (version (v) 12) software. All files from NVIVO® (v12), notes made on Microsoft Word® and were saved on the University OneDrive® to ensure security and data protection.

4.6.9 Participant Withdrawal

Participants were provided with an open channel of communication via email and were able to withdraw from the project up until one week following the interview having taken place. Following this, data were

captured, and so the right to withdraw was removed. The participant information leaflet included contact email addresses of the research team should they request to be omitted from the trial.

4.6.10 Evaluation of safety

A review of safety was conducted with definitions of adverse events and proposed measures taken to address the various aspects prior to conducting the research. These were captured within the protocol (Appendix 6).

4.6.10.1 Definition of adverse events

Confidentiality risk: This was defined as a potential breach of confidentiality through such events as institutional cyberattacks. Every effort was made to maintain confidentiality and minimise risk; it was prudent to consider every eventuality, including such things as criminality and cyberattacks. Data storage has been outlined and was in line with the host organisations data management policies. As the university had been subject to a cyberattack at the time of planning, security practices had been amended to involve an additional layer of protection that incorporated a two-factor authentication process when accessing any university system remotely via the Duo Security® software system and so provided further rigor in this regard.

Emotional distress: This was defined as participants required to recall events causing them emotional distress. Clearly, working throughout COVID-19 in frontline ambulances was a highly stressful time. The researcher was an advanced clinical practitioner, had experience working with patients and colleagues in highly stressful situations or crises. As such it was felt that they were well positioned to identify when participants should have the interview process paused, re-arranged, or terminated due to stress caused when recalling these events.

Disclosure of safeguarding issue / improper conduct: Defined as a research participant disclosing matters of illegality or intention to cause themselves or others harm, either directly or indirectly, or disclosing previous behaviours that could have caused serious harm to others, either professionally or personally. Prior to the interview, participants were informed in writing, as part of the consent process, that although the interview content was confidential and anonymised, the researcher was ethically bound to report any issues through the appropriate channels as part of their requirements as an HCPC registered paramedic. Risk assessments that considered safeguarding practices were conducted continually throughout the interview process, with the need for any future actions reviewed at the closure of the interview. There was an awareness that this disclosure might inhibit the richness of data obtained at the interview, a limitation of the researcher being a registered healthcare professional.

4.6.10.2 Potential risks identified

Researcher preconceptions: It was important that the researcher remained impartial to the interview process. Questions were designed to help structure this process. It was a focus of the interviewer to not allow the format or tone of delivery to restrict the broadness of the data collected. Researcher development training was attended to assist with preparation in this regard. However, this was identified as a potential limitation; by having an interviewer as a practising paramedic, it might be assumed by the participant that the researcher understood a particular point being made. As such, a mantra of 'no assumptions' was adopted throughout the process, whereby clarification was sought to ascertain the meaning of contentious points.

Researcher as a Healthcare Professional (HCP): The researcher's role as a healthcare professional (HCP) was recognised as potentially influencing participants' responses and the data gathered. Therefore, it was vital to acknowledge and address the power dynamics that might emerge during the

research. As the researcher was a senior paramedic, specifically an advanced clinical practitioner, the study involved interviews with less experienced or junior paramedics. This hierarchy may have influenced their responses, particularly regarding sensitive topics such as non-compliance with PPE policies. Participants might have felt uneasy or hesitant to fully share their thoughts or behaviours, especially if they sensed that their responses could be evaluated by someone senior. To maintain the research's integrity, ensuring transparency and honesty with participants was crucial. Steps were taken to prevent participants from feeling pressured to respond in a specific manner or fearing judgement for their answers. Furthermore, the researcher's clinical role was carefully overseen to avoid any inappropriate probing into sensitive subjects that could lead participants to share more than they were comfortable with during the consent process.

Participant distress: It was recognised that asking probing questions regarding clinical experiences throughout an extremely challenging time, both socially and professionally, may elicit emotional distress.

Breach of confidentiality: As alluded to earlier in the chapter, this was identified as possibly through a cyberattack or, additionally, through the researcher describing scenarios in the written text of any publication that may lead to the identification of the participant. Mitigating strategies were robust in this regard.

4.6.10.3 Methods to minimise risks

Researcher preconceptions: Researchers inevitably bring preconceptions through their own personal, lived experiences of any event described within the research process. Understanding and exploring the researcher's viewpoint through self-reflection following an extensive literature review prior to compiling

any questions or conducting interviews can aid in mitigating the influence of these preconceptions. As can knowledge and appreciation of their worldview and the research paradigm that informs the methodology. However, an acceptance that an inevitable limitation of research conducted in this manner will be due to it having been performed by a solo researcher, and so will be considered when making any potential conclusions.

Researcher being an HCP: The researcher's full role and title were disclosed at the consent stage. It is felt that having the researcher positioned as a healthcare professional provided benefits to participants that outweighed the risks. They can provide clinical and professional support during the interview process, should it be required, as well as be able to provide efficient and early identification of issues that might require follow-up, particularly regarding matters of mental health and safeguarding.

Participant distress: As mentioned above, having a clinically qualified researcher with previous experience in caring for people during mental health crises or with those experiencing emotional stress, in an acute clinical setting, helped to mitigate this risk. Details of the researcher were provided in advance of the interviews, providing participants with the opportunity to opt-out either before or once the interview had finished, for example, if the circumstance arose where they felt they had disclosed information that, on reflection, they later wish not to be included in the study. This eventuality did not arise but was mitigated for thorough planning.

Breach of confidentiality: As highlighted, a cloud-based storage system, utilising coded files, plus the use of two-factor authentication and password secure IT equipment, adequately mitigated this risk, as per University of Hertfordshire research data management recommendations.

4.6.11 Data and Quality Management

Consent forms were adapted from templates provided by the University of Hertfordshire's ethics committee and stored on the University of Hertfordshire OneDrive® as per Research Data Management recommendations at the time of planning. Original paper copies were avoided in favour of electronically signed consent as per COVID-19 research guidance.

4.6.12 Reporting

Supervisory research leads were informed through six weekly meetings held throughout the approved data collection period. They could also be arranged for the identification of adverse or serious adverse events.

4.6.13 Reflexive Thematic Analysis

Reflexive thematic analysis (RTA) (outlined in Braun & Clarke (2022)) was performed using NVIVO v12® and Microsoft® software. Reflexive thematic analysis offered an epistemologically flexible method to qualitative data analysis and so fit well with the pragmatic research design encompassed within this project. Furthermore, it is also recommended as a favourable analytical approach in relation to semi-structured interviews and novice researchers (Kiger & Varpio, 2020). RTA, as a method, enables the analysis and interpretation of patterns within the qualitative data through a process that provides a systematic framework for data coding and so facilitates the identification of common themes and trends. However, this description of RTA has been suggested as overly simplistic by some experts in the field, and instead, RTA should be thought of as more a methodology than a method, with reflexivity being a crucial element. By adding the process of reflexivity to the original concept of thematic analysis, it enhanced the rigour of the findings, leading to the acknowledgement that reflexivity is an essential

component of RTA, its presence is required to produce credible, critically interrogated themes (Braun & Clarke, 2022).

A particular strength of this approach centred upon the value RTA placed on researcher subjectivity and the associated presence of researcher bias. Indeed, this was seen as a key tool in order to be able to generate new knowledge. Rather than attempting to eliminate bias, researcher knowledge has been acknowledged as something to be embraced, as it can inform the production of themes rather than hinder them (Gough & Madill, 2012). Themes are actively discovered through the lens of the researchers' experiences and will inevitably be informed through their lived experiences. Having a systematic approach offered by RTA helps to optimise the effectiveness of this theme identification. This is less bias-causing artefact but more expertise leading to discovery (Elliot et al., 1999). The addition of reflexivity acts to recognise and indeed celebrate the contribution of the researcher's knowledge and experiences to the production of themes and allows for this influence to be critically interrogated, identified and mitigated if required. It is this addition of reflexivity that embeds RTA within a qualitative paradigm and shifts the scales of balance more towards it being a methodology rather than a method (Braun & Clarke, 2022). This evolution of method to methodology through underpinning it with a paradigm is not without precedent. Charmaz (2014) previously reimagined grounded theory, redirecting it away from its earlier origins in positivism, instead choosing to embrace the qualitative constructionist paradigm.

Reflexivity does not focus solely on the researcher's influence on the data collected, a term nicknamed 'navel-gazing' in some avenues of literature (Braun & Clarke, 2022). With that in mind, it has been encouraged that researchers look beyond their own impact on the research outcomes. Wilkinson (1988) suggested the need to differentiate between different facets of reflexivity. Part of Wilkinson's (1988) recommendations involved personal and functional reflexivity. As already discussed, personal reflexivity, as one might expect, centres around the researcher's own personal values and how they

might contribute to their research and its interpretation. Functional reflexivity, however, focuses on the chosen study design or methods. Delving into how this might influence any outcomes. An example is the consideration made in the protocol for Workstream 1. It was identified that having a researcher who was also an advanced clinical practitioner (ACP) might potentially influence the participant's answers. ACPs are senior clinicians from various professional backgrounds, including paramedics. With that in mind, as part of the reflexive journal/account that was produced, it was identified that should a relatively inexperienced paramedic enrol in the study, they might find this dynamic uncomfortable as the interview questions were designed to explore PPE non-adherence. This is when guidelines might not be followed and could potentially be construed as deliberate law-breaking, something they might not wish to admit to a senior clinician for fear of being judged negatively. Therefore, it was crucially important to maintain rapport and communication in such a manner that encouraged honesty without leading participants in their answers.

The stages of reflexive thematic analysis for this project have been created in line with recommendations from Braun and Clarke (2022) (see Figure 4.3).

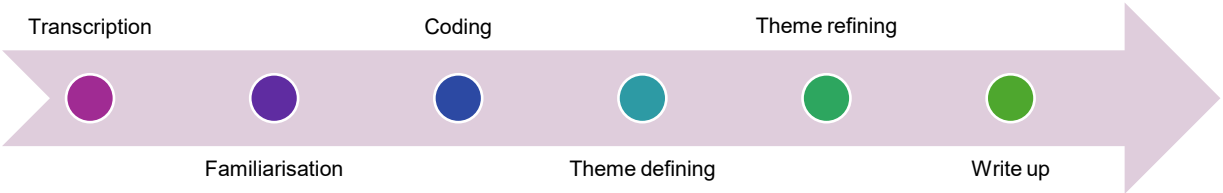


Figure 4.3 Six stages of reflexive thematic analysis, an adapted image from Braun & Clarke (2022).

The practical application of the recommended stages of RTA meant that these individual processes were much less sequential or step-wise, as the above figure alludes to. Instead, these were much more fluid and used as more of a spectrum or framework. This is acknowledged by the authors of the process as accepted good practice and the relevance of these features within the discussion in Chapter 6. Braun and Clarke (2022) define these processes themselves as being neither rigid, nor rules that must be obeyed, instead advising them to be viewed as more a framework of underpinning principles to guide and form the analyses. There have been criticisms of this perceived 'absence of explicit guidelines' regarding how to undertake each step (Xu & Zammit 2020). However, the authors acknowledge this omission as deliberate, recognising researchers and the lived experiences that they bring to any given project are an integral part of the research process, and so, adopting this approach, allows them the capacity to adjust, mould or shape their study as situations arise (Braun and Clarke 2022). For example, the process of manually transcribing the audio-visual footage to text aided the researcher in not only becoming familiar with their content but also eliminating the typical grammatical errors that were seen when using the automated transcription software that accompanied Microsoft© Teams. This inadvertently led to the familiarisation of the interview data, and so, stage two of Braun and Clarke's (2022) process began at the offset interview one.

4.6.13.1 Reflexive Thematic Analysis: A Walk-Through of the Analytic Process

As described, the qualitative data from Workstream 1 were analysed using the six-phase approach to RTA as per Braun and Clarke's description (2006; 2019), chosen for its compatibility with a pragmatic worldview and its emphasis on the active, interpretive role of the researcher. The process was iterative rather than linear, with movement back and forth between phases as understanding deepened. NVivo (v12) was used to manage the data, facilitate memo generation, systematic coding, and maintain an auditable trail of analytical decisions. The following section outlines how each phase was undertaken in practice.

Phase 1 - Familiarisation with the Data: All interview recordings were transcribed verbatim by the researcher, allowing early immersion in the language and context of participants. Transcripts were

repeatedly read while listening to the corresponding audio-visual files to ensure accuracy and recall of tone and affect. Early reflective notes were recorded in a reflexive diary, capturing initial observations, potential connections, and emotional responses to participants' accounts. These notes provided a foundation for reflexivity throughout the analytic journey.

Phase 2 – Initial Code Generation: Initial coding was undertaken inductively, focusing on the explicit (semantic) content of participants' accounts before moving to more interpretive (latent) analysis. Each transcript was examined line-by-line, with short descriptive labels applied to meaningful segments of text. Codes were kept deliberately close to the participants language to retain authenticity. Examples of early codes included 'conflicting guidance', 'impact on patient care', 'perception of vulnerability', 'war-like language'. NVivo software enabled the collation of all data extracts under each code and allowed comparison across transcripts. A reflexive memo was generated at the end of each coding sessions, capturing analytic impressions and potential links to emerging theoretical ideas. For example, after analysing an interview in which a participant described "feeling torn between helping the patient and protecting myself," a memo noted: "This tension seems deeper than procedural conflict — it reflects a clash between professional identity and personal safety. Possible connection to 'moral injury' literature; revisit once further transcripts reviewed to see if this is a common theme." These memos acted as a bridge between early descriptive codes and the later interpretative framing through identity fusion and moral injury.

Phase 3 – Constructing Initial Themes: Codes were systematically reviewed to identify patterns of shared meaning relevant to the central research question. Related codes were grouped together to form provisional themes. For instance, codes such as "dehumanisation of care," "delays due to donning of PPE," and "immediacy of care" were consolidated into an emerging theme labelled 'immediacy of care'. Similarly, codes including "fogging of visors," "inability to hear colleagues," and "reduced tactility" were categorised under the preliminary theme "sensory impairment". A thematic map was developed to illustrate relationships and overlaps among the emerging themes. For example,

the merging theme of "sensory impairment" was found to be linked to themes involving communication challenges, difficulties when breaking bad news, and PPE being a barrier to effective patient care.

Phase 4 – Reviewing and Refining Themes: Themes were reviewed in two stages, first at the level of individual coded extracts to ensure internal coherence, and then at the level of the entire dataset to confirm external distinctiveness. Several themes were collapsed or renamed following peer to peer or supervisory discussions. For example, operational urgency evolved into the the Thread of non-adherence to better capture the ethical tension between rapid action and procedural compliance. A record of these analytic decisions was maintained through versioned memos providing transparency and a trail of reflexive development.

Phase 5 - Defining and Naming Themes: Each theme was then defined in relation to its core concept and narrative function within the dataset. Short analytic summaries were produced to articulate what each theme captured and how it related to others. Theoretical lenses of identity fusion and moral injury were applied at this stage to provide an interpretive scaffold. For instance, data illustrating paramedics' willingness to assume personal risk for the perceived good of the patient were interpreted through identity-fusion theory, while accounts of guilt, frustration, and perceived betrayal by organisational policy were conceptualised as features of moral injury.

Phase 6: Write up: The final phase involved bringing the analysis together into a coherent account that conveyed both the participants' experiences and my own interpretation of them. Writing was treated as an active part of the analytic process rather than a separate step; as themes were described and illustrated, their boundaries and meanings continued to refine. Selected extracts were chosen to represent typical or particularly vivid examples and analytic commentary was interwoven to show how interpretations were reached. Throughout the writing, I revisited my reflexive diary to remain alert to how my dual perspective, as a practicing advanced clinical practitioner, later progressing to consultant paramedic, and academic

researcher, might influence the emphasis placed on particular narratives or tensions. The process concluded with the construction of the final thematic map, summarising the six key themes reported in Chapter 6.

4.6.14 Theoretical lenses

Theoretical lenses act to provide structure and guidance, a tool to assist the researcher in navigating the complexities presented by conducting mixed-methods research, particularly those that explore complex human behaviour in healthcare. The use of theoretical lenses within research has been described as an important consideration in all aspects of research implementation. However, they can be particularly valuable when conducting data analysis, enhancing the ability to interpret qualitative data and supporting integration with the quantitative aspects (Evans et al., 2011). In relation to reflexive thematic analysis, the use of theoretical lenses acts to offer additional mechanisms for which to conduct analysis of the data and act to counter the emic influence of the researcher (discussed in more depth in the following chapter). Lenses might be discipline-specific, but this is not mandated with their thought to provide a particular perspective, often through the provision of a set of predetermined questions that both differ from the original perspective of the researcher and enable data to be analysed in a different light. It is important that the chosen theoretical lens is applicable to the data and not applied haphazardly. Inappropriately applied theoretical lenses might lead to distortion of data (Sandelowski et al., 2000).

To provide structure and frame the reflexive thematic analysis of the transcribed interview data, various theoretical lenses were considered. Initially the 'Information – Motivation – Behaviour' (IMB) Model was initially utilised to frame code and theme generation. Figure 4.4 shows an amended IMB model taken from John et al. (2017). This theoretical model has been used extensively within literature exploring determining factors in preventative intervention strategies in healthcare (Gao et al. 2013.; Fisher et al.,

1996; John et al., 2017; Rongkavilit et al., 2010). This model focuses on three key facets that are thought to contribute to health behaviours. In this instance, the health behaviour under scrutiny is the adherence, or not, to PPE when dealing with cardiac arrest patients. The IMB model states that to obtain the derived behavioural outcome, individuals must be informed, motivated and have the appropriate skill required to be able to carry out the desired behaviour (John et al, 2017). Analysing this process further, information refers to instructions or guidelines that might be provided to inform individuals regarding a specific action. This information must be accurate and easily interpretable. For example, if the information is provided from an unreliable source, or overly complicated, the desired behavioural outcome would likely be negatively impacted. Motivation refers to an individual's motivation to carry out the desired behaviour and has two predominant aspects: personal and social. For example, a person's perception of their susceptibility to a threat might lead them to adhere to safety measures, whereas those who do not perceive a significant risk will not. With regard to social influences, this could relate to societal or cultural expectations. Workplace behaviours, for example, might be influenced either positively or negatively through peer pressure and the culture within that setting. Finally, behavioural skills might be either objective or perceived. If an individual does not believe they can carry out a task, they might not even attempt it despite having the relevant skill set to be able to do so (Gao et al., 2013; Rongkavilit et al., 2010). With this in mind, it is evident how this theoretical mode or lens might be used to view PPE adherence in paramedics. Indeed, pertinent to the chosen study area within this thesis, Song et al. (2022) applied this theoretical model to PPE application training in hospital staff during the COVID-19 pandemic. The non-prescriptive, broad headings and track record of being used in relation to PPE and COVID-19 meant this model was readily applicable to the interview data and a sound theoretical lens to guide initial analysis.

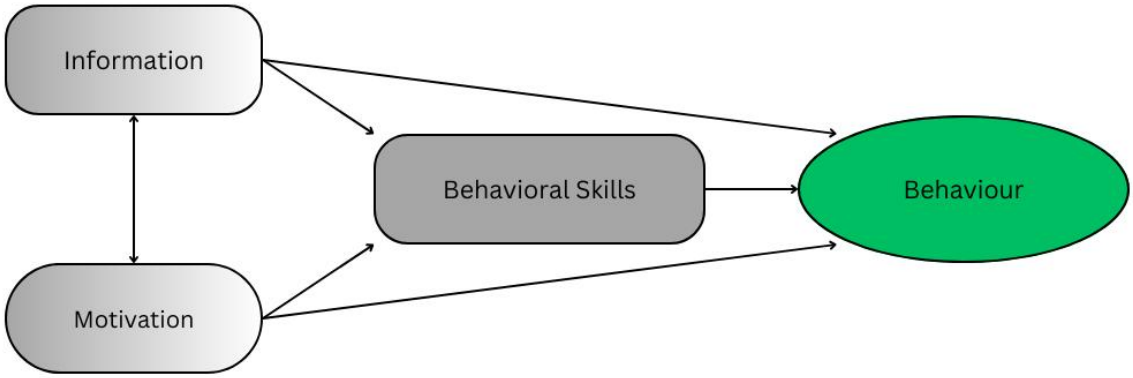


Figure 4.4 The 'Information – Motivation – Behaviour' model taken from John et al (2017).

Other models, including the 'Health Belief Model' (HBM) and 'Social Cognitive Theory' (SCT), were considered as theoretical lenses to frame the analyses.

4.6.15 Other considered theoretical lenses

Various other theoretical frameworks have been used in wider healthcare literature of this kind. Key models and their considerations are included in this section.

4.6.15.1 The 'Health Belief Model' (HBM)

The HBM has been used extensively in healthcare research since the early 1950's. It was developed by social scientists in the United States, who, as part of a Public Health initiative, attempted to explore people's failure to adopt preventative strategies or engage with disease screening programs. Later use of the HBM involved investigation of patient's compliance with medical treatment. Similar in premise to the IMB model, it centres around the suggestion that a person's belief or understanding of their own susceptibility to a disease, alongside their belief or confidence in the effectiveness of any proposed

mitigation measures, are key contributory factors to their adherence to any preventive strategies (McKellar et al 2020, Etheridge et al 2023). This is illustrated and summarised in Figure 4.5.

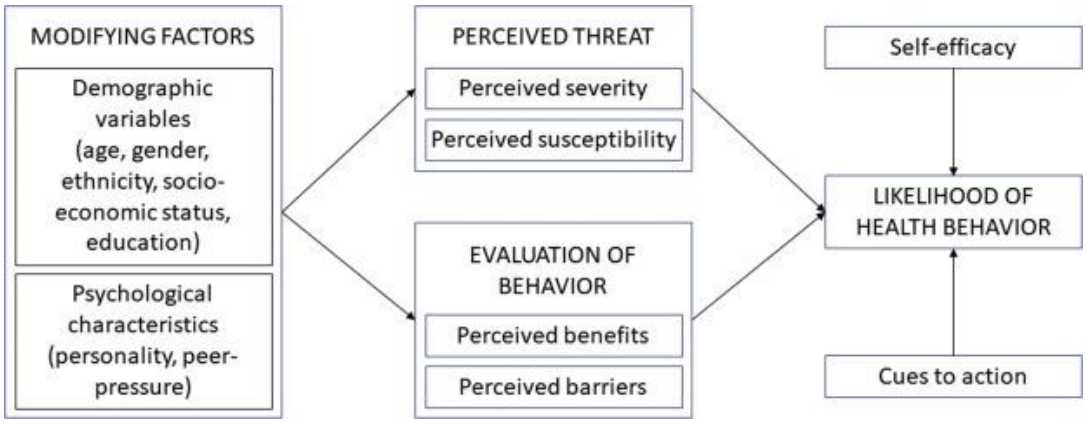


Figure 4.5 The Health Belief Model. Taken from Etheridge et al 2023.

On review it was felt that this model, although offering suitability for this thesis, was slightly more prescriptive in its application when compared to the preferred and more flexible IMB model. For example, a particular criticism of the HBM put forward in some areas of the literature suggests how the HBM neglects to consider behaviours that might be habitual, nor does it consider those behaviours that might be unrelated to health, for example, actions seen as a result of peer pressure, or influenced by the expectations of society, which could include workplace culture (Orji et al 2012, Davidhizar 1983). These elements were felt particularly pertinent when considering PPE use by paramedics and the working environments associated with this. Prior to the pandemic, ambulance staff experienced many years of limited and comparatively relaxed guidance with regard to PPE. Indeed, PPE, aside from disposable gloves semi-routinely, or high visibility jackets and helmets when attending road traffic collisions, was rarely seen by ambulance paramedics. Similarly, a theoretical lens must lend itself to allow for those behaviours that might be impacted by ambulance station culture, either positive or negative, and the

influence on adherence this might have. Therefore, it was felt the IMB model offered broader criteria for which to explore these potential contributors to non-adherence.

4.6.15.2 Social Cognitive Theory (SCT)

SCT evolved from the Social Learning Theory, in 1986, and is a theoretical framework, or 'lens', developed by Bandura, used to guide or implement systems or mechanisms that will elicit a desired behavioural change. It is a causal model that self-efficacy, namely the belief the individual has that they can achieve the goal, affects behaviour both directly and indirectly, and it has a particular focus on the importance of social influences (Beauchamp et al., 2019; Mobley et al., 2008; Bandura, 1989). SCT presents that learning is influenced by the experiences of individuals, the actions of those around them, and environmental barriers or enablers. The central premise of SCT is a person's desire for a sense of agency or ownership; worded differently, this is an individual's desire to believe they can control the notable events in their life (Schunk, 2012; Beauchamp et al., 2019).

SCT is particularly useful in implementing and, importantly, maintaining desired behavioural change through reinforcement. As such, it is widely used in the field of nutrition and is a commonly used framework in studies that attempt to adjust lifestyle changes such as diet, exercise, and weight loss, typically associated with diabetes treatments and prevention strategies (Wong et al., 2020). Aside from this area of study, SCT has also been used as a theoretical framework in a host of studies investigating human behaviour in various other healthcare settings. Some examples of these include phobias, leadership, parenting, group behaviours, risk-taking and societal violence (Williams, 1995; Dominick et al., 2010; Tasa et al., 2007; Merrifield et al., 2015; Card, 2011; Roberts et al., 2017). Risk-taking and group behaviours are the most pertinent to the qualitative aspect of this thesis.

The focus SCT has on achieving the maintenance of a desired behaviour is noted as a particular strength of the model. Reciprocal determinism, which lies at its core, is a principle-based upon interactions, being either dynamic or reciprocal, between people, their socially influenced environment, and goal-orientated behaviours. SCT possets that if a person observes a behaviour and the consequences thereafter, this in turn will inform their future actions and behaviour based on their recollections of the sequence of events they previously witnessed. The presence of rewards or punishments will also influence the replication of a witnessed behaviour (Buckley & Budzyna, 2023; Berk, 2017; Santrock, 2013).

Although an interesting option as a theoretical lens, it was felt that SCT would be better positioned as a theoretical framework to inform and review any devised strategies for PPE guidance and implementation rather than solely to explore the reasons behind non-adherence. Criticisms of SCT involve how it focuses more on the cognitive processes and abilities of an individual in relation to their decision-making and places an increased emphasis on the impact of their environment rather than considering more nuanced influences such as those that might be hormonal or biological in nature, widely recognised to affect behaviour, or the unconscious emotions and motives, such as personality traits, that might also guide an individual's behaviour (Beauchamp et al., 2019; Buckley & Budzyna, 2023).

4.6.15.3 The Predisposing, Reinforcing, and Enabling Constructs in Educational Diagnosis and Evaluation (PRECEDE) model

As stated earlier in the chapter, the processes of Braun and Clarke's six stages of Reflexive Thematic Analysis, when practically applied as part of this thesis, rather than being step-wise, were much more fluid than the illustration shown in Figure 3.4 might suggest. Indeed, adopting this approach and using the process in a less prescriptive manner and more of a spectrum to guide the analyses, as has been earlier discussed, is accepted as good practice by the authors (Braun & Clarke, 2022). As part of the

‘theme refining’ stage (stage 5), a review of the themes generated was conducted. This subsequently informed contributions to the reflexive journal. Through these reflexive contributions, and after further review, an observation was noted that the information-motivation-behaviour model fell short in allowing rich themes to be harvested. Although having been deemed suitable for application to this project for all the reasons stated previously, practical application to the data by a researcher with an ‘emic’ and ‘insider’ perspective, namely a paramedic, led to outputs being produced from a seemingly narrow point of view. These codes and themes were clearly created, as one might expect, from a paramedic’s perspective, thereby being much narrower than was anticipated. Researcher positionality is discussed in more depth in the following chapter.

The information-motivation-behaviour model was purposely chosen due to its previous use in similar studies that explored the experiences of healthcare workers, and it had been anticipated that its open, broad descriptors would lend flexibility to its application in this instance. However, on review, this broadness and openness to its interpretation, in fact, resulted in the production of themes with a restricted and narrowed viewpoint. On reflection, this was due to the researcher's lived experiences inevitably affecting the themes that were produced. Researcher subjectivity is celebrated in RTA; however, on review, it was felt it bore too heavy an influence in this instance. As a result of this observation and following further investigation on the matter of theoretical lenses, the ‘PRECEDE’ model was identified as a possible means to counter this influence. This model, an adaption of the ‘Predisposing, Reinforcing, and Enabling Constructs in Educational Diagnosis and Evaluation-Policy, Regulatory, and Organizational Constructs in Educational and Environmental Development’ (PRECEDE-PROCEED), was subsequently used as a theoretical lens that provided more of a structure to thematic analysis than that previously used. It both embraced the emic influence of a paramedic researcher but had a suitably structured framework from which to encourage more broader reflections. The goal is

thematic generation and analysis that would both embrace the emic influence of the researcher but also offer more broad and rich thematic content.

The PRECEDE-PROCEED model is recognised as a theoretical framework used in the production of guidance and evaluation of health promotion strategies for over thirty years and has been used to investigate self-protective behaviours of health workers when regarding bloodborne pathogens (Moore et al., 2005; Kim et al., 2022). Originally designed as the PRECEDE model by Lawrence W. Green in 1974, it was later developed to the PRECEDE-PROCEDE model by Green and Kreuter in 1991 (Porter, 2016). This model underwent further modification to the PRECEDE model presented in Figure 4.6, used by Dejoy et al. (1996). Dejoy used this as a theoretical model to inform their investigation exploring nurse compliance with universal precautions. The facets of the PRECEDE acronym represent several factors that influence an individual's self-protective behaviour. The codes elicited through the application of the information-behaviour-motivation model to the data fed directly into some of these various elements, particularly the 'predisposing' and 'enabling' aspects of the PRECEDE model. Whereby predisposing factors refer to a person's own beliefs, attitudes, and values, and enabling factors reference those factors that may either support, or indeed block, an act of self-protection, for example, a person lacking the required skill or knowledge to be able to perform a protective task such as donning PPE correctly, or there being limited access to appropriate PPE. Organisational elements such as training, availability of feedback, or cultural and social pressures are all included in the 'reinforcing' element of the model (Moore et al., 2005). A particular benefit of this model involved how it pushed beyond the individual perspective, acknowledging the notable contribution of context, namely the socio-environmental influences. The more structured presentation of this theoretical model helped to limit the researcher bias applied to the data set and encourage broader analysis. The anticipated mitigation of the emic influence on themes was seen through the use of this model.

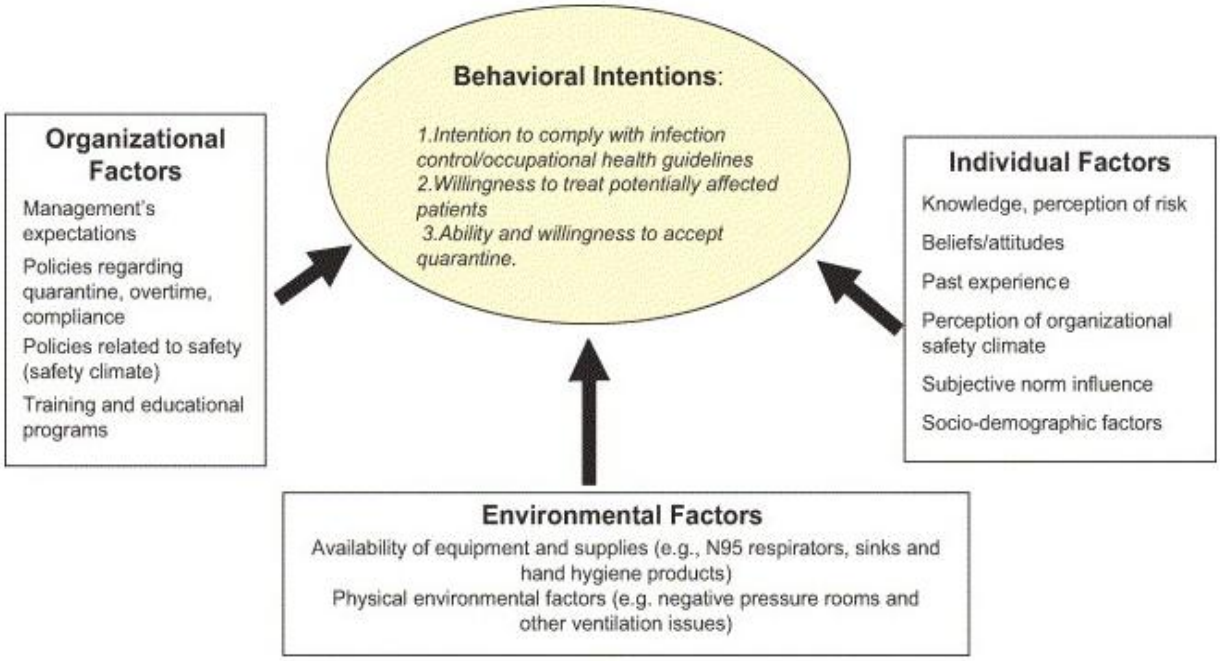


Figure 4.6 Dejoy et al (1996) adapted PRECEDE model.

4.6.16 Workstream 1: Summary

The method and methodological considerations within Workstream 1 were chosen to enable an exploratory study design to harvest novel concepts relating to paramedic experiences via qualitative means. The overall objective was to shed light on an area of research that investigated the PPE experiences of paramedics, specifically focussed on their non-adherence, in which a previous dearth of evidence existed. This would then be integrated with the quantitative element Workstream 2 and provide valuable insight into the paramedic dynamic risk assessment when using PPE in the presence of suspected contagious respiratory disease.

4.7 Workstream 2: STOPGAP: Investigation of chest compressions and defibrillation as aerosol generating procedures.

4.7.1 Short summary of rationale and background

Debate and disagreement exist in the literature regarding whether procedures of resuscitation should be termed aerosol generating. Prior to the pandemic, advice was to take immediate action and start chest compressions for patients in cardiac arrest. Since the COVID-19 pandemic this guidance was subject to repeated amendment due to concern of the potential for disease transmission, presenting a risk to the rescuer. To address this, the researcher was recruited as one-third of a paramedic research team and assigned to a project entitled 'the **St**udy **O**f Cardiopulmonary **P**rocedures Thought to **G**enerate **A**erosol **P**articles' (hence the project being called 'STOPGAP'). Supported by the College of Paramedics, three paramedic researchers investigated six routine procedures of resuscitation to identify their aerosol generating propensity, each recruited paramedic researcher assigned two procedures on which to focus. The STOPGAP protocol was made up of various 'work packages' using a multi-method design. One of these work packages features within this thesis and involves the quantification of aerosols at scenes of patients undergoing resuscitation following a prehospital cardiac arrest , whereby the research team worked alongside the ambulance service. The protocol is accessible in Appendix 6.

The ambulance environment, in which aerosol quantification took place for out-of-hospital cardiac arrest patients, presented considerable variability and unpredictability due to the nature of prehospital care. To address some of these limitations and strengthen the robustness of the data, a secondary data collection site was proposed within an Emergency Department (ED). The rationale was that the ED would offer a more controlled research environment, allowing for the measurement of baseline aerosol levels prior to the initiation of resuscitation procedures. This would have provided valuable comparative data, contributing to a more comprehensive understanding of aerosol generation during emergency care.

Following a thorough application process, the project secured full ethical approval and institutional support to proceed at Norfolk and Norwich University Hospital (NNUH). It was envisaged that data collected across these two distinct clinical settings, the prehospital and ED environments, could feed into a subsequent high-fidelity laboratory-based simulation. The goal of this simulation being to enable the randomisation and isolation of individual resuscitative procedures, thereby informing evidence-based decisions regarding which specific interventions should be classified as aerosol generating, and what levels of PPE would be appropriate in those contexts.

Despite the careful planning and ethical preparation, no participants were successfully recruited from the NNUH ED component. This was not due to a lack of effort or oversight. Several comprehensive strategies were considered and implemented in an attempt to support recruitment. The preferred method involved the researcher being physically based within the ED to respond immediately to relevant cases. However, this approach proved unfeasible due to operational and access constraints. As an alternative, the researcher was issued a cardiac arrest bleep to enable prompt notification should a cardiac arrest occur within the department. Regular research team meetings and staff engagement sessions were held to ensure awareness and support for the study throughout the data collection, which remained active for the entire duration of the data collection window. In all, the researcher on site conducted 82 twelve-hour shifts in the ED.

Further efforts that were reviewed to facilitate recruitment included:

- Analysis of historical shift patterns and ED data to identify periods with a higher frequency of cardiac arrests, ensuring the researcher was available during peak times.
- Development of ‘research champions’ within the ED team, who could be trained to operate the aerosol measurement equipment in the researcher’s absence.

Importantly, a retrospective review identified that out of 100 possible participants, only seven were eligible for recruitment. These seven possible recruitment events occurred outside of the researcher's on-site data collection shifts. All other participants did not meet the inclusion/exclusion criteria, with 42 having end-of-life directives in place, such as Do Not Attempt CPR orders (DNACPR). Therefore, while additional strategies would have driven significant demands in required on-site resources, the benefit to the study would have arguably not yielded any tangible benefit in terms of recruitment. Finite resources being a limitation in this regard.

While limited resources can often present challenges in clinical research, in this case, they did not compromise the overall integrity or validity of this thesis. Rather, they highlight the complex balance between feasibility and methodological ambition in real-world, high-pressure environments. Although resource constraints ultimately limited recruitment in this arm of the study, the proactive strategies implemented, and the careful documentation of efforts made, reflect rigorous planning and adaptability. These reflections offer valuable insights for the design and operational delivery of future research in similarly unpredictable clinical settings (O'Cathain et al, 2009; Greenhalgh et al, 2018).

Although this arm of the study did not result in data collection, it has been included in this chapter for the purposes of completeness, methodological transparency, and to uphold research integrity. While it will not be discussed further in the analysis or findings, the planning and implementation of this component provide valuable insight into the practical challenges of conducting emergency care research in real-world clinical environments. The experience also offers important learning for future research involving time-critical interventions and high-acuity patient groups.

4.7.2 Workstream 2: Study Objectives

As a reminder to the reader, the objectives of Workstream 2 were as follows…

- To document aerosol data recorded throughout active resuscitation of patients in cardiac arrest.
- To establish whether chest compressions and defibrillation delivered within cardiopulmonary resuscitation generate aerosols.

4.7.3 Investigational Plan

Workstream 2 aimed to quantify respiratory aerosols produced by patients during their active resuscitation in real-time, something which, at the time of planning, had not been previously identified following a review of the relevant literature (see Chapter 3, section 3.2). This data would record particle volume and size at regular time points during the resuscitation and be analysed to give insight into total mass and total particle number values for aerosol particles produced by patients receiving active resuscitation and ascertain whether chest compressions and defibrillation contributed to changes in circulating aerosol concentrations when delivered as procedures of resuscitation.

This was an observational study and, importantly, included no deviation from the expected level of patient care delivered to any of the patients involved. As mentioned, two methods of data collection were used: the prehospital aspect, whereby paramedic researchers crewed up with specialist paramedics in critical care (SPCCs) for Yorkshire Ambulance Service, and the ED aspect, set within NNUH.

The paramedic researchers assigned to lead both the prehospital and ED data collection are all Heath and Care Professions Council (HCPC) registered, experienced paramedics, practising to an advanced

clinical level. Therefore, the protocol was written in such a way as to harness and utilise their clinical experience, particularly within the prehospital data collection environment. For example, in circumstances where patients did not meet the inclusion criteria, or the level of clinical response was deemed insufficient to provide optimal patient care, the researchers were able to offer clinical support to the responding prehospital care teams, putting data collection activities on hold until additional resource arrived at the scene. Figure 4.7 shows the various stages that were required to be met before recruitment was successful within the prehospital aspect of the study.

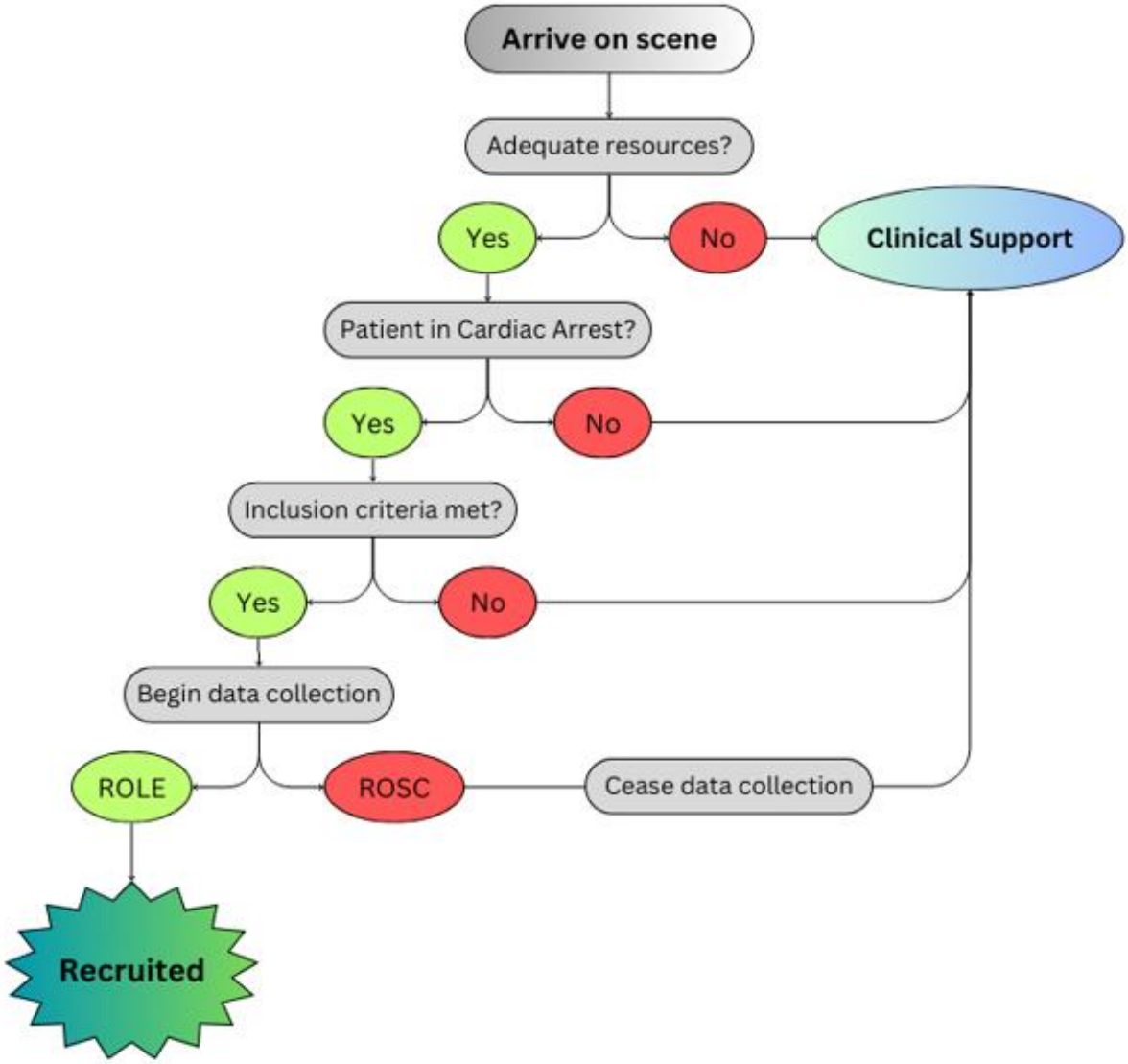


Figure 4.7 Recruitment process for Workstream two. Abbreviations used; Return of spontaneous circulation: ROSC, Recognition of Life Extinct: ROLE.

Note: ROSC was defined as having taken place when chest compressions were stopped, and post-resuscitation care had begun. This was noted by the presence of a palpable carotid pulse consistent with a life-sustaining cardiac rhythm during a rhythm check, or other signs of life, such as spontaneous breathing, or movement.

It was the desired intention that adequate resources would be on scene at any given incident and so the researcher would remain focussed on research activities, not involved in the provision of care unless necessary. In the instance where the SPCC and researcher arrived first on-scene at a cardiac arrest, they assisted in the initiation of CPR and continue in a clinical capacity until adequate assistance arrived.

4.7.4 Locations

Two centres were utilised from which to attempt data collection. The first being in a prehospital environment via Yorkshire Ambulance Service (YAS), and the second being within an Emergency Department (ED) at Norfolk and Norwich University Hospitals NHS Foundation Trust (NNUH). Both prehospital and Emergency Department aspects of the study ran concurrently. Two paramedic researchers conducted the prehospital element and were rostered to work with YAS employed Specialist Paramedics in Critical Care. YAS employed the researchers themselves in various capacities, one being a consultant paramedic, the other holding a paramedic 'bank', or 'zero hour', contract, meaning research passports were not required. A decision jointly agreed by organisational research leads.

In relation to the prehospital aspect, shifts were scheduled based on organisational cardiac arrest data to ensure optimal exposure to out-of-hospital cardiac arrests. The areas identified as out-of-hospital-cardiac-arrest 'hotspots', through continued review of this data, were locations within West Yorkshire, specifically Bradford and Leeds Central ambulance stations. When SPCC resources were limited due to their multiple other commitments or unforeseen absence, South Yorkshire SPCCs were utilised, at sites in Doncaster and Sheffield.

The ED research was led by one paramedic researcher, who similarly was employed by the acute trust and so again did not require a research passport. This individual was based at Norfolk and Norwich University Hospitals (NNUH) NHS Foundation Trust in the ED throughout this data collection period.

4.7.5 Procedures of observation

When in attendance at patients in cardiac arrest and the scene dynamics determined commencing data collection was appropriate, observations and notes were made of the following information on a pre-designed scribing log…

- Time of initial call for help
- Time that CPR was initiated.
- Whether any bystander CPR was administered
- Whether chest compressions were manual or mechanically administered
- ECG rhythms during the cardiac arrest
- Medications that were administered
- Airway patency and contributory factors to poor patency e.g. nature of soiling
- End tidal Carbon Dioxide
- Defibrillation shocks, magnitude, and timings
- Number of people in attendance and mask / PPE status
- Environmental features e.g., inside / outside, cigarette smoke.

In the event of a patient achieving ROSC but then going back into cardiac arrest (an event termed 're-arrest'), the time was recorded, and data collection resumed. Re-arrests were defined as the absence of palpable carotid pulse and respiratory efforts resulting in the need for chest compressions to continue. The decision to do so was made by the clinicians directly involved in the resuscitative efforts.

4.7.6 Operational sampling approach and eligibility criteria

Operational eligibility for Workstream 2 was defined prospectively within the STOPGAP protocol (Appendix 6) following consultation with patient and public involvement and engagement (PPIE) groups. Rather than employing a target-driven sampling strategy, case inclusion was necessarily pragmatic and opportunistic, governed by real-time clinical priorities, scene safety, and the requirement that research activity must not impede resuscitation or increase distress to patients or family members. The following inclusion and exclusion criteria therefore represent the decision rules under which data collection could occur in practice. Cases likely requiring rapid extrication and transport to hospital, including paediatric cardiac arrests and arrests meeting Resuscitation Council UK "special circumstances" criteria, were excluded as research activity would likely have impeded timely conveyance.

4.7.6.1 Inclusion Criteria

- >16 years old
- Out-of-hospital cardiac arrest, including overdose, hypothermia, pulmonary embolism, atraumatic major hemorrhage.
- Scene deemed appropriate following dynamic risk assessment.

4.7.6.2 Exclusion Criteria

- <16 years old
- Tracheostomy in situ
- Circumstances surrounding cardiac arrest that require police investigation.
- DNACPR / end of life directives in place
- OHCA due to drowning (dry or wet)

- OHCA secondary to smoke inhalation / house fires
- Multi-patient incidents
- Public places – following researcher led dynamic risk assessment
- Research impedes resus attempt
- Resuscitation not commenced based on futility, e.g., decomposition / putrefaction / rigor mortis
- Family request
- Scene deemed unsafe
- Crew request
- Return of spontaneous circulation (ROSC)
- Patients within institutions such as prisons, secure mental health facilities, nursing homes or care homes
- Patient with surgical airway in situ

4.7.7 Specialist Paramedics in Critical Care (SPCCs)

Specialist Paramedics in Critical Care (SPCCs) specialise in the delivery of prehospital care to critically ill patients, those with the most serious or complex medical or traumatic presentations, or patients requiring resuscitation. On discussion with senior clinical leaders within the critical care and research teams at YAS, it was widely agreed that these were the most appropriate group of clinicians in which to obtain optimal exposure to patients in cardiac arrest. A limitation of this approach was the amount of time the researchers spent attending multiple other incidents aside from patients in cardiac arrest. Every effort was made to target cardiac arrest only incidents. However, SPCCs were allocated to complex

cases where crews required assistance or incidents such as road traffic collisions where major trauma might be suspected.

To target eligible out-of-hospital cardiac arrest patients and avoid the research team being despatched to non-research related incidents, several alternative options were explored. Examples included having the research team paired with other roles within YAS, including Team Leaders or paramedics on Double Crewed Ambulances (DCAs). Additionally, consideration was given to the sourcing of an externally provided response vehicle. However, on review of activity data, and following further discussion with various clinical leads within at YAS, it was deemed that pairing the research team with critical care paramedics would be the optimal route. It was expected this would yield the highest productivity in the most efficient, cost-effective manner.

The protocol (Appendix 6) was written in such a way as to include anticipated scenarios that might occur when responding to emergency details with the SPCC. This covered instances such as resource allocation and circumstances where it would be appropriate, or not, to begin data collection. Any decisions made to commence or cease data collection were made with best interest of the patient at their forefront. Paramedic researchers would only begin data collection in patients that met the strict inclusion and exclusion criteria and when sufficient numbers and grade of clinician were present at the scene. Sufficient resources were agreed in advance of the project and were deemed as being comparable to the usual level of response required to deliver the expected level of care for the patient or patients. It was critical that the process of data collection would not impede the resuscitation attempt.

4.7.8 Equipment & Devices

For the prehospital data collection, two Optical Particle Counter (OPC) were used to analyse aerosol data at the patient's mouth and at baseline. The specific device employed in this aspect of the study was an Alphaphase® OPC-N3 (Alphasense® Ltd., Essex, UK) particle monitor. This was preferred over other alternative aerosol analysers as it was easily portable due to it being light weight and small in size. It is a robust and compact particle analyser capable of measuring particles within a size range of 0.35µm to 40µm. Able to detect particles across this size range by using 24 bins that enable categorisation of size.

The Alphasense® OPC-N3 (Alphasense® Ltd., Essex, UK) measures 75mm by 63.5mm (see Figure 4.8). Literature has demonstrated its use in dusty environments and so felt had the characteristics necessary for prehospital data collection (Kaur et al 2023). Due to this small size, the Alphasense® OPC-N3s (Alphasense® Ltd., Essex, UK) and associated power sources were easily transportable in light weight, hand-held carriers, powered by portable batteries or through attachment via Universal Serial Bus (USB) connection to a Dell laptop.

In practical application in the prehospital environment, it was found utilising the laptop as the power source was a more efficient mechanism for which to activate the Alphasense® OPC-N3s (Alphasense® Ltd., Essex, UK). It enabled both OPCs to be plugged in and activated simultaneously. Once attached to an adequately charged laptop, that had been switched on, the Alphasense® OPC-N3s (Alphasense® Ltd., Essex, UK) sampling could be activated and visualised on a display screen through the Alphasense® OPC-N3 software package [OPC 1.0.6457.18465], which was not offered with the USB power source. It was also noted that when the USB battery pack power source was used, a delay of one to two minutes would occur before data collection was activated. An additional drawback of the USB battery pack involved the lack of visual display to observe particle data in real time. This option was unavailable when

the OPC was powered by the USB battery and so made trouble-shooting more challenging, hence the preferred use of the Dell® laptop.

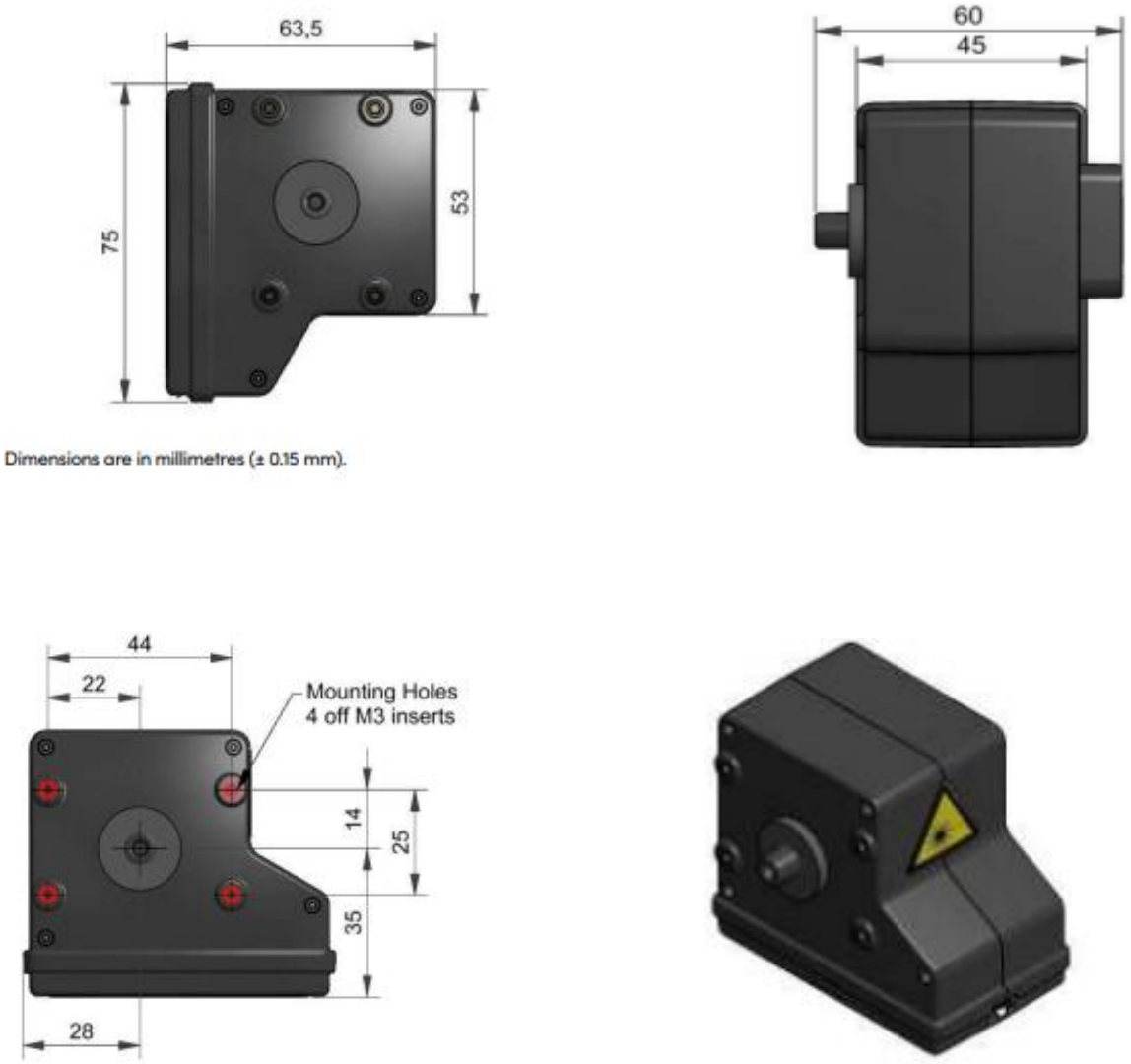


Figure 4.8 The Alphasense® OPC-N3. Images taken from Alphasense® Ltd., Essex, UK (2024) – OPC-N3 Technical Specifications Version 1.0.

Two 2-metre lengths of PVC tubing were used, one for each sampling tube (Cole-Parmer Instrument Co. Tygon S3® E-lab tubing). The specific measurements for this tubing feature in Table 4.1. Each individual length of tube was attached to its own Alphasense® OPC-N3 (Alphasense® Ltd., Essex, UK). Silicone tubing offered several advantages. As it was chemically inert, with a smooth inner surface, it minimised aerosol deposition, thereby reducing the potential for particle loss or reaction. It offered a good degree of flexibility and was suitably durable, thereby lending itself well to the varied prehospital environments that were attended with no instances of kinking reported. It additionally had good resistance to degradation at the environmental temperatures seen prehospitally and the fact that it was transparent meant that it could be regularly inspected for debris, moisture, or blockage. Both OPCs were linked to the same Dell laptop to view in real time, capture, and save, the particle data. One OPC recorded particle data at the airway, the other at the baseline.

Table 4.1 Sample tubing characteristics

	Sampling tubing characteristics (Cole-Parmer Co. Tygon S3® E-lab tubing)
Material	Translucent platinum-cured silicone
Length	2 metres
Wall thickness	1.6 mm
Internal Diameter	7.9 mm
Outer Diameter	4.8 mm

When the on-scene dynamics were appropriate for data collection, i.e. sufficient clinical resources were on scene to deliver effective patient care, the paramedic researcher positioned the sampling tube approximately 20 centimetres (cm) proximity to the patient's mouth, a distance in line with similar studies of this kind (Shrimpton et al 2023). The tubing was held in place either using a weighted bean

bag or by any additional ambulance resource at scene. The distance from the participants mouth would not exceed one metre, if the sample tube were required to be moved during delivery of patient care, it would be repositioned near the patient mouth as soon as it was safe and practical to do so. The baseline sampling tubing was placed in the same room at a point as far from the patient as was achievable. Figure 4.9 shows a simulated replicated data collection scene.

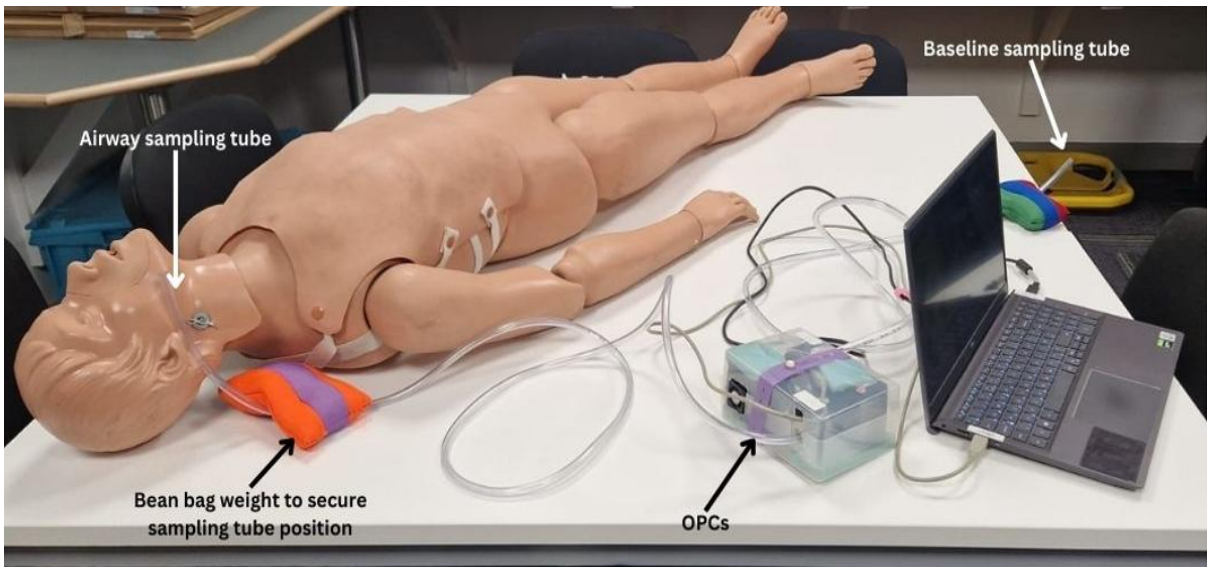


Figure 4.9 A photo of a simulated data collection scene

To minimise the time required to set the equipment up and so aid the process of sampling through rapid activation of the Alphasense® OPC-N3 (Alphasense® Ltd., Essex, UK), the sampling tube was attached to both the aerosol analysers in advance of arriving on scene. The aerosol analyser would then be connected to a laptop and data collection would commence. A digital record was kept of the chronology of the resuscitative events as they unfolded using Microsoft Excel® and saved the University of Hertfordshire's OneDrive®.

The research paramedic would take up a position that enabled adequate oversight of the resuscitation but that also ensured their presence would not detract from patient care in any way. In practice, it was

found the research paramedic could oversee data collection and offer emotional support to any family in attendance, acting as a conduit between the care team and family. This came with an element of risk. Through offering psychological support to witnesses the researcher could have potentially become too involved in this supportive process and be unable to trouble shoot any data sampling issues that might arise, however in practice this worked well and was balanced proportionately between the two tasks. Figure 4.10 shows an example of how data collection occurred in a generic scenario based upon several of the scenes in which data capture was successful.

The Dekati® ELPI®+ was considered to for use in this setting, however the device and its associated air pump weighed 22Kg and 25Kg respectively. A Peli™ case (Peli Products (UK) Ltd, 2023) was adapted in attempt to enhance the portability of the device but in testing was found to be not practical for use in the prehospital environment. Hence the Alphasense® OPC-N3 (Alphasense® Ltd., Essex, UK) was preferred in that instance due to the Dekati® ELPI®+ lacking the lightweight, portability required to meet the dynamic demands of prehospital work.

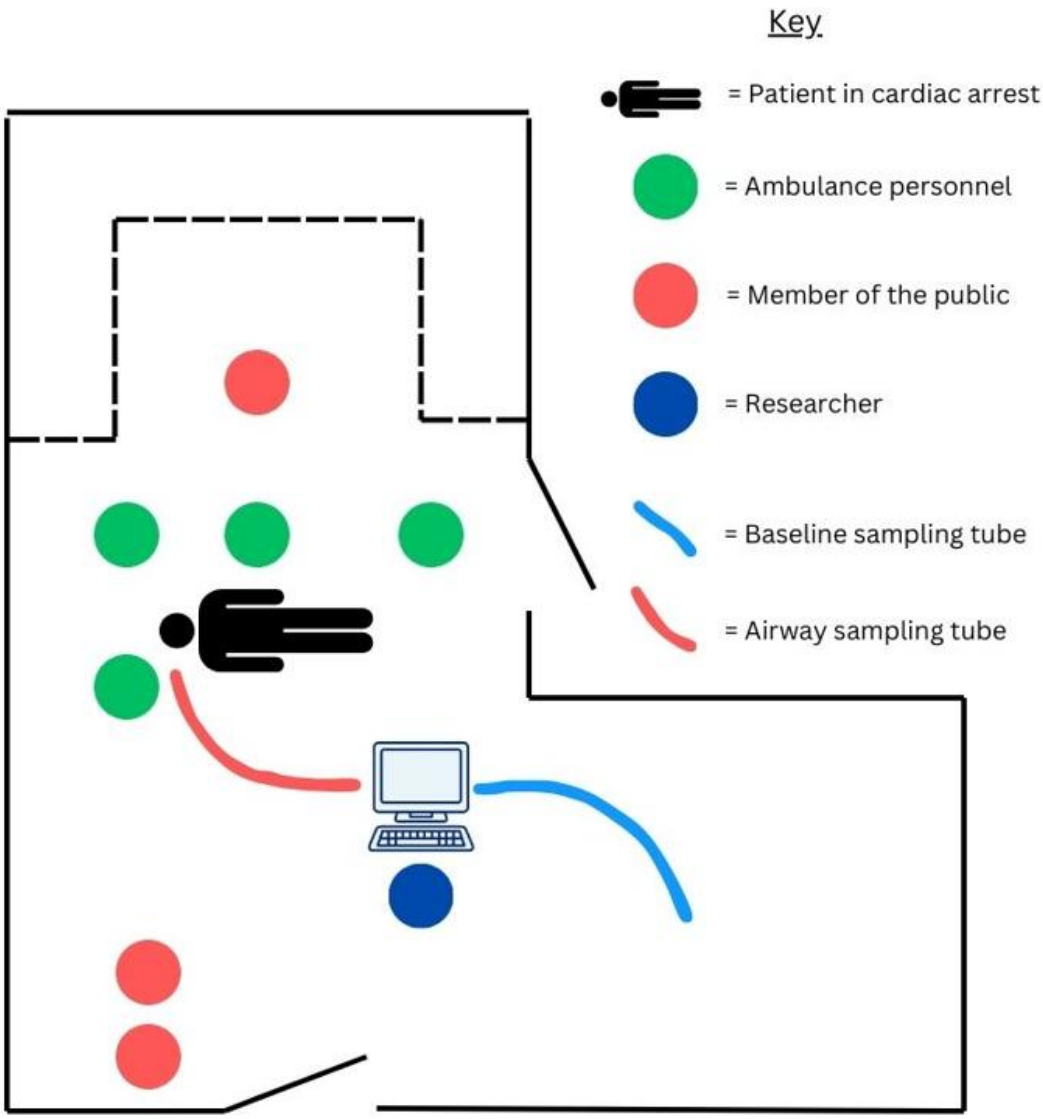


Figure 4.10 Example scenario to enable visualisation of a generic / fictional setting in which data collection might have occurred in the prehospital environment. This image shows a cardiac arrest scene within an open kitchen / dining area and is loosely based on several real-life resuscitative events that occurred during data collection, demonstrating the approximate positioning of research equipment and human resources in relation to the resuscitation attempt.

4.7.9 Adverse Event Definitions

Any anticipated adverse events were outlined within the protocol with appropriate mitigation strategies created (see Appendix 12). The protocol was subsequently scrutinised by the regional Yorkshire Research Ethics Committee (REC) and IRAS application.

4.7.10 Data collected

The primary outcome measure for the study included total aerosol particle number concentration and aerosol particle mass concentration. This was analysed via PRISM GraphPad® where comparisons with baseline data were made. Data relating to relative humidity and temperature were also recorded.

4.7.11 Power calculation and sample size

To perform the power calculation, an assumption was made that the actions of resuscitating a patient in cardiac arrest would act to increase circulating aerosols at the airway when compared to baseline, or these levels would remain constant. It was also assumed that these activities would not contribute to reduced levels of circulating aerosol numbers. As this involved two independent means, namely the aerosols quantified at the airway and the aerosols quantified at baseline, and were based on a theoretical expectation of change, an 'a prior', 'one sided' T-test was used. This was completed using peer reviewed, open access software package G*Power (v3 1.9.6) (Faul et al., 2007).

To inform this calculation for both the Emergency Department (ED) and prehospital aspects of STOPGAP, data were obtained from a previously conducted, unpublished, laboratory-based study that had quantified exhaled aerosols in healthy participants (Chilcott, RP unpublished data (2022) (Appendix

13)). This study had been previously approved by the University of Herefordshire's Ethics Committee with Delegated Authority (ECDA) (reference; acHSK/SF/UH/0449). At the time of planning, no further relevant studies were identified in relation to chest compressions and defibrillation as aerosol generating procedures within wider literature.

Assumptions made when performing the calculation included a twofold increase in significance for doubling the total aerosol particles. The calculation of the sample size determined a targeted total of 72 participants across both the Emergency Department (ED) and prehospital elements of the STOPGAP study. The target was for an equal split of 36 participants in each of the two groups. However, this target was not achieved, which limited the generalisability of the findings. It is important to note that this research was exploratory in nature, and as such, limitations such as this were anticipated. The sample size calculation was primarily used to guide the sampling strategy, but the final sample fell short of the target. Table 4.2 shows how this was reached.

Table 4.2 Sample size calculation with G*Power (v3 1.9.6) inputs / outputs

Input		**Output**	
Tail(s)	1	**NONCENTRALITY PARAMETER δ**	3.3243287
Effect size d	0.7835518	**CRITICAL T**	1.6669145
α err prob	0.05	**Df**	70
Power (1 – β err prob	0.95	**SAMPLE SIZE GROUP 1**	36
Allocation ratio N2/N1		**SAMPLE SIZE GROUP 2**	36
		TOTAL SAMPLE SIZE	72
		ACTUAL POWER	0.9502296

4.7.12 Data Analysis

The primary outcome measure for the study were particle number concentration and particle mass concentration, both calculated from the raw data measurements of aerosol particle size distribution obtained across the bins of the Alphasense® OPC-N3, collected during each of the resuscitation attempts. Data were presented in case study format that compared each individual resuscitative event alongside the baseline data. Noteworthy events in the resuscitation process were time stamped by the researcher who had been in attendance and captured within an electronic record entitled 'scribing log', a record that documented a brief narrative of events in Microsoft Excel®, accurately recording the timings to the second. This document features as part of the STOPGAP protocol in Appendix 1.

Descriptive statistics were used to show means, medians, and totals for continuous data. Standard statistical tests were not used due to the prehospital research setting not being conducive to the creation of an adequate and reliable control group.

4.7.13 Research challenges

Various challenges arose during this project's planning and implementation, leading to notable amendments to the originally proposed study design of STOPGAP. The presence of the COVID-19 pandemic confounded these challenges, a finding not unique to this study (Nomali et al 2023). The original research proposal included a critical care line of inquiry; however, due to the significant impact of COVID-19, this line of inquiry was unavailable. This initial proposal involved the research team working closely with critical leads to identify and recruit newly deceased patients. Following consent being granted via their next of kin, randomisation of procedures of resuscitation would be performed to identify the aerosol-generating propensity of each. A full study design with ethical considerations was written

and presented to a Patient and Public Involvement and Engagement (PPIE) group. Notably, consultation with the public led to widespread support of the critical care research element, with several PPIR members volunteering to be advocates for the project. They recognised the potential benefits that this approach offered in gaining deeper understanding of aerosol generation in resuscitative procedures. However, critical care leads expressed significant reservations about proceeding with this line of inquiry despite this support. Given the traumatic and overwhelming experience healthcare professionals had endured during the COVID-19 pandemic, they were reluctant to subject their staff to a study that involved resuscitation efforts on recently deceased patients. The emotional toll and the strain placed on critical care teams throughout the pandemic led to concerns that further involvement in such ethically challenging research could be detrimental to staff well-being and morale. As a result, the critical care arm of the study was withdrawn, prioritising the mental and emotional health of the healthcare professionals involved.

The Emergency Department (ED) was initially considered a viable alternative for the study's critical care component, with a research plan that aimed to closely replicate the prehospital workflow. The goal was to explore aerosol generation during resuscitation in the ED, based on the belief that it would provide a more controlled setting compared to prehospital environments. This control was expected to facilitate the establishment of a baseline by analysing environmental aerosols before resuscitation began. Despite significant effort from a research partner who dedicated several weeks on-site at NNUH to recruit eligible participants, no patients were enrolled. Therefore, the ED aspect of the study is not explored further in this thesis, except in this chapter.

The reasons for the failure to recruit eligible patients were multifaceted. One key factor was secondary care policies related to cardiac arrest and end-of-life management, which severely limited opportunities to recruit appropriate patients. According to ambulance service guidelines, patients in cardiac arrest are

only transported to the ED if they achieve return of spontaneous circulation (ROSC) or under exceptional circumstances. This policy ensures that only patients with some form of sustained recovery are admitted to hospital, significantly reducing the number of patients in cardiac arrest who are brought to the ED.

Furthermore, even in cases where patients are transported in cardiac arrest, they typically undergo resuscitation for a very brief period before decisions about the futility of further treatment are made. This brief resuscitation window further reduced the likelihood of patients remaining in a state suitable for aerosol analysis during resuscitation. In these cases, the intervention is often limited to a short period, and once a decision about futility is made, patients are either transferred to a critical care unit for definitive treatment or end-of-life care is initiated.

Additionally, the clinical safety mechanisms in place within the ED to identify patients at risk of deterioration played a significant role in the low recruitment rates. ED staff are highly trained to quickly identify patients who may be at imminent risk of cardiac arrest or other life-threatening conditions. Upon arrival, these patients are immediately assessed and treated according to established protocols, which may involve rapid escalation to critical care for further management or, in some cases, the initiation of end-of-life planning. Given the early identification of such patients and the fast-tracking of interventions, there were fewer opportunities to recruit patients for the study, as they were either quickly stabilised or moved to palliative care pathways. In summary, the combination of stringent secondary care policies around cardiac arrest management, the brief period of resuscitation for most ED patients, and the early identification and intervention strategies within the department meant that the conditions required to recruit eligible participants for aerosol analysis were rarely met. As a result, the research team was unable to progress with this line of inquiry within the ED setting, leading to the exclusion of this aspect from the thesis.

4.8 Ethical approval

4.8.1 Workstream 1

Ethical approval was granted by the University of Hertfordshire's Health, Science, Engineering, and Technology ECDA (HSK/PGT/UH/04962). No PPIE group was consulted in relation to this element of the study.

4.8.2 Workstream 2

Patient and Public Involvement (PPIE) consultation meetings were conducted throughout the research planning phase. Concerns raised during this process involved the activities of research potentially impeding the resuscitation attempt, or the research team causing undue stress to family members by explaining the purpose of their presence. The study was scrutinised by the Yorkshire Research Ethics Committee (REC) (REC reference; 23/YH/0027, appendix 14) and via application to the Integrated Research Application System (IRAS) (reference; 304724).

4.9 Ethical issues

4.9.1 Workstream 1

Investigating paramedics' experiences of delivering clinical care during the COVID-19 pandemic, a period associated with significant morbidity and mortality among healthcare workers, raised important ethical considerations. The emic positionality of the researcher has been discussed and felt offered suitable mitigating strategy in this regard. Having lived and worked through similar experiences, it was felt this insight and empathy would act as a support to participants. As already discussed, the researcher, being an experienced healthcare professional with experience in caring for mental health patients in crises, also provided valuable insight and additional skills.

4.9.2 Workstream 2

The ethical journey for the overall STOPGAP project involved consultation with various subject matter experts. Initially the plan involved data collection of newly deceased patients in a controlled environment within a critical care unit. PPIE opinion was sought on this matter and support granted. On

discussion with critical care leads within Yorkshire, an opinion was voiced around the need to safeguard staff and family from undue stress, cognisant of the intense pressures they had been under throughout the initial waves of the COVID-19 pandemic. This is why a proposal for data collection within the Emergency Department , as this offered the opportunity to detect baseline aerosols prior to any resuscitation event occurring. It was felt this baseline data could complement the prehospital data. This approach was approved by the REC and hence features within the protocol, although no participants were recruited as part of this work stream.

A contentious point centred around retrospective consent of patients in cardiac arrest and a number of discussions occurred with the REC and PPIE members. A waiver of consent was sought and approved for patients that were declared deceased at scene following these consultations. A point of note from review by the Yorkshire REC included their request that patients' consent be sought once they were well enough should they achieve a return of spontaneous circulation (ROSC). This would have required the research team to contact those patients who had been 'successfully' resuscitated and transported to hospital. Should the patient not be well enough, or dead, consent would need to be sought from their next of kin. Furthermore, West and South Yorkshire, the location in which the research was conducted, is served by over ten Emergency Departments and specialist centres. Having access to patient data through these various institutions would require the research team to negotiate each hospital's data protection and information governance processes. Gaining consent in this fashion was rejected for two key reasons. Firstly, it was felt beyond the scope of a small research team to access all potential hospital destinations and become fully compliant with their data protection policies within the limited time period of the study. Secondly, the research team were mindful of the PPIE findings, where it had been highlighted how they had notable concern around the research process resulting in undue stress to families, specifically when approaching families to gain consent. Patient outcomes for those who experience an out-of-hospital cardiac arrest (OOHCA) are poor. Despite achieving ROSC during the initial resuscitation mortality rates remain high in this demographic. It was felt that contacting families retrospectively, via any means, to gain their consent on a relative's behalf, weeks after the presumed

stressful event of an OOHCA of a relative would be better avoided, despite the recommendations of the regional REC after further discussion where the research team asked for a review of that decision. Therefore, the protocol was amended to state that any patients achieving ROSC would be excluded.

The rationale behind seeking a waiver of consent was in appreciation of the PPIE groups' concerns. A participant information leaflet (PIL) was designed, available to be given to people on scene should information be requested, although this was never required. The PIL included details of the study, contact details of the research team should further questions arise, and information given regarding how one might withdraw from the study. A language line was also made available for those who may require it, a recommendation made by YAS's own Clinical Governance Group due to the varied patient demography in the Yorkshire footprint. It was felt that this approach was thorough yet conservative and so ensured the research did not increase emotional stress faced by family members. This approach was endorsed following further PPIE consultation and ethical approval was granted by the Yorkshire and Humber – Leeds West, Research Ethics Committee (REC reference 23/YH/0027).

4.10 Summary

This chapter has outlined the methodological decisions that underpinned the study design. The research adopted a pragmatic paradigm, allowing for the integration of both qualitative and quantitative methods to address the research question in a flexible and practical manner. A mixed-methods approach was selected to gain a richer, more nuanced understanding of paramedics' experiences with PPE during the COVID-19 pandemic, combining subjective insights with quantifiable aerosol data. Key considerations included philosophical underpinnings, sampling strategies, ethics, data collection tools, and analytical techniques. The mixed-methods design was not only intended to capture complementary types of data, but also to allow for the eventual synthesis of findings through meta-inference. The following chapter

explores the researcher's positionality, addressing how their professional background and identity were managed to ensure transparency and rigour throughout the study. This reflexive discussion provides a bridge into the Results chapter, where both strands of data begin to converge, and the process of drawing integrated conclusions commences.

Chapter 5: Researcher positionality

Researcher positionality plays a key role in mixed-methods research, indeed in all research. As alluded to in the previous chapter, maintaining a reflexive log provided an opportunity to review and reflect on the processes involved in data collection and analysis. Specifically, regarding this thesis, this action led to the recognition of how profoundly the researcher's emic perspective, or their 'lived experiences', had contributed to the codes and themes that had been produced. Through critical reflection and reflexivity, it was identified that having a researcher with an emic perspective, despite offering benefits as described in the previous chapter, also contributed to code and theme generation that had been derived from a somewhat monocular, or singular, viewpoint, that being one of a paramedic. Critical reflection as a process involves exploration of what had been learned as a result of an experience; reflexivity differs in that it acts to provide strategies for the researcher to both question how they have viewed the data and the world therein, but also acts to seek solutions to broaden the richness of their findings (Bolton & Delderfield, 2018). Following these processes led to amendments of the study design to provide a framework to the analysis to limit the influence of this emic viewpoint, and support analysis of data via a broader lens to deepen the analysis. Positionality and its contribution to the research are discussed in more detail within this chapter.

5.1 Personal statement

To understand the researcher's positionality, it is important to create a personal statement to illuminate their various influences.

My career in the ambulance service began in 2009 following several years working in pharmaceutical sales. Although financially rewarding. I struggled with the ethical compromise required in order to

promote products that I knew to be inferior to similar treatments to prescribers in the name of sales. Hence, I made the move into paramedicine and became a paramedic with Yorkshire Ambulance Service (YAS) in 2009. Over time, I progressed into the role of Advanced Clinical Practitioner (ACP) within an Emergency Department and then onto consultant paramedic. It was during the completion of the dissertation aspect of the Advanced Practice master's programme that my interest in research began. I would describe myself as being motivated through a desire to help others, be they patients, relatives or colleagues and regard myself as empathetic and compassionate.

Having been a frontline clinician and practicing clinically throughout the COVID-19 pandemic as an ACP I understood, through close firsthand experience, the challenges faced by healthcare workers through the introduction of personal protective equipment. The ethical dilemma, and associated moral injury, faced by clinicians in these settings when faced with deteriorating patients in need of rapid intervention was something I experienced firsthand. As were the anxieties around PPE and the doubts regarding the protection it offered. A key motivator found in the literature review centred around whether PPE offers protection adequate to protect ones' own family, something which resonated deeply, however during my practice it was clear that not everybody shared the same personal motivations. Similarly, these experiences in clinical practice required I utilise reflective practice, and so led to familiarisation with the Rolfe et al (2001) model of reflective practice. This acted to both inform and structure reflective writing in respect to clinical practice. Through years of use it has become embedded in my psyche, and as such, has impacted the study design and chosen methods, discussed in more detail later in the thesis.

5.2 Researcher beliefs

A challenge when conducting this research involved the influence of researcher positionality on various aspects. Two aspects of note were around methodological choices regarding the qualitative aspect, and

the surprising yet profound effect positionality had on researcher well-being during the ambulance data collection phase, an unanticipated observation. Positionality involves recognising a researcher's identity and assessing its influence on the research process and findings. To do this effectively, reflexivity is required. This is a continuous process carried out throughout the research process. To understand their positionality, researchers must consider how their individual experiences and individual characteristics influence their decision-making and evaluate the impact on the study design and interpretation of findings.

Developing an understanding of positionality enhances mixed-methods research. It is typically a process associated with qualitative research as this involves human subjects' behaviours, experiences, and feelings. Interpretation of subjective findings will differ between researchers, a difference born through their experiences. Therefore, articulating one's positionality acts to both inform bias mitigation strategies but also provide future reviewers an opportunity to assess the level influence this might have on any given findings, providing both context and boundaries to the interpretation (Wison et al 2022, Jafar 2018).

5.3 Positionality

As a concept, positionality is commonly associated with qualitative research due to it involving human subjects and the complexities involved in exploring their feelings, behaviours, and experiences. Researchers are similarly complex, their interpretation of interview transcripts, as an example, will be influenced by their past experiences. Less frequently, positionality features in quantitative study design. It's absence in this regard, has been cited in literature in reference to emergency medicine research, as a notable omission that challenges its validity (Jafar 2018). In this context Jafar (2018) argues that positionality is linked to researcher bias and so could distort interpretation. To elaborate, not

understanding the motivations, desires, pressures, or other influencing factors behind the researcher's decision to investigate a given phenomenon, or the rationale behind the choices they might make regarding data analysis, fails to provide the reviewer with suitable contextual depth. The sentiment regarding benefits of reflexivity in the quantitative sphere is further echoed by Jamieson et al. (2023), where it is proposed that the embedding of reflexivity in all research both adds rigour and credibility, whilst also acknowledging bias.

Positionality can play a significant role across a variety of research paradigms, and specifically in relation to this thesis, within mixed-methods research (Knoblauch 2021, Jafar 2018). An argument has been put forward that neglecting to acknowledge the researcher's positionality deprives scrutiny of its influence on the study's findings (Wilson et al 2022). Within this research a registered paramedic was lead researcher. This immediately employs an emic, or insider, perspective, when required to interview other paramedics. The researcher could be considered part of the investigated community and understand the culture within, a fact that came with advantages, access to the study demographic, and an understanding of terminology and workplace culture being notable examples. At the study design phase, it was felt these, and other benefits outweighed their potential detriment. Indeed, literature supported adopting an emic perspective for these reasons (Brannick and Coghlan 2007). An advantage of note centred upon interview participants likely being less guarded around those which they see as like them, therefore this provided an opportunity to harvest data, more rich and candid than that which might be obtained by an etic researcher, who the studied sample could potentially, and somewhat understandably, see as an outsider, and so intuitively be more suspicious of their intentions (Chew-Graham et al 2002).

5.3.1 Impact on the qualitative aspect of this study

The researchers' own firsthand experiences present an opportunity for potential bias to influence the methodological and analytical choices as well as the interpretation of data produced. With that said it is important to recognise that bias is not solely a consideration within qualitative research. Research in all guises comes with an element of subjectivity as it is ultimately conducted by humans. Data do not analyse nor interpret themselves and so any choices in the techniques used to create and analyse data, be they via qualitative or quantitative means, will involve subjectivity and variance between researchers (Gupta et al, 2023; Smith & Noble, 2025). Understanding and exploring the researcher's viewpoint through self-reflection is critical if one is to accept and address the influence of our own lived experience in this regard. Following extensive literature review, and prior to compiling any interview questions, or conducting any interviews, a reflexive journal was created and maintained throughout the research process. The intention of maintaining this journal is to identify actions that could be taken to mitigate the influence of any preconceptions, add rigour to the discussion, and support future readers with the potential transferability of the findings.

One such example includes the decision to disclose the researcher's full role as a senior healthcare professional to the participants. The protocol was designed with an understanding that when the researcher disclosed this information to participants, that this could influence the data collected. To elaborate on this point further, the researcher, at the time of the interviews, worked as an advanced clinical practitioner (ACP). This role is comparable to that of an advanced paramedic and regarded, by some, as a senior paramedic, although it is noteworthy that the author does not subscribe to a hierarchical approach to multi-professional working. Having the researcher positioned as the interviewer meant they were required to ask questions, on certain occasions, to those who might see themselves as more junior clinicians. Questions will be put forward pertaining to matters regarding their potential breaches of PPE protocol, answers of which they might not feel disclosing to a 'senior' clinician.

It was important to always be open and honest with participants and required a fine balance of encouragement without leading the participant to overly disclose. Every attempt was made to ensure participants did not feel pressured to behave in a certain way or feel they would be viewed negatively for disclosing their answers with candour, in line with the no blame principles integral within 'just culture' guidance (NHSE 2025).

As part of the qualitative data analysis within this project, themes were identified within the dataset through the application of reflexive thematic analysis (RTA). Specifically, the guidance stipulated within Braun and Clarkes' (2022) six stages of RTA. These were applied to the raw, anonymised, transcribed, interview data, with codes and themes produced and analysed using NVIVO™ (v12) software. As described in Chapter 4 (section 4.6.14), the process of RTA has been typically described within literature as a stepwise approach, however, through the practical undertaking of these processes, it was observed that this was much less rigid and a far more fluid, taking the form more of a spectrum of analyses rather than a sequential or staged approach. This involved the reviewing or revisiting of earlier phases, or concurrent an observation recommended as good practice by the authors. To illustrate the fluid application of RTA in the first instance, an example of note involved the decision to halt the use of transcription software in favour of manually transcribing and anonymising the raw interview data, an action supported within literature (Silva 2021). This was a pragmatic decision made following contributions to a reflexive journal, that focussed on the researcher's experiences following completion of the first interview. It became apparent that the use of transcription software led to multiple, significant grammatical errors within the written data set. The software's inability to interpret subtle nuances within regional dialect, slang or colloquial language, led to transcription that was not reflective of the verbal dialogue captured within the interviews. A clear example of this was the frequent use of sarcasm by participants. The decision to manually transcribe the data had multiple benefits, the researcher not only addressed the automated misinterpretation of dialect and slang but also began the process of data

familiarisation, which in turn led to early-stage code generation. The process of manually inputting each interview to a Microsoft Word™ document, although more time consuming, led to RTA phase one (familiarisation), phase two (coding) and, as the study progressed further, phase three (initial theme generation), all occurring concurrently. Written notes and electronic memos were also produced during manual transcription for reference later in the study, and as this process continued deeper into the study, early themes began to emerge from the data, enhancing the richness of the themes.

Likewise, a second example of how the process of RTA was less stepwise and more fluid in nature, involved the processes associated with phase 3 and 4, namely, theme generation and refinement. The application of the Information-Motivation-Behaviour (IMB) Model which was used as the first theoretical lens to structure the RTA, led to unanticipated findings, and an element of bias was identified. It was initially felt during the conceptual phase of the project, that the IMB model, due to its broader criteria, would offer a less restrictive framework in which to conduct RTA, and so supported theme identification. This decision was reached following review literature involving similar research of this kind that focussed on capturing experiences and factors affecting adherence to IPC measures in other healthcare studies. The expectation was that use of this theoretical lens would offer a platform for code and theme generation that could facilitate identification of themes, that were both rich and broad in nature. Surprisingly, this proved not to be the case. Through continued contributions to a reflexive journal, recognised as good practice when conducting RTA, it was noted when reflecting on the impact of the theoretical lens of the transcribed interview analysis, that the themes produced through using this model were, unexpectedly, narrower than originally anticipated. Further review identified how using this theoretical lens created a theoretical space for analysis that was too vast, and that lacked structure or boundaries to guide the analyses away from the personal perception of the user. The effect being that this then allowed the researcher's insider, or emic positionality, to have a notably negative impact on theme generation and so a bias presented itself. This bias meant that the impact of the researcher, when

reviewing the dataset, was too pronounced, having a larger influence on the codes produced (Byrne 2021, Braun et al 2022, Braun and Clarke 2022). This is not an entirely negative finding, having a researcher as a paramedic, offered unique insight in certain aspects of the analyses. A mitigating strategy was required, however, and so a review was undertaken. It was noted that this issue arose during completion of stage four (see Figure 4.1) which was when themes were developed and reviewed. It required stage three to be revised and repeated. A new theoretical lens was identified that both embraced the emic positionality of the researcher but acted to not allow overpowering of this influence the analyses. This was done following further literature review which identified a suitable alternative. This theoretical lens was both broad enough yet structured, to allow for rich themes emerge but also offered mitigation of the emic bias, guiding away from the influential paramedic viewpoint held by the researcher. As a result, the PRECEDE model was identified. It was noted that when this was applied to the data set as the second theoretical lens, this emic positionality was utilised optimally.

5.3.2 Positionality: An observation from prehospital data collection

At the time of data collection, the two researchers assigned to the prehospital data collection were Ruth Fisher (RF) and myself. RF an educator and registered paramedic, and former employee of Yorkshire Ambulance Service (YAS), retained a 'zero hours' or 'bank contract' with the host organisation. I, on the other hand, had recently been recruited to YAS as a consultant paramedic, my first post in a senior leadership role, having previously practiced clinically in a hospital setting, the consultant paramedic role came with a burden of expectation. Ruth and I, being registered healthcare professionals, found that an internal conflict arose when faced with the juxtaposition in priorities, born from having a negative patient outcome being viewed as a success in terms of recruitment. To expand on this further, the inclusion and exclusion criteria stipulated that a waiver of consent could be issued to patients that died, therefore making them eligible for recruitment. These patients could then be viewed as 'successfully' recruited,

despite having been unsuccessfully resuscitated. Those patients that survived however, were excluded from the study as they did not meet the inclusion / exclusion criteria and were ineligible for a waiver of consent. These criteria were somewhat imposed on the research team by the Research Ethic Committee's (REC). Following scrutiny of the protocol, the REC took a view whereby they advocated for the research team to gain deferred consent in all patients who obtained return of spontaneous circulation (ROSC), an event that meant the participant had been transported to hospital. Principally this makes sense however the research team felt some unease in pursuing this route. This unease was based on 'survival to discharge' rates for patients who undergo CPR. These rates are incredibly low, recorded as low as 7-8% within a hospital setting and worse still in those that suffer out-of-hospital cardiac arrests (National Institute of Clinical Excellence (NICE) 2024). These low survival rates meant the research team would likely be required to approach recently bereaved families to seek consent on behalf of their relative should they follow the REC's recommendations, in the balance of probability, the patient would likely not survive an out-of-hospital cardiac arrest. When considering the discussion that would need to be put forward to the families, the nature of the consent would be regarding a non-invasive event, namely environmental air sampling, which likely occurred during an anticipated time of immense stress for the family. Having a relative undergo CPR by paramedics in a prehospital setting is very rarely anything other than unimaginably upsetting and emotive. It was felt that this would cause unnecessary and undue emotional stress; a sentiment echoed and supported by the PPIE group, following further consultation. This stance is also supported within relevant literature (Brown et al 2020, Terry et al 2017, Fitzpatrick et al 2022). Unfortunately, the REC rejected the appeal made by the team on this matter. Therefore, to avoid the research inflicting distress to families, a decision was made whereby any participant that underwent transportation to hospital having obtained ROSC was excluded from the study. Hence, the creation of a juxtaposition whereby a successful recruitment to the study meant an unsuccessful resuscitation of a patient and so, by definition, a successful research event meant a patient's death had occurred. Figure 5.1 shows an excerpt taken from the reflexive journal maintained throughout the project. It illustrates the

impact and implications of this juxtaposition whereby death became a measure of success (in a research context).

Figure 5.1 TM Reflexive journal entry

> *'I vividly recall being invited onto an ambulance for a debrief following attending our second 'jumper' that week. A particularly nasty and emotive job. I had purposely avoided the initial invite to join the team, instead offering to go on a coffee run. Having been summoned a second time it was unavoidable, I positioned myself at the furthest point I could, away from the conversation, avoiding eye contact with the 6 people in the back of an ambulance, no mean feat in such a cramped space. "Tim, you're being very quiet at the back". I'd been rumbled, quickly I offered my admiration for the teamwork I had witnessed, diverting peoples gaze with a self-deprecating joke (my go to mechanism) about being the third wheel. Then as the clinical leads lavished praise on all those in attendance I remember feeling a fraud, not worthy of praise, of even being in their presence. Perhaps that's why I bought so many coffees for everyone during the data collection shifts? To buy favour? I mean these guys deserved it. They were out there doing it for real. Not like me. I was just there with these fancy epaulettes and even fancier aerosol machines, not really helping, just making sure I did not 'impede the resuscitation attempt' (as our carefully worded exclusion criteria stipulated). Imposter syndrome had always been simmering but it began to bubble over. Eased only by the immense support and camaraderie of my fellow researcher, either via a well-timed WhatsApp or when handing over the equipment, and also by the support of all the fantastic critical care team members who I had the pleasure of being paired with.'*

This excerpt demonstrates how this '*outsider*' positionality manifested itself both internally within the researcher's mind and externally through their physical positioning of themselves a distance away from

the clinical group. An explanation of this act might be considered in the context of role identify. Role identity originates from a broader group of identity theories and explains how individuals' sense of self develops through their enactment of social roles. When these roles hold a perceived importance to the individual they help build a sense of self, acting as a signal to wider society regarding who they are, and what they stand for, and as such is closely linked to wellbeing, both physically and emotionally (Thoits 2011, Thoits et al 2012, Mausz et al 2022). Paramedic role identity has been defined as four dimensional, comprising caregiving, thrill seeking, competence in challenging scenarios (also termed capacity), and duty. Paramedics being respected professionals held in regard by wider society (Donnelly et al 2015). Problems arise, however, when individuals are unable to fulfil their role in a way in which they have become accustomed. This sentiment links both the qualitative and quantitative aspects of this thesis. Regarding the qualitative interview data that are discussed later, paramedics reported feelings of frustration reported as being more evident when PPE detrimentally impacted their ability to deliver patient care. Within the quantitative data collection at prehospital cardiac arrest sites, the researcher juxtaposition between care giver and researcher might also be explained in this regard. Both RF and I are experienced paramedics with advanced clinical training, however in a research setting, found ourselves attending critically unwell patients in a first responder capacity, stripped of any advanced interventions we had become accustomed to and adept at using in our previous clinical roles. Therefore, a state of clinical impotence arose, unable to initiate the care one would expect to see delivered of one's own accord, dependent entirely on the critical care paramedic. Using the lens of paramedic role identity and then introducing the context one can envisage how this might detrimentally impact emotional wellbeing.

An additional contributor to this negative feeling of self-perception was also prevalent when considering the new role of consultant paramedic and the self-imposed burden of expectation that existed. It was repeatedly a question asked at scene debriefs by members of the team on meeting them for the first time, the seemingly innocuous… "so… who what do you do?" that compounded this self-doubt. At face

value, a simple question to invite conversation, however being so new into role the answer was not in fact riddled with doubt and uncertainty. Imposter syndrome is a contemporary psychological concept that developed from imposter phenomenon, first described in 1978. It describes high achieving individuals' feelings of self-doubt an individual might experience in their position, status, or skills. Individuals affected by imposter syndrome struggle to internalise success and so suffer unwarranted fears of being exposed as incompetent, even fraudulent, through feeling as though they have conned peers into overestimating their skills, intelligence, or abilities (Chrousos et al 2020, Bravata et al 2020, Huecker et al 2023). Feelings of imposter syndrome became amplified in both members of the research team when they considered their position within the context of the clinical team and the wider ambulance service in which they were data collecting, both described a feeling as though they had seemingly infiltrated an organisation for their own gain, hence the coining of the phrase '*paramedic cuckoo*'.

'Paramedic cuckoo' evolved through informal conversation between research team members when describing their feelings regarding their position within the clinical team. Cuckoos exploit the caring nature of other birds for their own gain. One might consider the host bird and the contents within their nest as being their 'team'. The cuckoo infiltrates this team for its own gain; hence the analogy being used to describe the researcher's presence within the critical care team. The researcher's presence, being almost entirely research focussed (circumstance dependent) meant a relinquishing of their previous and more accustomed clinical focus. This then contributed to an overly self-critical impression that they were being, in some way, self-serving, in it for their own gain, the gain being less about patient care and more around data collection. This was an entirely unjust stance and overly harsh self-assessment, however worthy of unpicking. On reflection, this was perhaps due to underlying feelings of imposter syndrome that had become exacerbated through the underlying self-doubt that had arisen by being in a new senior role within the ambulance service, and compounded by a position of clinical impotence,

whereby they were more a clinical support rather than being their clinical lead in which they were more accustomed. The research team were able to offer a level of clinical support however this was limited being more an assistant than a clinical lead and only when insufficient resources were at the scene of the incident. Both researchers were more accustomed to being clinical leads at cardiac arrest incidents. Having said this, despite both being experienced clinicians, neither researcher had any previous clinical experience as a critical care paramedic. As such, both were required to emotionally and professionally juggle the pressures that came with supporting the critical care ambulance role. The '*fancy epaulettes*' reference within the reflexive journal entry in Figure 4.2, alludes to the pressures faced in having a researcher who was also a consultant paramedic. There would inevitably be an expectation of higher standards of clinical knowledge, advanced clinical care, and expectations of overall conduct, that would be offered by a consultant paramedic at any given prehospital scene. However, in reality this clinical experience had, in recent years, been confined to the much more controlled environment within an Emergency Department inside a hospital setting, vastly different to the varied settings that a critical care paramedic, and indeed all paramedics, work within. This led to self-doubt, feelings of being a fraud and fear of exposure as incompetent. All these feelings have been described as strongly associated with imposter syndrome within wider literature (Sfantou et al 2017). There was also an awareness of the research team that hierarchical leadership in healthcare can contribute to negative outcomes (Fernandopulle 2021). Adaptive behaviours were taken that mitigated the pressure of identity; whereby uniform choices were made that were both accepted for use by the Trust but also limited the visibility of the epaulette, one such example being sourcing ambulance jackets with no capacity to attach the epaulettes. A further mitigation was the preference for the critical care paramedics to introduce the research team as 'paramedic researcher' rather than consultant.

Communication has been highlighted within literature as a useful tool for which to counter feelings of imposter syndrome and improve wellbeing (Huecker et al 2023, Naylor 2019). Due to the necessity to

handover equipment at the end of each run of research shifts, the research team would schedule a place to meet. These became impromptu and informal, well-being support sessions, and became invaluable to both members when negotiating the conflicting headspace between researcher and clinician. An important consideration for future prehospital researchers would be around wellbeing support particularly for those embarking on solo research projects. Furthermore, it is challenging to determine whether these circumstances and associated feelings arose due to the individuals involved, or their previous roles and experience. If non-clinical aerosol scientists conducted the research would the same set of circumstances occur? Cases could be made for and against. One might argue that it would not, but this is not certain. Having non-clinical researchers in place of paramedic researchers might have triggered more extreme, visceral reactions when faced with the scenes associated with delivery of prehospital critical care and are an important consideration in future prehospital research of this kind.

Chapter 6: Results

6.1 Introduction

This chapter presents the results of the study in two parts, reflecting the mixed-methods design and the pragmatic paradigm that guided it. Data were collected from both qualitative interviews and quantitative aerosol measurements during resuscitation events, with each dataset contributing to a broader understanding of paramedic experiences with personal protective equipment (PPE) and the risks associated with aerosol-generating procedures, to inform the paramedic dynamic risk assessment process.

The qualitative component involved semi-structured interviews with patient-facing paramedics who worked during the COVID-19 pandemic. These interviews explored paramedics' perceptions of PPE use, barriers to adherence, and considerations that informed their risk assessments in the context of their decision-making in high-pressure clinical environments. Reflexive thematic analysis was used to generate a rich, nuanced understanding of the lived experiences of these healthcare professionals, with illustrative quotes used throughout this chapter to support identified themes.

The quantitative component involved aerosol sampling during real-time cardiac arrest resuscitations in the prehospital environment. Data are presented in a case study format, with particle mass and volume tracked and visualised over time to assess patterns of aerosol generation during chest compressions and defibrillation. These measurements provide objective insight into the environmental risks faced by clinicians, offering a practical context regarding understanding PPE use and adherence.

By presenting the findings from each strand in parallel, this chapter builds toward integration, where connections between the subjective experiences of paramedics and the objective data on aerosol exposure begin to emerge. These links are further explored through meta-inference generation that will be discussed in depth in the chapter that follows.

6.2 Workstream 1

This addressed the first research question, namely:

What are paramedics' experiences of delivering patient care using PPE during the COVID-19 pandemic?

Purposive sampling successfully facilitated recruitment of paramedics from a variety of extended or advanced roles within the paramedic profession, as well as including those more traditional 'front line', double crewed ambulance (DCA) paramedics. This was in line with the 'not all paramedics wear green' premise by the College of paramedics (CoP) which recognised the evolution of the paramedic profession, whereby paramedics now work in a host of settings aside from ambulances, and so added diversity to the findings (CoP 2023). Paramedic participants were from a variety of different ambulance services (seven in total) within the United Kingdom (UK), with demographic data illustrated in Table 6.1. This qualitative investigation informed a peer reviewed poster presentation that was presented at a university event to promote the launch of the Centre for Applied Clinical, Health and Care Research (CACHE) (see Appendix 15).

Table 6.1: Interview demographic information

Interview reference	Interview duration (mins)	Years of ambulance experience	Ambulance Service Trust, UK.
1	41.4	6	Yorkshire Ambulance Service
2	45.5	2	Yorkshire Ambulance Service
3	47.3	7	West Midlands Ambulance Service
4	58.0	3	South Central Ambulance Service
5	54.2	12	North East Ambulance Service
6	43.2	5	Yorkshire Ambulance Service
7	63.2	21	Scottish Ambulance Service
8	45.4	17	Northeast Ambulance Service
9	46.0	10	East Midlands Ambulance Service
10	45.2	4	Yorkshire Ambulance Service
11	50.2	22	South East Coast Ambulance Service
12	50.5	6	Yorkshire Ambulance Service
13	30.0	7	Yorkshire Ambulance Service
14	43.4	8	Yorkshire Ambulance Service
15	53.1	10	Yorkshire Ambulance Service
16	52.4	18	Southeast Coast Ambulance Service
Mean	**48.0**	**10**	**-**

Interviews were manually transcribed verbatim and notes were made simultaneously to support early code identification prior to any theoretical lens being applied, an example is accessible in Appendix 16 and Appendix 17. As described in the previous chapter, two theoretical lenses were subsequently used to enhance the richness of code development and subsequent identification of themes and their analysis. This was a pragmatic response to insights gained from a reflexive journal. A reflexive journal was kept throughout the planning, data collection, and analysis phases, as is recommended as good practice when conducting reflexive thematic analysis (Braun & Clarke, 2022). Through practical application of the Information – Motivation – Behaviour (IMB) model, it was found that the researcher's

emic perspective led to codes and themes being produced that had a narrower perspective than was originally anticipated. Initially, it was thought that the broad descriptors and unrestrictive nature of the IMB model would allow for broader thematic identification, however in practical application the opposite was noted, hence a secondary theoretical lens being sought.

On further investigation, it was identified that the codes produced through application of the IMB model as the primary theoretical lens, fed neatly into specific aspects of the PRECEDE model. As such, the PRECEDE model was used as a secondary theoretical lens to both add depth and support enriching of the codes and themes identified as well as counter the overly influential emic perspective of the researcher. An example of this influence is shown in Appendix 18. An example of early, theory-informed coding supported through analytic memos using the IMB model is provided in Appendix 19. Theoretical lenses were used interpretively to inform analysis, with analytical memos supporting reflexive engagement with the data, rather than functioning as predetermined coding structures.

The process of applying a pragmatic approach to reflexivity—supported by regular entries in a reflexive journal and ongoing reviews of its contents—allowed for early recognition and correction of narrow or overly specific codes that emerged during the first interview. This reflexive practice was maintained throughout both data collection and analysis to help ensure that the findings were interpreted with a broad lens, balanced, and rich in their insight. Importantly, the use of two theoretical lenses—the Information-Motivation-Behavioural Skills (IMB) model and the PRECEDE framework—enabled a more nuanced and layered analysis. This dual-theory approach facilitated the development of deeper, more meaningful themes than would likely have emerged from a single theoretical perspective. The coding and thematic development processes, as informed by each model, are visually outlined in Figure 6.1 and Figure 6.2, respectively. Examples of the codes / node structure produced within NVIVO[12] are provided in Appendix 20. The interaction of the two theoretical lenses with their codes and themes produced as a result are illustrated in the thematic map shown in Figure 6.3. Appendices 15, 20, 22 and 23 together

provide an audit trail illustrating early familiarisation and coding (Appendices 17 and 19), theory informed code refinement (Appendix 18) and the resultant code structure with NVIVO[12] (Appendix 20).

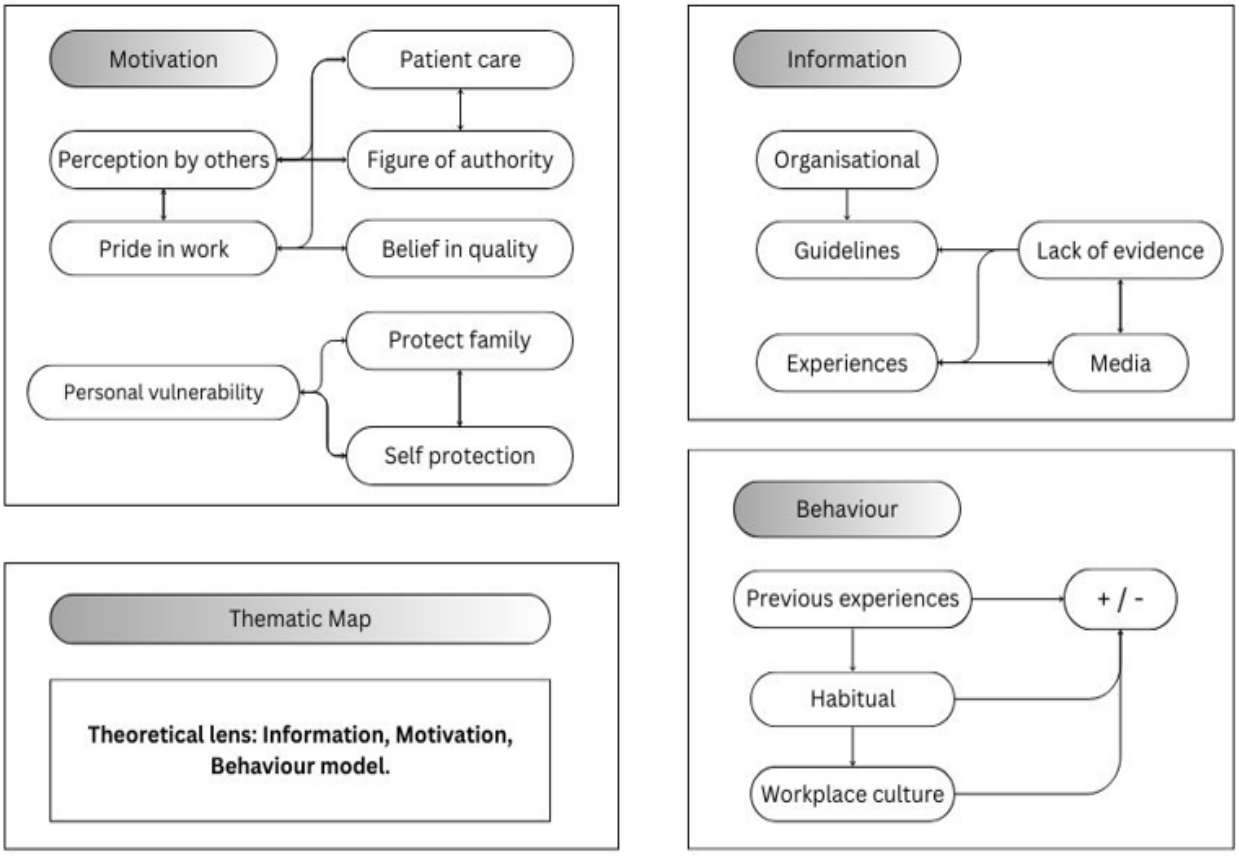


Figure 6.1: Thematic map following initial application of the 'Information – Motivation – Behaviour Model' used as a theoretical lens to guide theme production.

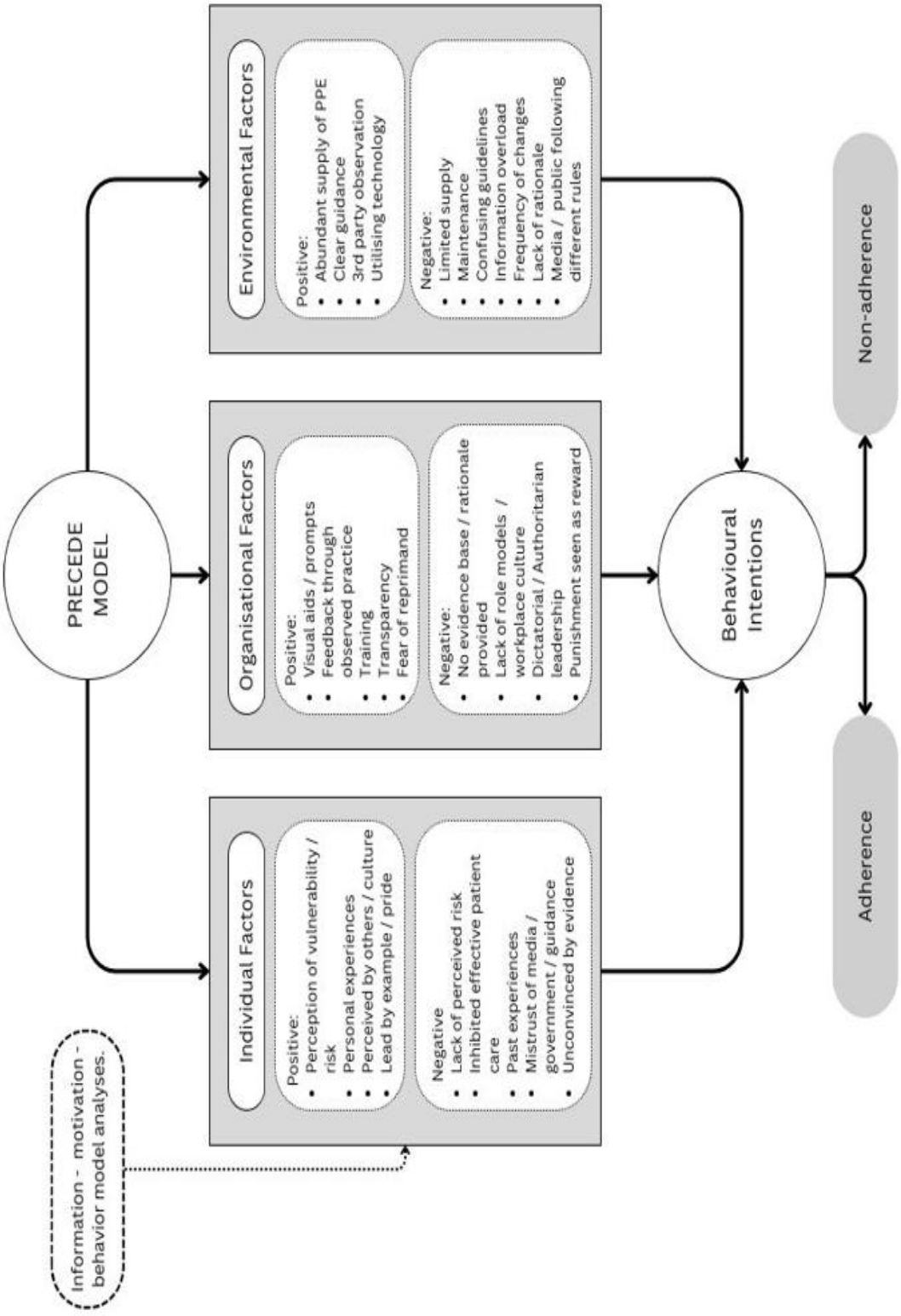


Figure 6.2: Thematic map showing application of the PRECEDE model

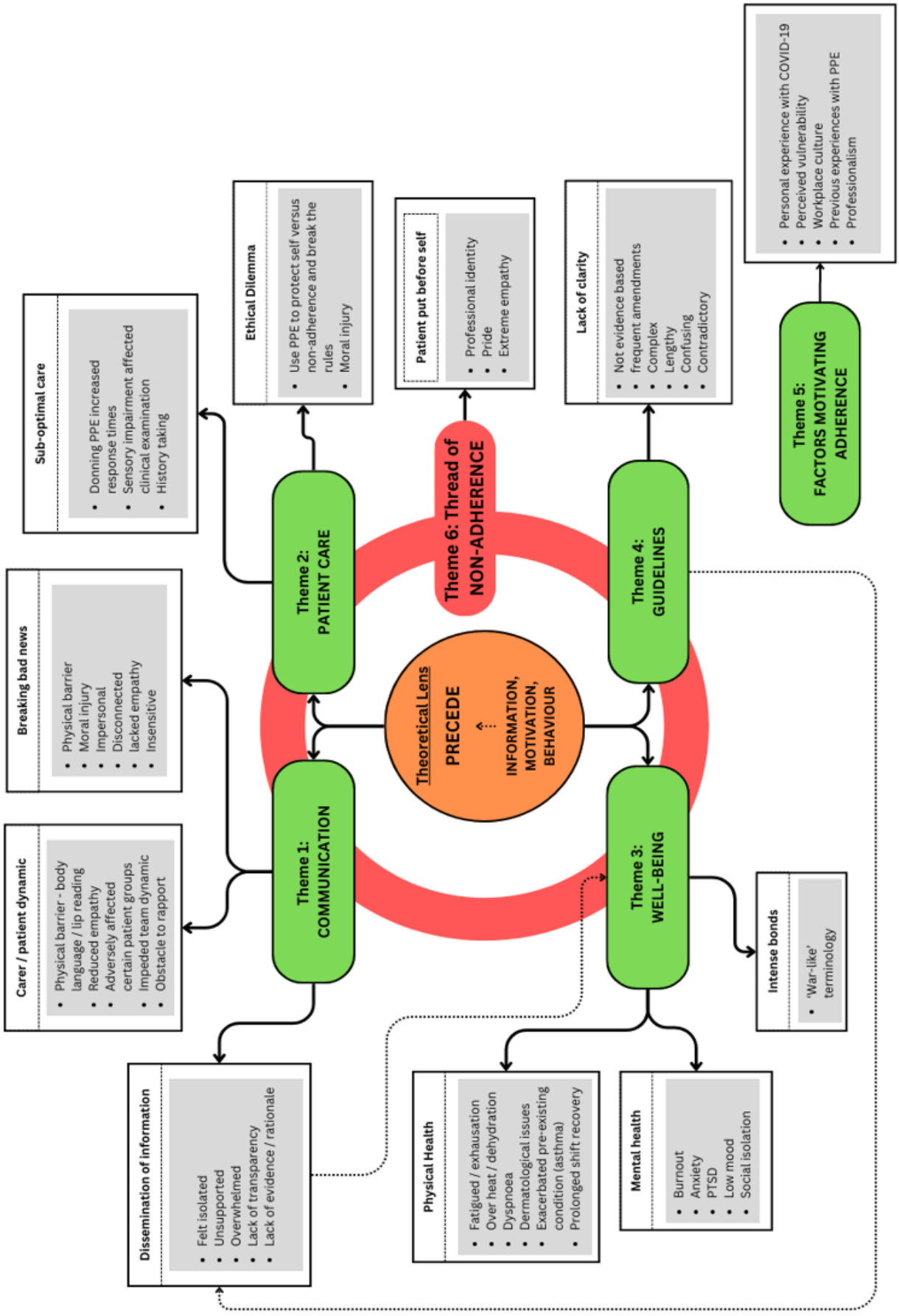


Figure 6.3: Final thematic map illustrating themes and sub-themes

6.2.1 Theme 1: Communication

This theme examines the ways in which respiratory PPE altered the way paramedics interacted with both patients and colleagues. Wearing masks, visors, and respirators frequently led to muffled voices, making it difficult for team members to hear one another clearly during urgent situations. Visibility was also compromised by foggy visors or bulky equipment, which sometimes made it challenging to read facial expressions or gauge a patient's emotional state. These limitations often turned routine exchanges into confusing or awkward encounters, impacting not only the efficiency of medical care but also the ability to offer comfort and build trust. As a result, many paramedics found that these barriers did more than cause inconvenience, they fundamentally disrupted the empathy, human connection, and reassurance that are at the heart of high-quality healthcare.

Barriers to Verbal and Non-Verbal Communication: Participants repeatedly described PPE as a barrier to effective communication, a finding consistent with wider literature on healthcare interaction under infection control restrictions (Hoernke et al., 2021). Verbal exchanges were often compromised by muffled speech and the need to shout, affecting interactions not only with patients but also with family members and colleagues:

"*It can pose a fairly significant barrier to communication between you and a patient*." (Interview 9)

"*You literally could not communicate at all… you would have to shout and still people would struggle to hear.*" (Interview 4)

The physical obstruction of masks and visors also removed vital non-verbal cues. Participants noted the absence of facial expression, warmth, and gestures that ordinarily conveyed empathy or reassurance:

> "*It created like a barrier between me and the patient… I'm reading your facial expressions, that patient could not read mine other than my eyes. I found it harder.*" (Interview 14)

"*You're not able to physically show certain signs of empathy through your body language.*" (Interview 10)

These accounts show that PPE not only impeded clinical efficiency but disrupted the *emotional grammar* of care — the unspoken interactions that establish trust, calm, and humanity in distressing situations. Paramedics described feeling detached from patients, unable to comfort them in familiar ways. The result was a recurring sense of guilt and inadequacy — a moral discomfort that aligns with the concept of moral injury (Litz et al., 2009; Williamson et al., 2020), where professionals experience psychological strain when their actions are constrained by external factors and fall short of personal moral standards.

Patient Groups Most Affected: Participants recognised that certain patient groups were disproportionately impacted by PPE-related barriers. These included older adults, children, those experiencing mental health crises, individuals with cognitive impairment or neurodiversity, and patients who were hard of hearing or reliant on lip reading:

"*…you go to patients that are a little bit hard of hearing, deaf patients that lip read, they cannot tell what you're saying… patients with sensory needs, autism, learning difficulties." (Interview 14)*

"Patients who might have communication difficulties such as hard of hearing… I did find it quite difficult in that respect." (Interview 2)

One participant reflected on how PPE appeared to heighten paranoia in a patient experiencing psychosis:

"*Patients… suffering with psychoses… I've had instances where patients have been adamant that we are talking about them, saying they can't see what we are saying. When in reality all we*

are discussing is that they have a high blood pressure or that their pulse might be high."

(Interview 1)

These accounts illustrate that the communicative barrier introduced by PPE was not evenly distributed: it compounded vulnerability in patients already at risk of misunderstanding or distress, and in doing so, challenged paramedics' ability to deliver equitable, compassionate care.

Impact on Clinical Effectiveness: Communication barriers also affected operational performance. Paramedics leading resuscitations reported that the inability to coordinate verbally made team management more difficult, particularly during high-intensity events:

"*I was not as effective in leading a team for the communication issues… You can't run a scene like that if no one can hear you – it is impossible.*" (Interview 11)

"*When you're at a cardiac arrest and you try to talk to somebody else when you've both got these masks on, you cannot hear what each other are saying.*" (Interview 5)

These extracts highlight how impaired communication directly influenced leadership, situational awareness, and the execution of time-critical tasks — key components of dynamic risk assessment.

6.2.1.1 Communication sub-theme: Breaking bad news

Breaking bad news through PPE was described as one of the most distressing experiences of the pandemic. Paramedics reported difficulty managing tone and expression when delivering death notifications, often feeling that the protective barrier stripped away the humanity required in such moments.

'*I still think about this to this day… the emotional trauma I must have caused relatives when I tried to deliver bad news through that mask… the only way to make yourself heard is to shout…*

the syntax and the diction is that of a man shouting at them that their husband… has died… God only knows how much trauma I must have caused.'

(Interview 11)

'…it's a barrier to basic humanity. It'll be this horrendous moment…and all [the next of kin] are talking to is a mask and a pair of steamed up glasses… it's more difficult to have a human conversation with that barrier… hiding so many emotions and the empathy that I want to demonstrate… to show that this decision isn't something we have callously made… someone's put some thought and some humanity into it… I feel like the masks are stopping me doing that.'

(Interview 12)

'…it feels so insensitive… so impersonal having to wear aprons and gloves and face masks and all that sort of stuff… a lot… relies upon your whole ability to communicate. It is not necessarily just the words that you say, but it's how you say them. It's how you posture yourself. It's how you connect with whoever that individual is. I think that is one area of clinical practice where the requirements to wear PPE has quite significantly affected.'

(Interview 9).

These experiences highlight how the disruption of communication intersected with paramedic role identity. Participants described feeling unable to deliver the level of empathy, reassurance or human presence they considered integral to a standard they had become accustomed. Within paramedic culture, professional identity is strongly tied to immediacy of care, calm leadership and relational competence (Rees et al., 2020; Ross et al., 2019). When PPE restrict these behaviours, clinicians reported a sense of personal and professional failure — not simply frustration. This tension reflects the mechanism of moral injury described by Litz et al. (2009), in which individuals experience psychological

distress when prevented from acting in accordance with their moral code or occupational ideals. In the context of the pandemic, being physically present yet unable to provide the human connection, comfort or quality of care the circumstance required undermined the very attributes through which many paramedics define professional worth. Similar findings have been observed across UK ambulance services, where clinicians reported guilt and moral dissonance when system constraints prevented them from meeting patient or self-imposed standards of care (Billings et al., 2021; Jordan et al., 2022).

6.2.1.2 Communication, sub-theme: Dissemination of information and support

A general feeling existed between ambulance staff, within the sample, that they felt unsupported. A feeling linked to criticisms of the various methods which ambulance services used to disseminate guidance and a perception by staff that these were ineffective. Contributory factors to these feelings were cited as the lack of provision of rationale or underpinning evidence to support mandated instructions, and when they were provided the restrictions on paramedic time to then review these relevant documents that had been issued due to huge operational pressures of the time.

> '*…I was feeling very much on my own… I rang for guidance and the people, I was ringing didn't know what was going on or what to advise. So, I had to do what I thought was right, but I wasn't very sure at the time if I was doing the right thing or not.*'
>
> (Interview 5)

> '*It was as clear as mud. There were times where you didn't know what you were wearing or why. Especially when it first came in and you had to adapt quite quickly but there was never a rationale for staff behind it, as in "we are doing this because…".*'

(Interview 1)

This suggests a breakdown not only in operational communication but in organisational trust. The absence of clear, transparent messaging eroded confidence and contributed to a sense of professional alienation, a theme echoed in broader pandemic literature on healthcare communication and moral distress.

6.2.1.3 Communication, sub-theme: Carer / Patient Dynamic

Finally, PPE altered the fundamental dynamic between paramedic and patient. What had once been an open, relational exchange became distant and impersonal:

> '*…at times you feel a bit distant from your patients. You're not able to give the same level of reassurance because they can't see your whole face. It can make some people a little more untrusting of you…particularly children or people who don't understand why it is you are there… I think some people do get a lot from a simple smile… from just being able to see your face. They feel they can trust you because they can interact with you.*'
>
> (Interview 10).

Participants viewed this distance as more than emotional discomfort; it represented a loss of authenticity in their caring role. This sense of disconnection aligns with theories of identity fusion (Swann et al., 2012; Gómez et al., 2011), in which professional and personal identities are tightly bound. When that bond is disrupted, individuals can experience moral strain and reduced coherence of professional self. Despite this, many found adaptive ways to preserve connection through tone, body language, or humour, reflecting resilience within constrained circumstances.

Communication using PPE was experienced as both a practical and moral challenge. Barriers to speech and visibility affected not only practical clinical performance but also the emotional

integrity of care. The loss of relational connection and organisational clarity contributed to frustration, guilt, and moral distress. Yet, within these constraints, paramedics demonstrated adaptability and commitment to their professional identity. These findings underscore how communication is central to dynamic risk assessment - informing decisions not just about safety, but about how to remain human within protective boundaries.

6.2.2 Theme 2: Patient care

A key concern raised by paramedics questioned, and voice by the majority of participants, involved their perception of the detrimental impact PPE had on their ability to deliver patient care to a standard they would expect. Wearing PPE was described as dehumanising the care-giving process and impacted almost all aspect of the care they provided. A pertinent point raised involved the impact of PPE on soft skills of care such as tactility during clinical examination. These reflections indicate more than technical frustration; they signal a deeper disruption to how paramedics understand and perform their professional role. Loss of tactility and embodied connection challenged core elements of paramedic identity, moving the theme beyond sensory impairment into questions of professional self-efficacy and relational competence. Paramedic role identity in the UK context has been described as grounded in autonomous clinical decision-making, embodied assessment, and the relational, human elements of care that underpin compassionate practice (Eaton et al., 2018; Reeve et al., 2008; O'Hara et al., 2015). These accounts therefore illustrate how PPE interfered not only with technical performance, but with the core professional behaviours through which paramedics understand and enact their role.

> '*...you're not even getting a skin contact... these are such important parts of our world... these human elements*.'
>
> (Interview 7)

This sense of diminished human connection aligns with concepts of identity fusion later discussed, where professional identity and personal identity merge, heightening the emotional impact when care delivery feels impaired.

Reasons behind this negative impact were multifaceted. It was described how PPE impaired sensory elements and created barriers to effective clinical examination. Notably goggles or other forms of protective eye wear would steam up and impair vision. Concerns were also raised regarding respiratory hoods leading to paramedics being unable to use stethoscopes, as well as gloves dulling sensitivity of hands and fingers when performing clinical examinations, or procedures such as IV cannulation. These impairments were repeatedly understood as undermining the skillset and expertise that paramedics rely on to deliver their day to day duties, therefore PPE became more than a simple operational inconvenience.

> '*...wearing gloves for clinical examination, there's so much tactile sensation that you lose...*'
>
> (Interview 5).
>
> '*...you lose your sense of touch because you've always got to have your gloves on...*'
>
> (Interview 4)

6.2.2.1 Patient care, sub-theme: Sub-optimal care

The introduction of PPE presented a particular barrier when delivering critical care to patients in cardiac arrest. Again, in this scenario, visibility was an issue, due to the physical exertion associated with delivery of chest compressions leading to misting of eyewear more rapidly. In addition, the restrictive nature of PPE on movements through its presence compounded the issue.

'*There's never a point in a paramedic's life where you need to be more on top form is there really then an ALS or even BLS, CPR job, and to be hindered with overheating, vision problems, fogging up…*' (Interview 13)

Accounts such as this demonstrate that PPE-related barriers were interpreted through an ethical and identify-based lens by paramedics, rather than as purely technical deficits. Paramedics linked their performance against internalised professional standards, creating significant emotional and moral strain when they felt unable to meet these high standards. These standards were shaped both by wider societal narratives or by self-critique.

'*…it was not effective resuscitation that we were delivering…*'

(Interview 11).

Specifically in patients with the cardiac arrest, the delays associated when required to don PPE prior to attending led to significant frustrations and were perceived to contribute to worse patient outcomes. Not being able to deliver the care to ones expected standard creates circumstances known to contribute to morale injury (Rabin et al 2023). The paramedics included in the sample were frequently subjected to conditions where this potentially could occur. This illustrates a path towards moral injury, whereby clinicians perceive that external constraints prevent them from fulfilling what they see as fundamental professional obligations.

'*We all know in a cardiac arrest time is really important… time to do chest compressions… time to shock … advanced life support obviously as a clinician is the goal for these patients. To not be doing that as quickly as you know you could be doing it is something that was difficult to deal with…*' (Interview 6).

'*You do feel like you're letting your patient down ultimately, as with regards to advanced life support, you are unable to initiate that treatment that the patient ultimately needs*.'

(Interview 1).

'*...you had families... waiting for you to come in and help... some jobs were cardiac arrests... you had to say, "we'll be there in a moment", and you'd be a couple of minutes putting on your protective gear... Did it make a difference?... if you add up all those jobs that happen day by day... add up minutes and hours and work out time lost due to donning PPE... it adds up*.'

(Interview 16)

These expressions point to shame-based self-appraisal, highlighting how participants' felt a deep sense of professional identity that was challenged when they felt unable to deliver the standard of care they believed patients deserved. These frustrations around the imposition of PPE led to conditions that could contribute to development of morale injury, particularly in the setting of cardiac arrest resuscitation. It was not that these scenarios were cited as frequent examples where non-adherence to PPE guidelines would arise.

'*...it became increasingly difficult to justify why we were essentially providing a lesser standard of care...*'

(Interview 5).

'*...going into a cardiac arrest... it takes time to put level 3 on... People say it only takes a few minutes... it didn't! It didn't take a few minutes... you had to find it... you had to faff*

about getting it on. It made jobs a lot more stressful because you wanted to do the right thing.'

(Interview 14).

Viewed collectively these accounts highlight the cumulative moral and emotional toll created when repeated delays and performance constraints conflicted with paramedics' internalised expectations of effective, timely resuscitation. PPE therefore became a persistent source of moral strain within cardiac arrest care, rather than simply a practical barrier.

6.2.2.2 Patient care, subtheme: Ethical dilemma

The frustration associated with delays that arose through the introduction of PPE were described to present the paramedic participants with a 'moral dilemma' (as referred to within Interview 1). Knowing that delays due to donning PPE could lead to loss of life, it was evident that this burden laid heavy and was something that they carried with them. Policy dictated that a paramedic's non-clinical should enter a location and begin compression only CPR as the paramedic donned higher level PPE outside. This was assumed to be a less risky strategy as procedures of airway management were deemed aerosol generating. Participants would become emotional when describing their experiences, emotion shown through anger or sadness in their tone and demeanour.

'…I remember thinking ethically, I just couldn't do it. When you're in there and your committed, you're the only paramedic… running the resuscitation, there's no way I'm [letting them] go in there and just doing chest compressions…'

(Interview 12)

'…pulling up outside… my colleague was saying to me "they're at the window, they want us to go in" but we had to get… in the PPE… it did play on your mind. You felt guilt….'

(interview 16).

'*I take a lot of pride in what I do, I put a lot of ownership on trying to do my best for patients, and leaving a patient's side who is critically unwell to then try and change into a different level of PPE… I found that really, really tough, really challenging.*'

(Interview 10)

This illustrates how organisational guidance came into direct conflict with participants' established paramedic role identity. Being present at the patient's side, acting without delay, and assuming responsibility for critical interventions were described as core expectations of "what a paramedic does". When PPE protocols required stepping back, delaying entry, or delegating initial actions to a non-clinical colleague, participants experienced this as a violation of these role expectations. The resulting guilt and distress therefore stemmed not from procedural inconvenience, but from the perception that adherence to guidance prevented them fulfilling the fundamental duties through which they define themselves as clinicians.

6.2.3 Theme 3: Well-being

Well-being featured throughout the interviews and was affected in variety of different ways. These are demonstrated in the following three sub-themes.

6.2.3.1 Well-being, sub-theme: Physical Health

Minor physical symptoms were reported by the majority of participants. Inability to adequately hydrate or thermoregulate were frequently highlighted as were associated symptoms of diaphoresis, overheating

and headaches. Dermatological issues were also reported such as pressure damage over the ears and nose.

> '*…it was tough. Exhausting as well, physically. When it was very hot I remember being just drenched in sweat under… being absolutely dehydrated.*'
>
> (Interview 16)

> '*…walking upstairs… wearing PPE… I can be quite short of breath… if I was doing a run of shifts, I'd have acne round the face and nose*'
>
> (Interview 1)

It was also raised how some had sought medical advice due to worsening symptoms of pre-existing medical conditions, presumed to be as a result of wearing masks for prolonged periods of time.

> '*I felt like… it was the wearing of facemasks that was irritating it and now we're not required to wear the facemasks as much I'm not having to use… my preventer*'.
>
> (Interview 7)

The contribution of increased demand on prehospital services seen during the COVID-19 pandemic, plus the wearing of PPE meant paramedics were unable to eat and drink in their usual manner. This had negative consequences particularly around post-night shift recovery.

'*It was soul destroying, wearing PPE for practically the whole shift. You're becoming dehydrated, you're getting headaches… you're not getting your breaks as you would normally. PPE did prevent me eating and drinking as I would normally… and the volume of calls that were coming in, it was call after call after call, so combining these elements was almost like the perfect storm for poor health…*'

(Interview 7)

6.2.3.2 Well-being, sub-theme: Mental health

Although not the sole contributor, it was felt that the continued requirement to wear PPE added to the significant emotional stress felt by paramedics when working throughout the pandemic, increasing their feelings of anxiety, contributing to possible burn out and suspected of increasing attrition rates. An example as a source of anxiety was around concerns regarding threat of transmission, and so questioned the effectiveness of PPE and the protection it afforded.

'*…it's been a great concern to me, PPE, and the quality of it… I personally don't feel like it is any good… my mental health has been a problem… I'm currently having counselling… I got COVID… was on intensive care… I thought I would never see my daughter again… I saw colleagues not wearing masks and not doing the things they should because they didn't want to… people thought they were invincible, and they weren't bothered about it, it won't affect them… that annoyed me. My mental health suffered because of my situation and my worry… increased… because of the quality of the PPE.*'

(Interview 13)

'Did PPE contribute to burnout?... the answer has got to be yes... do I want to go back to it? No, I do not really want to go back to wearing it... one of my colleagues is off with PTSD, he's done 29 years. And I went into my old station the other week and at least half... are leaving or wanting to leave.'

(Interview 3)

Viewed collectively, these accounts shown within 6.2.3.1 and 6.2.3.2 show how the sustained physical and emotional pressures associated with PPE could contribute to a wider deterioration in well-being that extended beyond discomfort alone. Participants described a cumulative erosion of energy, resilience and psychological reserve consistent with burnout. This depletion mattered, as it potentially reduced capacity to contextualise constrained care as a consequence of system pressures rather than personal failing. In practice, this meant that situations arising from PPE-related delay or impaired performance were more readily internalised as an "I failed" action rather than "the system limited what I could do". Burnout therefore could act as a catalyst, heightening vulnerability to shame-based self-appraisal and increasing the likelihood that routine moral tensions were experienced as morally injurious events.

6.2.3.3 Well-being, sub theme: Intense bonds

To support each other through these unprecedented challenges paramedics seemingly adopted a mentality akin to one that might be experienced by those in a war zone. As a result, intense, interpersonal bonds within the ambulance team arose. Stations seemingly described to become more united. Colleagues describing how they looked out for one another more so than previous.

'There was an intense camaraderie... this feeling of front line, warfare-ism... colleagues that were in the military... completely agreed that was how it felt. These bonds of camaraderie that were forged in that moment, held us all through.'

(Interview 11)

'I'd go into work 45 minutes… before I come on duty… I call it 'battle preparation'… I make sure everything's done. When I go into work I'm prepared for war, if you like.'

(Interview 15).

The war-zone framing described here carried implications beyond team cohesion. Through invoking imagery of battle, duty and collective threat, participants positioned themselves within a professional narrative where self-sacrifice, endurance and acting despite personal risk were expected norms. This strengthened sense of duty reinforced their commitment to one another and to patients, but it also intensified the moral weight when PPE requirements prevented them acting in accordance with these expectations. In this way, the same bonds that supported well-being simultaneously heightened the personal cost of constrained care. This war-zone framing may also have shaped non-adherence behaviours. YB adopting a mindset in which personal sacrifice was normalised, participants described feeling compelled to prioritise the patient's immediate needs above their own. Within this narrative, removing PPE to communicate, intervene faster, or provide enhanced care was less rule breaking and more fulfilling the moral expectation of the role, a form of 'doing the right thing' in the face of threat. Several participants explicitly describing personal risk as an expected part of paramedic practice, positioning PPE removal as almost an act of professional duty rather than deviation. In this way, the cultural emphasis on self-sacrifice within the team may have unintentionally increased the propensity for non-adherence when PPE was perceived to obstruct timely or compassionate care.

6.2.4 Theme 4: Guidelines

As alluded to in the last quote featured in the communication subtheme, some overlap arose between themes as they emerged. Participants described confusion when required to decipher and interpret

guidelines leading to a lack of clear understanding of their respective Ambulance Service Trust's expectations of them and the required levels of PPE. This was particularly evident during the evolving, dynamism of the first wave of the pandemic. Participants were generally sympathetic to the challenges faced by Trusts, however, regarding the events as unprecedented. Criticism of guidelines centred around the methods in which host organisations disseminated information and the lack of access to a clear rationale behind any decisions made. An interesting point was the notable differences seen when comparing responses of paramedics from differing ambulance services.

These inconsistencies created an additional cognitive burden at a time when clinicians were already managing heightened clinical, emotional, and operational pressures. For many, unclear guidance intersected with a strong desire to "do the right thing", amplifying the sense of uncertainty around what safe or expected practice actually looked like. This lack of clarity therefore contributed not only to confusion, but to moral tension when paramedics felt unable to reconcile policy with their own expectations of good clinical care.

> '*There were times where you didn't know what you were wearing or why*.'
>
> (Interview 1).

> '*…I still think it's really vague… we'll get sent these very lengthy memos… a dozen pages long… I feel like they still have quite contradictory information in them*.'
>
> (Interview 5).

> '*…let us know what you need us to do, and we'll do it. Don't change the rules every couple of days, it just gets confusing*.'
>
> (Interview 8).

In juxtaposition to paramedics who desired evidence to support policy, some paramedics had a contrary opinion. These individuals felt the clarity provided by the issued guidance was adequate and disputed the need for organisations to offer any further explanation, as demonstrated in the following two direct quotes. These demonstrate the paramedic's preference for direct instruction. Interestingly the paramedics who both provided this viewpoint disclosed having had previous experience in the military, used to acting on orders without question.

This divergence highlights how personal history and professional socialisation shaped responses to policy demands. For some individuals, clarity was synonymous with brevity and direction; for others, clarity required transparency and justification. Such variability underscores why no single communication approach met the needs of all staff, and why guideline interpretation became a source of friction, uncertainty, and at times reduced trust. It may also reflect the wider societal context of the time. Public mistrust in government communication, contested narratives about risk, and broader debates around COVID-19 policy ad vaccination created a climate in which official guidance was scrutinised more critically than usual. For some participants, this societal uncertainty may have compounded their existing doubts about the rapidly changing PPE directives, whereas others, particularly those accustomed to hierarchal structures such as ex-military, were less influenced by these external discourses

> '*It was fairly clear. You had to wear a mask. You had to wear a hood. You were wearing the apron in case fluids got on to you. You were wearing the full suit because you were getting more protection, so, I was quite happy with all that.'*
>
> (Interview 15)

> '*Does an individual trust need to justify something to all of their employees?... I don't know*

whether there really is an absolute requirement to justify it all, personally.'

(Interview 9)

It was suggested that simplified guidance that highlighted any key changes would be an improvement and trusts that adopted this policy received praise from the participants within this study. Also utilising other technologies other than email was suggested, e.g., the use of apps. Paramedics were generally understanding to the immense challenge faced by organisations and understood supporting evidence might have not been available. Greater transparency on this matter could have improved trust in the policy decisions.

Overall, inconsistent communication and limited rationale created conditions in which staff felt unsure, overloaded, or disconnected from organisational decision-making. This uncertainty fed into the wider emotional landscape described across themes, shaping subsequent behaviours including adherence, non-adherence, and broader perceptions of institutional support.

6.2.5 Theme 5: Factors motivating adherence

This theme stood alone from the others. Factors that motivated paramedic adherence described by the participants were multi-faceted. A common motivator to adhere to PPE policy was the desire to protect one's family or colleagues. Close first-hand experiences of COVID-19 increased awareness and perceptions of personal vulnerability therefore the use of PPE led to the wearer feeling protected.

These motivations demonstrate that adherence was rooted in relational responsibility as much as organisational compliance. The desire to protect loved ones and colleagues provided a moral rationale for strict PPE use, often overriding frustrations or discomfort experienced elsewhere in their accounts.

'…At the start, I was terrified… then we had 3 members of staff who died, and then it became real. And when I say members of staff, I mean people who we actually knew, friends and family and that type of thing. So, I think a lot of our station became quite nervous, we would use the PPE religiously… it brought it home, how dangerous it was what we were going into.'

(Interview 8)

'…my own family was shielding. And quite a few paramedics had similar situations. You sort of felt responsible for looking after yourself and making sure you didn't come down with this virus.'

(Interview 16)

'My youngest daughter has got a lot of health problems; I remember coming home from shifts… The idea of bringing it home and giving it my kids, or anyone for that matter, was absolutely terrifying.'

(Interview 12)

Professionalism and pride in their duties alongside a positive workplace culture also promoted adherence to PPE policy.

'*We were… championing the level 3 PPE because we were using it more than anyone else…*'

(Interview 11)

'…at cardiac arrests we went through a stage of having a team leader… that would often attend.

At the end of the cardiac arrets I was taking off the PPE in the wrong order and the pointed this out to me. It wasn't a significant critique, but it made me realise where I was going wrong…'

(Interview 10)

These accounts show how professionalism, peer observation, and shared cultural norms acted as reinforcing mechanisms for adherence. Where teams fostered a constructive, non-judgemental environment, adherence became an expression of collective responsibility rather than individual obligation. In this sense, adherence behaviour was shaped as much by social and moral drivers as by policy requirements.

6.2.6 Theme 6: Thread of non-adherence

Non-adherence to PPE guidance or protocols had influence in many different facets. It linked themes, identified as a 'thread' that bound themes one, two, three and four specifically. Circumstances highlighted within any one of each of these themes could lead to paramedic non-adherence, and non-adherence was witnessed by all participants in some regard. Participants also described deviation from expected practice regarding PPE as common place in ambulance stations, and the prehospital workspace generally. Various influencing factors or triggers to non-adherence were identified. Participants described either directly being non-compliant or indirectly witnessing non-adherent behaviour in the following circumstances repeatedly; when an inability to communicate or deliver effective patient care arose, if they experiences discomfort or adverse physical or mental effects through wearing PPE for prolonged periods, if they had a perception that PPE was ineffective or that they were low risk in terms if disease vulnerability, or in the presence of a negative workplace culture.

'*Compliance has certainly been an issue… they [colleagues] were putting me and their patients at risk by being non-compliant*.'

(Interview 10)

A particular issue around workplace culture was communicated where the perceived lack of role modelling exhibited by senior leaders and witnessing peers with relaxed attitudes contributed to wider staff non-adherence and an acceptance of the behaviour.

> '*I have witnessed non-compliance in others… People of all roles and ranks… I think people just got fatigued with it all.*'
>
> (Interview 5).

> '*…we also had some management who were not bothered… some were not leading by example.'*
>
> (Interview 8).

Preferred PPE was varied, most favoured the FFP3 facemask over the protective hood. Aprons were unanimously mentioned as the most disliked item of PPE, described as 'completely pointless' (Interview 2) by one participant, and 'possibly the worst PPE' (Interview 3) by another. Sentiments echoed by others due to their perceived lack of protection and quality, described as trip hazard by one participant and so was the most common item to be frequently not worn.

> *'The aprons, admittedly, I became willingly less compliant with those towards the end of the pandemic if I'm honest, only because I felt they didn't really provide us with a great deal of protection on any level.*'
>
> (Interview 10)

'*Aprons – prehospitally they were an absolute pain*.'

(Interview 7)

Similar feedback was provided about alternative body coverings for example Tyvek suits.

'The Tyvek suit – no, just no!'

(Interview 3)

'I won't even talk about Tyvek suits because they were just 100% horrific – you couldn't get them on, you couldn't even get to your radio, you couldn't have your radio on because there was nowhere to stick your radio, you couldn't get to your pen, you couldn't get to anything in your pockets…'

(Interview 14)

Participants described non-compliance most frequently occurred in the front of ambulances between emergency calls. The reasons behind this were multifaceted. Some felt this specific guidance was contradicted by that issued in other settings, such as guidance in public places, or at certain ambulance stations. Other participants described the impractical nature of maintaining compliance during long, arduous, shift work meant simple acts of maintaining one's own well-being were blocked. For example, eating and drinking prior to COVID-19 was commonplace in the front of ambulances, in-between calls.

Therefore, participants described how non-compliance would occur in order to remain adequately hydrated or simply to eat when unable to return to their ambulance station due to service pressures.

> '*The moment you weren't required to wear masks anywhere pretty much outside of work I think everyone's threshold for risk changed. You were in a clinical setting, so you were more at risk of coming into contact with somebody with covid I suppose but I think that was where I saw it in people and felt it myself. I was going out to Tesco without any mask on, OK, then all of a sudden, my worry and my threshold for risk at work changed and instead of doing my religious safe undressing procedure at the end of every patient contact like I had before I began doing what everyone else was doing, grabbing my mask and just chucking them in the bin and getting a lot more relaxed about it if I'm honest.*'
>
> (Interview 12)

Patient care, or rather the inability to communicate effectively to deliver adequate patient care, was another significant contributor to non-adherence. Interactions with particular patient groups, described in the earlier communication theme whereby PPE presented a barrier, led to non-adherence. Examples included those who were hard of hearing or the very young. It typically took the form of temporary removal of masks to assist with communication.

> *'..you have the elderly patients who can't hear very well. 90% of the time you end up pulling your mask down so they can lip read'*
>
> (Interview 1)

> '*I want them to know it's going to be OK… to see in my face that I'm relaxed… there's certain patients that its more important… children… when I want that human connection when I'm explaining something that's quite important and… scary for them, I want to have that connection with them. I'll drop the mask and talk to them and let them see my face… every other time that I breach PPE… is for that human side of it.*'
>
> (Interview 12)

More extreme examples included complete removal of respiratory hoods during cardiac arrest resuscitation attempts due to overheating or the fogging of eye wear. Participants described more frequent non-adherence as the pandemic progressed, as they felt protected from serious illness due to vaccinations.

> '*…if I was doing CPR for example… getting hot and I needed my mask off, but there was nobody else to do it I would have had to reduce my mask, just to get some fresh air, to save me from passing out.*'
>
> (Interview 13)

These accounts show that non-adherence was rarely a simple act of convenience or defiance. Instead, it emerged from a complex interplay of role identity, moral responsibility, and situational pressure. Where PPE was perceived to obstruct timely, compassionate, or effective care, participants framed removal not as rule-breaking but as a necessary extension of their professional obligation. In this sense, non-adherence can be understood as a morally motivated behaviour, shaped by the internalised expectation that a paramedic should prioritise the patient above self and persist despite personal risk. This framing helps explain why breaches occurred even when individuals understood the dangers: acting in line with

role identity felt more morally coherent than adhering to policies that limited their ability to 'be the paramedic' they believed they were expected to be.

6.2.6.1 Non-adherence, sub theme: Patient put before self

Repeatedly, paramedics expressed an extreme sense of duty and professional pride in the work they did and the tasks they must undertake as part of this. This was linked closely to several examples of non-adherence, whereby the patients' needs would be prioritised over that of their own.

> *'I went home at the end of the shift knowing I had done all I could for that person and compromised my own safety… to do so.'*
>
> (Interview 7)

PPE might be omitted or removed midway through a patient care episode. It was suggested by several participants that the consequences of a potentially life-threatening disease were a lesser burden to carry, emotionally, than the thought of having let a patient or their family down during the delivery of their duties, particularly in the instance of critically ill paediatric cases.

> *'…for me to fanny around putting PPE on when there's a child involved – it is not going to happen… I am not going to put the patient at risk… It is not fair on the family. It's not fair on the patient… The patient is time critical. I accept the consequence.'*
>
> (Interview 15)

This sense of duty was closely linked to the barrier PPE presented to effective communication and the delivery of patient care. The act of non-adherence in this instance was a result of the frustrations raised by some that PPE's presence made them less effective and so might be seen as a mitigating measure to limit the moral injury experienced by the care giver.

> '*I had a palliative patient… fallen out of bed… I ended up just taking it all off… to try and get hold of him, I even took my mask off just because the poor bloke was scared… he was COVID positive. I picked him up, carried him back to bed…, I understood completely that I hadn't followed the guidance and… put myself at risk…*'
>
> (Interview 3)

This led into deeper philosophical concepts around the paramedic identity and expectations of the role and what it meant to be a paramedic in time of crisis.

> '*… our role, the nature… of what paramedics are. They will put themselves at risk to try and help others… It's just that it is what we do… I know that I would appreciate it if paramedics were struggling to communicate… perspiring heavily… feeling uncomfortable, or struggling… because this mask is getting steamed up, that they removed it and got on with the job… to try and saved my loved one… I… felt that it was my own risk… if something happened to me… I was prepared to accept that.*'
>
> (Interview 7)

> *'…it just adds that extra element to the job again. You're faffing about away from patients, that's not who I am as a paramedic. As a paramedic I want to be there, helping that person, I don't want to be running off, doing something else, to then come back.'*
>
> (Interview 14)

Taken together these accounts illustrate how non-adherence was often rooted in deeply held beliefs about what it means to be a "good" paramedic in moments of crisis. For many participants, stepping towards risk, remaining physically present with the patient, and acting without delay were not optional behaviours but fundamental elements of their professional identity. When PPE requirements disrupted these expectations, removing or omitting equipment became framed as an ethically justified response rather than a breach. In this sense, non-adherence reflected a moral calculus in which protecting the patient, preserving human connection, and maintaining professional integrity outweighed personal safety. This identity driven orientation towards self-sacrifice therefore played a central role in shaping when and why participants felt compelled to prioritise the patient before themselves.

These interpretations did not arise in isolation but were shaped by the broader cultural landscape of the pandemic. Public narratives positioned healthcare workers as 'front-line heroes', the widespread use of war-like metaphors, and societal expectations of sacrifice reinforced the idea that clinicians should act decisively, even at personal risk. At the same time, fluctuating national guidance occurred at a time of growing public mistrust in government communication thereby creating conditions in which some paramedics felt more comfortable relying on professional instinct then on rapidly changing PPE directives. This wider context may therefore have contributed to a climate in which deviations from guidance could be understood as a morally defensible act rather then one of rule breaking.

6.2.7 PPE fatigue

An objective of this project was to attempt to define 'PPE fatigue' in relation to the paramedic viewpoint. Participants were asked directly with regards to their views and understanding of this term. The question was met with mixed responses. Several participants interpreted PPE fatigue in a literal form, that is to say they understood PPE made them physically exhausted and so fatigued. However, others understood in the context of the RCEM safety poster, despite not having been familiar with the campaign. This is encapsulated within the following two excerpts that demonstrate how a desensitisation to risk and apathy to guidelines and preventative measures began to occur with time and experience.

> '*My understanding is… COVID; that new and scary disease… everyone is quite worried… over time as people become conditioned to the risk, they tolerate the risk more, they become less worried … their views towards PPE… They are less vigilant or less concerned. They might've become disillusioned with the rationale of using it or the effectiveness of it.*'
>
> (Interview 4)

> '*PPE fatigue is a threshold in which people stop wearing it… it means fed up with wearing it, so they… cut corners, they will start to not be compliant with guidelines… Occasionally you'd have to remind a colleague "listen, we're in the cab now, service policy is masks on". They'd roll their eyes.*'
>
> (Interview 7)

Participants were asked to give two words that first came into their mind when asked about working in healthcare wearing PPE. The purpose of this was to enable the creation of a word cloud to represent their feelings in an illustrative format. This word cloud is illustrated in Figure 6.4. Clearly evident is that, despite all the notable and significant negative narratives around PPE in prehospital settings, as illustrated in the themes created, the two most frequent words to feature within this word cloud might

be associated with a positive view of PPE, namely '*protection*' and '*safe'.* However, it is noteworthy that this cannot be assumed and demonstrates a limitation of presenting data in this format.



Figure 6.4 Word cloud generated from paramedic participants when asked to provide two words that came to mind when working in PPE in the ambulance setting.

6.2.8 Workstream 1: Summary

Participants included in the sample spanned a range of experiences and offered valuable, candid insight into their PPE experiences in a variety of clinical settings, during their delivery of patient care, throughout the COVID-19 pandemic. Themes were identified following reflexive thematic

analysis and the application of two theoretical lenses identified how non-adherence bound four key themes, featuring significantly throughout. Despite a generally negative and critical view towards PPE's perceived detrimental impact to paramedic practice, an encouraging positive tone did resonate. This involved paramedic professionalism and diligence in the line of duty, firstly, highlighted in their determination to deliver patient care, almost at any cost, and certainly at possible detriment to their own wellbeing, but also in their drive to protect patients, colleagues and their own family.

6.3 Workstream 2

The quantitative element of this mixed-methods research involved quantification of aerosols during active resuscitation of patients in cardiac arrest in the prehospital setting. Two samples were collected as part of this process, one sampling tube placed in proximity to the mouth opening, this being named the 'airway' sample, and the other at the furthest distance achievable from this point, termed 'baseline'. This was done to address the research question:

Do chest compressions and defibrillation delivered during active resuscitation of a patient in cardiac arrest generate aerosols and so pose a transmission risk to the rescuer?

Aerosols were measured throughout the active resuscitation of human subjects who had experienced an out-of-hospital cardiac arrest and for whom Specialist Paramedics in Critical Care, accompanied by a researcher, had attended. Overall, the research team completed 51 prehospital, critical care shifts. This led to attendance at 154 incidents. Each patient care episode was assessed in the context of the strict inclusion and exclusion criteria, which had undergone regional Research Ethics Committee (REC) scrutiny and was subject to a rigorous ethical approval process that included repeated PPIE consultations. Of the 154 incidents that were attended, 19 met the inclusion criteria and yielded successful recruitment of 18 participants.

Data were presented using a case study format. Key events during each resuscitation were timestamped and clearly highlighted on the corresponding charts. Information related to chest compressions and defibrillation was shown alongside baseline measurements for comparison. These baseline

measurements were taken in the same room as the resuscitation, no more than four metres from the patient's mouth or airway. This distance was determined by the sampling equipment: each of the two sampling tubes was two metres long and connected to its own Alphasense® OPC-N3 device, both of which were linked to a single Dell® laptop. As a result, four metres was the maximum separation possible between sampling points.

Samples from both the airway and baseline positions were collected at the same time. While the baseline readings allowed for a comparison of aerosol particle quantities and sizes within the same environment, they did not represent a true control. Creating a true control group would have required data collection before any resuscitation procedures began, ideally in a controlled setting. However, because out-of-hospital cardiac arrests happen unpredictably and in varied environments, this wasn't feasible. Therefore, using baseline measurements as a point of comparison was considered a practical and acceptable compromise to support the interpretation of the results.

6.3.1 Overview of research activity

This section quantifies the practical challenges encountered during the implementation of the quantitative component of the study, specifically concerning the identification and attendance of eligible cardiac arrest incidents. Despite close collaboration with critical care paramedics—who respond to various high-acuity emergencies—only a small proportion of cases met the stringent inclusion criteria required for enrolment. Two primary barriers emerged: firstly, the time-sensitive nature of out-of-hospital cardiac arrests, combined with the extensive geographies covered by critical care paramedics, made it exceptionally difficult for the research team to arrive early enough in the patient pathway to capture meaningful aerosol data; secondly, many attended emergencies, while clinically significant, did not involve cardiac arrest or failed to meet other protocol-specific eligibility requirements. As shown in

Table 6.2, although the research team attended 284 emergency incidents during the study period, only 6% resulted in successful participant enrolment.

Furthermore, these operational constraints rendered the creation of a meaningful control group virtually impossible. The unpredictability of the emergency environment, coupled with the immediacy of resuscitation interventions, meant the opportunity to collect baseline environmental data prior to clinical activity would almost certainly never arise. The dynamic and uncontrolled nature of prehospital care fundamentally limits the ability to standardise conditions across incidents. As such, while the study provides valuable insight into aerosol generation during real-world resuscitation, it also highlights a significant methodological limitation: the inherent impracticality of establishing an adequate pre-intervention comparator in this setting.

Table 6.2 Activity summary

Descriptor	**Total**
Number of shifts covered	51
Number of emergency calls research team allocated to	284
Calls attended	154
Stood down enroute to incident	130
Possible missed opportunities	17
Number of participants excluded	263
Eligible participants for recruitment	19
Number of successful recruitments	18

Further detail regarding the range of emergency incidents attended by the research team is included within the appendices. Appendix 21 presents a table outlining the nature of incidents allocated to the Specialist Paramedic in Critical Care (SPCC), with whom the research team was embedded. The incident descriptors were derived from the standardised categories used by the Ambulance Medical Priority Dispatch System (AMPDS), offering a clear view of the broad spectrum of cases managed during the study period. Appendix 22 presents this data in diagrammatical form to visually reinforce that, despite the variety of calls attended, out-of-hospital cardiac arrests remained the primary focus of the research team's efforts and underpins the appropriateness of collaborating with critical care paramedics. Their advanced clinical expertise resulted in frequent attendance at high-acuity incidents, which, along with their strategic deployment patterns, reaffirmed their position as the most effective means of accessing this patient group. While limitations were inevitable, the decision to work alongside this team maximised the potential for successful enrolment and ensured that the study was positioned as close to the point of intervention as realistically possible within the operational context.

6.3.1.1 Exclusions

Due to the highly varied nature of the incidents allocated to the Specialist Paramedics in Critical Care, many patients were excluded from the research. The reasons varied on the patient presentation and are highlighted in the Table 6.3.

Table 6.3 Exclusions

Exclusion reason	Number
Under 16 years of age	23
Breathing on arrival	25
Care home resident	1
Close resources therefore stood down	2
Conscious and breathing on arrival	122
Diverted to alternative incident	1
Do Not Attempt CPR order in place	5
Dead on arrival	14
Futility decision made	26
Hoax call	3
Inappropriate for researcher to attend	1
Lack of adequate resources / nature of location not suitable	1
Multiple patients	2
Police incident / crime scene	1
ROSC	11
Stood down enroute	46
Total	283

A criticism of the AMPDS system employed by ambulance service trusts is that not all incidents that are coded as 'cardiac arrest' have an actual patient in cardiac arrest at their source. Similarly, even for the patient that were true cardiac arrest patients, many did not meet the strict inclusion and exclusion

criteria. The below Table 6.4 shows a breakdown of cardiac arrest calls and the specific aspects of the exclusion criteria that were met. This is illustrated in a simple bar diagram in Appendix 23.

Note: One cardiac arrest which met the inclusion criteria had an insufficient quantity of data required to create a case study in the desired format. This was due to the resuscitation attempt being terminated almost immediately as the researcher arrived on scene.

Table 6.4 Cardiac arrest code exclusion reason

Exclusion Criteria	Number
Under 16 years of age	3
Breathing	7
Care home resident	1
Close critical care resource	1
Patient conscious and breathing on arrival	17
DNACPR	4
DOA	11
Futility	21
Hoax call	1
Multiple patients	1
Police incident	1
ROSC	9
Total	86

6.3.1.2 Ambulance shift data

Activity data were recorded in the form of number of shifts recorded. Shifts typically were ten hours in duration, with some twelve-hour shifts included. Often shifts would over run past their originally planned end time. Stations in which the Specialist Paramedics in Critical Care were based included Doncaster and Sheffield, in South Yorkshire, and Leeds, Bradford or Manor Mill (a station that also was co-located with the regional Hazardous Area Response Team (HART)). Table 6.5 shows the number of shifts undertaken out of these respective stations, and Table 6.6 shows the number of successful recruitments yielded from these respective stations. West Yorkshire was favoured over South due to activity and cardiac arrest data showing increased likely exposure to cardiac arrest patients in this geography.

Table 6.5 Stations used and total number of SPCC shifts completed at each

Total shifts: 51

Ambulance station location				
South Yorkshire		**West Yorkshire**		
Doncaster	**Sheffield**	**Leeds**	**Bradford**	**Manor Mill**
5	3	20	22	1

Table 6.6 Number of recruited participants at each station

Ambulance station location				
South Yorkshire		**West Yorkshire**		
Doncaster	**Sheffield**	**Leeds**	**Bradford**	**Manor Mill**
1	0	11	7	0

6.3.1.3 Participant demographic data

Analysis of the successfully recruited participants was broken down across a range of demographic parameters. These data are presented in the following series of tables and figures. Table 6.7 illustrates that two-thirds of participants were male (n=12), and 27.8% (n=5) were aged between 70 and 79. Figure 6.5 shows the median age to be 65 years, with an interquartile range (IQR) of 23.75 years (Q1 = 50, Q3 = 73.75), capturing a broad age spread among participants, who ranged from 30 to 90 years old.

The objective in collecting these demographic and clinical data was to enable further analysis of the potential relationships between individual patient characteristics—such as age, sex, and comorbidities that could then be considered alongside quantified aerosol data during resuscitation. Comorbidities recorded included cardiovascular disease (n=7), chronic obstructive pulmonary disease (COPD) (n=4), hypertension (n=4), chronic kidney disease (CKD) (n=1), obesity (n=8), and intravenous drug use (n=3). Of the 18 successfully recruited participants, 50% (n=9) were described as average build with the three most prevalent comorbidities being heart disease or heart failure (38.9%), respiratory disease (22.2%) and hypertension (22.2%) (Table 6.8). However, the relatively small overall sample size (n=18), combined with the limited number of participants in each comorbidity category, presented substantial challenges to conducting meaningful subset analysis. The presence of overlapping health conditions further limited the ability to isolate the influence of any single variable. Despite these limitations, the intention behind capturing such detailed clinical data remains valid. The structured approach to data collection lays a foundation for hypothesis generation and identifies key variables of interest that could be explored more robustly in future, larger-scale studies. This experience also provides valuable methodological insight into the challenges of real-world prehospital research and underscores the need for collaborative, multi-centre approaches when attempting to investigate complex physiological outcomes in dynamic clinical environments.

Table 6.7 Participant age and sex data

	Sex		Age					
	Male	**Female**	**30-39**	**40-49**	**50-59**	**60-69**	**70-79**	**80-89**
n=18	12	6	2	2	4	2	5	3
%	66.7	33.3	11.1	11.1	22.2	11.1	27.8	16.7

Figure 6.5 A 'box and whisker' plot showing interquartile range, with minimum and maximum values regarding age data of successfully recruited participants. Note; median marked as +.

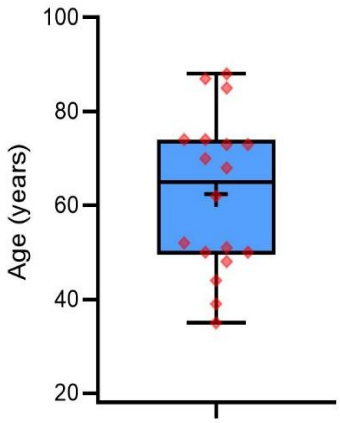


Table 6.8 Breakdown by descriptors of successfully recruited participants' body habitus and comorbidities.

(Key: Hx = History, COPD = Chronic Obstructive Pulmonary Disease, CKD, Chronic Kidney Disease, HTN = Hypertension, IVDU = Intravenous Drug User).

	Appearance / build			Comorbidities					
	Average	**Overweight**	**Cachexic**	**Cardiac Hx**	**COPD**	**CKD**	**HTN**	**Diabetes**	**IVDU**
n=18	9	8	1	7	4	1	4	2	3
%	50	44.4	5.6	38.9	22.2	5.6	22.2	11.1	16.7

6.3.1.4 Overview of compression delivery method

Chest compressions was a focus of this project. An observation was that all participants received manual chest compressions prior to the researcher's arrival. During data collection, participants received either manual or mechanical chest compressions, or both, manual being the most frequently observed method during data collection (61.1%) (see Table 6.9).

Mechanical chest compressions were performed by the AutoPulse® Resuscitation System which was standard issue to specialist paramedics in critical care within Yorkshire Ambulance Service.

Table 6.9 Breakdown of the number of participants that received either manual and / or mechanical chest compressions in the presence of the research team.

	Chest Compressions		
	Manual	**Mechanical**	**Both**
n=18	11	2	5
%	61.1	11.1	27.8

6.3.1.5 Out-of-hospital Cardiac Arrests calls not attended by research team

Auditing of cardiac arrest calls was carried out to identify peak times in which out-of-hospital cardiac arrest calls occurred and also to assist with shift and station selection in order to optimise exposure. This process enabled the identification of cardiac arrests that were not attended by the research team and so presented a possible missed opportunity to recruit potential participants, illustrated in Table 6.10.

Table 6.10 Incidence of out-of-hospital cardiac arrests (OHCAs) not attended by the research team.

Unattended OHCA	**Number**
Cardiac arrest	25
Hanging	1
Traumatic cardiac arrest	1
RTC	1

Audit of cardiac arrest calls that were not attended by the research team were reviewed to identify any inefficiencies in the research process. In total there were 28 cardiac arrests that were identified. These were either categorised as 'cardiac arrest', 'hanging', 'traumatic cardiac arrest', or 'Road Traffic Collision' (RTC) as per AMPDS. It was noted that these were due to the limited resources available to the research team. Cardiac arrests inevitably occurred when no researcher was on shift, or multiple cardiac arrests might occur in the same day and at similar times. Typically, two critical care resources would cover a large geography across Yorkshire at any given time and so would be required to travel significant distances to attend the scene. During these journey times, closer resources might become available and so be prioritised over the researchers' critical care resource. Similarly, when embarking on the journey to support the resuscitation, the non-specialist paramedic at scene might take the decision to stop resuscitation based on futility, likely due to information being identified at scene, as the researcher made their way to them and time progressed. It was simply not possible to maintain data collection 24 hours a day, 7 days a week, nor simultaneously over multiple vehicles in the same shift with the limited resources at the research team's disposal. Other reasons included alternative resources being in closer proximity to the emergency, critical care paramedics being taken off duty to complete alternative, non-clinical, duties, or the critical care resource being diverted to other emergency incidents such as a nearby car accident, involving patients that would not meet the inclusion criteria of this project. Critical care paramedics are senior clinicians and subject matter experts within their field, therefore the wider ambulance service would occasionally require them to attend meetings, such as governance days or support clinical safety reviews. This meant the critical care resource was unavailable to respond to emergencies throughout their whole shift and so also contributed to a missed recruitment. Table 6.11 lists the reasons for all the 28 cardiac arrests that occurred without the researcher in attendance and potentially met the research inclusion criteria, however this was not confirmed.

Table 6.11 Reasons for the 28 unattended OHCA

Reason	Number
SPCCs attending governance day	2
Closer critical care resource	4
SPCC closer to another emergency incident	1
Crew ceased resuscitation due to futility when SPCC enroute	1
Diverted to another emergency call	2
Occurred during night shift	16
No research shifts available	1
Critical care stood down for late meal	1
Critical care unavailable	1

6.3.2 Case Study data

Data collection for this study took place across multiple, complex, and highly variable prehospital environments, each centred around an active out-of-hospital cardiac arrest resuscitation attempt. These dynamic scenes presented numerous uncontrollable factors, including variable environmental conditions, the presence of multiple responders, and differing sequences of clinical interventions. In every case, chest compressions had already been initiated, either by bystanders, community first responders, or ambulance personnel, none of which wore PPE, and all of which occurred prior to the commencement of data collection. Given this lack of control over the timing and standardisation of interventions, establishing a formal control group was not feasible.

However, a baseline aerosol measurement was obtained in each case by recording particle levels at a distance from the resuscitation scene, within the same room or setting. While not equivalent to a matched control group, this approach provided a useful environmental comparator against which changes in aerosol dynamics during resuscitation could be interpreted.

Due to the heterogeneity of the cases and environments, the data are presented as individual case studies. Each case begins with a brief narrative describing the event alongside a summary table outlining key contextual and clinical background information. This is followed by two time-series charts: the first displaying total particle number concentration over time, and the second illustrating total mass concentration over time. Key clinical events, such as defibrillation, airway interventions, or return of spontaneous circulation, were time-stamped on each chart to support the reader with their interpretation. The dual-chart approach was designed to provide a more complete picture of aerosol behaviour during resuscitation. Total particle number concentration indicates the quantity of particles generated, while total mass concentration offers insight into particle composition, potentially distinguishing between lighter, inorganic material and heavier bioaerosols such as respiratory secretions. Together, these metrics allow for contextualised interpretation of aerosol generation collected within these real-world emergency care environments.

6.3.2.1 Case Study 1

This cardiac arrest involved a patient at home who received mechanical CPR throughout the data collection period. One defibrillator shock was administered prior to the researcher's arrival; a summary of resuscitation activity is captured in Table 6.12. The room was poorly ventilated with multiple people participating in the resuscitation at the time of monitoring. The total particle number and mass concentrations of aerosols recorded in the airway are notably higher than those at baseline (Figures 6.8 and 6.9). In this case, repeated spikes were noted in total mass concentration were recorded, peaking above >0.04 $gcm^{-3}min^{-1}$. Movement, verbal communication, and patient handling may have influenced aerosol dynamics. While the data reflect a clear increase in aerosol mass coinciding with continued resuscitative efforts, it is likely that both residual and ongoing aerosol-generating activity contributed to the pattern observed. With that caveat, the presented charts do reveal a significant generation of aerosols during mechanical chest compressions. The mass concentration chart demonstrates distinct spikes, indicating periods with a substantial total mass of aerosolised particles, that could potentially include larger respiratory droplets or biological material. The particle number concentration chart confirms a surge in the number of airborne particles during CPR, with sustained elevation throughout the resuscitation. These findings strongly suggest that, in this case, chest compressions could be a high-risk procedure for aerosol generation, capable of dispersing particles into the immediate environment. It is also important to note that although it is highly probable that bioaerosols were generated during the resuscitation, the mass and number concentration charts alone do not provide absolute confirmation.

Table 6.12 Summary of Case Study 1 pertinent background information

Environmental features	Inside residential dwelling, poorly ventilated room
Background	Witnessed cardiac arrest when sat on sofa by bystander. Immediate CPR.
Patient age & sex	62-year-old male
Comorbidities	Nil reported
Body habitus	Average / overweight
Prior to arrival of researcher	1 x defibrillator shock (200 joules) and an IV adrenaline administered
Cardiac arrest Rhythm	VF then PEA
Airway patency	I-Gel in situ
Total number of defibrillator shocks	1
Number of people in vicinity of patient	5 ambulance, 4 family
PPE status of those present	None worn
CPR	Mechanical CPR throughout data collection

Figure 6.8 Case Study 1 - Total Particle Number concentration against time

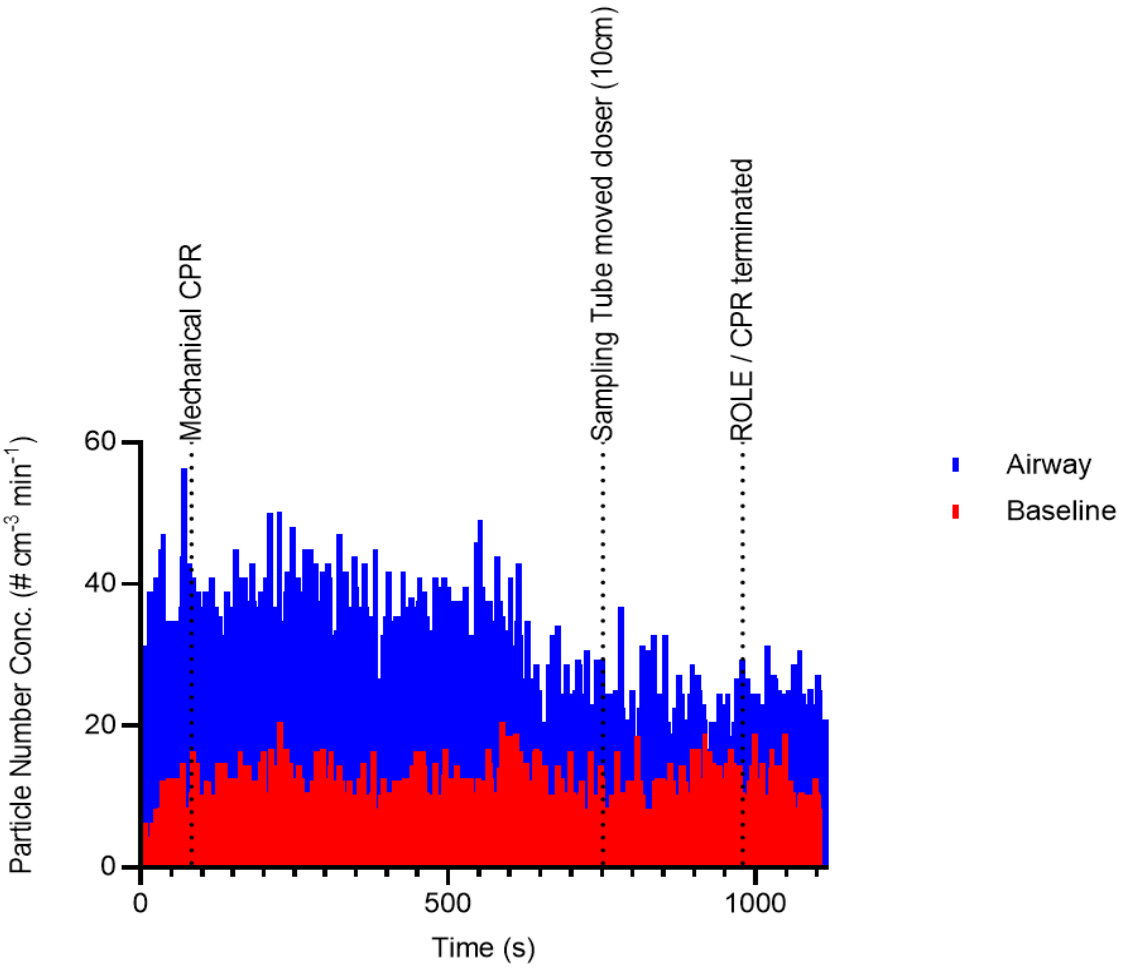
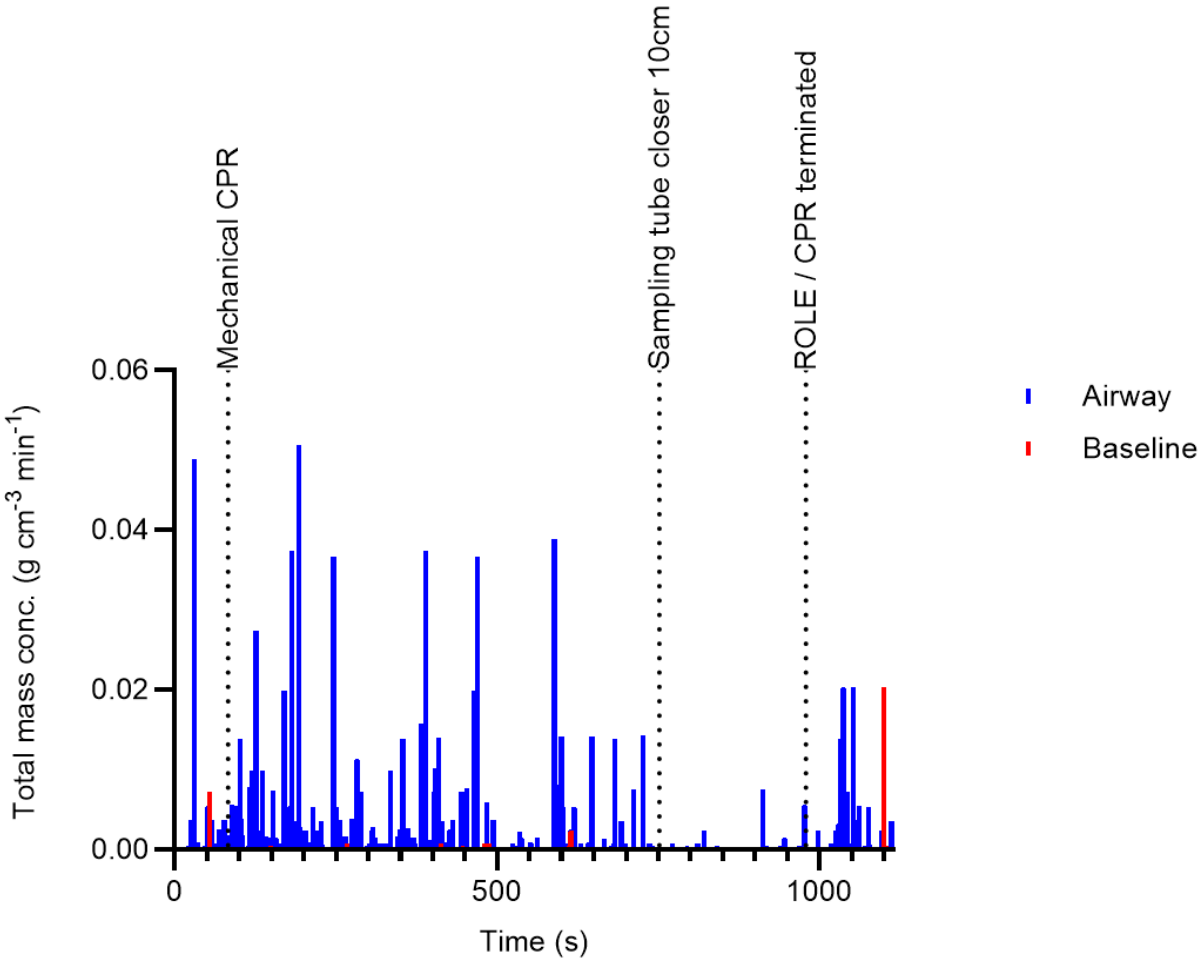


Figure 6.9 Case Study 1 - Total Particle Mass concentration against time



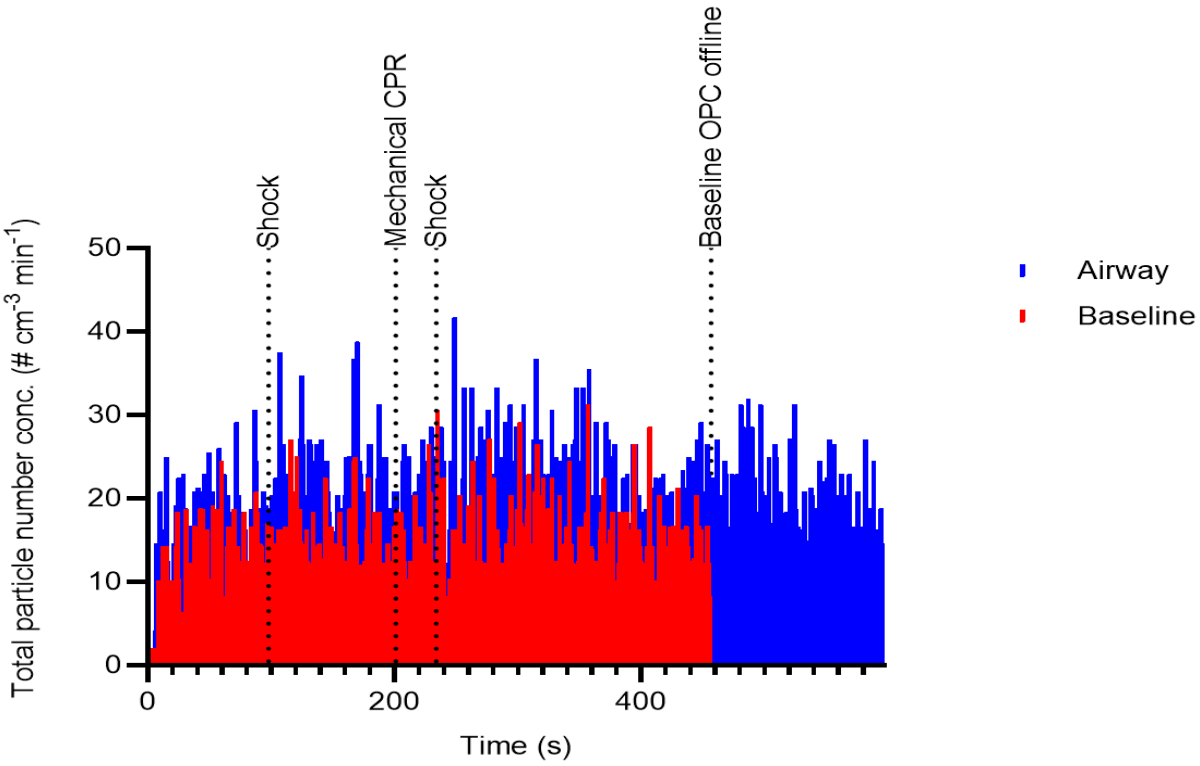
6.3.2.2 Case Study 2

Case Study 2 involved the resuscitation of a patient in an open, indoor industrial environment. A total of 9 defibrillator shocks were administered, 3 of which occurred during data collection. These shocks were accompanied by mechanical chest compressions that were performed throughout (Table 6.13 summarises the resuscitation event). It is noteworthy to mention that the OPC located at the baseline area was briefly taken offline due to a period of CPR-induced consciousness, which complicated data collection. Shortly afterwards, the patient achieved Return of Spontaneous Circulation and data collection ceased; however, a further cardiac arrest occurred, and the patient was declared deceased upon arrival at the hospital, hence the inclusion of their data (see Figure 6.10 and 6.11). While the mass concentrations are generally lower than in the previous case, the spikes in particle number following defibrillator shocks suggest the generation of numerous smaller particles that could still carry infectious agents. The presence of background particles in the industrial setting adds to the overall airborne particle burden. Overall, aerosol concentrations appear lower in this open industrial setting than in the previous case; however, the procedures of mechanical CPR and defibrillator shocks still seem to be associated with some aerosol generation from the patient's airway. The open environment may influence dispersion, but this chart again highlights the importance of consistent PPE to protect healthcare providers from potential bioaerosol exposure.

Table 6.13 Summary of Case Study 2 pertinent background information

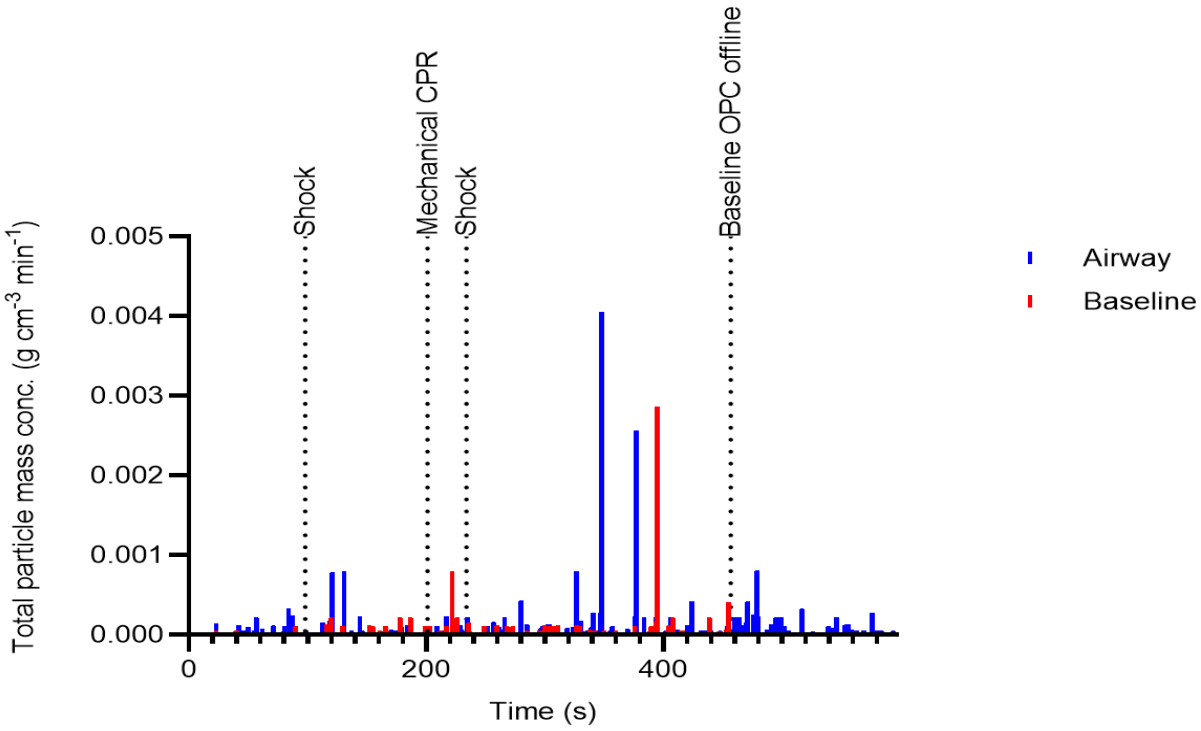
Environmental features	Warehouse, large open factory workspace.
Background	Felt lightheaded at work. Witnessed cardiac arrest. Bystander CPR.
Patient age & sex	48 year old male
Comorbidities	None known
Body habitus	Appeared overweight
Care prior to arrival of researcher	6 shocks. 1 IV adrenaline, 2 IV Amiodarone
Cardiac arrest Rhythm	Refractory VF / VT
Airway patency	I-Gel in situ
Total number of defibrillator shocks	9 total. 3 during data collection
Number of people in vicinity of patient	6 YAS, 1 bystander
Mask status of those present	None worn
CPR	Mechanical CPR throughout data collection

Figure 6.10 Case Study 2 - Total Particle Number concentration against time.



Note: 'Shock' indicates a defibrillator shock was administered.

Figure 6.11 Case Study 2 - Total Particle Mass concentration against time.



6.3.2.3 Case Study 3

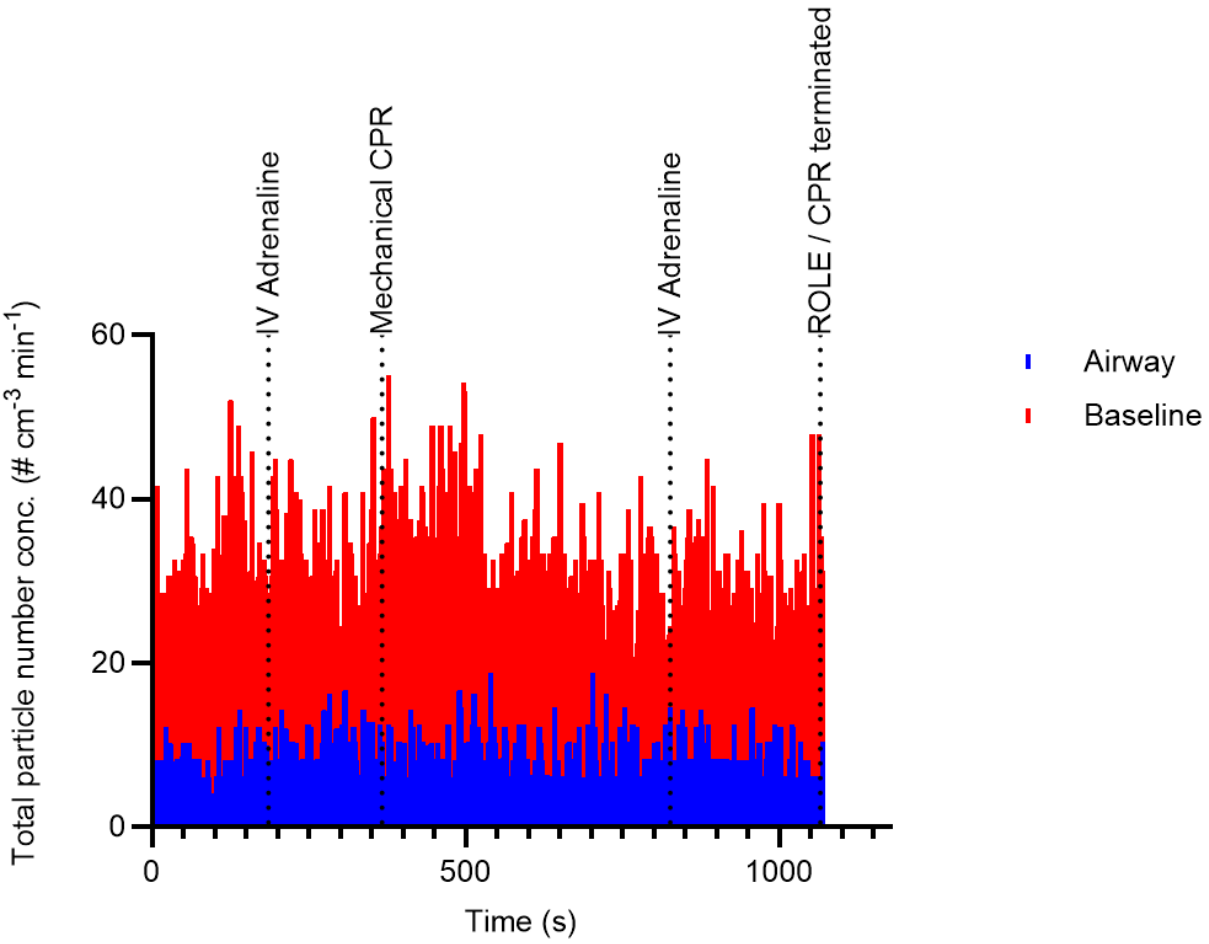
In contrast to the earlier case studies, this cardiac arrest scene was outdoors and notably showed a total particle and mass concentrations to be higher at baseline. The scene involved a patient who had been pulled from a vehicle having suffered a suspected medical cardiac arrest, that is to say no road traffic collision had occurred (summarised in Table 6.14). The conditions were windy, with the patient shielded by the vehicle and the resuscitation team. The baseline sample port, however, was exposed to the very window conditions, which might explain this disparity (see Figures 6.12 and 6.13). The patient's airway, heavily soiled with vomit, likely contributed to the reduced generation of respiratory aerosols at the airway. The data presented, particularly the mass concentration chart, suggests that the spikes observed in the baseline are predominantly due to windborne environmental particulate matter, such as

dust. The baseline shows distinct, sharp spikes, characteristic of intermittent wind gusts carrying concentrated bursts of larger, heavier particles past the sensor. While the presence of some bioaerosols from either the patient or the environment cannot be entirely discounted, the consistently high baseline levels and the lack of significant increases in the airway, coupled with the soiled airway, allude to environmental dust as the primary contributor to the measured particle mass. The soiled airway further diminishes the likelihood of substantial aerosolisation of respiratory fluids, and thus, a significant mass contribution from patient-generated bioaerosols.

Table 6.14 Summary of Case Study 3 pertinent background information

Environmental features	Outside, near a car, windy weather (background OPC not shielded by car)
Background	Found in locked car, no obvious trauma.
Patient age & sex	51 year old, male
Comorbidities	Unknown
Body habitus	Average
Care prior to arrival of researcher	i-Gel inserted,
Cardiac arrest Rhythm	asystole
Airway patency	Initially heavily soiled with vomit initially, i-Gel in situ at SPCC arrival
Total number of defibrillator shocks	0
Number of people in vicinity of patient	7 YAS, 10 fire, 4 police + 2 dogs.
Mask status of those present	None worn
CPR	Manual & mechanical

Figure 6.12 Case Study 3 - Total Particle Number concentration against time

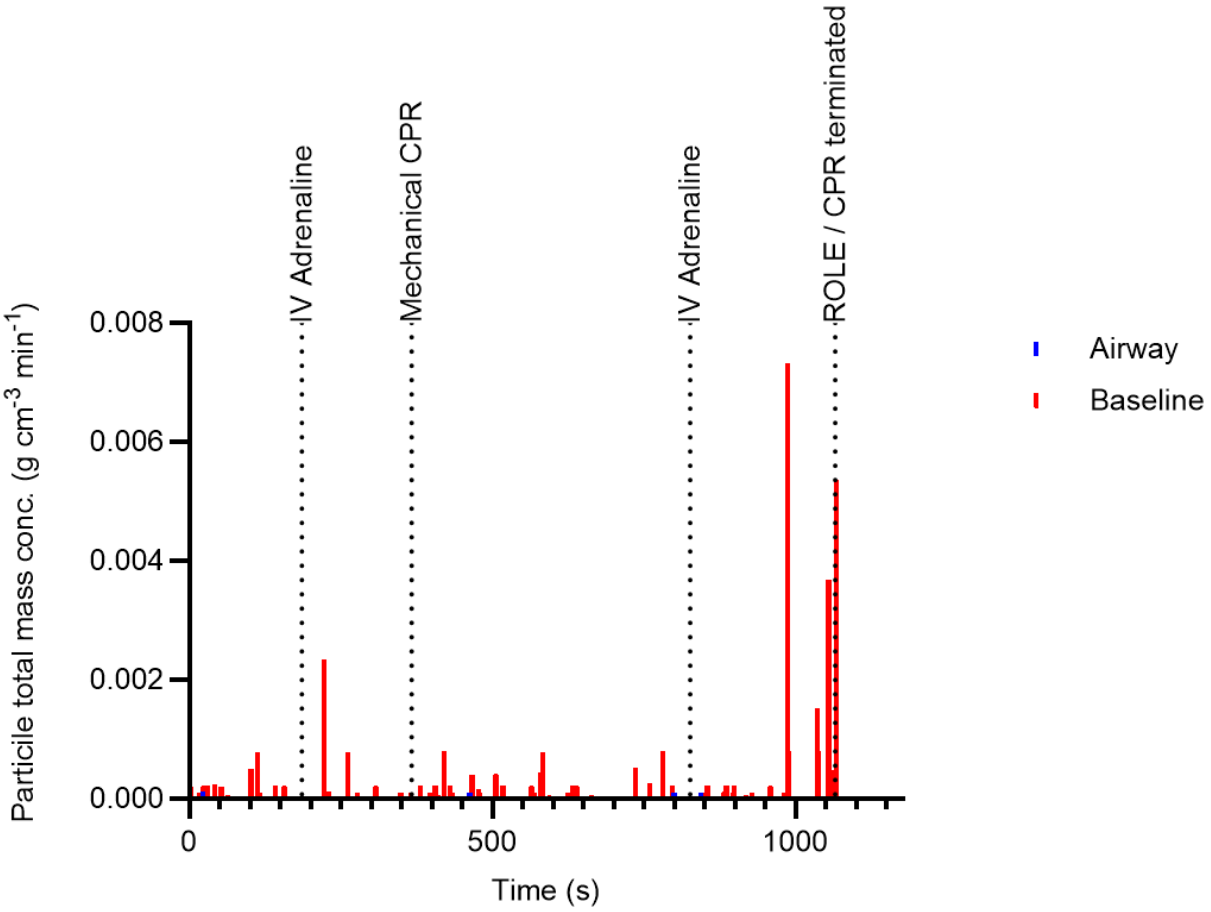


Note:

'IV adrenaline' indicates intravenous adrenaline had been administered.

'ROLE' indicates 'Recognition of Life Extinct' and so cessation of the resuscitation attempt.

Figure 6.13 Case Study 3 - Total Particle Mass concentration against time



6.3.2.4 Case Study 4

This resuscitation attempt occurred within a small studio apartment room with a suggestion that the patient may have been deceased for a protracted period however, due to CPR being in progress by the police at the time of the critical care paramedics' arrival, ambulance guidance advises resuscitation to be continued until the full facts regarding any futility decision can be established. Events are summarised in Table 6.17. The associated charts for total particle number and mass concentration are both suggestive of higher levels at the airway versus baseline (see Figures 6.14 and 6.15). When considered together, the observations from both the particle number and mass concentration charts in Case Study 4 indicate a significant release of aerosols from the patient's airway within the confined space of the studio apartment. The particle number chart shows a generally higher concentration of particles originating from the airway, with spikes at the beginning and end of data collection and sustained elevated levels during mechanical CPR. The mass concentration chart further emphasises this, revealing prominent spikes in larger, heavier particle size ranges which coincide with the start and end of CPR and a sustained elevation in airway mass concentration throughout. These findings, coupled with the case description, suggest a potentially deceased patient with stagnant airway fluids pointing to a high likelihood of bioaerosol generation, including both smaller and larger particles. The confined environment would exacerbate the risk by limiting aerosol dispersion, leading to higher concentrations in the rescuers' breathing zone. Therefore, both charts underscore a possible risk of exposure to potentially hazardous bioaerosols to rescuers in attendance, highlighting the importance of PPE and careful consideration of the duration and potential futility of resuscitation efforts.

Table 6.17 Summary of Case Study 4 pertinent background information

Environmental features	Residential dwelling. Studio flat.
Background	Evidence of mottling & suggestion of rigor mortis
Patient age & sex	50 year old, male
Comorbidities	History of alcohol and intravenous drug use.
Body habitus	Overweight
Care prior to arrival of researcher	Police carrying out CPR at arrival of SPCC.
Cardiac arrest Rhythm	Asystole throughout resuscitation attempt
Airway patency	Soiled with suspected vomit
Total number of defibrillator shocks	0
Number of people in vicinity of patient	8 YAS, 4 police.
Mask status of those present	None worn
CPR	Early switch to mechanical from manual CPR

Figure 6.14 Case Study 4 - Total Particle Number concentration against time

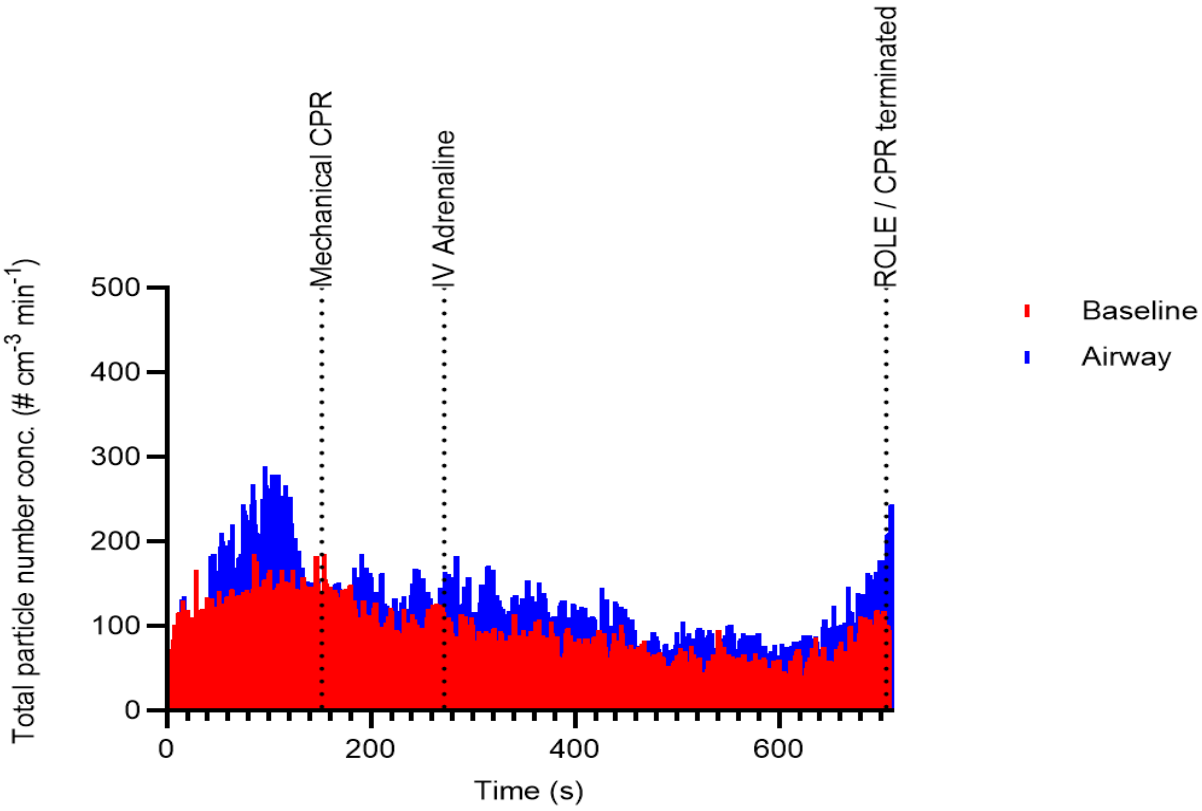
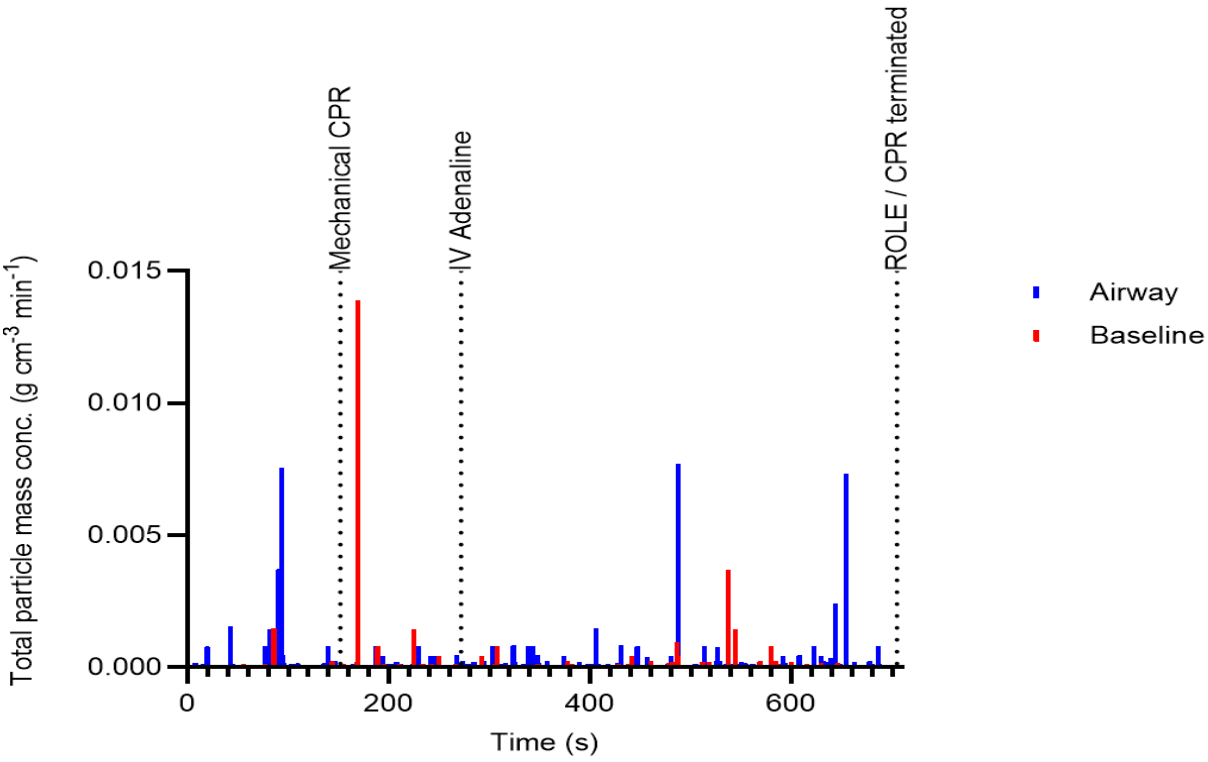


Figure 6.15 Case Study 4 - Total Particle Mass concentration against time



6.3.2.5 Case Study 5

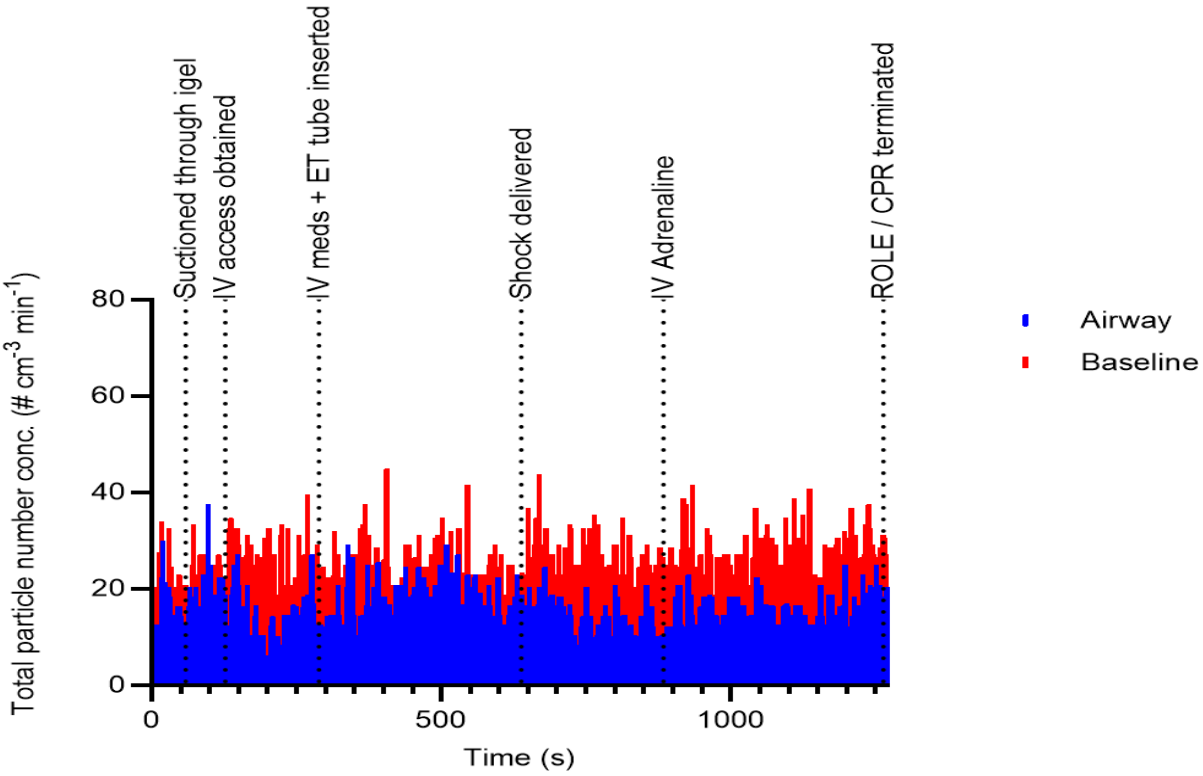
This case involved manual chest compressions in a domestic, residential setting. 9 people were part of the rescue attempt, none of whom wore masks. One defibrillator shock was administered during the resuscitation and captured within the data with no apparent spike in number or mass concentration at the airway (see Table 6.16). Interestingly higher concentrations were noted at baseline for total particle number and mass concentrations throughout (Figures 6.16 and 6.17). The patient had been moved from one room to another to enable access and support the resuscitation attempt which might be a contributor in this regard. This movement of the patient and a large number of people present could have potentially increased environmental aerosols in circulation by mobilising and redistributing existing household dust and allergens, leading to the elevated baseline readings observed throughout the resuscitation attempt.

Combining the observations from both the particle number and mass concentration charts in Case Study 5 reveals a scenario where the initial airway procedures (suctioning and IV access) generated a transient release of both numerous smaller particles (high number concentration spike) and larger, heavier particles (high mass concentration spike) from the patient's airway, seen at around the 100-second point in both charts. During the subsequent manual chest compressions, the airway particle number remained relatively stable and lower than the baseline. At the same time, the airway mass concentration also stayed low, suggesting that manual CPR, in this instance, did not forcefully aerosolise significant quantities of particles.

Table 6.16 Summary of Case Study 5 capturing pertinent background information

Environmental features	Moved from small kitchen to living room to enhance access.
Background	Breathlessness then collapsed. Witnessed arrest with bystander CPR
Patient age & sex	88 year old, male
Comorbidities	Cardiac issues, dementia
Body habitus	Average
Care prior to arrival of researcher	CPR and suctioning of airway and i-Gel inserted
Cardiac arrest Rhythm	Asystole - VF - Asystole – PEA
Airway patency	Soiled initially, i-Gel replaced with ETT
Total number of defibrillator shocks	1 (200 joules)
Number of people in vicinity of patient	7 YAS, 2 witnesses
Mask status of those present	None worn
CPR	Manual

Figure 6.16 Case Study 5 - Total Particle Number concentration against time



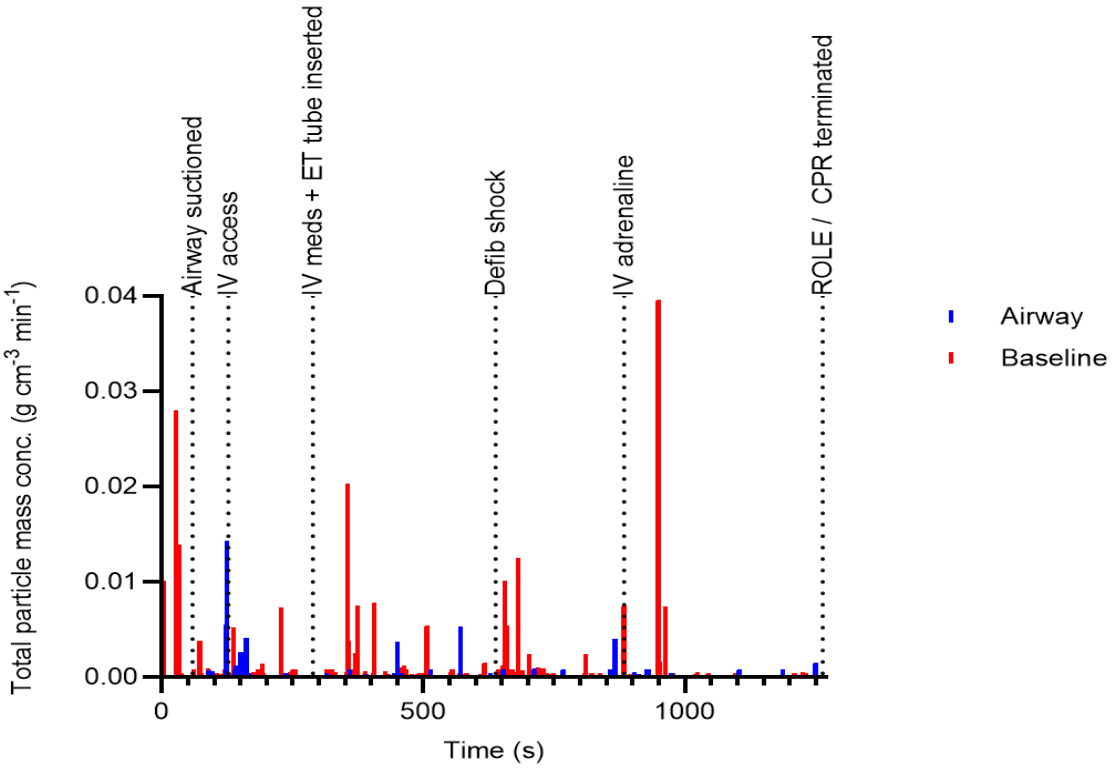
Note:

'Igel' refers to a supraglottic airway device used by Yorkshire Ambulance Service.

'ET Tube' refers to endotracheal intubation taking place.

'IV meds' refers to intravenous medications, this will include adrenaline, fluids and amiodarone.

Figure 6.17 Case Study 5 - Total Particle Mass concentration against time



6.3.2.6 Case Study 6

Similarities in the setting, level of attendance, and actions performed at the scene can be observed when comparing Case Study 6 with the previous Case Study 5. A notable difference is the level of ventilation and the omission of any movement of the patient. Data capture occurred within a well-ventilated, spacious apartment that enabled access and negated the need to pull the patient to a more open area (see Table 6.17). They received two defibrillator shocks prior to the the arrival of the researcher, and data showed increased total particle number and mass concentrations at the airway versus baseline with 10 rescuers/witnesses in the vicinity (Figures 6.17 and 6.18). During the initial phase of manual chest compressions, the total particle number and mass concentrations were elevated in the patient's airway compared to the baseline. This indicates that manual chest compressions as potential direct source of aerosol generation, expelling both numerous smaller particles and some larger, heavier particles from the patient's airway. Despite the well-ventilated environment potentially aiding in the dispersal of these aerosols, the higher concentrations measured near the airway during manual CPR suggest a potential risk of exposure to bioaerosols for the nearby rescuers, again underscoring the importance of respiratory protection even during manual chest compressions, although any generalisable findings based solely on this case should be made with extreme caution.

Table 6.17 Summary of Case Study 6 pertinent background information

Environmental features	Domestic apartment. Open door providing ventilation.
Background	Bed bund 5 days, respiratory issues. Witnessed cardiac arrest by YAS Immediate CPR.
Patient age & sex	68 year old, female
Comorbidities	Heart failure, hypertension, obesity, kidney disease, squamous cell carcinoma, disease, lung malignancy.
Body habitus	Overweight
Care prior to arrival of researcher	CPR, 'i-Gel', 2 defib. shocks prior to SPCC arrival.
Cardiac arrest Rhythm	?VT - asystole – PEA
Airway patency	Clear. Maintained with i-Gel throughout.
Total number of defibrillator shocks	2 (prior to SPCC arrival)
Number of people in vicinity of patient	6 YAS, 4 carers
Mask status of those present	None worn
CPR	Manual

Figure 6.17 Case Study 6 - Total Particle Number concentration against time

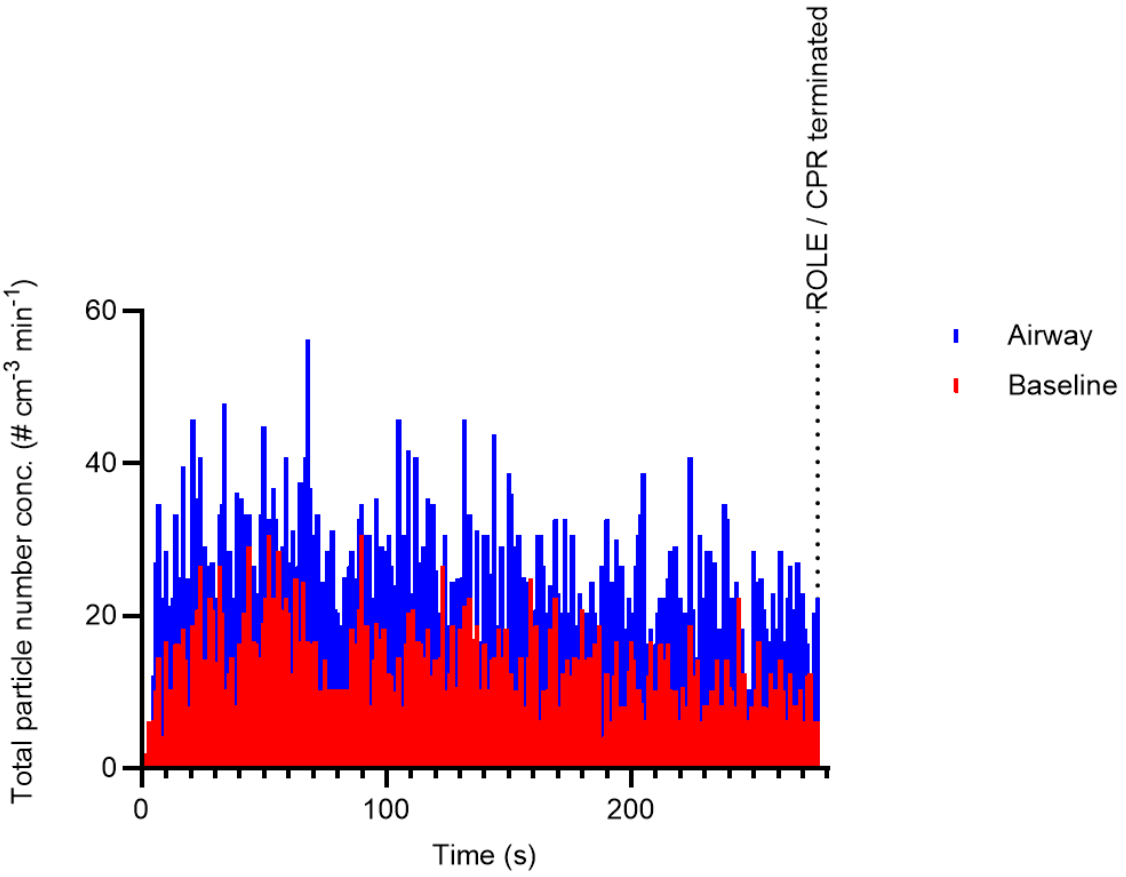
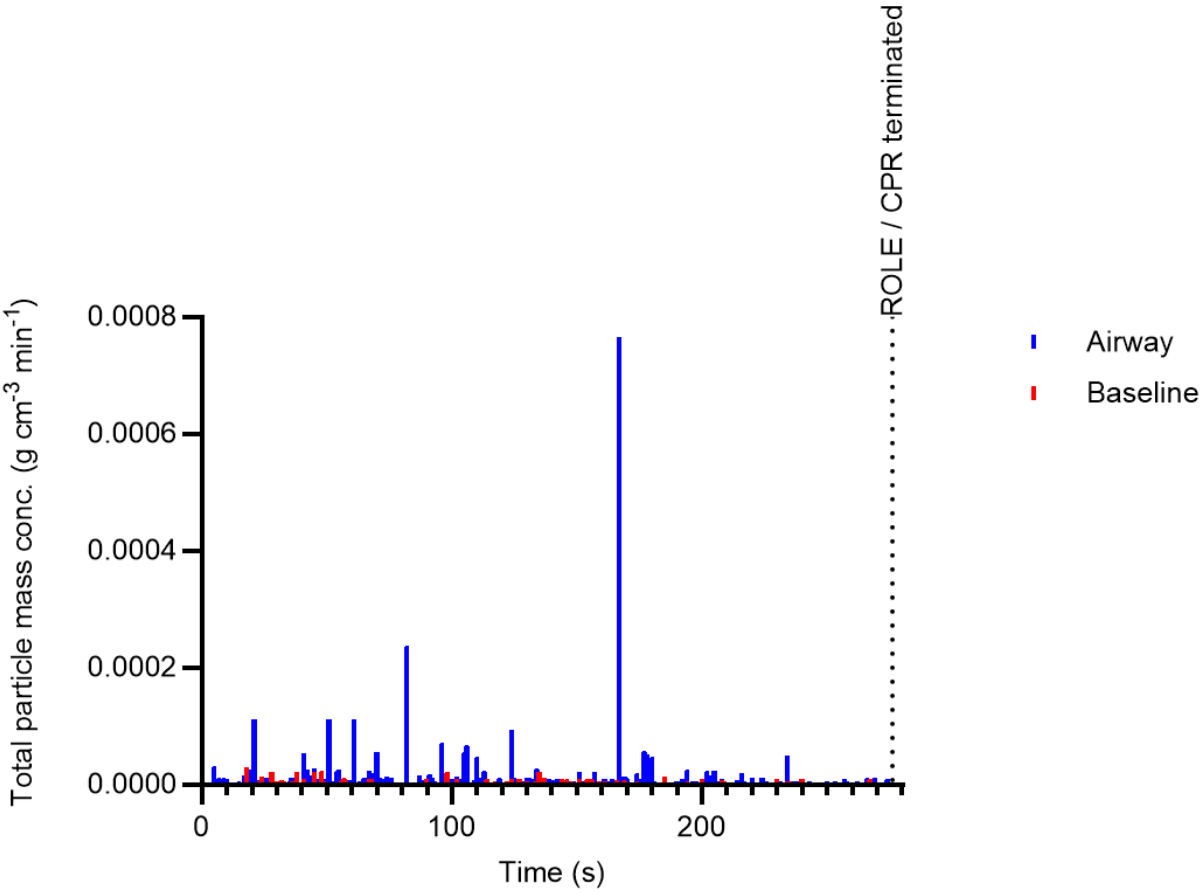


Figure 6.18 Case Study 6 - Total Particle Mass concentration against time



6.3.2.7 Case Study 7

Case Study 7 features a 52-year-old make and recreational drug user who achieved repeated ROSCs (return of spontaneous circulation). They received both mechanical and manual chest compressions. Data collection was stopped at each ROSC and then reinstated as the patient went back into a cardiac arrest state. The patient was transported to the hospital and later pronounced deceased, hence their inclusion. A notable spike in total particle number and mass concentration was observed at the airway sampling OPC shortly after the first episode of 're-arrest', at around the 150-second mark (see Figures 6.19 and 6.20). This had no link to any procedures of resuscitation other than manual chest compressions that were administered throughout this period.

Case Study 7 reveals a consistent picture of significant aerosol generation from the patient's airway during resuscitation, particularly in conjunction with chest compressions. The particle number data shows a notable, unexplained spike shortly after the resumption of manual CPR, indicating a sudden release of numerous smaller particles. This event is corroborated by a corresponding spike in the mass concentration data, signifying the expulsion of larger, heavier aerosols, simultaneously likely of biological origin given their size and the fact they were detected at the airway. Both charts also show elevated levels during periods of both manual and subsequent mechanical CPR, confirming that chest compressions, regardless of the method, effectively aerosolised particles of varying sizes from the patient's airway. Despite these significant airway events, the baseline particle number and mass concentrations remained generally low, suggesting that the aerosol release was localised to the patient's immediate vicinity. Overall, the data highlights the potential for significant and unexpected aerosol release during CPR and the need for consistent and robust respiratory protection for rescuers involved throughout the resuscitation attempt.

Table 6.18 Summary of Case Study 7 pertinent background information

Environmental features	Small living room. Well-ventilated via open windows
Background	Found on sofa not breathing, unwitnessed arrest, bystander CPR for 15 minutes. Suspected overdose.
Patient age & sex	52 year old, male
Comorbidities	Recreational drug user.
Body habitus	Above average
Care prior to arrival of researcher	i-Gel and CPR
Cardiac arrest Rhythm	Asystole and with multiple ROSC
Airway patency	Clear, i-Gel throughout
Total number of defibrillator shocks	0
Number of people in vicinity of patient	7 YAS, 1 witness
Mask status of those present	None worn
CPR	Manual & mechanical

Note: 'PEA' refers to Pulseless Electrical Activity which is a rhythm in cardiac arrest whereby the electrocardiogram shows activity suggestive of heart activity, but no pulse is produced.

Figure 6.19 Case Study 7 - Total Particle Number concentration against time

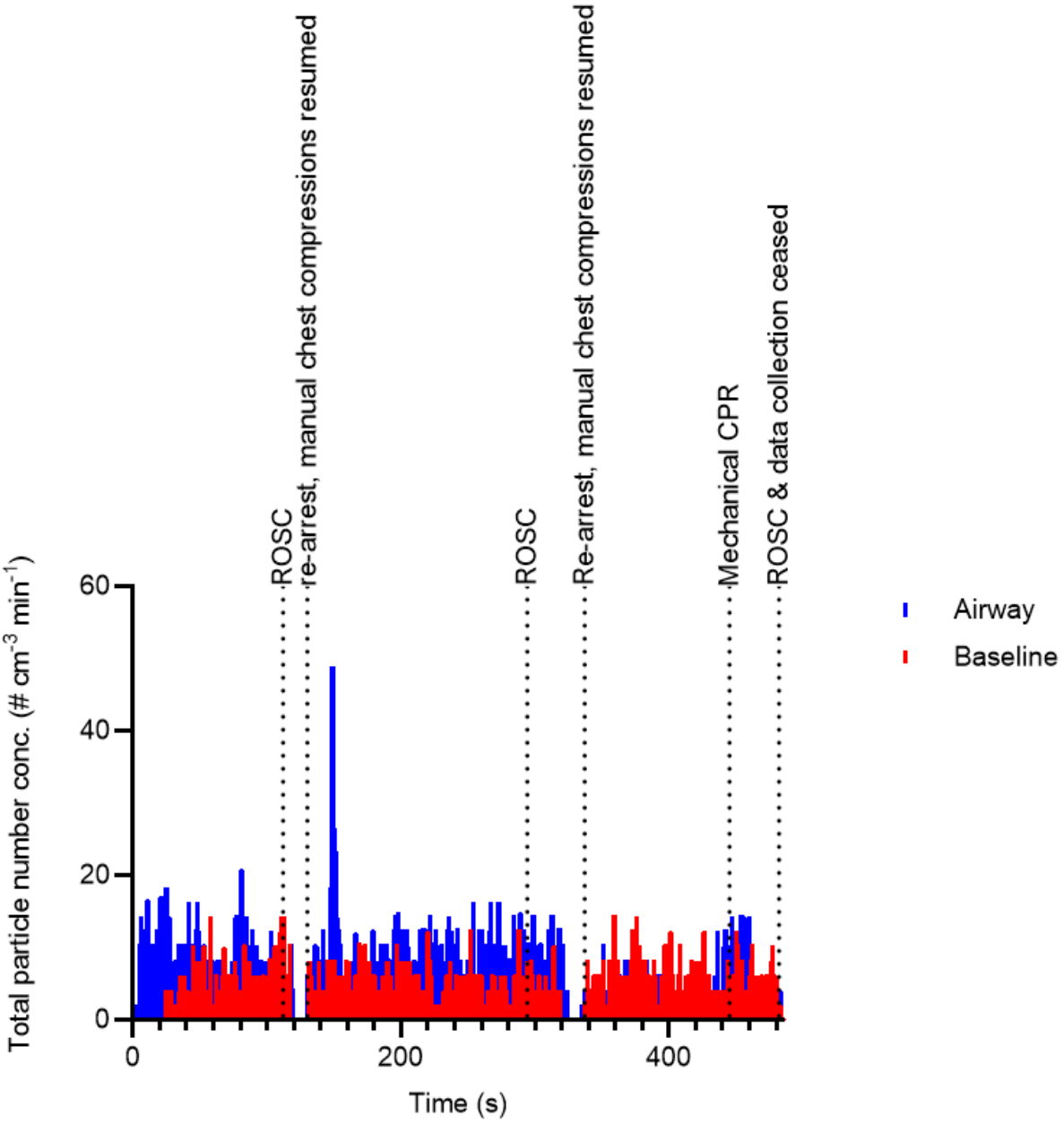
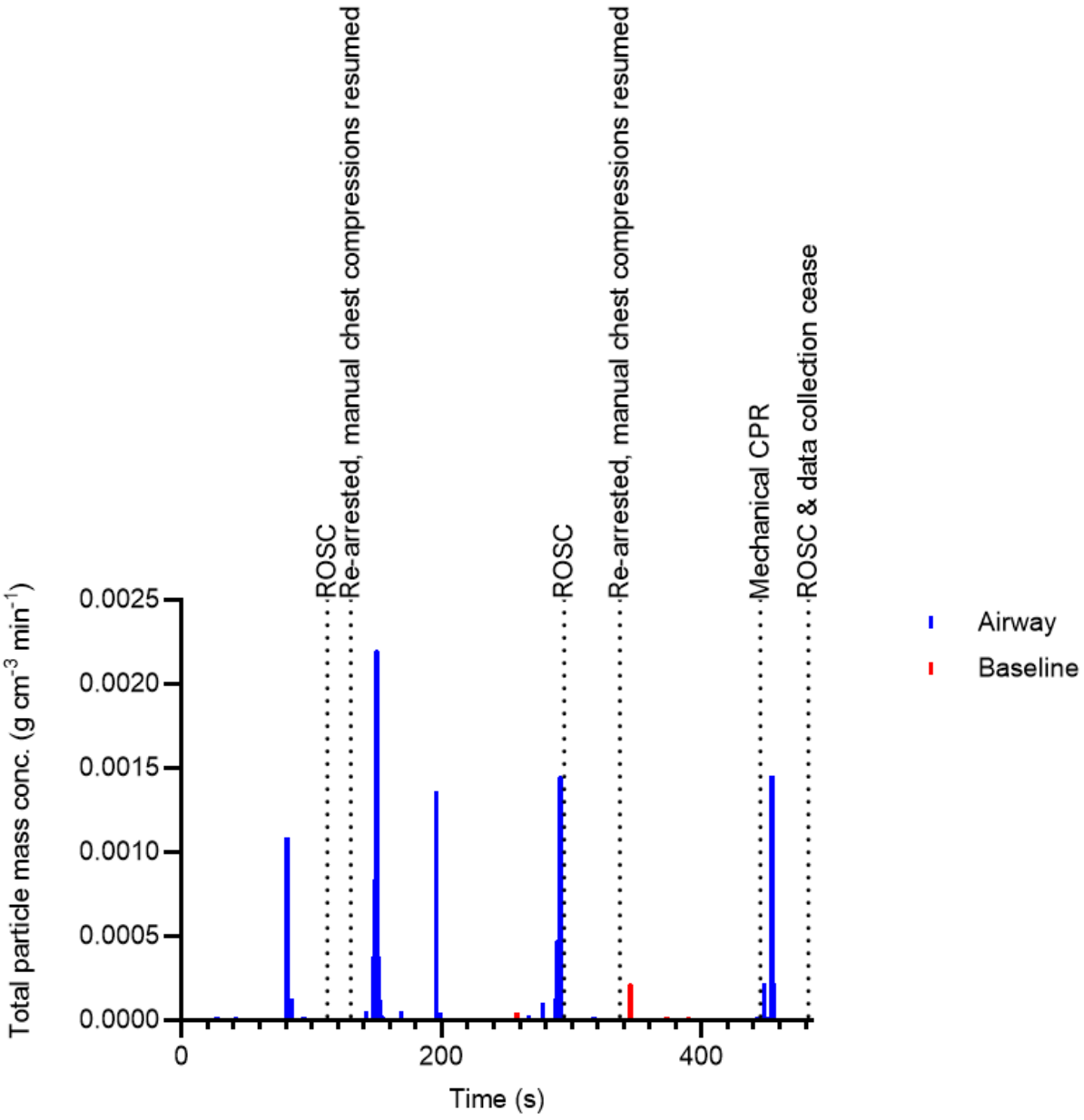


Figure 6.20 Case Study 7 - Total Particle Mass concentration against time



6.3.2.8 Case Study 8

This comparatively young male received resuscitation within the bedroom area of small studio flat. Manual and mechanical chest compressions were administered. The resuscitation attempt had been underway for a period prior to the researcher and critical care paramedics' arrival (Table 6.19 summarises the relevant, pertinent points of the overall resuscitation attempt). There is a suggestion on both charts of marginally increased concentrations of both total particle number and total particle mass at the airway when compared to baseline during the delivery of chest compressions (see Figures 6.21 and 6.22). The mass and number concentration data show marginal increase in larger aerosol release from the patient's airway during prolonged mechanical CPR. While the levels are not dramatically different, they still indicate a potential risk of exposure to larger bioaerosols for rescuers close to the patient. The low baseline mass data suggests limited environmental contamination.

Table 6.19 Summary of Case Study 8 pertinent background information

Environmental features	Studio flat, open front door, patient in living / bedroom, drug paraphernalia evident.
Background	Witnessed cardiac arrest by YAS
Patient age & sex	39 years old male
Comorbidities	Heart disease
Body habitus	Cachexic
Care prior to arrival of researcher	i-Gel, CPR, Intra Osseous access gained.
Cardiac arrest Rhythm	PEA – asystole
Airway patency	Clear, i-Gel
Total number of defibrillator shocks	0
Number of people in vicinity of patient	6 YAS, 1 witness
Mask status of those present	None worn
CPR	Manual & mechanical

Figure 6.21 Case Study 8 - Total Particle Number concentration against time

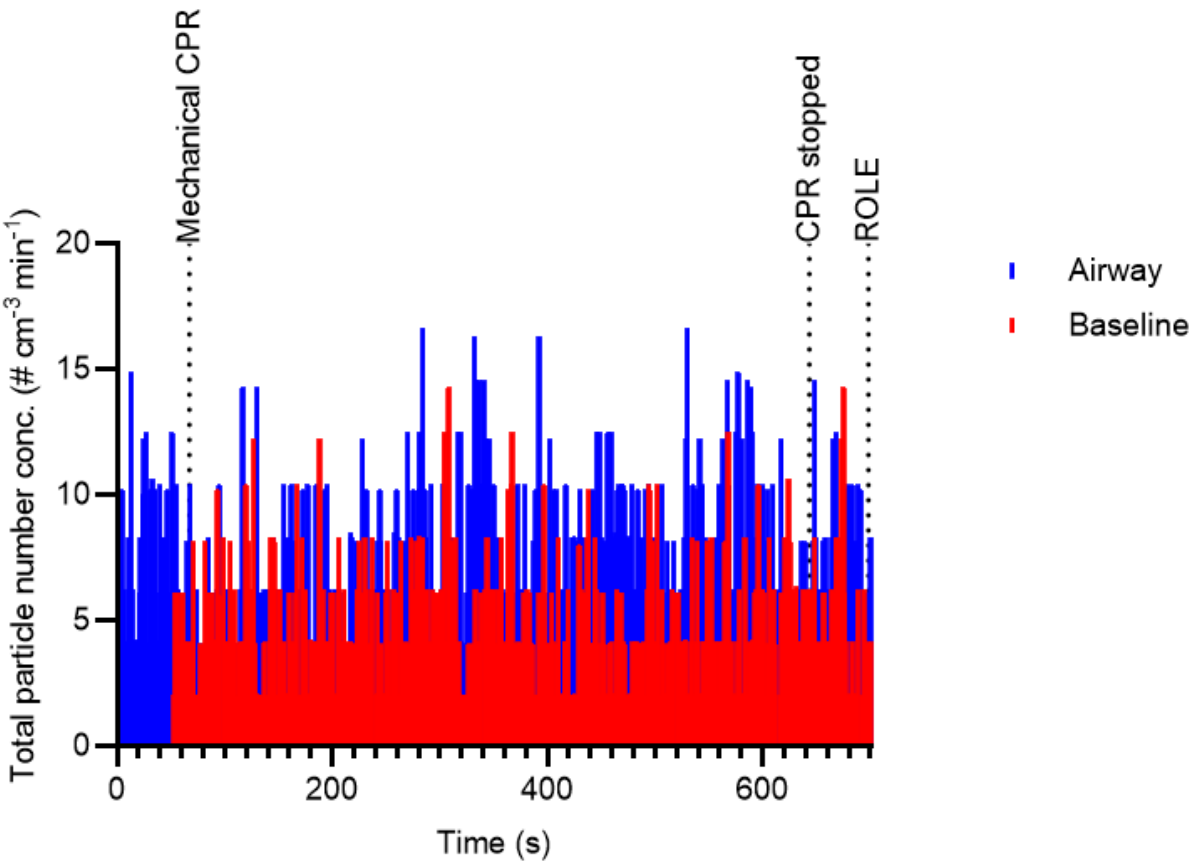
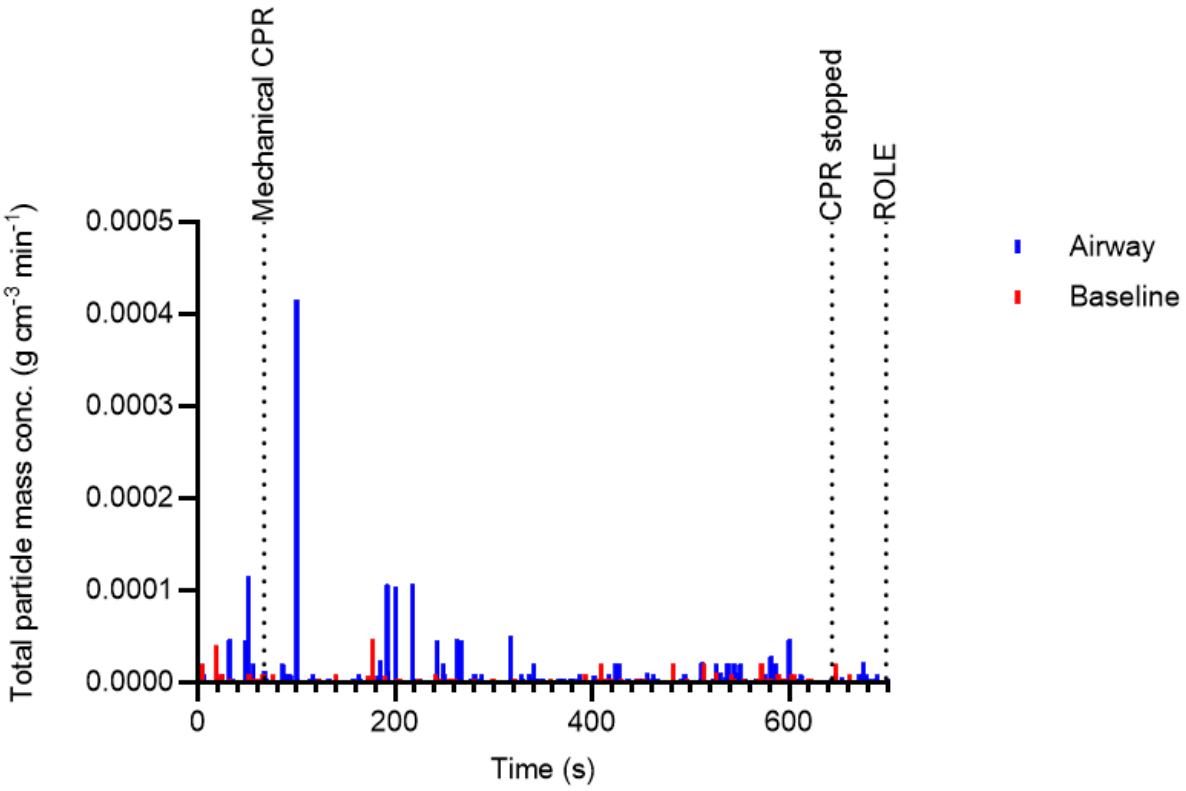


Figure 6.22 Case Study 8 - Total Particle Mass concentration against time



6.3.2.9 Case Study 9

This captured data during a brief period of CPR administered to elderly patient who was noted to have the presence of rigor mortis and so hence the resuscitation attempt was immediately stopped due to this being a condition unequivocally associated with death (see Table 6.20). A minute delay occurred between activation of the OPC at the baseline and the OPC at the airway which explains the lack of airway data for the first 70 seconds. For the limited amount of data gathered there is a suggestion of marginally higher particle number and mass concentration at the baseline (see Figures 6.23 and 6.24). This might be explained by CPR being administered for a brief period and the fact that rigor mortis indicates the patient had been dead for some time, thereby one might expect some drying of the oral mucosa and a reduced propensity to generate aerosols.

Table 6.20 Summary of Case Study 9 pertinent background information

Environmental features	Residential dwelling, bedroom.
Background	Found in bed, blood in mouth, last seen 24 hours earlier. Cold to touch.
Patient age & sex	85 year old, female
Comorbidities	Cardiac issues
Body habitus	Overweight
Care prior to arrival of researcher	CPR
Cardiac arrest Rhythm	Asystole
Airway patency	Clear but unable to insert i-Gel due to stiffness of jaw
Total number of defibrillator shocks	0
Number of people in vicinity of patient	6 YAS
Mask status of those present	None worn
CPR	Manual

Figure 6.23 Case Study 9 - Total Particle Number concentration against time

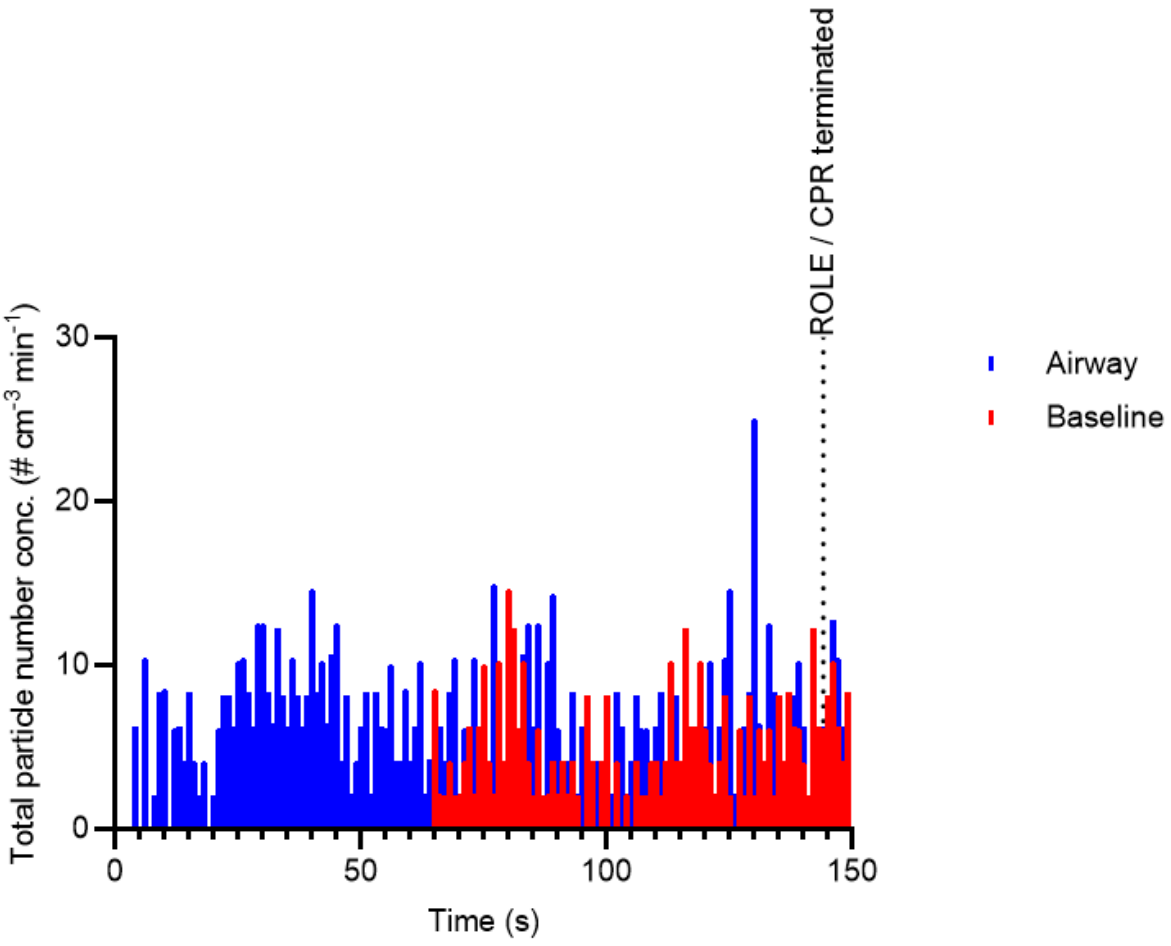
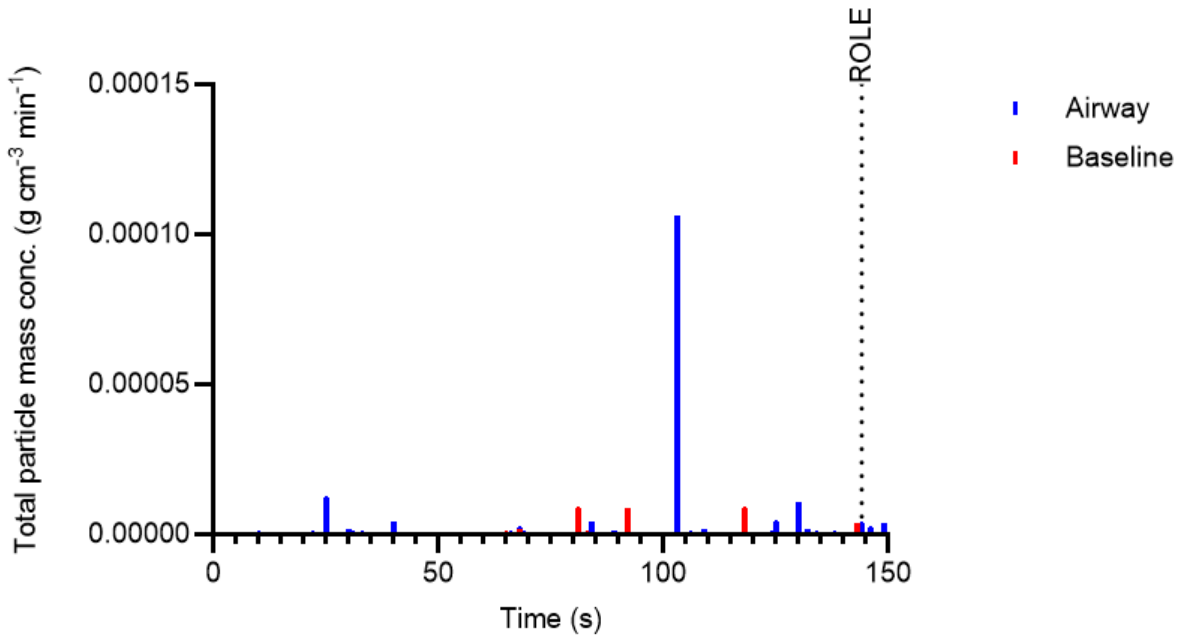


Figure 6.24 Case Study 9 - Total particle mass concentration against time



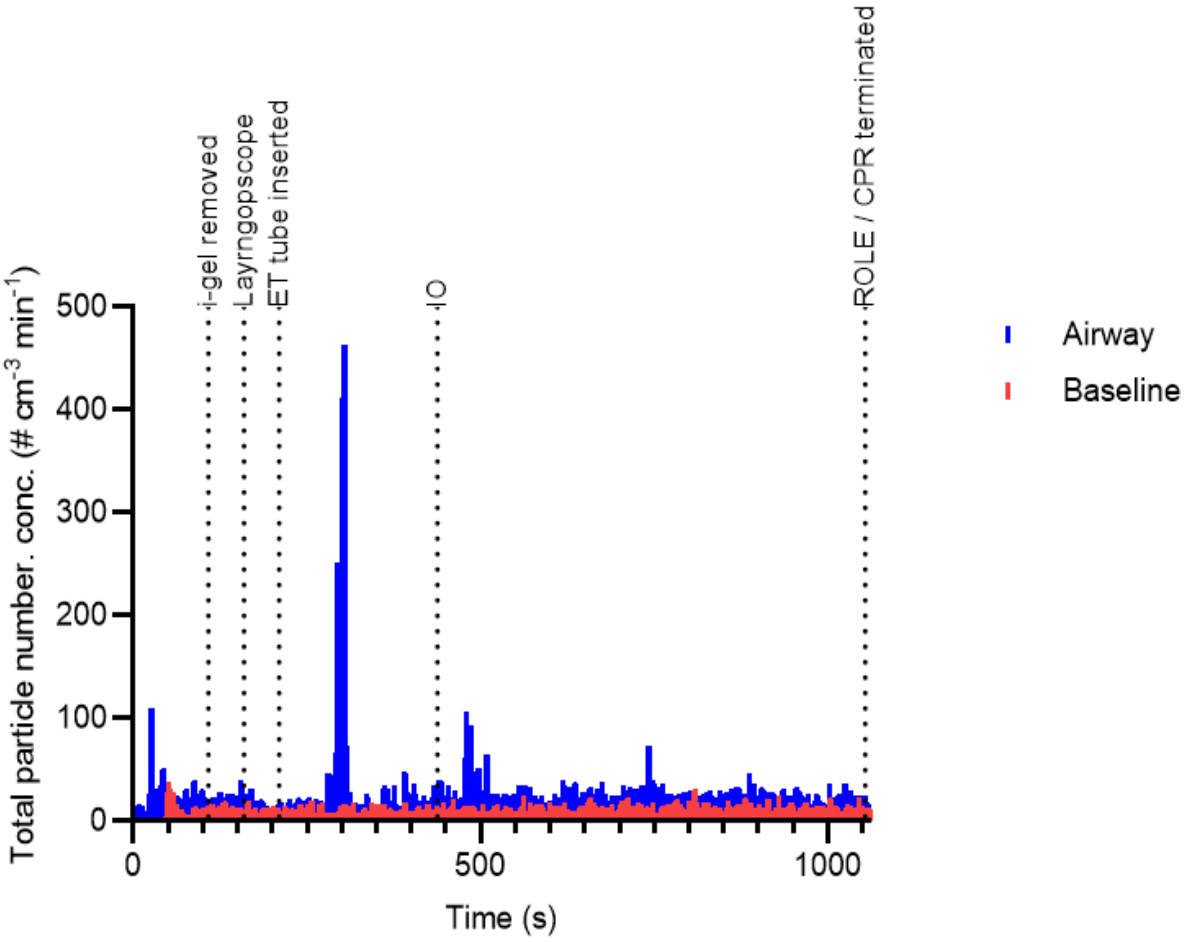
6.3.2.10 Case Study 10

Case study 10 featured a female patient of unknown age, estimated to be her in 70's and for whom resuscitation involved an endotracheal intubation tube insertion at around 200 seconds followed by a notable spike in total particle number and mass concentration some 80 seconds afterwards. Details of the resuscitation attempted are summarised within Table 6.21. The data shows a significant release of aerosols, both in terms of particle number and mass concentration, from the patient's airway, particularly following endotracheal tube insertion, which stands out as a high-risk procedure for aerosol generation. The particle number chart shows a prominent spike in the number of small particles approximately 80 seconds after intubation. In contrast, the mass concentration chart displays a corresponding spike in larger, heavier particles at the same time, highlighting likely bioaerosol origin. Smaller peaks in both charts are also observed around 480 seconds (after intraosseous cannulation) and 750 seconds (during chest compressions), indicating aerosol generation, albeit to a lesser extent, during these interventions. Throughout the resuscitation, the airway concentrations for both particle number and mass remain generally elevated compared to the relatively low baseline, underscoring a persistent risk of aerosol exposure for rescuers, especially during airway manipulation and immediately following intubation (see Figures 6.25 and 6.26).

Table 6.21 Summary of Case Study 10 pertinent background information

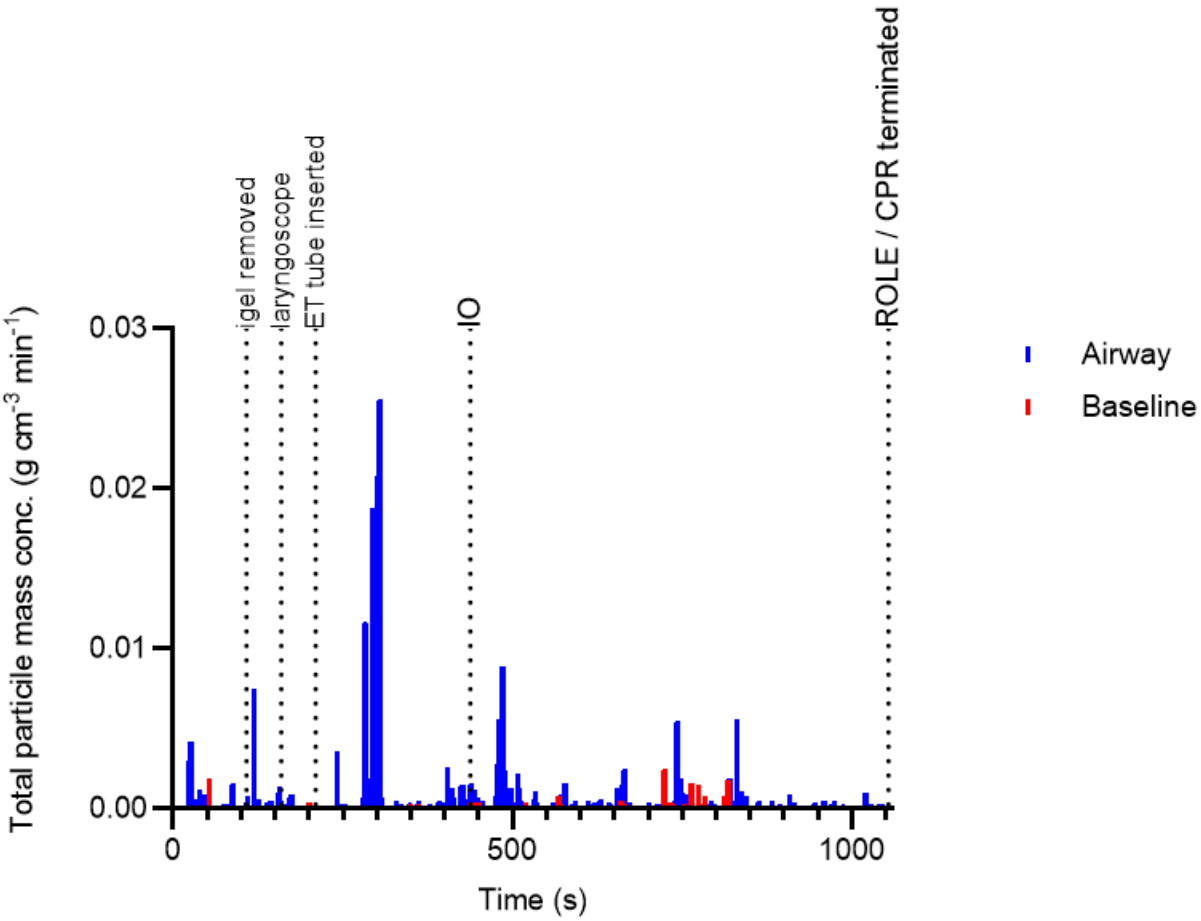
Environmental features	Residential dwelling, small hallway, door open bear by providing some ventilation.
Background	Unwitnessed cardiac arrest. Found blue, apnoeic then low quality bystander CPR. Slight dyspnoea 24 hours earlier.
Patient age & sex	Estimated to be in their 70's, female
Comorbidities	Hypertension
Body habitus	Obese
Care prior to arrival of researcher	i-Gel inserted, poor ventilation.
Cardiac arrest Rhythm	Asystole
Airway patency	Clear, i-Gel
Total number of defibrillator shocks	0
Number of people in vicinity of patient	6 YAS, 2 CFR, 2 witnesses
Mask status of those present	None worn
CPR	Manual

Figure 6.25 Case Study 10 - Total Particle Number concentration against time



Note: 'IO' indicates intraosseous cannulation has taken place.

Figure 6.26 Case Study 10 - Total Particle Mass concentration against time



6.3.2.11 Case Study 11

Case study 11 involved a scene in which a patient had undergone 27 minutes of CPR prior to the arrival of the critical care paramedic and researcher. The critical care paramedic therefore adopted the role of clinical lead and immediately instigated discussions around the appropriateness of continuation of the resuscitation attempt and formed a collaborative decision to halt resuscitation based on futility (see Table 6.22 for a summary of the pertinent resuscitation events). Despite this eventuality, 200 seconds of data were captured as these conversations were conducted however a 25 second delay occurred at the onset of data collection due to slight lag in activation of the baseline OPC. No significant event other than chest compressions occurred during this time frame. These were administered manually. Overall, marginally higher total number and mass concentrations appear present at the baseline compared to the airway sample (see Figures 6.27 and 6.28). This suggests that the ambient air in the environment contained slightly more airborne particles, both small and (to a lesser extent) large, compared to the immediate vicinity of the patient's airway during the ongoing manual chest compressions. The airway readings indicate a low level of aerosol generation, both in terms of particle number (numerous small particles) and mass concentration (larger, heavier particles), during this specific 200-second window of prolonged manual CPR. The immediate risk of high aerosol exposure from the patient during this phase appears low based on these data. However, the significant duration of CPR prior to this data collection, coupled with the potential for intermittent aerosol release not captured in this brief snapshot, is a notable consideration.

Table 6.22 Summary of Case Study 11 pertinent background information

Environmental features	Residential dwelling. Kitchen. Odour of cigarette smoke.
Background	Heavy smoker, recent antibiotics for chest infection. Startled by dog, collapsed, found by neighbour moments later not breathing. Bystander CPR.
Patient age & sex	74 year old, female
Comorbidities	Heart failure, lung disease
Body habitus	Average
Care prior to arrival of researcher	27 minutes CPR, i-Gel inserted
Cardiac arrest Rhythm	Asystole
Airway patency	Clear, i-Gel
Total number of defibrillator shocks	0
Number of people in vicinity of patient	5 YAS, 1 witness
Mask status of those present	None worn
CPR	Manual

Figure 6.27 Case Study 11 - Total Particle Number concentration against time

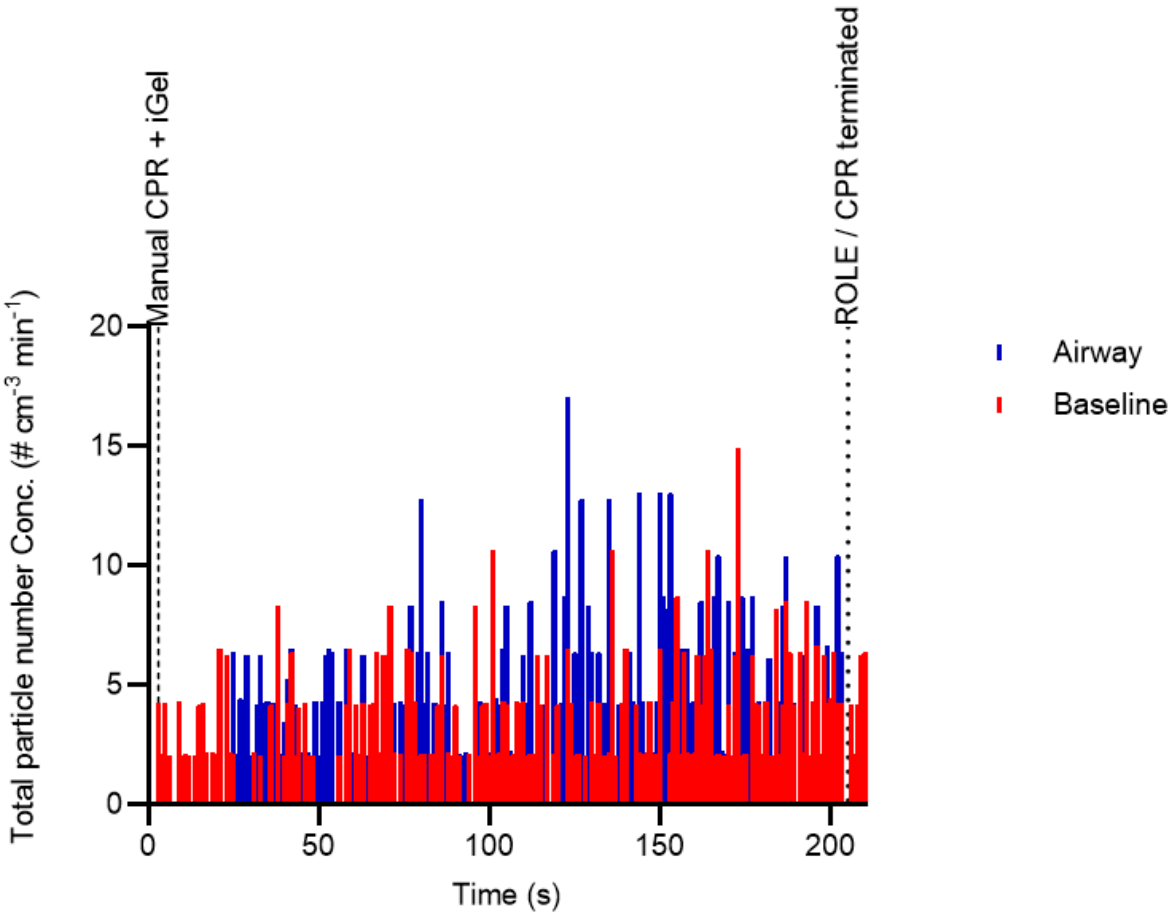
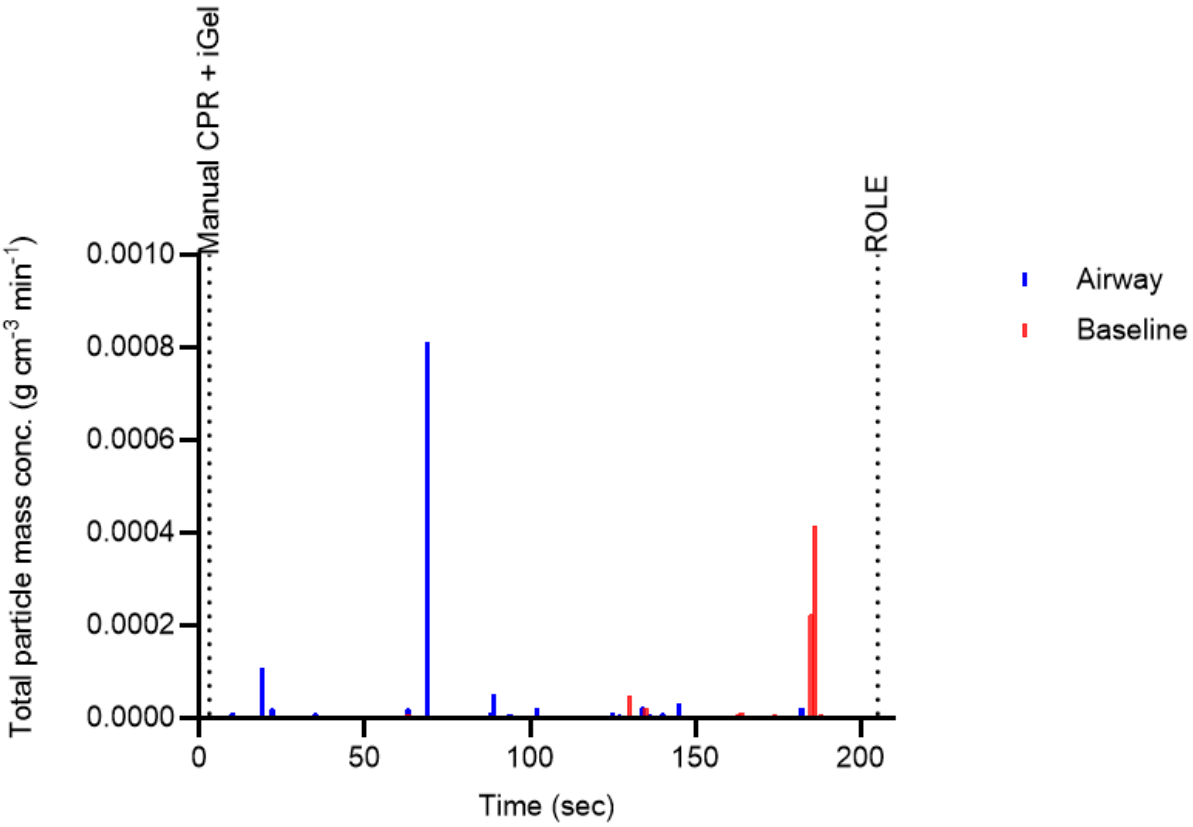


Figure 6.28 Case Study 12 - Total Particle Mass concentration against time



6.3.2.12 Case Study 12

Set within a small, poorly ventilated room, this case study involved a patient who went into a state of cardiac arrest shortly before the ambulance arrived. The patient achieved a return of spontaneous circulation (ROSC) hence data collection being terminated, however suffered a later cardiac arrest when transported to the hospital and so was included in the study (see Table 6.23 for a summary of case).

Reviewing the total particle number and mass concentrations, generally small bit notably higher levels are seen at the airway than baseline. Spikes are evident in airway total particle number concentration when the sampling port is moved closer to the airway and shortly before the patient achieves ROSC. Total particle mass concentration showed spikes at similar times. It is also noteworthy that manual chest compressions were performed throughout (See Figure 6.29 and 6.30). The mass concentration data strongly supports the particle number findings, showing higher levels of larger aerosol detected at the patient's airway during manual chest compressions. The prominent spike before ROSC indicates a particularly high-risk event for exposure to larger bioaerosols, although is not attributed to any specific activity other than manual chest compressions. Notably. proximity to the airway increased the measured concentrations.

Table 6.23 Summary of Case Study 12 pertinent background information

Environmental features	Residential dwelling. Bedroom - small. No ventilation noted.
Background	Unwell throughout the day. Cardiac arrest when waiting for ambulance to arrive. Bystander CPR
Patient age & sex	73 year old, male
Comorbidities	Cardiac issues / heart failure, lung disease.
Body habitus	Average
Care prior to arrival of researcher	SPCC arrived with crew
Cardiac arrest Rhythm	PEA – brief ROSC - PEA
Airway patency	Clear, i-Gel
Total number of defibrillator shocks	0
Number of people in vicinity of patient	5 YAS
Mask status of those present	None worn
CPR	Manual

Figure 6.29 Case Study 12 - Total Particle Number concentration against time

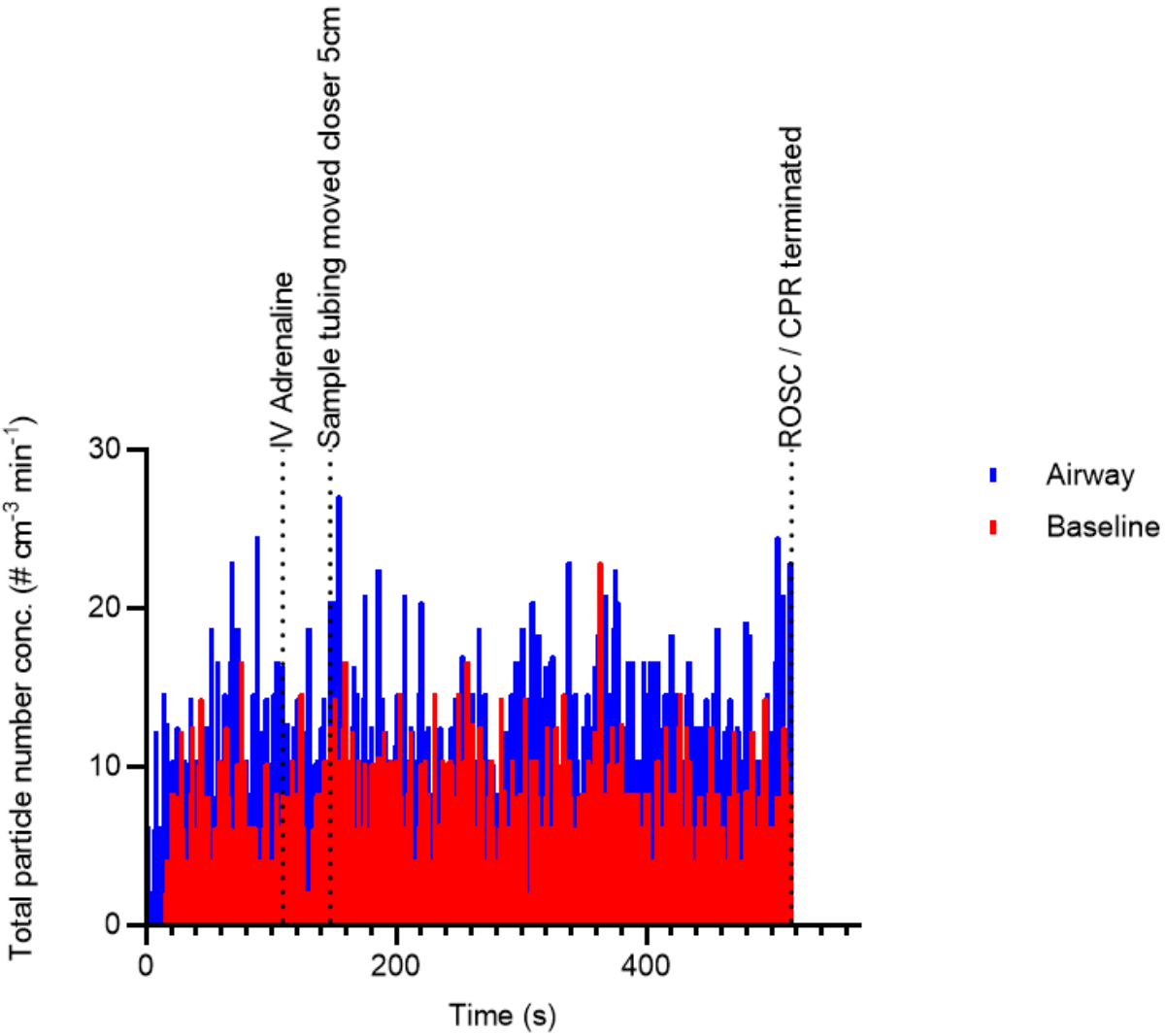
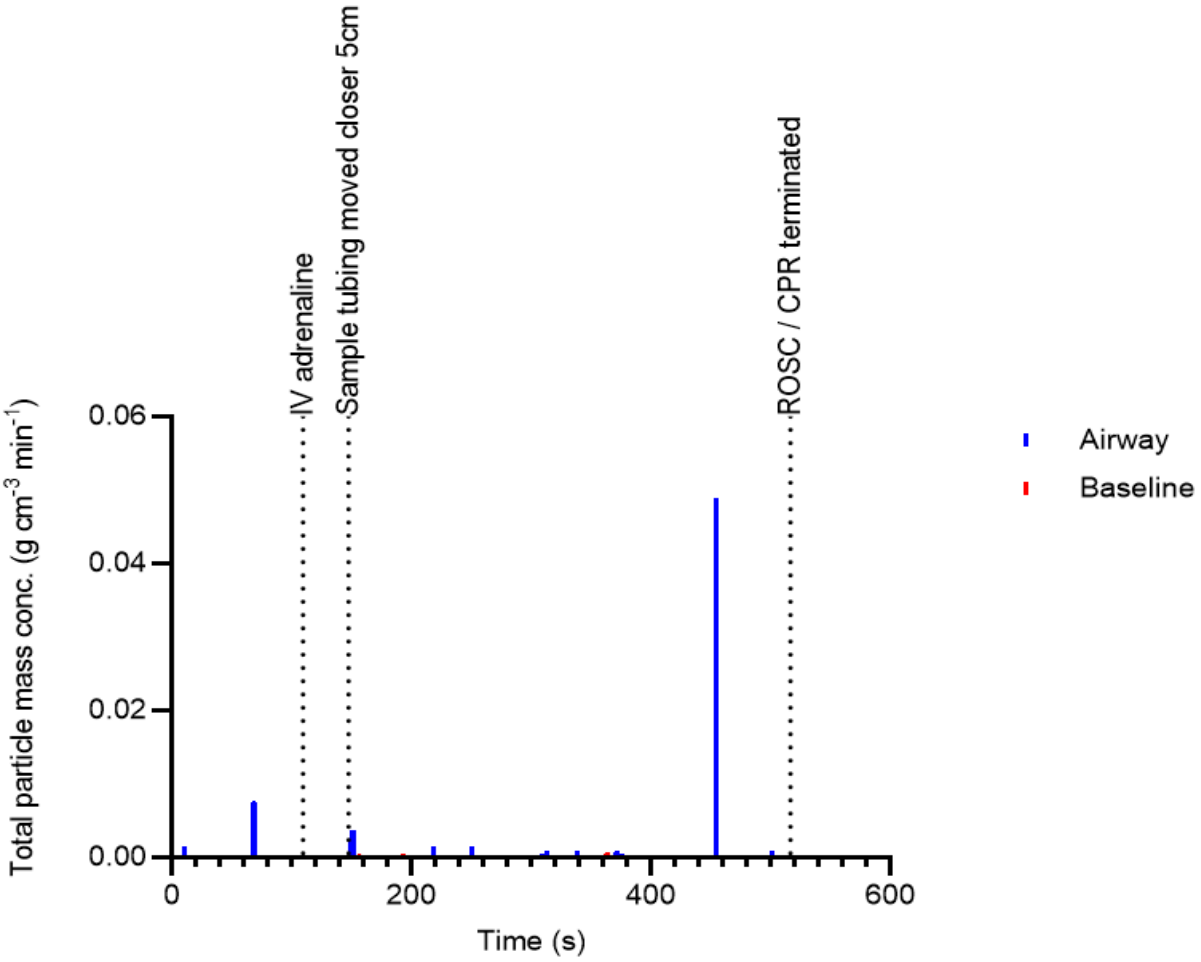


Figure 6.30 Case Study 12 - Total Particle Mass concentration against time



6.3.2.13 Case Study 13

Case Study 13 captured data during resuscitation of an overweight patient in asystole, a non-shockable, electrocardiogram (ECG) rhythm associated with cardiac arrest. They had a heavily soiled airway requiring suctioning and endotracheal tube insertion to ensure its maintenance (see Table 6.24). There is a notable higher concentration of total particle number and mass at the airway compared to the baseline sample throughout this data collection episode. Interestingly, there is a large peak seen in both the airway and baseline sampling data at around 500 seconds, which is unexplained when observing the events that occurred through the cardiac arrest, assumed to be an environmental factor due to its similar effect on both airway and baseline data (see Figures 6.31 and 6.32). The mass concentration data corroborates the particle number findings, highlighting airway management (suctioning and intubation of a soiled airway) as a suspected high-risk procedure for releasing larger, potentially highly contaminated aerosols evidence by a spike in mass shortly after ET tube insertion. The significant, unexplained environmental event caused a simultaneous spike in larger particles in both the airway and baseline. Elevated airway mass persisted post-intubation. Rescuers faced risks from airway procedures, an external environmental hazard involving larger particles, and ongoing exposure to larger aerosols from the patient's airway after intubation. The consistently elevated levels of both small and large particles in the airway throughout the recording strongly suggest that chest compressions were also a continuous source of aerosol generation.

Table 6.24 Summary of Case Study 13 pertinent background information

Environmental features	Residential dwelling. Living room – small. Limited ventilation.
Background	Drank heavily, found unresponsive and cyanosed in the morning. Bystander CPR commenced.
Patient age & sex	35 year old, male
Comorbidities	Nil
Body habitus	Overweight
Care prior to arrival of researcher	i-Gel and CPR
Cardiac arrest Rhythm	Asystole
Airway patency	Soiled, i-Gel replaced by ETT. Blood on suctioning
Total number of defibrillator shocks	0
Number of people in vicinity of patient	6 YAS
Mask status of those present	None worn
CPR	Manual

Figure 6.31 Case Study 13 - Total Particle Number concentration against time

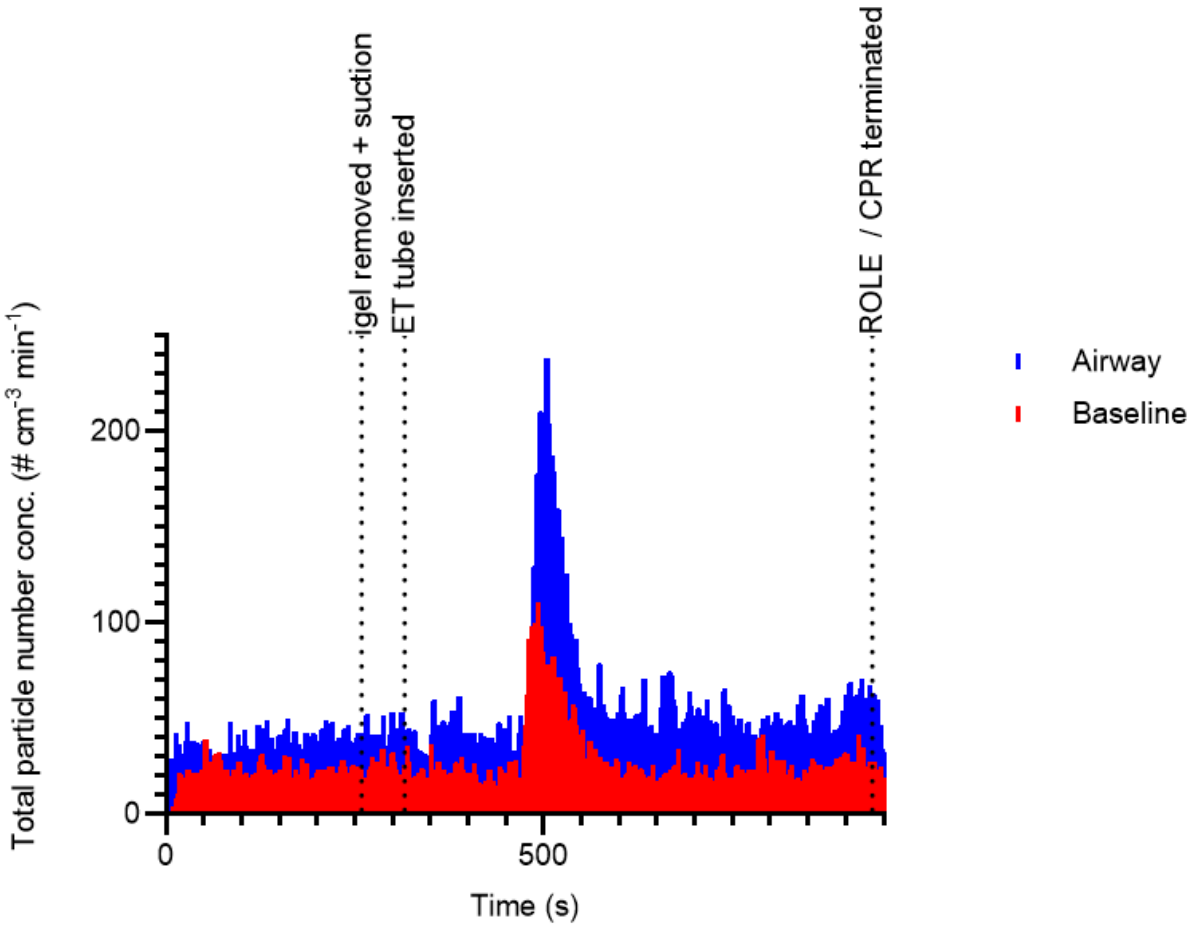
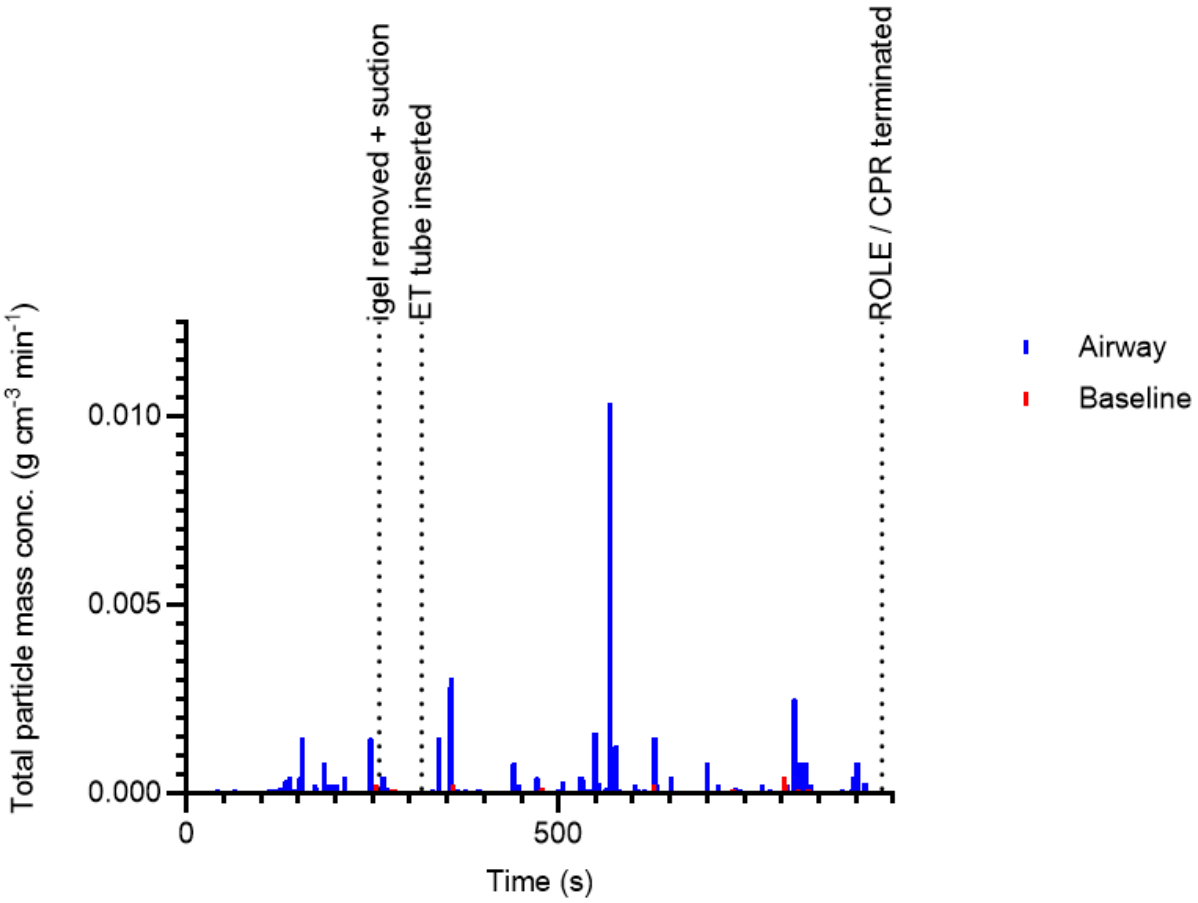


Figure 6.32 Case Study 13 - Total Particle Mass concentration against time



6.3.2.14 Case Study 14

Occurring within a kitchen in a domestic dwelling, Case Study 14 featured a male patient in cardiac arrest with a soiled away. This patient received bystander CPR prior to the resuscitation team getting to scene. On their arrival, the cardiac arrest ECG rhythm was noted to transition into ventricular fibrillation, a shockable rhythm. This was rapidly identified, and the patient received a defibrillator shock which led to ROSC, before ultimately, they experienced a further cardiac arrest from which they were unable to be resuscitated (further details within Table 6.25). Generally, the airway total particle number concentrations were higher than the baseline (see Figure 6.33). The mass concentration data (Figure 6.34) clearly shows spikes in larger aerosol release from the patient's soiled airway which are associated with all key resuscitation events: airway management, defibrillation shock, and the initiation of mechanical CPR. The sustained elevated airway mass concentration seen during mechanical CPR indicates an ongoing risk. An unexplained environmental spike was also observed in the baseline. This unusual baseline spike was not associated with any event and may be due to rescuer activities.

Table 6.25 Summary of Case Study 14 pertinent background information

Environmental features	Residential dwelling. Kitchen.
Background	Found unresponsive shortly after a telephone call for help. Bystander CPR.
Patient age & sex	74 year old, male
Comorbidities	Hypertension, obesity, heart disease, diabetes
Body habitus	Obese
Care prior to arrival of researcher	Bystander CPR
Cardiac arrest Rhythm	Asystole - VF – PEA – ROSC - PEA
Airway patency	Soiled
Total number of defibrillator shocks	1
Number of people in vicinity of patient	6 YAS, 1 witness
Mask status of those present	None worn
CPR	Manual and mechanical

Figure 6.33 Case Study 14 - Total Particle Number concentration against time

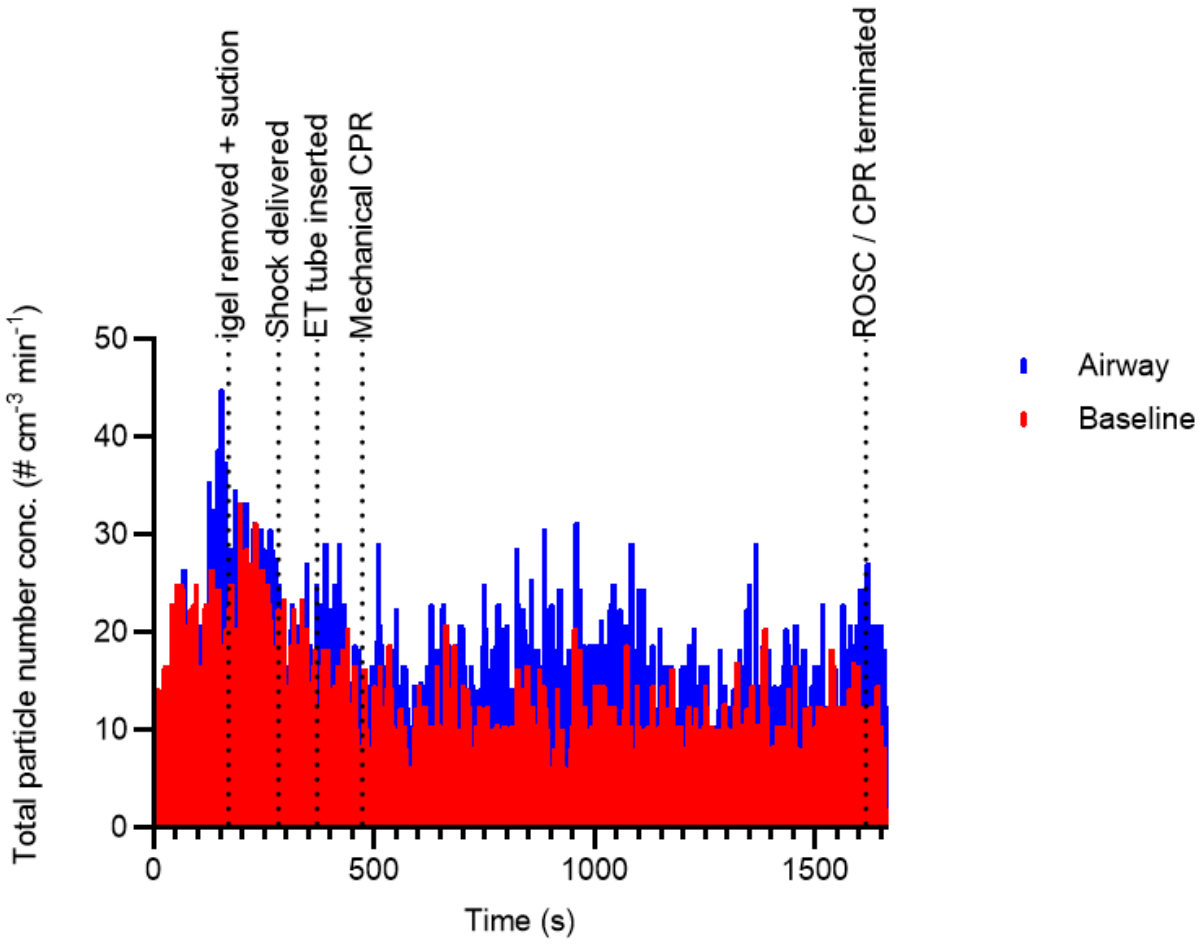
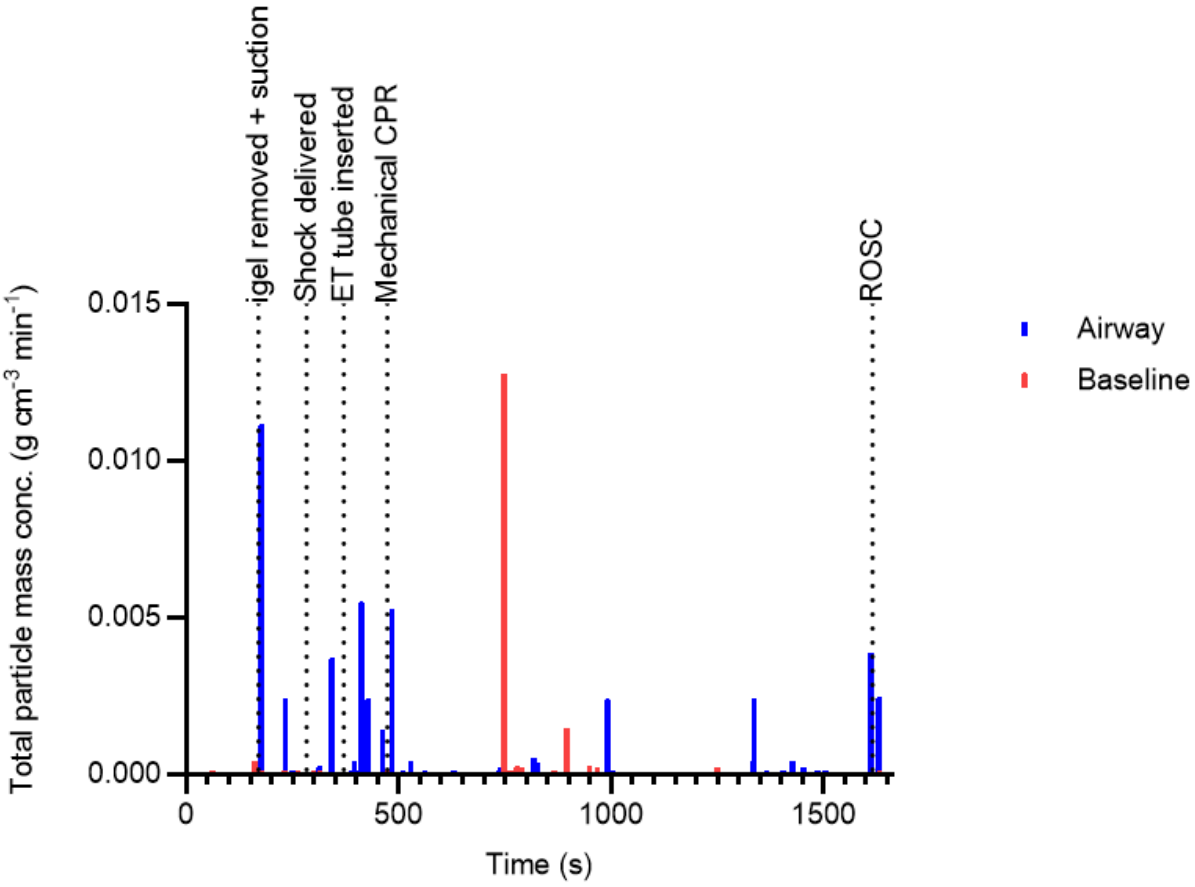


Figure 6.34 Case Study 14 - Total Particle Mass concentration against time



6.3.2.15 Case Study 15

Case Study 15 documented a young male experiencing cardiac arrest in a gym (see Table 6.26). Throughout the data collection, he received a total of 13 shocks, including four during this period, along with manual and mechanical chest compressions. The data on total particle number shows a consistently higher concentration originating from the patient's airway during resuscitation efforts. Notably, there are no significant increases in particle release that directly correlate with the administration of multiple defibrillator shocks. The heightened airway particle counts likely indicate ongoing aerosol production from chest compressions, possibly originating from the patient's airway itself, however, although indicative, this remains undetermined. The mass concentration data reinforces the particle number findings, indicating a consistently higher concentration originating from the patient's airway. The elevated airway mass likely indicates ongoing aerosol generation from chest compressions and potentially from the patient's airway. Rescuers faced a continuous risk of exposure to larger bioaerosols, and the shocks themselves did not appear to acutely increase this risk concerning particle mass. There are some minor increases following medication administration (see Figures 6.35 and 6.36).

Table 6.26 Summary of Case Study 15 pertinent background information

Environmental features	Gymnasium changing room. Open. Well ventilated.
Background	Finished workout, found collapsed in changing room, agonal respiration
Patient age & sex	44 year old, male
Comorbidities	Unknown
Body habitus	Overweight
Care prior to arrival of researcher	Advanced life support, 9 shocks delivered
Cardiac arrest Rhythm	VF – asystole
Airway patency	Clear, i-Gel
Total number of defibrillator shocks	13
Number of people in vicinity of patient	8 YAS, 2 police
PPE status of those present	None worn
CPR	Manual and mechanical

Figure 6.35 Case Study 15 - Total Particle Number concentration against time

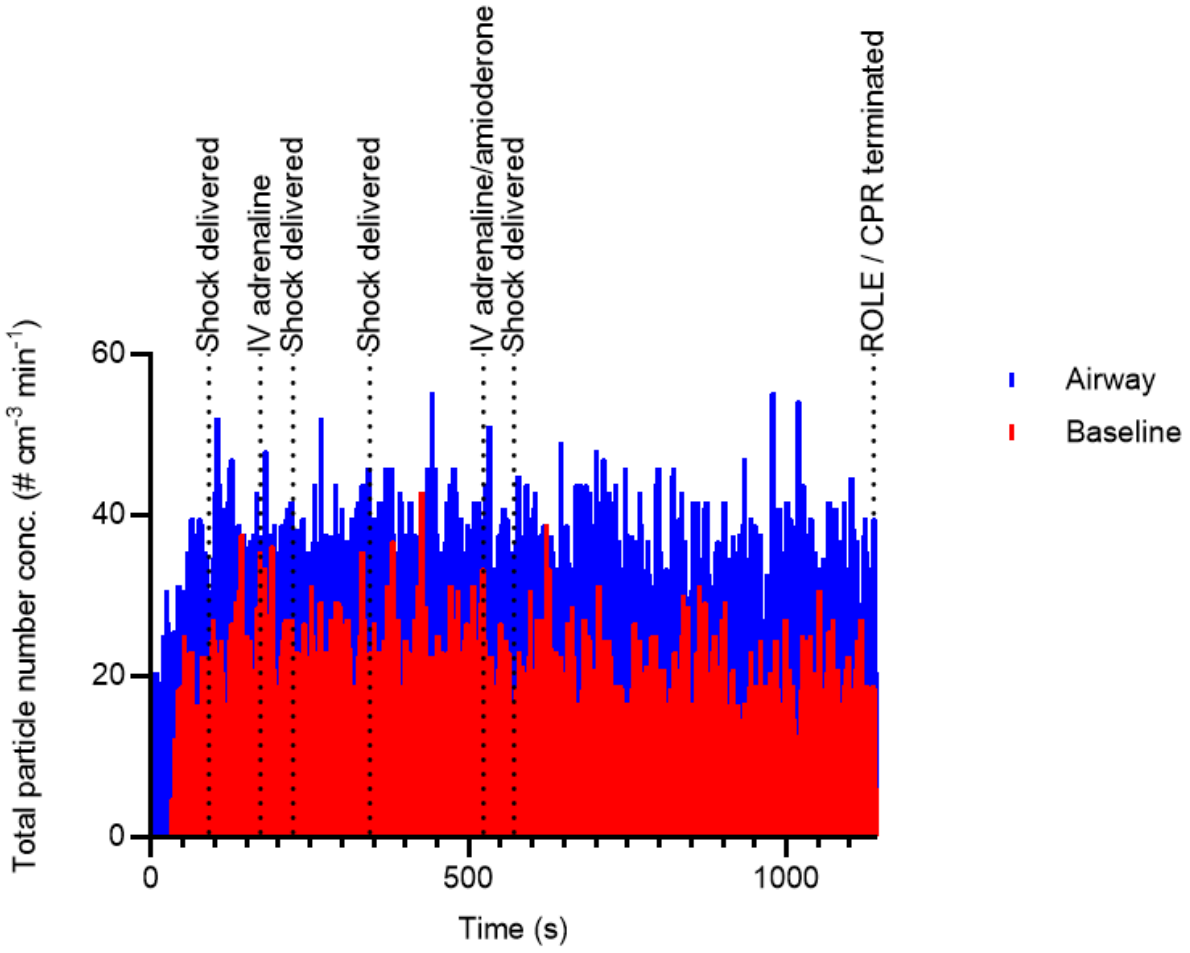
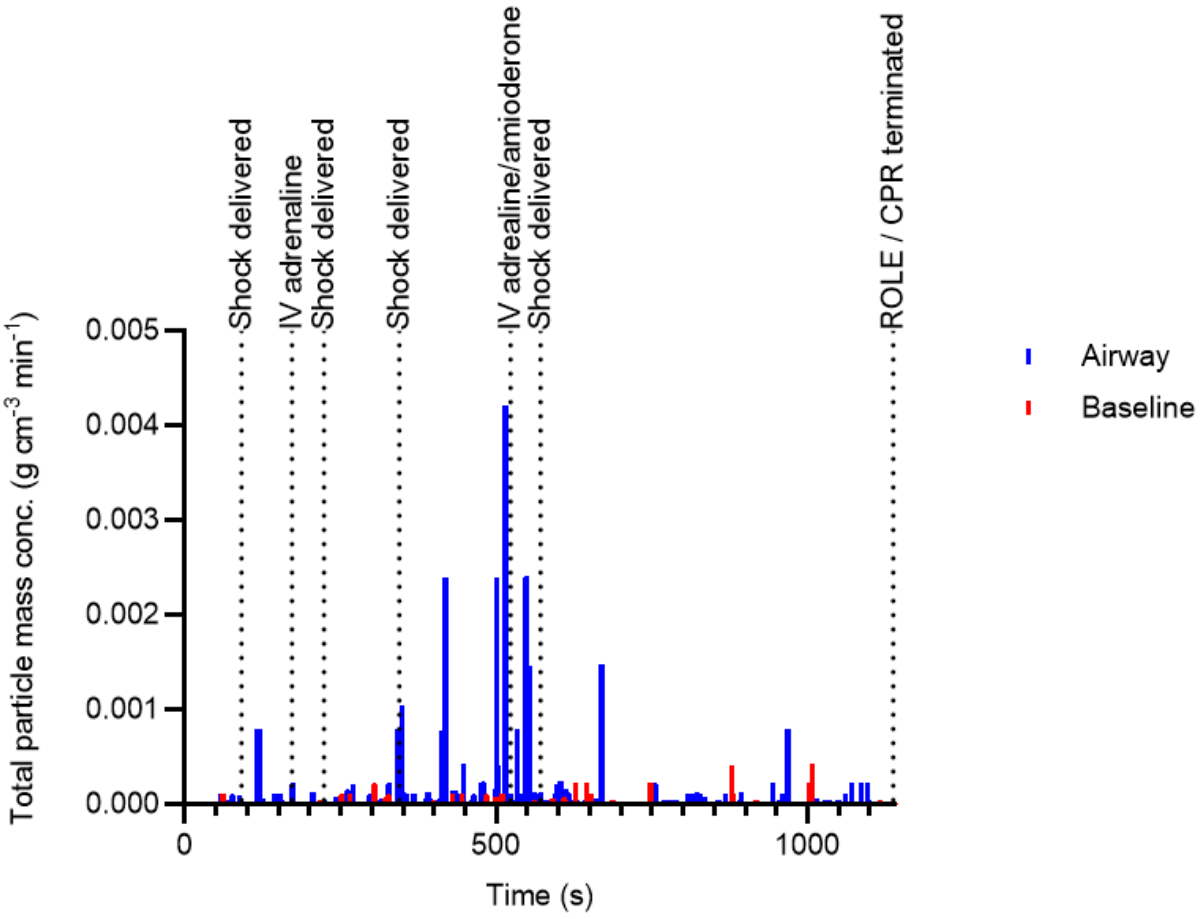


Figure 6.36 Case Study 15 - Total Particle Mass concentration against time



6.3.2.16 Case Study 16

This case involved an elderly male patient receiving a very brief period of resuscitation as a clinical history was obtained and a decision made as to the futility of the resuscitation attempt. Further information is captured within Table 6.27. There was a 75 second delay between activation of the sampling OPC at the airway and at baseline. The sparse data whereby both sampling OPCs were activate simultaneously shows little difference between them (Table 6.37 and 6.38). It is difficult to extrapolate any reasoning from this case, but it has been included for completeness.

Table 6.27 Summary of Case Study 16 pertinent background information

Environmental features	Residential dwelling, Kitchen, small, poor ventilation, ashtray full of cigarettes
Background	Not seen for 12 hours, found unresponsive.
Patient age & sex	87 year old, male
Comorbidities	Unknown
Body habitus	Average
Care prior to arrival of researcher	Basic Life Support
Cardiac arrest Rhythm	Asystole
Airway patency	Clear, OPA
Total number of defibrillator shocks	0
Number of people in vicinity of patient	5 YAS
Mask status of those present	None worn
CPR	Manual

Figure 6.37 Case Study 16 - Total Particle Number concentration against time

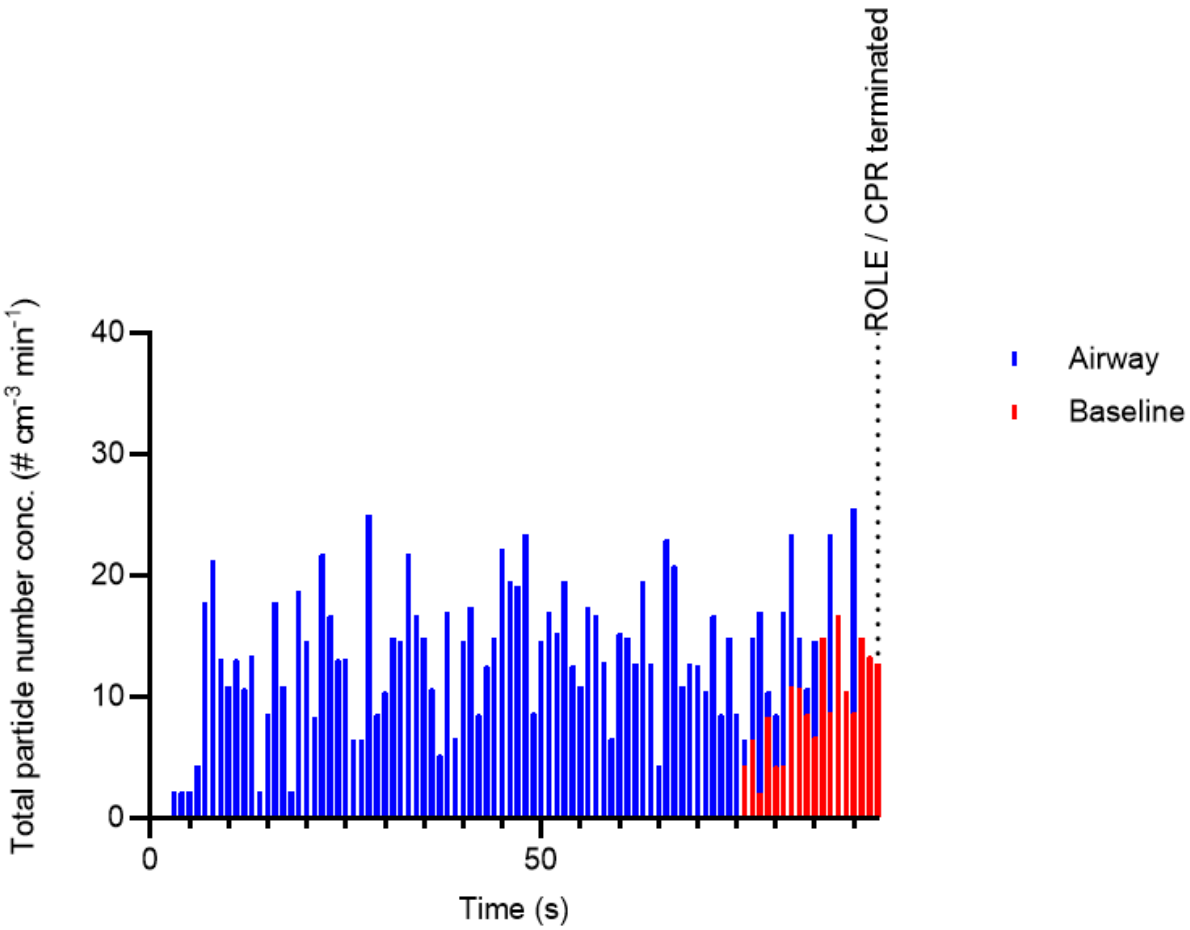
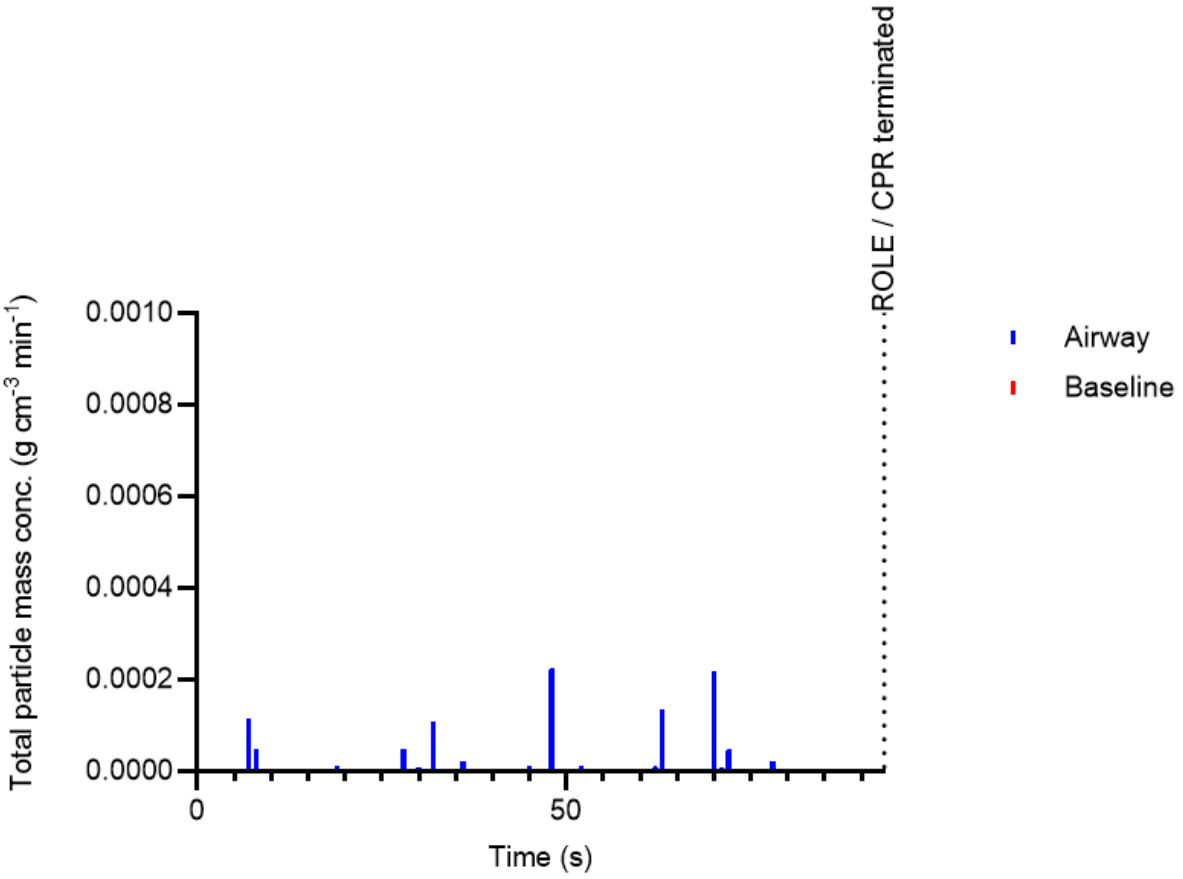


Figure 6.38 Case Study 16 - Total Particle Mass concentration against time



6.3.2.17 Case Study 17

A palliative patient without a clear advanced care directive received a period of resuscitation as a comprehensive clinical history was taken to inform the decision making process. They remained in asystole throughout and received manual chest compressions only (see Table 6.28). A delay in activation of the baseline OPC of 60 seconds occurred. Data obtained showed no clear differences between total particle number concentration at the airway or baseline OPCs (Figures 6.39 and 6.40). The data from this brief resuscitation attempt shows minimal evidence of significant aerosol generation that differentiated the patient's airway from the surrounding environment. Both particle number and mass concentrations were low in the airway during the period of overlapping data with the baseline, suggesting that the manual chest compressions did not forcefully expel a large number of small or large particles into the air. Consequently, the immediate apparent risk of exposure to bioaerosols generated by the chest compressions during this short timeframe appears to be low for the attending rescuers. However, it's important to note that baseline data was delayed, so we lack a comparison for the initial 60 seconds. Overall, for this isolated case, data presented suggests that in certain circumstances, particularly during brief manual chest compressions on a patient in asystole where no other aerosol-generating procedures are performed, the risk of significant bioaerosol exposure might be minimal.

Table 6.28 Summary of Case Study 17 pertinent background information

Environmental features	Residential dwelling. Small living room, with open front door as ventilation. Smokey environment.
Background	Witnessed cardiac arrest when smoking a cigarette, immediate bystander CPR.
Patient age & sex	73 year old, female
Comorbidities	COPD. Terminal cancer – skin with liver metastases.
Body habitus	average
Care prior to arrival of researcher	Basic life support.
Cardiac arrest Rhythm	Asystole
Airway patency	Clear, OPA, BVM.
Total number of defibrillator shocks	0
Number of people in vicinity of patient	6 YAS, 1 witness
Mask status of those present	None worn
CPR	Manual

Figure 6.39 Case Study 17 - Total Particle Number concentration against time

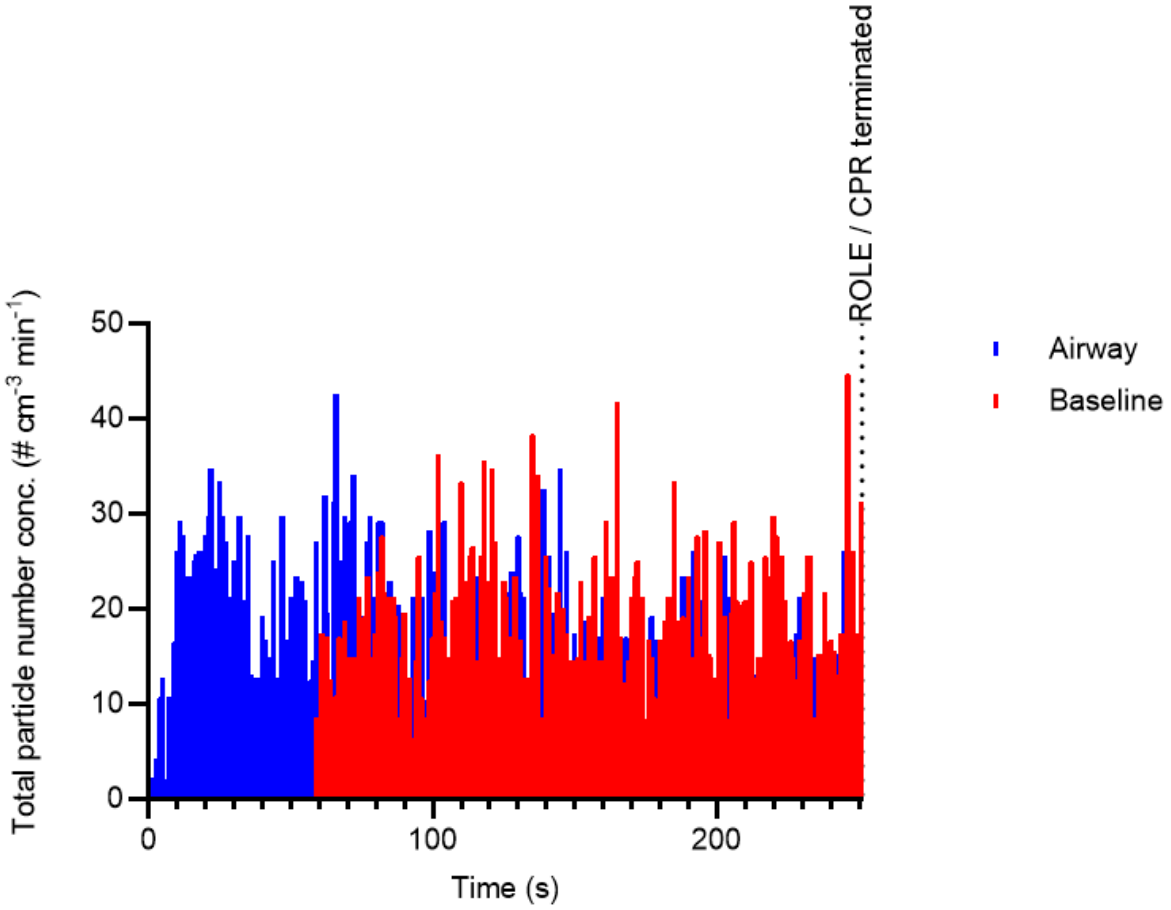
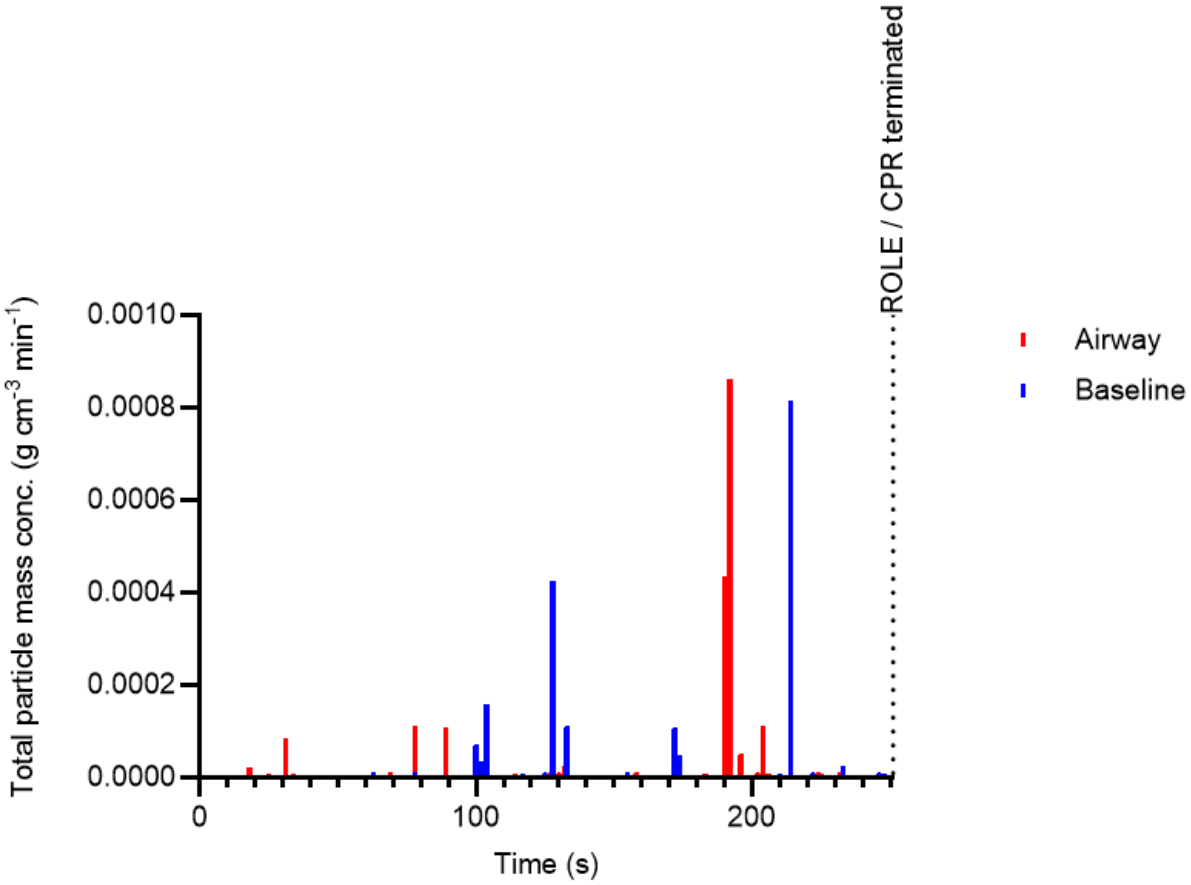


Figure 6.40 Case Study 17 - Total Particle Mass concentration against time



6.3.2.18 Case Study 18

Case Study 18 involved a patient who was witnessed to experience a cardiac arrest when smoking a cigarette in the doorway of their kitchen, bystander CPR was administered immediately. The patient had begun treatment for lower respiratory tract infection-like symptoms for approximately a week prior. The original cardiac arrest rhythm was shockable, as such the patient received a defibrillation at the start of data collection and was administered manual chest compressions. ROSC was achieved for a brief period. However, the patient re-arrested and recognition of life extinct followed shortly afterwards (see Table 6.29). The ambulance and critical care paramedic arrived simultaneously at the scene, enabling data collection to occur almost immediately. Notably, total particle number data reveals suspected high levels of particle aerosolisation from the patient's airway, with a large spike immediately following the defibrillation shock. The sustained elevated levels throughout manual chest compression delivery, considered alongside the continuously high baseline data, indicate a significant and continuous risk of exposure to potentially infectious bioaerosols, likely exacerbated by the patient's suspected respiratory tract infection. This case also suggests that defibrillation shocks can be an aerosol-generating event in certain patients and underscores the critical importance of robust PPE. The mass concentration data mirrors the particle number findings, showing a significant initial release of larger aerosols immediately following the defibrillation shock. The sustained elevated airway mass and intermittent spikes likely reflect the patient's infected airway, contributing to ongoing aerosolisation during manual chest compressions, thereby highlighting the risk of exposure to larger bioaerosols, particularly associated with defibrillation in this context, emphasising the crucial need for comprehensive PPE (Figures 6.41 and 6.42).

Table 6.29 Summary of Case Study 18 pertinent background information

Environmental features	Residential dwelling. Between narrow kitchen, living room and backdoor to outside which was open. Smoky environment.
Background	Cough for approximately 1 week, worsening in past 2 days. Went outside for air, staggered into kitchen doorway. Witnessed cardiac arrest. Bystander CPR. Heavy smoker.
Patient age & sex	50 year old, female
Comorbidities	Diabetes, hypertension, obesity
Body habitus	Overweight
Care prior to arrival of researcher	Bystander CPR
Cardiac arrest Rhythm	VF – asystole – PEA – brief ROSC – PEA
Airway patency	Clear, i-Gel
Total number of defibrillator shocks	1
Number of people in vicinity of patient	6 YAS, 3 witnesses
Mask status of those present	None worn
CPR	Manual

Figure 6.41 Case Study 18 - Total Particle Number concentration against time

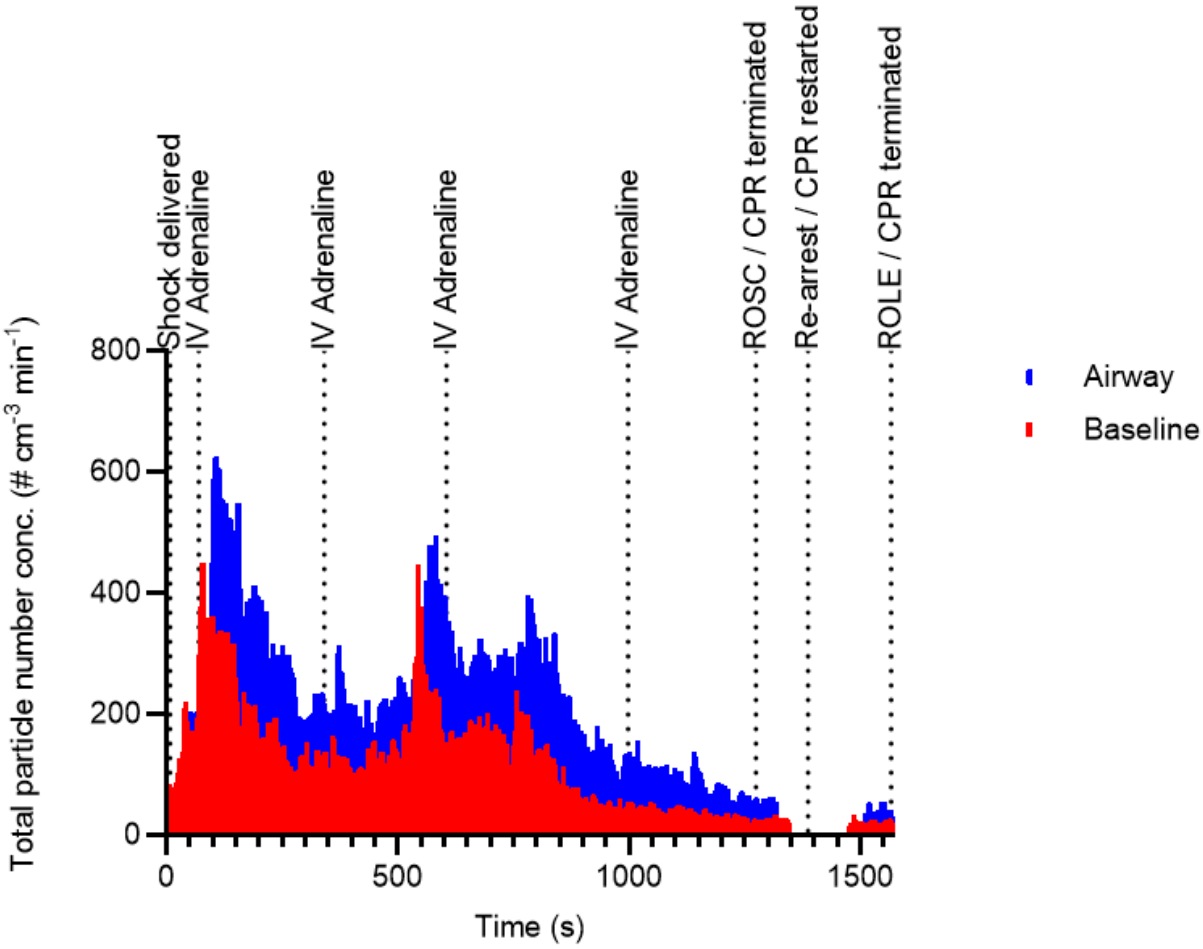
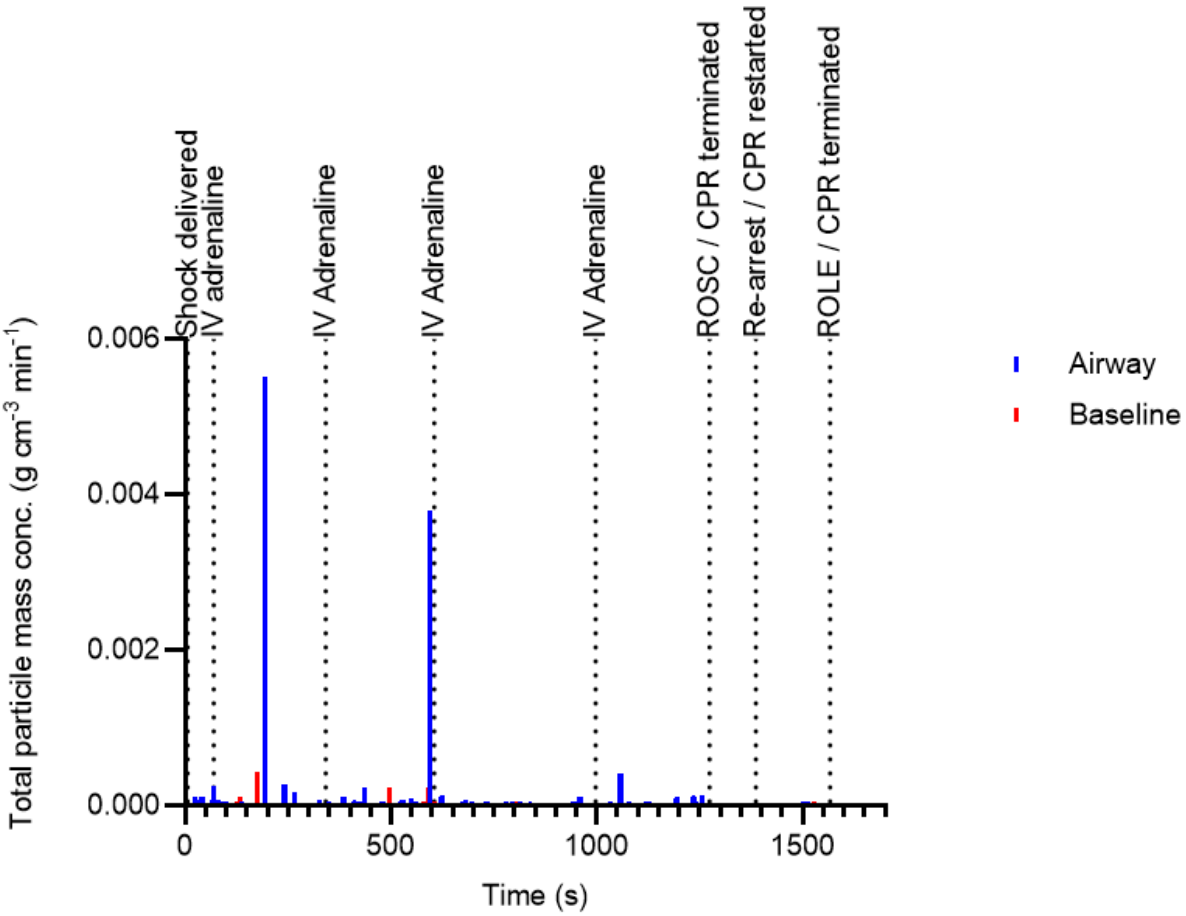


Figure 6.42 Case Study 18 - Total Particle Mass concentration against time



6.3.3 Chest compression data analysis

Descriptive statistical analysis of chest compressions data took the form of simple mean comparisons of aerosol data collected two minutes prior to the cessation of the resuscitation when both mechanical and manual compressions were being administered. This was then compared to their respective baseline data and shown in the following charts (Figures 6.43 and 6.44). Focusing on this latter-stage time period offered an attempt to mitigate the huge variability witnessed during the early phase of cardiac arrest management, where multiple interventions would coincide, thereby providing a more standardised measure of sustained aerosol production specifically linked to each compression technique. It, therefore, provided a snapshot of aerosol generation during these latter stages of CPR and was not fully representative of aerosol dynamics seen throughout the entire resuscitation attempt.

Analysis of aerosol total number concentration in the final two minutes of resuscitation revealed a consistent elevation at the airway during both manual and mechanical chest compressions compared to baseline, highly indicative of ongoing aerosol generation from CPR at the airway. The higher airway concentrations observed during mechanical CPR suggest a potentially greater and more dynamic release of aerosol particles compared to manual CPR in these terminal phases of resuscitation.

Figure 6.43. shows mean aerosols total number concentration two minutes prior to termination of CPR when manual chest compressions were administered when compared to baseline OPC data. Figure 6.44 shows the same but when mechanical chest compressions were administered.

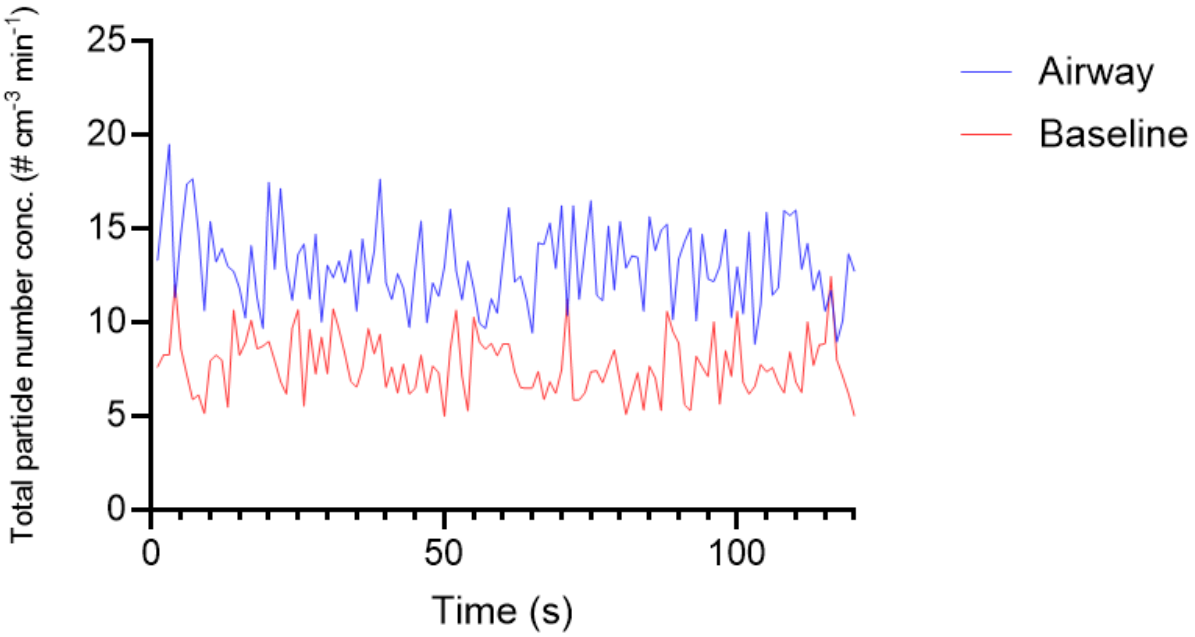


Figure 6.43 Mean aerosol 'total number concentration' two minutes prior to termination of CPR in all cases where manual chest compressions were administered.

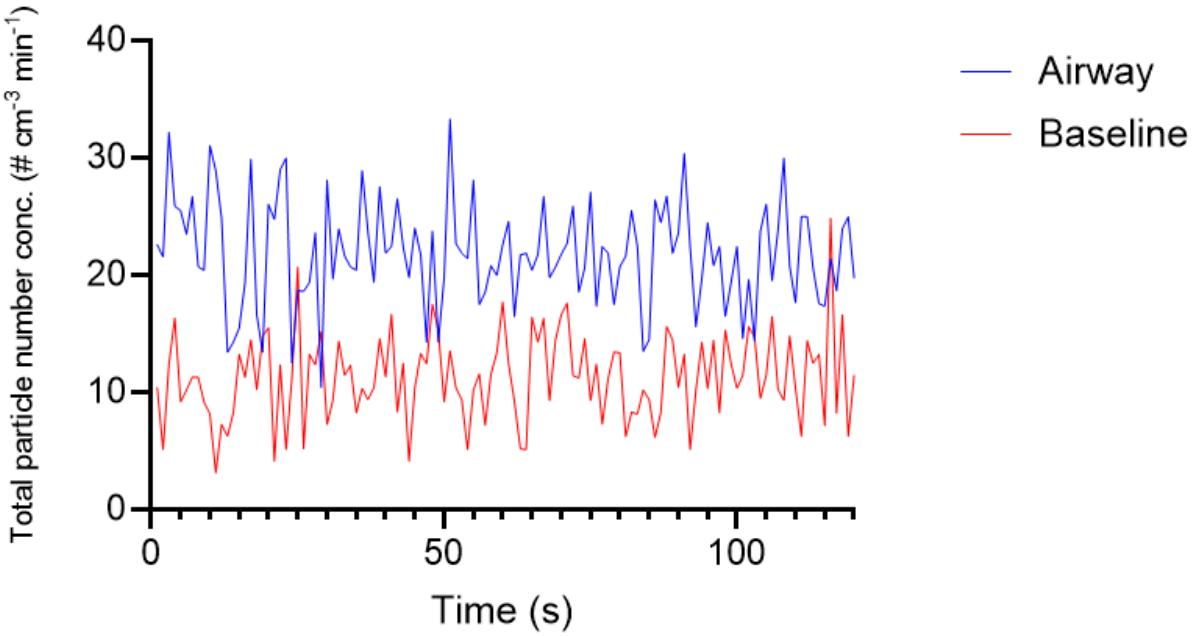


Figure 6.44 Mean aerosol 'total number concentration' two minutes prior to termination of CPR for all cases where mechanical chest compressions were administered.

Minute data were presented in chart format. This was calculated for the 60 seconds 'pre' activation and 60 seconds 'post' administration of mechanical chest compressions. These data used the total number concentration data and was intended to allow observation of any changes that might have occurred as a result of the commencing of mechanical chest compressions, illustrated in Figure 6.45. It is noteworthy that in all cases where mechanical chest compression data were captured, manual chest compressions were administered for a significant period time prior to the Autopulse® device being activated. That is to say that during the 'pre' mechanical chest compression phase manual chest compressions would have been administered. This is standard practice to ensure maintenance of circulatory perfusion pressures and would have been unethical to request cessation of these practices.

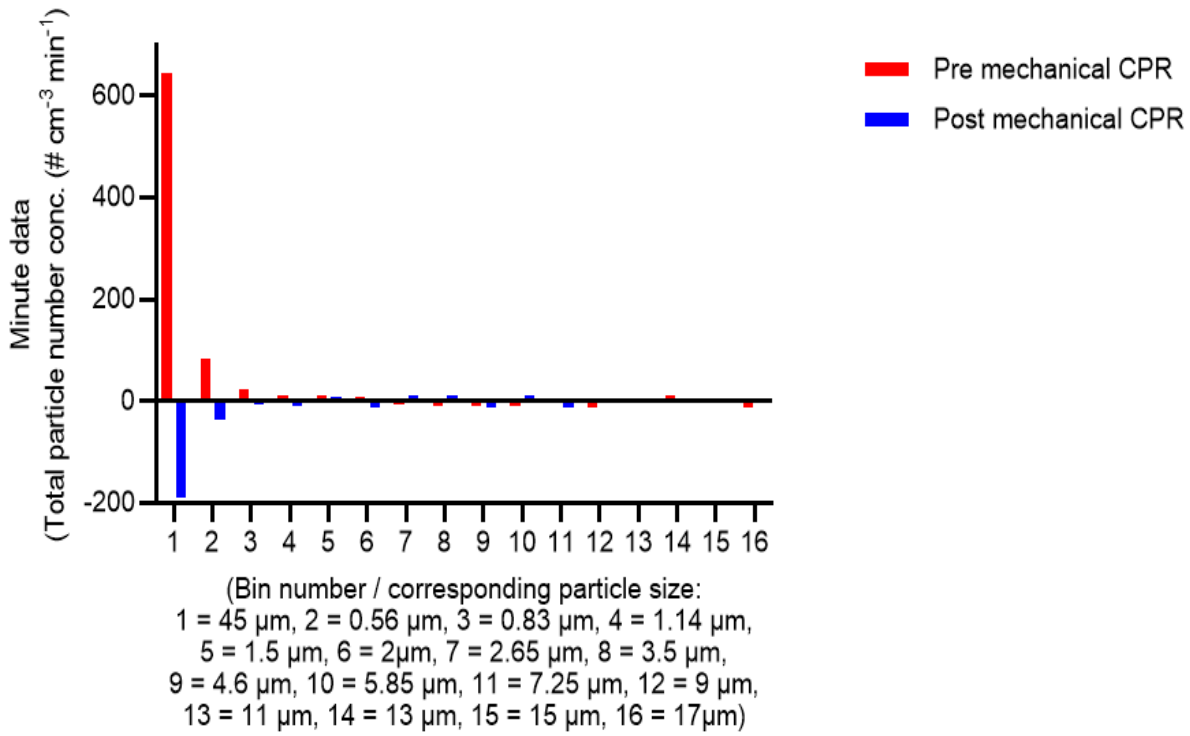


Figure 6.45 Minute data 60 seconds 'Pre' and 'Post' intervention (intervention being the commencing of mechanical CPR).

6.3.4 Defibrillation analysis

Analysis of defibrillation data was done through a similar mechanism, again by using the 'minute data' collected 60 seconds immediately before ('pre'), and after ('post') the delivery of a defibrillator shock. This is demonstrated in Figure 6.46.

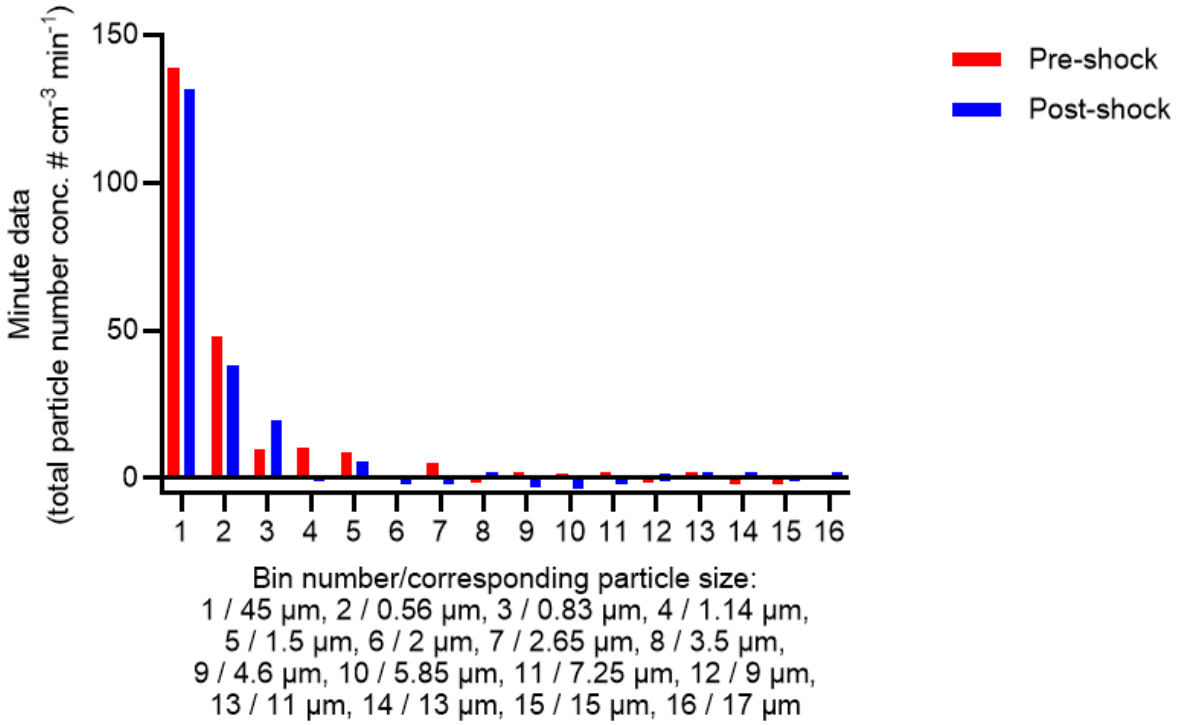


Figure 6.46 Total number concentration pre and post defibrillator shock using minute data at each bin size

Figure 6.47 shows total particle concentrations in a box and whisker plot, using mean total particle concentration minute data detected across all Alphasense® OPC-N3 (Alphasense® Ltd., Essex, UK) bin sizes pre and post defibrilator shock.

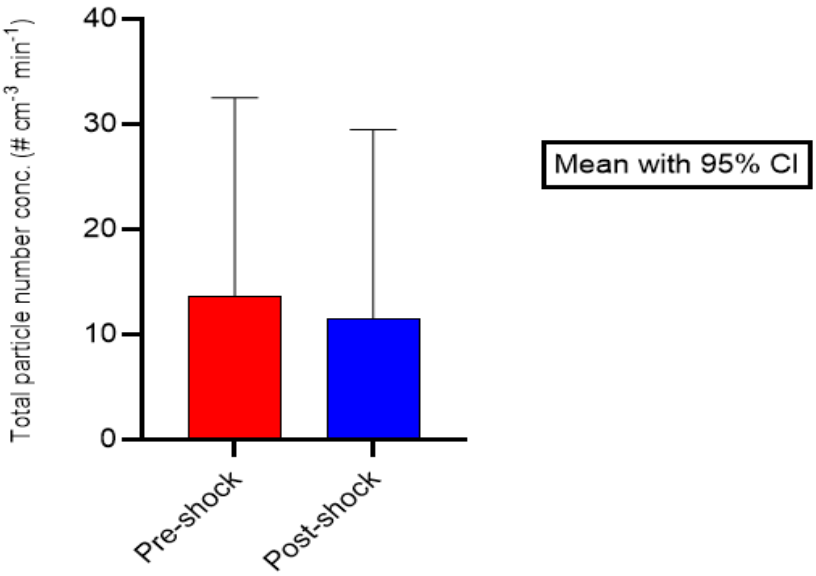


Figure 6.47 Box and whisker plot of mean total particle concentration minute data detected across all Alphasense® OPC-N3 (Alphasense Ltd., Essex, UK) bin sizes pre and post defibrilator shock.

6.3.5 Workstream 2: Summary

The data presented in case study format which underwent simple descriptive statistics, performed to illustrate trends, were suggestive that a difference existed between total particle concentration at the airway, compared to baseline data, during active resuscitation in the prehospital setting when chest compressions were administered. A consistent finding is the patient's airway as the primary source of both small and large particle aerosols, with concentrations frequently exceeding ambient background levels. Notably, airway management procedures, encompassing suctioning, device insertion and removal, consistently emerged as high-risk events characterised by significant aerosol release. While chest compressions, both manual and mechanical, also contributed to aerosolisation, the magnitude appeared influenced by factors such as delivery mechanism, technique and duration of CPR. Of the 18 case studies that were created, seven showed notably increased levels of aerosol at the airway when compared to the baseline sample measurements, specifically when considering total particle

number concentration values. These included case studies 1, 6, 10, 13, 15, 16 and 18. Of these, case studies 1 and 15 stood out due to them exhibiting notably higher concentrations at the airway. Five case studies showed marginally higher total number concentrations at the airway versus that collected at the baseline sample. Two case studies showed higher levels recorded at baseline, with environmental elements considered to be a possible source and so explain this unexpected observation.

The impact of defibrillation shocks on aerosol generation was less uniform, with variation seen within the case studies possibly suggestive of how patient-specific characteristics might play a role. Environmental factors, including ventilation and the number of personnel present, demonstrated the capacity to influence baseline aerosol levels and potentially the dispersion of patient-generated aerosols.

Observing mean aerosol values across all 18 case studies two minutes prior to the cessation of resuscitation, either due to termination of the resuscitation attempt or due to the patient achieving a sustainable pulse (termed return of spontaneous circulation (ROSC)), resulted in the creation of charts again suggestive of higher total number concentrations at the airway. This was observed for both mechanical and manual chest compressions (section 6.3.3).

A key limitation of the data is that aerosol measurements were often taken in the minutes leading up to the cessation of resuscitation, potentially underestimating the risk of aerosol generation during earlier, potentially more aerosol generating, procedures. As such, the data should be interpreted as a snapshot of aerosol generation during a specific time window rather than a comprehensive assessment of total aerosol exposure. Due to the varied, unpredictable nature of

the prehospital environment as a setting in which to conduct research of this kind, a satisfactory control group was unachievable therefore, although the 'baseline' sample acted to guide discussion, true statistical analysis and significance testing were not conducted. It is, however, also important to acknowledge that this limitation is inherent to prehospital research of this kind.

6.4 Integration / Meta-inference generation

Meta-inference within this thesis refers to the insights generated through the intentional integration of qualitative and quantitative data streams, consistent with established mixed-methods methodology (Whitley et al., 2020). Rather than seeking confirmatory convergence between datasets, integration was undertaken to produce explanatory meta-inferences that extend beyond the findings of either workstream in isolation. This process was operationalised through side-by-side comparison and tabulation of findings to support systematic integration, presented within Table 6.30.

Through this approach, the integrated analysis illuminates how uncertainty within the empirical evidence base itself shaped paramedic risk behaviour, with decision-making influenced not solely by aerosol data, but by professional identity, moral obligation, and contextual pressures operating within time-critical prehospital care.

Table 6.30 Meta-inference generation

Quantitative Findings	Qualitative Findings	Integrated Meta-Inference
Findings of aerosol generation during chest compressions were inconclusive, though case study airway data suggests an overall increase in aerosol levels versus baseline during resuscitation	Paramedics described PPE as uncomfortable, cumbersome, restrictive, and a barrier to effective patient care.	Even without definitive aerosol data, infection control concerns must be balanced against 'real world', practical & operational challenges alongside expectations associated with the role of paramedic.
A potential risk of aerosol transmission during CPR cannot be ruled out.	Dissemination of information left paramedics confused as to course of action	There is a gap between the identified risk of aerosol transmission and paramedics' understanding (during the early stages of the pandemic) and adherence to the guidelines. Clear, simple PPE instructions would reduce misunderstanding and could improve compliance.
Case study aerosol data were varied, with multiple confounding variables meaning it difficult to determine the exact risk posed specifically by chest compressions alone.	PPE was felt to delay response times, particularly in time-critical emergencies where it slowed resuscitation efforts	Delays caused by donning PPE conflict with paramedics' role identity as rescuers whose primary duty is to save lives, potentially influencing their adherence to PPE protocols.
Chest compression data were suggestive of increased aerosol quantities at the airway. Defibrillation was not, within this limited data set	Paramedics reported that in paediatric emergencies, they would choose not to wear PPE in order to reach a child faster.	The decision to forgo PPE, particularly when children were involved, highlights how paramedic role identity as lifesaver and protector of the vulnerable can override personal safety concerns.
Aerosols generated by CPR may increase the risk of COVID-19 transmission	Paramedics favoured PPE primarily if they felt vulnerable, as it offered protection for their families	Perception vs. Practice re PPE: Although paramedics recognise the importance of PPE for family protection, they may not fully engage with PPE practices due to impractical application, discomfort or view of low immediate personal risk during CPR. Messaging that links PPE use directly to personal health as well as family protection could drive adherence.

6.5 Summary

This chapter examined paramedics' experiences with personal protective equipment (PPE) during the COVID-19 pandemic, with a focus on the factors influencing non-adherence, particularly regarding the delivery of resuscitative care. Interviews with paramedics revealed that PPE is widely perceived as a barrier to effective patient care, described as cumbersome, impractical, and often responsible for delaying emergency interventions. This tension is especially pronounced during emergencies involving time-critical patients, such as paediatric cases, where rapid action is seen as essential. The perceived conflict between adhering to PPE protocols and fulfilling their professional identity as life-savers often challenges compliance in these scenarios.

While participants recognised the importance of PPE in protecting themselves and their families, many reported that practical challenges, combined with a perceived low immediate risk during procedures like CPR, contributed to non-adherence. Complementing these qualitative insights, quantitative analysis of eighteen resuscitation case studies demonstrated that several procedures, specifically chest compressions, were suspected of generating significant increases in aerosol concentrations at the airway. These findings suggest a tangible risk of airborne transmission to paramedics and other healthcare workers during the delivery of life support to patients in cardiac arrest.

The next chapter will build on these insights further, developed through meta-inference generation, integrating qualitative and quantitative findings to deepen the understanding of dynamic risk assessment in paramedic practice and to inform future PPE guidance and policy.

Chapter 7: Discussion

7.1 Introduction

This section will interpret and discuss the results and findings presented in the previous chapter. Both workstreams shall be discussed as standalone, individual projects and so will provide a specific answer to their respective research questions. The discussion will then be integrated. The integration process will address the thesis's aim, contextualised within the paramedic dynamic risk assessment and its implications for future pandemic preparedness. Integration is described by experts within the field of mixed-methods research as an indicator of good practice in mixed-method research. When research integrates findings of the project's component parts, the discussion is said to become richer through the addition of both rigour and validity to the findings (Fetters et al., 2013; Siriwardena & Whitley, 2022; Creswell & Clark, 2011). In this mixed-methods study, the predominantly qualitative exploration of paramedics' lived experiences using PPE during the COVID-19 pandemic provides nuanced insights into the complexities underpinning non-adherence behaviours, particularly under conditions of uncertainty, time pressure and perceived threat to life. These rich, contextual understandings are then strengthened and contextualised by the quantitative data, which examines the levels of aerosol generation during critical procedures such as chest compressions. This discussion aims to achieve a more comprehensive understanding of the challenges and risks involved in bringing these distinct yet complementary datasets into dialogue, with relevance for informing organisational policy, training and PPE guidance in future respiratory pandemics. The qualitative findings offer depth and meaning to the numerical data, explaining why certain behaviours might occur, while the quantitative results provide a measure of the potential airborne risks associated with those behaviours, thereby enhancing the overall rigour and validity of the conclusions drawn.

The findings from this thesis are discussed in relation to the latest evidence and guidelines pertaining to this specific field of research. Specifically, regarding the investigation of aerosol generation during chest compressions and defibrillation, notable advances were identified within literature, not present at the time of performing the initial literature review which initially formed the chosen methods and methodology (refer to Chapter 3). These innovations have been included in this chapter and feature as part of the discussion, allowing the findings to be situated within an evolving evidence base and to inform future pandemic preparedness and workforce protection strategies.

7.2 Workstream 1: What are paramedics' experiences of delivering patient care using PPE during the COVID-19 pandemic?

While there has been qualitative research on paramedics' overall experiences in the prehospital environment during the COVID-19 pandemic, there is a lack of qualitative, exploratory studies that specifically examine the perspectives of UK-based paramedics who used PPE throughout this time in the delivery of their daily duties (Rees et al 2021; Millington et al., 2022). Regarding this study, overall, twenty paramedics expressed an interest in participating, sixteen of whom met the inclusion and exclusion criteria. The recruited sample consisted of paramedics who had been responsible for the delivery of patient care throughout a minimum predetermined time frame during the pandemic and included Health and Care Professions Council (HCPC) registered paramedics from a variety of differing clinical roles, aside from the more traditional ambulance paramedic. This variation was deemed to be a positive aspect of this exploratory study by the author based on the developing role of the paramedic in contemporary medicine.

Paramedics now work in many different areas as the role has evolved and developed since its conception. As a result, the College of Paramedics (CoP) have launched an online awareness campaign to illustrate this and support those in more novel and isolating roles, entitled '#notallparamedicsweargreen' (CoP, 2024). It was felt this broad sample supported this initiative and ensured an inclusive sample from which to capture the views of some of the various paramedic roles that exist in contemporary healthcare settings. It was expected that this would both add to the richness of the findings and the depth of discussion. Participants included paramedics from different levels of seniority and experience. The range within the sample included newly qualified ambulance paramedics, specialist paramedics in critical or urgent care, paramedic advanced clinical practitioners specialising in primary care or acute medicine, as well as those practising at consultant level. The sample was designed to capture the clinical experiences of paramedics and included those working at a total of

seven different ambulance service trusts spanning two countries of the United Kingdom, offering the potential to capture a wide variety of experiences.

Overall, six key themes were identified following thematic analysis (refer to section 6.2). These were as follows...

1) Communication
2) Patient care
3) Well-being
4) Guidelines
5) Factors motivating adherence.
6) Non-adherence

Upon analysing the data, a fairly negative undertone emerged. This tone was apparent even in discussions regarding the development of theme five, where adherence motivations were concerned. Paramedics expressed strong opinions, indicating that the introduction of PPE negatively affected their work lives. Criticism surrounding PPE encompassed almost every aspect of its rollout. Notably, paramedics criticised the process of integrating PPE into their practice, pointing out that the guidance provided was overly complex and lacked transparency regarding its rationale. Additionally, a major concern revolved around the feasibility of delivering patient care to the standard they were used to, and they felt PPE's introduction hindered their capability to provide even adequate care, as well as complicating even the most basic of self-care measures, such as staying hydrated.

Interestingly, despite these negative observations, a significant juxtaposition was observed when, as part of the interview process, paramedics were tasked with providing two words that encapsulated their views of using PPE when delivering patient care. This was then illustrated within a word cloud (see Figure 6.4). Using this method to represent their views diagrammatically demonstrated positive phrases that

had been repeatedly recited, such as ‘protection’ and ‘safe’, as standing out over a background of a variety of negative words and phrases. This perhaps suggests that despite the many frustrations of paramedics regarding PPE use in the prehospital setting, they were still appreciative of its presence, however word clouds are restrictive when attempting to make such clear inferences.

Non-adherence appeared in several other themes, particularly in themes one through four. This connection is highlighted in Chapter 6, specifically in Figure 6.3. While the concept of non-adherence justified its own thematic distinction, it was significantly influenced by PPE's negative associations with both physical and mental well-being, alongside the participants' mistrust or difficulty in understanding the guidelines. All of these factors notably contributed to paramedic non-adherence.

Two themes; patient care and communication, predominately had a discourse that centred upon the negative impact PPE had on paramedics’ abilities to deliver both aspects effectively. These observations, whereby PPE detrimentally impacted communication between patients and the wider care team, both directly and indirectly restricting effective delivery of patient care, were consistent with wider research exploring healthcare workers in other settings (Montgomery et al., 2021; Hoernke et al., 2021; Millington et al., 2022). Significantly, PPE also had a detrimental influence in the management of resuscitation and the conversations thereafter between rescuers and family members. The conversations whereby paramedics would break bad news to the family became a particular issue should the resuscitation attempt be unsuccessful. These are highly emotive and challenging conversations and require, tact, thoughtfulness, and empathy. Frequently they would involve highly stressed families at a time of crisis (Brinkrolf et al, 2021). The impact PPE had on these conversations was a notable factor reported as a significant contributor to the interviewed paramedics' non-adherence behaviours. It is also noteworthy that these factors also had implications regarding the theme of well-being. A perceived failure to deliver effective patient care by paramedics, due to the presence of PPE,

either indirectly through an inability to communicate with colleagues, or directly through their impedance of sensory perception or dexterity, had concerning effect on their well-being and will be discussed later in the context of moral injury.

The frequent non-adherence in these circumstances centred around the apparent willingness of paramedics to repeatedly put the health needs of their patients ahead of their own, personal health and safety. Multiple examples were cited within the captured interview data obtained from the recruited participants. Paramedics would make the conscious decision to deviate away from recommended guidance despite having a reasonable appreciation of the potential risk this action might present to themselves. Examples captured within the dataset include paramedics choosing PPE, which offered speed of application despite an awareness of this being less effective with regard to protection. An example being in cases of cardiac arrest, whereby a decision is made to opt for a simple face mask over that of the recommended level 3 respiratory hood. This appeared a more premeditated choice to deviate from guidance. Their rationale behind this decision was explored, where it was described how this was motivated by the speed in which the less effective PPE could be applied. It was deemed by those asked as an acceptable risk as, in their view, it would at least offer a degree of protection, and meant they could deliver interventions to patients more rapidly. However, they were appreciative that this was not the optimal level of protection and put them at risk.

Paramedics shared instances where they chose to remove or forgo their PPE, believing this decision greatly improved patient care. For instance, during resuscitation efforts, it might impede sensory perception and communication. These choices were often reactive, shaped by the specific situations they encountered. Further questioning revealed that they found PPE to be unnecessarily cumbersome in diverse contexts ranging from critical cases to everyday situations. In some interactions, paramedics considered wearing PPE to be unnecessary based on their assessment of urgency when delivering life-

saving interventions. This was particularly evident in scenarios involving critically ill children or patients, including those in cardiac arrest. They also identified situations where the benefit of wearing protective gear seemed minimal, especially in relation to the aprons issued at this time, which were frequently removed or ignored. The removal of PPE may be considered necessary as it can obstruct sensory perception while carrying out critical clinical tasks. One interview underscored this issue, particularly during airway management for a cardiac arrest patient, emphasising that PPE impeded visibility. As alluded to, both verbal and non-verbal communication were cited as notable contributors to PPEs removal. These criticisms of PPE were echoed in wider literature exploring healthcare workers' experiences of working in PPE during COVID-19. Although no testimony from paramedics was captured, those working in critical care or emergency medicine described similar feelings of unbearable discomfort associated with wearing PPE (Dempster et al., 2024; Jose et al., 2021; Hoernke et al., 2021). A notable observation by Hoernke et al. (2021) highlighted how healthcare workers such as nurses and doctors who featured within their sample echoed the sentiments described by paramedics within this research, whereby non-adherence might occur when an inability to communicate became apparent, particularly the ability to demonstrate empathy was compromised such as might be apparent when breaking bad news. A particularly emotive example that encapsulated a variety of these factors involved a paramedic with a dying cancer patient who had been confirmed as COVID-19 positive. The patient had fallen from bed on a particularly humid day. The paramedic felt PPE, the associated condensation in their goggles, the presence of a mask and the lack of grip due to gloves and apron, meant they were unable to provide effective or empathetic care in the person's last moments. Nor were they able to help them back into bed due to an inability to safely lift the patient due to their levels of perspiration, hence they chose to completely remove their PPE. Describing their desire to deliver humane treatment and trumping the need to protect themselves. Although harrowingly emotive, this was not a unique case in this regard, with PPE repeatedly cited as a clear barrier to effective and empathetic communication by participants in this research and wider literature (Dempster et al., 2024; Jose et al., 2021). More than one participant described PPE's introduction as dehumanising patient care, particularly when

paramedics were required to engage in challenging conversations with relatives associated with breaking bad news or supporting patients through their care. This instinctive drive to preserve humanity in moments of vulnerability aligns with research on empathy as an evolved trait essential to social bonding and moral decision-making (de Waal, 2008). The decision to remove PPE to show empathy reflects a deep-rooted human inclination toward altruism, whereby the immediate need to show compassion or maintain a human connection can override any self-preservation instincts (Batson, 2011).

These experiences highlight the operational and emotional obstacles that paramedics encounter, while also uncovering the profound psychological motivations that shape their actions throughout the pandemic. To gain deeper insights into the motivations influencing behaviour, especially during times of heightened stress and uncertainty, the idea of identity fusion provides a valuable perspective for investigation.

7.2.1 Identity fusion

To gain insight into the strong sense of duty demonstrated by paramedics in this study, especially their readiness to face significant personal risk, it is useful to examine the professional principles of 'duty of care' or 'duty to treat' alongside the psychological idea of identity fusion. This concept provides an important perspective to understand how profoundly individuals can intertwine their personal identity with their professional roles, which offers a proposed explanation as to their self-sacrificial behaviours seen in their actions.

Duty to treat is described by McConnell (2020) as relating to general societal expectations that healthcare workers (HCWs) take more risk than that expected of a member of the broader public when

going to aid those in need. The Joint Royal Colleges Ambulance Liaison Committee (JRCALC) guidelines for ambulance clinicians define duty of care in a similar vein. They describe how proportionate steps should be taken to mitigate a presenting risk, but risk cannot be eliminated entirely and so an element of risk must be accepted when delivering patient care in the prehospital setting. In practical application in healthcare settings, both concepts of 'duty to treat' and 'duty of care' are a delicate balance of responsibilities to themselves and their patients. Healthcare workers' obligations lie professionally and morally with the patient, but also personally to themselves, their dependents, and their family (McConnell 2020, NARU 2021, JRCALC 2022).

Identity fusion is a psychological concept which refers to a visceral feeling of oneness and the blurring of boundaries between the needs of oneself and that of others, usually effecting an individual within a group (Chinchilla et al 2022). The circumstances required for individuals to experience identity fusion can become heightened during shared, intense, physical, or emotional experiences. The nature of these might be positive or negative, with typical examples of self-sacrifice presented within literature cited as parental feelings towards their children or the sacrifices made by soldiers for their comrades when in battle (Swann et al., 2010; Swann et al., 2014; Chinchilla et al., 2022). Indeed, comparisons were made that likened working in healthcare settings during the COVID-19 pandemic to that of working within a warzone (Baldwin & George, 2021). The collective trauma experienced during the COVID-19 pandemic is thought to have been akin to that experienced by those in a battlefield environment, suspected to have contributed to ideal conditions in which identity fusion might occur (Gomez, 2020).

An example of how circumstances during COVID-19 might contribute to identity fusion involves the implications of the 'clap for carers' initiative, later rebranded as 'clap for heroes'. This involved the public being encouraged by governments, not just in the United Kingdom but throughout many western countries, to applaud frontline workers from their doorsteps during government-imposed lockdowns.

These occurred at a designated time each week. The undertone is the informal acknowledgement of the risks healthcare workers were facing and their potential sacrifice in doing their professional duty during these unprecedented times, positioning them as almost quasi-war heroes in the so-called battle against COVID-19 (Cox, 2020; Mitchell, 2021).

Performing collective rituals such as this has been considered to increase the propensity for identity fusion to occur, with further examples cited as being within martial arts ceremonies, pilgrimages, or folkloric rituals or marches (Páez et al., 2015). The act of performing these rituals encourages an increased sense of belonging and enhances a feeling of shared values between communities (Lobarto, 2021). It is proposed that the combination of an extreme sense of duty to treat, with circumstances conducive to an increased propensity for identity fusion, as occurred during the pandemic, potentially led to paramedics experiencing a state of overpowering urges both to save and of duty. This led to the patient's needs taking precedence over all else. The intense, war-like camaraderie, reported by several participants within the interview transcripts, further underpins this theory. This heightened rescuer state is proposed as being termed 'the blue mist'. A term aligned to how crimes of passion might be as a result of extreme anger, which are also referred to as the more recognisable phrase 'the red mist' (Howe 2023). To provide further context, blue mist was first coined as a phrase by Albert Knaggs, a now-retired paramedic and emergency driving instructor. He used the term when delivering driving sessions to students in reference to trainee emergency response drivers' use of excessive speed when responding to emergency ambulance calls. By putting themselves and others at risk to get to the patient in a timely fashion he would describe how "the blue mist had sent in", thereby clouding their judgement and so affecting their decision making.

Intermittent explosive disorder (IED) is a behavioural disorder associated with extreme and disproportionate aggression and is the medical term used to describe 'red mist' incidents such as those

seen in crimes of passion or road rage cases (Galovski et al., 2002). Neuroanatomical studies that investigated IED found amygdala hyperactivity present in this patient group (McCloskey et al., 2016). The amygdala is located in the medial temporal lobe of the brain and becomes activated during times of heightened fear or threat. Interestingly, it also plays an important role in empathy and human response to emotion, becoming stimulated when showing extreme empathy (Goerlich-Doebra et al., 2015). Therefore, it is posited that this blue mist state of heightened and extreme empathy that led to paramedics seemingly disregarding their own safety for that of their patients could be due to similar amygdala activity or dysfunction. Further studies, similar in design to McCloskey et al. (2016), would be required to ascertain this.

The heroism narrative at the time of the COVID-19 pandemic, encapsulated by the 'clap for heroes' initiative, is suspected to be a key contributor to non-adherence. The promotion of healthcare workers as heroes was met with a mixed response in a survey exploring the impact of the Clap for Carers initiative. An interesting finding within this involved how this was felt to add to the pressure already felt by healthcare workers attempting to go about their usual professional duties at this time. It was felt that to be heroic meant to be self-sacrificing (Manthorpe et al, 2022). It is noteworthy to consider heroism in the context of the 9/11 terror attacks. Emergency first responders were rightly lauded as heroic for their levels of self-sacrifice (Furness et al., 2021). Nurses repeatedly played down this narrative, instead describing themselves as professionals over heroes (Mitchell, 2021; Manthorpe et al., 2022). A sentiment echoed by a paramedic during interview 7, who interestingly, despite an absolute rejection of the hero narrative, also gave multiple examples of non-adherence in high-risk situations whereby they knowingly and intentionally compromised their own safety for the betterment of patient care. This rejection of the hero label and the connotations therein was further repeated in the wider literature, where it was described how paramedics would often play down any hero narrative, instead positioning themselves as more of an anti-hero through sarcasm and self-deprecation. However, they would often

describe the heroic actions of the wider team over those of the individual (Tangherlini et al., 2000). Healthcare workers' decision to take this stance could be viewed as a form of self-preservation in two key ways. Previously, paramedics were celebrated as heroes for their lifesaving efforts; however, it's clear that not every life can be saved. If heroism is defined by lifesaving, what does it mean when a life is lost, especially during the pandemic when many lives were lost? Additionally, in a post-9/11 world, the term hero now carries an implied societal expectation of self-sacrifice while on duty (Rees et al., 2022; Furness et al., 2021; Manthorpe et al., 2022).

This complex relationship between professional identity and societal expectations, particularly the tension between rejecting the hero label while demonstrating heroic behaviours, highlights the psychological strain faced by paramedics. While identity fusion helps explain the strength of commitment and willingness to act self-sacrificially, it does not fully account for the emotional aftermath when outcomes are poor or when actions conflict with deeply held values. These circumstances create fertile ground for moral injury, a concept that captures the emotional distress experienced when professionals feel they have violated their own ethical or moral code, whether through action or inaction.

7.2.2 Moral Injury

The use of the term ‘hero’ throughout the pandemic in reference to healthcare workers must also be considered alongside identity theory. This potentially played a pivotal role as a contributor to the moral injury alluded to by paramedics within the sample. Moral injury is a form of psychological trauma which involves extreme feelings of guilt and shame. It developed as a psychological construct from the original concept of moral distress, described as the negative feelings associated with circumstances ‘when one knows the right thing to do, but institutional constraints make it nearly impossible to pursue the right

course of action' (Lentz et al., 2021). Moral injury develops when individuals experience unresolved dissonance between their morals and their values, such as that might be experienced by soldiers at war (Jinkerson, 2016). By donning PPE as advised by their Trusts, paramedics would inevitably contribute to a delay in their time to arrive at the patient. As such, it could be said that following PPE guidance meant they were less able to follow clinical guidance. For example, 'time is brain' is a phrase commonly associated with emergency response to stroke patients and emphasises the need for rapid action to prevent damage to brain tissue, similarly 'time is muscle' refers to heart attack patients and the pressing need for quick action to save the heart muscle from ischemic death (Saver, 2005; Antman, 2008). Not being able to deliver to the standard one would expect could have deep psychological consequences to the paramedic in question. Captured within the data were paramedics' descriptions of feelings of frustration at delays associated with donning PPE, alongside an awareness of how they could do better for their patients. It was candidly shared how they felt guilt and shame as a result. The paramedic role identity, in some individuals, acts to define who they are as individuals and links closely to their overall sense of purpose, in some cases providing them with meaning as to their place in the world (Mausz et al., 2022; Tangherlini, 2000). Paramedics are universally seen as compassionate caregivers (Murcot et al., 2014; Johnston et al., 2016; Furness et al., 2021). Indeed, this sentiment of frustration around the inability to deliver adequate care has been captured in wider literature, further underlining this observation, whereby healthcare workers within hospital settings described their work during the pandemic as akin to 'going into a war zone without a weapon' (Baldwin & George, 2021).

When discrepancies exist between their perception of the role of a paramedic, or indeed any healthcare worker, and the actual role they are able to perform, it can lead to serious consequences regarding their mental wellbeing. This disparity between work as imagined (WAI) versus work as done (WAD) is heavily featured within the literature on human healthcare factors (Hollnagel, 2015; Ashraf et al., 2022). A barrier preventing the effective delivery of a role as perceived by an individual can be described as an

identity-relevant disruptive event (Degarmo et al., 1996; Mausz et al., 2022). PPE's introduction during the pandemic might be described as one such barrier. The subsequent impact can be notable, affecting individuals' psychological health and emotional wellbeing through them being subject Ato the symptoms of moral injury. Exposure to potentially morally injurious events (PMIEs) can increase the likelihood that the individual will progress to experience moral injury and can also act as a predictive indicator of future post-traumatic stress disorder (PTSD) (Papazoglou et al.; Lentz et al., 2021). Interestingly, these findings in relation to COVID-19 have also been observed in the literature reviewing the experiences of healthcare professionals, all be it not paramedics, who have worked throughout earlier pandemics. Mental wellbeing was adversely affected, and recorded data suggest healthcare workers who found themselves exposed to work activities related to patient care of patients diagnosed with Ebola, MERS, and SARS were 1.7 times more likely to develop PTSD than those healthcare workers who were not tasked with caring for these patients (Billings et al., 2021).

7.3 Workstream 2: Do chest compressions and defibrillation delivered during active resuscitation of a patient in cardiac arrest generate aerosols and so pose a transmission risk to the rescuer?

7.3.1 Developments in wider literature

At the time of designing the research proposal and following completion of a review of relevant literature (see Chapter 2), it had been identified that quantification of aerosols produced during resuscitation of human subjects in cardiac arrest, collected in real-time in a prehospital setting, to the best of the researcher's knowledge, had never before been documented. During completion of this project, further developments were noted within contemporary literature, notably in early 2024, a study was published by Shrimpton et al. (2024) entitled 'a quantitative evaluation of aerosol generation during cardiopulmonary resuscitation'. Shrimpton et al (2024) observed aerosol production in the context of

active resuscitation of human subjects who had experienced a prehospital cardiac arrest. The study focused on chest compressions and defibrillation, specifically aerosol generating events. Their study design utilised an adapted supraglottic airway that had been altered to house an optical particle counter within a closed-circuit of an airway management system. The authors cited the collection of aerosols within a closed-circuit as a particularly advantageous design feature due to its reducing the influence of confounding variables by eliminating background aerosols. However, as is described in Gregson et al (2021), the perfect sampling strategy does not exist. When considering aerosol dynamics involved in this chosen method, several considerations need to be addressed. Firstly, aerosols collected within the closed-circuit of the supraglottic airway tubing will not be representative of respiratory aerosols that would be expelled into the atmosphere during standard CPR, as environmental or atmospheric influences would not have yet impacted them. The aerosols measured have been quantified within the constraints of a sampling tube. Once aerosols are exposed to the environment, they will be subject to differing temperatures and humidity levels. Expelled air in a small, narrow, plastic sampling tube would be subject to notably different elemental influences, much warmer and humid than conditions outside of the tubing within the general atmosphere. Therefore, it could be said that the area within the closed-circuit sampling technique might create a microclimate, dissimilar to that of the surrounding environment and not reflective of what might be seen if expelled into the atmosphere. Respiratory particles expelled directly into the open environment would be subject to varied and differing atmospheric conditions than those expelled into the sampling tubing. Spatial heterogeneity of room air, alongside the surface area of the particles expelled, can lead to dilution, or dispersion, of aerosol particles. This occurs as the particles mix with atmospheric conditions, leading to particles changing shape and mass (Gregson et al., 2021). These phenomena are prevented from happening when aerosol sampling occurs within a closed circuit protected from atmospheric conditions. Similarly, the rate or frequency of coalescence, the process that describes how aerosols collide or 'clump' together, might be affected when they are housed within a closed circuit. Considering the principles of Brownian motion, the random movement of particles suspended in a fluid (in this case, air) due to their collision with the

fast-moving atoms or molecules in the gas, expelled aerosols in the external environment are more likely to encounter each other due to this chaotic motion. This increased likelihood of collision, particularly as they mix with cooler and typically less humid air than is seen within airways, arguably leads to a higher rate of coalescence. The closed circuit could be seen as an extension of the airway system, thereby reducing the likelihood of this Brownian motion-driven coalescence and so offering false reassurance (Jarvis, 2020; Zaichik et al., 2008; Alonso et al., 2001).

Additionally, supraglottic airways (the featured adjunct within the study) differ from endotracheal intubation in that they do not always create a seal of a patency required to prevent aspiration of gastric contents. The authors detailed how airways that were documented as being notably soiled with gastric contents were excluded from their data, however, it cannot be assumed that the aerosols detected within the included data were entirely made up of respiratory particles as the seal is not as effectively closed as would be seen if an endotracheal tube had been used. Like the data within this thesis, the authors presented individual resuscitation data and timestamped key events as part of their published article format, noting any trends in aerosol that were observed. These data were then used to inform a porcine model, which enabled analysis of aerosol data prior to and immediately following an induced cardiac arrest in pigs, and thereby, in their view, provided a robust control group. This model had limitations regarding the generalisability of findings taken from a porcine model to that of a human sample, namely the various in anatomy.

Shrimpton et al (2024) found that CPR performed on human subjects consistently generated higher levels of aerosol concentrations compared to earlier studies. These earlier studies differed in that they included participants who were not actively being resuscitated. Instead, these subjects were either awake or anaesthetised. For subjects who were awake, aerosols were measured either during coughing, or when performing other similar expiratory activities, such as speaking or shouting. Anaesthetised

subjects had circulating aerosols measured in proximity to their airway in the context of various procedures of airway management. In some cases, CPR was observed to create as much as 100 times the volume of circulating aerosols (Brown et al., 2020; Shrimpton et al., 2021, [1]Shrimpton et al., 2022, [2]Shrimpton et al., 2022).

Other literature released following the completion of the literature review (section 3.2.1), which informed the methods of this study, included a study by Hung et al. 2023. They performed a comparative analysis exploring exposure risk and mitigation strategies during CPR in the prehospital and inpatient settings. The methods used within this study adopted a lower fidelity model that involved mannequins and synthetic aerosol production. Hung et al. (2023) echoed the presence of risk highlighted by Shrimpton with regard to CPR administration and nosocomial transmission. Interestingly, they found more risk associated with the leader of the arrest being positioned at the feet. Advocating the application of N95 face masks to the patient's face during CPR to reduce aerosols until such time as a definitive airway, such as a supraglottic airway, can be inserted and the circuit can be closed (Hung et al., 2023).

The discussed developments in the wider literature, particularly the findings of Shrimpton et al. (2024), provide a valuable contemporary context for the findings of this thesis. While their study design offered advantages in controlling background aerosols through closed-circuit sampling, the inherent limitations of this approach, as discussed through the lens of aerosol dynamics and Brownian motion, underscore the importance of considering the potential for a microclimate and altered aerosol behaviour compared to the open environment. Therefore, the findings of this thesis, which capture aerosol measurements in a real-world prehospital setting, offer a unique and complementary perspective, directly reflecting the challenges and conditions faced by paramedics in the field. The comparison with Shrimpton et al.'s (2024) work highlights the need for careful consideration of sampling methodologies and the potential impact of environmental factors when interpreting aerosol data in the context of resuscitation.

7.3.3 Workstream 2: Interpretation of the datasets

The case study data present a picture suggesting higher numbers of aerosols sampled at the airway than seen at baseline. As one would expect in the prehospital setting, the data collection sites were both highly varied and challenging environments in which to conduct research. These settings included a wide variety of data collection sites. They comprised various rooms within residential properties, such as kitchens, living rooms or bedrooms as well as indoor public spaces such as gymnasiums and warehouses. Data were also collected outdoors, and the narrative provided described the Opticle Particle Counters being exposed to the elements. Four of the indoor settings were noted as having an odour of cigarette smoke; the relevance of this shall be discussed later in the chapter. Personal protective equipment such as facemasks, was not worn on any occasion by any of those in attendance at the various scenes, either layperson or professional.

Participants were similarly varied in their presentation. Two-thirds of the recruited sample were male, with the median age of participants being 65 years. The interquartile range was calculated as 23.75. Of these recruited participants, 50% were observed as having an average body habitus following a general, 'end of the bed' inspection by the researcher. Heart disease was the most common comorbidity (38.9%), followed by respiratory disease (22.2%) and hypertension (22.2%).

Despite these variations in both scenes attended and participant characteristics, 15 of the 18 case studies recorded higher aerosol particle number concentrations (# cm-3 min-1) at the Alphasense® OPC-N3 (Alphasense® Ltd., Essex, UK) placed in proximity to the airway, compared to that at baseline. Exploring the nature of aerosol characteristics in each of these settings found particle sizes recorded within the 0.41 – 0.83 µm size range contributing almost entirely to these higher concentrations captured as at the airway. It is noteworthy that some larger particles were also detected, however, in much smaller

quantities. This has notable relevance when considering this finding in the context of infection risk to rescuers. Studies have shown significant volumes of respiratory aerosols associated with exhalation or other respiratory activities that can carry pathogens to the submicron level (Morawska et al., 2009; Ai et al., 2018; Lindsley et al., 2010). Submicron aerosols, when deposited deep within the airways, pose a significant risk in relation to disease transmission.

Although the suspected contribution of confounding variables has been raised as a limitation of data collection within the prehospital sites, evidence exists to confute their influence on the data set. Cigarette smoke, as an example, would be an unlikely source for the spikes detected within the 0.41 – 0.83 µm particle size range in this instance. This is because, while some variability exists in the literature, the general consensus suggests that cigarette smoke, whether firsthand or second-hand ('side-stream'), exhibits a significantly narrower particle size distribution. Indeed, it certainly causes no detectable particles at the larger size ranges that were seen in small levels within these case studies. Peak size ranges in relation to tobacco smoke are associated with the lower end of the submicron range, which is between 0.02 µm and 0.2 µm (Braun et al., 2019; Keith et al., 1960; Nazaroff et al., 2003). Another considered source of contaminate particles contributing to these higher levels within this range were activities such as the opening of paper packets that housed medical devices such as intravenous or intraosseous cannulation paraphernalia in the vicinity of the airway, both of which were used in the resuscitation attempts, in this instance. This again was discounted as a particle source of the spikes seen at the 0.41-0.83 µm size range as literature has quantified aerosols recorded in paper shredding to be of even smaller magnitudes than cigarette smoke, namely 0.02 – 0.03 µm (Shin et al, 2019). It could be assumed that this higher level was made up of exhaled bioaerosols. However, it is noteworthy that none of the ambulance resuscitation team were wearing masks at any of the cardiac arrests and so could have contributed to these increased levels through normal exhalation activities associated with speaking or physical exertion.

As identified in section 6.3.5, the baseline could not be termed a proper control due to reasons that were multifaceted in nature. Primarily, this was due to the unpredictable nature of the prehospital data collection sites leading to huge variance in environmental features. Furthermore, although every effort was made to ensure parity at each of the data collection sites, airway and baseline samples were inevitably collected at slightly varying distances, due to accessibility issues. Airway sampling tubes were placed at approximately 20 centimetres from the participant's mouth opening in line with other similar studies (Shrimpton et al., 2023), with baseline sampling tubes placed a distance as far away as possible not exceeding 4 metres away from the resuscitation (a distance imposed by the length of sample tubing used within the study, two lengths of tubing of 2 metres in length both attached to OPCs linked to a central laptop) .

Interestingly, of the few case studies that recorded higher aerosol concentrations away from the airway, Case Study 3 showed higher baseline concentration values when compared to those captured at the airway. This specific case involved a data set collected in an outdoor environment, in the open air, and exposed to the elements. The data collection form completed by the researcher at the scene detailed how this particular environment was exposed to high levels of wind. It was journaled how the recruited participant had been pulled from a car, in a state of cardiac arrest, and was situated in such a position whereby the car and the resuscitation team afforded the participant protection from these high winds. In this instance, one might expect these higher particle and mass concentrations to be made up of larger particle sizes as the main contributor. This is due to contaminant particles such as dust typically measuring greater than 1 µm (Zhu & Hinds, 2022). However, recorded size ranges were, in fact, similar (0.41 – 0.83 µm) to those seen in other case studies within an indoor environment, casting doubt on the assumption that differences seen at the airway at the submicron level are of respiratory origin, captured within the other (indoor) case studies. Case study 5 also showed higher baseline aerosol concentration

than that at the airway however, in this instance the research site occurred in a small kitchen situated within a residential dwelling. This further highlights the need for research conducted within a controlled setting or mandates that all rescuers wear some kind of surgical face mask to mitigate their influence on the results.

Charts comparing both mechanical (n=2) and manual (n=11) chest compressions with baseline data were created. These data were collected two minutes prior to the cessation of the resuscitation. The rationale behind this was due to it being witnessed that manual chest compression would be administered continually up until the moment the Autopulse® resuscitation system was ready to be activated (Autopulse® being the standard equipment used by Yorkshire Ambulance Service Specialist Paramedics in Critical Care (SPCC) for which to deliver mechanical chest compressions). Guidelines in resuscitation stipulate manual chest compressions should be administered at the onset of cardiac arrest and pauses should be kept to an absolute minimum. Therefore, aerosols circulating would likely have been due to manual chest compressions on activating the Autopulse® resuscitation system. In addition, the onset of data collection also marked the SPCC arrival on scene at the prehospital resuscitation attempt, due to the researcher accompanying the critical care paramedic. The arrival of the specialist paramedic in critical care would typically be associated with a plethora of other procedures or activities that would occur almost immediately upon their arrival. For example, they might take over the management of the airway either through adjustment or replacement of the existing airway device or repositioning of the patient to increase accessibility. Therefore, it was felt observing data collected at the cessation of resuscitation, rather than the activation of mechanical chest compressions, could mitigate the influence of these other procedures on the findings.

Notable caution must be applied when attempting to interpret any of these data due to the presence of multiple confounding variables. As this was an exploratory investigation, it was never the intention to

make generalisable definitive conclusions. The presence of confounding variables and the expected small sample size were anticipated at the planning stage. Taking that into consideration and having reviewed the chest compression data within these charts, it was evident that an approximate two-fold increase in the aerosol particle concentration was captured at the airway OPC compared to baseline.

The action of compressing a patient's chest to a third of its depth as recommended by resuscitation guidance (RCUK 2021) requires a significant degree of force to achieve. Therefore, accepting the findings within the limitations of this trial, one can make an argument that it is indeed plausible that compressions could be an aerosol generating procedure, a suspicion highlighted within the New and Emerging Respiratory Virus Threats Advisory Group (NERVTAG) and Public Health England's, since withdrawn, combined statement made in April 2022 (PHE 2022). The mechanism supporting this theory centres around aerosols being produced through the passage of turbulent air created via the change in intrathoracic pressure associated with manual, or mechanical compression of the chest and it has been postulated that these aerosols originate from the alveoli and within the larynx due to these turbulent vibrations (Gregson et al., 2021).

Regarding defibrillation, aerosol analysis used minute data to investigate the effect of delivering a defibrillator shock during CPR. Minute data compared OPC aerosol data 60 seconds before and after delivery of each defibrillator shock. Notably four recruited participants underwent a total of 9 defibrillator shocks in the presence of the research team and so were captured during data collection. Significantly more shocks were delivered prior to the arrival of the SPCC / researcher and these data did not feature and so could be termed a missed opportunity.

Analysis of the minute data suggests no notable difference was seen in the circulating aerosol number concentration before or after a defibrillator shock was delivered. This was in contrast to the findings of Hsu et al (2021) in which they found neither chest compressions nor defibrillation alone to be aerosol generating. However, their data suggested that delivering a defibrillator shock followed by chest compressions did have aerosol generating propensity. This was a finding accepted within the confines of their limited swine model study that utilised three female pigs, chemically induced into cardiac arrest and then subject to resuscitative procedures. The case study data captured within the Hsu et al. (2021) project do not show any notable spikes in circulating aerosol mass of number concentration once a defibrillation shock has been administered and chest compressions have resumed.

7.3.4 Challenges and limitations

This aspect of the research faced notable challenges, some of which were discussed earlier in this thesis (see Chapter 4 and section 6.3.1). A primary issue arose from researching cardiac arrest patients in a prehospital context, a setting that is characteristically unpredictable and challenging to manage. These obstacles included ethical considerations, difficulties in recruiting participants, and challenges in controlling confounding variables. The existing literature highlights best practices for assessing and characterising exhaled aerosols, including the need to remove background aerosols and the capability to collect data over extended periods (Gregson et al., 2021). Nevertheless, achieving either requirement in a dynamic prehospital environment proved unattainable. These constraints were acknowledged early in the planning process, and strategies to mitigate them were incorporated into the study design.

One such strategy involved the proposal to conduct research within a critical care environment. Specifically, the use of an isolated theatre suite was considered, where background aerosol levels could be controlled. In this controlled setting, it was proposed that newly deceased patients could be enrolled

and randomly assigned to undergo one of six resuscitative procedures. This would have allowed for a robust control group and enabled the isolation and analysis of individual procedures. However, due to ethical and logistical constraints, this approach was not pursued. The ethical implications of conducting research such as this were analysed, then presented to, and scrutinised by, a Patient and Public Involvement and Engagement (PPIE) group, as part of an ethical consultation process. The proposed study design was met with initial hesitancy, followed by widespread approval by all in attendance after a thorough explanation of the methods involved in the research process. This enthusiasm seen at PPIE was not reciprocated when the study design was presented to critical care leads within various hospitals in South Yorkshire. At the time of holding these discussions the UK had just negotiated its way through the third wave of the SARS-CoV-2 pandemic. It was a period in time which saw critical care staff face unprecedented challenges in terms of working conditions, acuity of patients and levels of death. Despite a considered study design that was highly supportive to staff in this regard, critical care leads made the decision that this would be too much of a burden psychologically for their staff, and so this line of inquiry was abandoned. Literature has since been published that brings into focus the detrimental impact COVID-19 had on the well-being of healthcare workers in critical care settings (Elliott et al., 2023).

An alternative countermeasure was the planned use of an Emergency Department (ED) as a research site. A further amendment to the study design was made in which it was proposed that data collection would be carried out during active resuscitation of patients in cardiac arrest within the ED. Similar in nature to the prehospital arm, it was identified that the ED offered the additional benefit of an environment that allowed for analysis of background aerosols prior to, as well as during and after, the resuscitation, and so enabled creation of a comparator group. It was accepted that this approach would yield fewer participants and was a less controlled setting than that of a critical department, but offered a much more stable and predictable environment than that seen in the prehospital setting. Additionally, the comparator group could have potentially allowed for more rigorous statistical analysis. Ethical

approval was granted, and a research team member was positioned in an ED resus room, in Norfolk and Norwich University Hospital (NNUH) NHS Trust. Unfortunately, however, no participants were recruited during the data collection period in ED. A recommendation for future studies would be to learn from this experience and pursue a critical care data collection site that might enable a more stable comparison group to be organised whilst also supporting the randomisation of resuscitative procedures.

As highlighted in Section 4.7.1, while limited resources are often cited as a constraint in clinical research, particularly in acute and unpredictable environments, they do not inherently undermine research quality. In this case, although resource constraints limited recruitment in one setting, they did not compromise the core study objectives or the validity of the data obtained from the prehospital arm. Rather, they reflect the complex balance between methodological ambition and real-world feasibility, an issue well-recognised in health services research (O'Cathain et al., 2009; Snooks & Hutchings, 2001). The proactive planning, ethical preparedness, and transparent reporting of limitations serve to uphold the rigour of this thesis, in keeping with best practice guidance for complex intervention research (Craig et al., 2008; Toerien et al., 2009). These experiences contribute valuable insights into the operational challenges of conducting research in emergency settings and offer practical learning for future studies targeting high-acuity patient populations (Greenhalgh & Papoutsi, 2018).

Looking at other possible models that attempted to quantify aerosol generation during CPR, it is clear that a paucity of literature remains in this area. Shrimpton et al (2024) is one particularly good example for discussion in this context. As discussed earlier, this paper was published in 2024, two years after the launch of this project, during data collection, and so did not inform the planning phase nor feature as part of the literature review. Their study design recruited human participants who had experienced an out-of-hospital cardiac arrest (OOHCA) and utilised an adapted a supraglottic airway (SGA) circuit with an enclosed aerosol analyser. This was issued to air ambulances and enabled a close-circuit from which

to analyse expired aerosols. This model had the advantage over the model reported within this thesis, in that it offered the aerosol analyser protection from the external atmospheric contaminants. As has been seen in the case study data within the previous chapter, each scene was highly varied, with various contaminating factors, such as the presence of bystanders or ambulance crews without masks and significant exposure to other elements.

Shrimpton's technique was novel in its approach and was coupled with criteria that excluded resuscitative events where aspiration of visible gastric contents was observed to contaminate the airway. Even with this added level of assurance, one cannot categorically conclude that a design such as this would lead to isolation and detection of respiratory aerosols alone. Gregson et al (2022) identified that burping (termed 'eructations') observed during elective oesophago-gastro-duodenoscopy (OGD) led to detectable levels of aerosol production. They also found that notably higher aerosol numbers were detected during coughing induced during OGD placement when compared to volitional cough alone. These findings had several possible explanations. The cough associated with OGD placement might be more forceful than a volitional cough. Additionally fluid lubricant used during OGD insertion might have contributed to more favourable fluid dynamics through dilution of mucous membranes. Similarly, the presence of the OGD itself caused narrowing of the available space, and so could increase air pressures within the oropharynx due to reduced space for exhaled air to pass through. As has been discussed, increased air pressures can lead to airway turbulence and the liberation of aerosol particles. Regardless of the cause, these findings underscore the significant challenges prehospital researchers face in accurately quantifying and isolating the specific source of aerosol generation during resuscitation. As a result, they cast doubt on any firm conclusions that the aerosols captured in studies, whether using Shrimpton's closed-circuit model or the approach employed in this project, can be definitively attributed to respiratory origin alone.

In the context of respiratory disease transmission and SARS-CoV-2 risk, research has shown that the acidic environment of the stomach renders SARS-CoV-2 non-infective. However, the acidity (or pH) of the stomach can vary drastically between fasting and feeding states. These pH's can range from approximately 1.2 during periods of fasting to 6.7 postprandially (after feeding). SARS-CoV-2 virions can evade deactivation during these less acidic states, seen during, or immediately after feeding. Therefore, aerosols originating from gastric contents can still pose a potential transmission risk under specific conditions, particularly when the stomach's pH is elevated (Esseili, 2023). With that said, gastric contents are anthropogenic bioaerosols and so present a risk, a pertinent point to consider regarding Norovirus. Norovirus is the world's primary cause of gastroenteritis, and it is spread easily in vomit. Aerosolisation of vomit or gastric fluids can occur through a host of mechanisms and so put those in proximity to an infected person at risk of transmission (Misumi et al 2021). It is reasonable to suggest gastric contents, visible or not, can contribute to circulating aerosols during resuscitation and pose a risk to the rescuer. Indeed, studies have documented incidence of aspiration or regurgitation following CPR to occur in approximately one third of cases and occurs through a variety of mechanisms, either through loss of oesophageal sphincter tone, gastric insufflation following manual ventilations via bag valve mask or mouth-to-mouth or important in regards to this study, due to changes to intraabdominal pressures through chest compressions (Lin et al., 2022; Jost et al., 2015; Virkkunen et al., 2007; Lawes et al., 1987; Simons et al., 2007). This complexity highlights a significant methodological challenge in aerosol research: accurately identifying the origin of aerosols, whether respiratory or gastric, and assessing their infectious potential is essential, yet inherently difficult, particularly in dynamic clinical scenarios such as resuscitation.

7.4 Integration: Implications to dynamic risk assessment

Bringing the two phases of the thesis together requires the collective review of the presented findings through the selected lens of the paramedic dynamic risk assessment. Meta-inferences in mixed-methods are insights or conclusions harvested through the integration of individual data sets and have been presented in Chapter 6, section 6.4 (Younas et al., 2025). The creation of these meta-inferences acted to inform this chapter. Duty of care has been described in guidance issued to ambulance clinicians, both by the Joint Royal Colleges Ambulance Liaison Committee (JRCALC) and the National Ambulance Resilience Unit (NARU) and has been earlier introduced in this thesis in relation to the paramedic dynamic risk assessment. The dynamic risk assessment involves fine-balancing all the considered risks and an ultimate decision as to whether to chart a course of action versus inaction. Dynamic risk assessments are performed by all front-line ambulance staff, not just paramedics, and are required at every patient encounter. These assessments might involve decisions of extrication methods at an extraordinarily complex, multi-vehicle, multi-casualty, road traffic collision. Alternatively, they could involve the routine considerations when attempting to lift an elderly patient following a fall. These cognitive processes can occur in a split-second, the crux of which will be a decision hinging on whether to proceed with an action to engage with a clinical setting when responding to emergency incidents, or not (Raveendran et al, 2022; Pilbery et al, 2019).

Clearly, emergency incidents, by their very definition, are likely to be time-critical in nature, or certainly they will be presumed to be in the first instance. As a result, a patient must receive a timely clinical assessment to ascertain whether their presentation is in true need of time-critical intervention. The paramedic is therefore required to balance, through rapid dynamic risk assessment, the perceived risks to themselves and their team, should they choose to proceed onto a scene in which a patient is located in order to conduct their patient assessment, against that of the potential risk to the patient should they

deem the scene too unsafe to proceed and so delay assessment and any subsequent treatment that might result. The decision to delay patient care could have potentially catastrophic results, depending on the pathophysiology behind their presentation. This balance and assessment of risk, in essence, is a rapid evaluation of how the paramedics' actions might impact the care they are able to deliver, with what is reasonably expected of them as professionals, wider society, and the law, and so they must chart a course to act accordingly (Pilbery, et al 2019).

In the context of respiratory disease, factors that inform the dynamic risk assessment and the decision to proceed to the patient in a timely fashion versus that of delaying in order to don PPE are multifaceted. This is evidenced within this thesis through the qualitive workstream and thematic analyses of interview data gathered from paramedics. Factors that influence this decision include the patient presentation i.e. the suspected versus the confirmed presence of contagious respiratory disease, and importantly, the paramedics' own perceptions of their susceptibility to the disease in question. These are not the only considerations, however. These are alongside additional factors such as the paramedics' proximity to procedures that might be aerosol generating, the effectiveness of the protective equipment available to them, and their assessment of the needs of the patient and the underpinning evidence base. Other considerations will be both social and professional in nature. Social considerations involve the paramedic's wish to protect family or friends who might be clinically vulnerable or who might be dependent on the paramedic for support. Professional considerations centre around the protection of future patients whom the paramedic might attend during the course of their working week, who might be immunosuppressed or clinically vulnerable, as examples. These considerations extend to include their colleagues in this regard also (Lim et al 2023, Wakefield et al 2021).

As described in the opening chapter of this thesis, paramedics are obligated morally, professionally, and legally in this regard. These obligations come with expectations that ambulance personnel, indeed all

emergency service workers, take adequate steps to ensure maintenance of their own personal safety, but also be willing to accept an element of risk when safety precautions might not be able to guarantee their safety, so that they are able to deliver adjusted care that might be referred to as either '*effective*' or '*reasonable*' patient care, as described in JRCALC and NARU guidance respectively (JRCALC 2022, NARU 2021).

The question then arises as to what is an 'acceptable risk' to paramedics? Acceptable risk is a recognised term that features in disaster management guidance and is influenced by a multitude of factors in this context (United Nations Office for Disaster Risk Reduction (UNDRR) 2024). The term is highly subjective, meaning that what might be an acceptable risk to one individual could be interpreted as unacceptable to another, a variance that will be dependent on both the context of the situation and the individuals involved. Influencing factors will undoubtedly involve the professional skill set of the individual alongside the individual's perceived vulnerability both of themselves and the implications to their personal circumstances, specifically their family. For example, an acceptable risk to a police officer will differ significantly from that of mountain rescue personnel. Even within the same profession, disparity might occur. As a theoretical example, an acceptable risk for a paramedic who was a strong swimmer might be that they enter a body of water to help a drowning patient. However, if the paramedic cannot swim and has a family to support, the personal risk of entering the water might become entirely, and understandably, unacceptable (Sibson, 2011).

Contributors that inform the moral obligations in this regard include an individual's own personal beliefs, alongside their social conscience, as well as that of broader or more general societal expectations of the profession. Moral obligations are, therefore, highly subjective. In contrast, one might expect professional obligations to be more objective in nature as these are ultimately provided by healthcare professional or governing bodies. In the instance of paramedics, the governing body is the Health and

Care Professions Council (HCPC). In addition to the regulatory oversight provided by the HCPC, professional bodies such as the College of Paramedics contribute to developing ethical frameworks and professional standards, further influencing how paramedics navigate complex situations like those encountered during the pandemic. On further review of the HCPC's Paramedic Standards of Proficiency (2023), the importance of paramedics acting to maintain their own physical and mental well-being is explicitly stipulated. However, it is noteworthy that this is alongside the HCPC requirement that paramedics always promote and protect the interests of their service users. When considering these stipulations in the context of the decision to delay time critical patient care to don PPE, one can see conflict as this is somewhat of a juxtaposition. This is caveated later within the HCPC standards where the importance of understanding and exercising professional duty of care is highlighted, alongside the need to work safely by taking appropriate measures to mitigate a given risk, as well as being able to justify decisions and actions (HCPC 2023). The pandemic brought this balance of contrasting obligations into sharp focus. One must endeavour to deliver patient care and save lives whilst also protecting oneself, neatly demonstrated in the below quote taken from an article discussing personal risk versus patient care in the context of COVID-19 in a critical care setting.

> '*Instead of "Primum non nocere" (first do no harm), we are forced to change to "Primum non nocere ad te" (first do no harm to yourself).*'
>
> (Kulkarni et al (2020)

Legal obligations of National Health Service (NHS) ambulance services have been demonstrated in case law. Previous landmark legal cases have established the expectations of ambulance services when delivering care to patients. It is written in law that ambulance services have a duty to provide a reasonable standard of care to the patients they serve, and this should be done without an unreasonable

delay. This duty begins as a legal requirement the moment the emergency call is accepted by the receiving service and the service has agreed to attend the incident (Kent V Griffiths 2001). In law, the definition of a reasonable standard of care involves care that, when retrospectively reviewed, would be supported by a responsible body of medical opinion (Bolam V Friern 1957). It is also stated that any opinion provided in this regard must have a logical basis (Bolitho v City and Hackney Health Authority 1998) (NARU 2021). Regarding clinical care provided by paramedics specifically, the standards supported by a responsible body refer to the aforementioned standards outlined in the HCPC standards of proficiency. Therefore, when suspicion of transmissible respiratory disease exists, the rapid dynamic risk assessment will involve a decision as to whether the paramedic proceeds immediately into the clinical setting or delays donning PPE. In cases where there is an absence of clear, explicit, and definitive guidance, subjectivity will be present through individual variance in the assessment of risk and understanding of the underpinning data. Once subjectivity exists, uncertainty and inconsistencies in practice will arise. It has been captured in relevant literature how uncertainty in a clinical context contributes to heightened states of anxiety and so negatively impacts healthcare workers' well-being (Meyer et al., 2021; Bamforth et al., 2023).

Literature supports the claim that infection prevention and control (IPC) guidance, specifically regarding PPE recommendations during the initial phase of the COVID-19 pandemic, was confusing for healthcare workers and the wider public (Hoernke et al., 2021; Rees et al., 2020., Wilkinson 2024). A literature review undertaken as part of this thesis demonstrated how several key healthcare organisations and professional bodies adopted differing stances with regards to PPE guidance for cardiac arrest patients, due, in part, to the dearth of evidence regarding procedures of resuscitation as potential aerosol generating, outside of retrospective case study analysis. Guidelines have been amended as contemporary research attempts to address these issues. The Royal College of Nursing (RCN) (2024) continues to endorse the RCUK (2022) stance that FFP3 respirators be worn by those administering

chest compressions. The rationale offered by RCUK states chest compressions could be a potential aerosol generating procedure; hence, where there is doubt, precautions should be used. NHS England's National Infection Prevention and Control Manual for England (2024) also recommends FFP3 when in the presence of procedures thought to be aerosol generating, although they do not highlight chest compressions or CPR specifically. Emerging evidence from Shrimpton et al. (2024) found high levels of circulating aerosol in the airway during CPR and reiterated the need for higher levels of PPE when performing CPR in the presence of high-risk pathogens. The findings within this thesis, although requiring further study for clarity, observed higher levels of circulating aerosols at the airway in several cases suggestive of a transmission risk during CPR.

This is of relevance when considered alongside the recent position statement issued on the approach to winter 2023/2024 by the National Ambulance Service Infection Prevention and Control Group (NASIPCG). This specifically focussed on suggested actions for ambulance services in response to seasonal respiratory infections and IPC guidance for ambulance workers. This statement highlighted the potential need for fluid-repellent surgical masks (FRSMs) when in ambulance clinical settings. It was described how this would be a dynamically adaptive approach, dependent on local risk assessment. Members of staff who had a personal desire to wear masks would be supported in doing so, but this was not mandated. There was no specific mention of SARS-CoV-2, CPR, or level 3 PPE in this regard, putting the onus back on ambulance workers and their interpretation of their own personal risk. It has been highlighted within the thematic analysis how paramedic mental well-being was detrimentally affected when guidance was inconsistent. Those who felt clinically vulnerable described feelings of notable frustration and anxiety when others were not mandated to adhere to policy.

The findings of literature review 3 (see section 3.3) further compound the complexities regarding the dynamic risk assessment and the decision to don PPE or not. This found data suggesting that masks do

not offer adequate protection when the wearer is required to administer chest compressions for prolonged periods of time (Wong et al, 2020). However, the specific 'level 3' PPE (FFP3) used by several UK ambulance services did not feature within the key studies that contributed to this literature review; studies featuring similar masks focused on N95 respirators and FFP2 masks rather than FFP3. The recommendations from these articles were that FFP2 use should not be mandated for routine use in clinical settings over surgical masks, as they proved non-superior (Knoblock et al, 2023). Slight differences exist between N95 and FFP3 respirators. N95 are so termed due to their classification by the United States of America's, National Institute for Occupational Safety and Health (NIOSH). This organisation sets the American standards to which respirators must adhere. Several classes exist, differentiated by their level of oil resistance; hence, 'N' represents 'non-oil, ' meaning it is not for use in the presence of oil. N95, therefore, describes a non-oil respirator that filters 95% of particles. In contrast, in Europe, the Filtering Face Piece (FFP) system of classification is used, similar in premise but subtly different to its American counterpart. These respirators must meet the standards held within the European Standard EN 149:2001 which define FFP2 masks as those that filter 94% of particles and FFP3 masks, 99%. FFP3 can be used in the presence of extremely small particles such as asbestos.

Furthermore, one might consider the physical activity associated with administering chest compressions for prolonged periods and the effect on the rescuer/mask wearer. CPR is a strenuous activity and can lead to increased rates of breathing and force of exhalation, also leading to increased body temperatures and, subsequently, higher levels of perspiration. The issues of perspiration and humidity within the masks leading to wearer discomfort were highlighted in studies that explored PPE's effect on healthcare workers in intensive care departments, whereby climate control would be present, something often not afforded to a prehospital clinician (Rojo-Rojo et al., 2022).

The effect of increased humidity on mask effectiveness led to a safety alert issued in relation to valved FFP3 specifically. Condensation was observed to collect at the exhalation valve which resulted in a documented breach in the sterility of the surgical field during an elective surgical procedure (National Patient Safety Alert, 2021). It is reasonable to assume that elective surgery involves a more controlled environment, with less physical exertion, than that which might be seen at the active resuscitation of a patient in cardiac arrest in a prehospital setting during the heat of summer. Valved masks were designed to improve the comfort of the wearer by allowing exhaled air to escape through the valve, thereby reducing the internal humidity within the mask. However, this feature led to a criticism of the mask, in that they only protect the wearer but not anyone else in the same environment, based on the finding that particles of sub 0.3μm can escape via this mechanism (Staymates, 2020). This size range is pertinent as it was identified as circulating in the airway in several of Workstream Two's case studies and of a magnitude able to carry virions. Should a valve be faulty, potentially through the build-up of moisture due to condensation, and a delay be induced to the valve's closing, it is plausible that particles might even enter the mask via this same route (The National Personal Protective Technology Laboratory (NPPTL) 2020).

Chest compressions are a highly dynamic activity. Depending on the rescuer's level of experience, the administration of compressions can be associated with significant, sometimes severe, movements of the rescuer's head and neck. The aforementioned factors, namely increased humidity coupled with dynamic head movements, in combination, might contribute to suboptimal conditions in which to maintain seal patency and, therefore, put rescuers at risk (Shao, 2020). To remain current, guidelines stipulate that face fit testing be repeated by PPE wearers every two years (Health Education England, 2020). NHS providers can choose either qualitative or quantitative fit testing methods, both of which have been approved by the Health and Safety Executive (HSE), and both occur within UK ambulance services. The qualitative fit test is subjective in nature, requiring participants to be exposed to an

aerosolised component; those that can detect the unique taste and smell are declared to have failed the fit testing. Despite HSE approval, literature exists that shows the qualitative fit testing to pass participants who then went on to fail quantitative fit testing, thereby creating a potential for the test to provide false assurance (Cagliari et al., 2023; Hon et al., 2017). With that said, it has also been demonstrated that in over 12000 thousand healthcare workers that the probability of fit test failure, in the same FFP3 within three years is as little as 0.5%, offering some level of assurance in this regard (Martin et al., 2024).

Therefore, these considerations, alongside the findings of this thesis, present paramedics with two issues, firstly it is suggested that CPR will likely result in higher circulating aerosols at the airway of the patient – an area where paramedics will be situated, with it also noted that particle masses at this area were of a magnitude large enough to carry virions, thereby presenting a potential transmission risk. However, it is also suggested that FFP3 use during prolonged episodes of CPR offered inadequate protection, particularly regarding the valved FFP3.

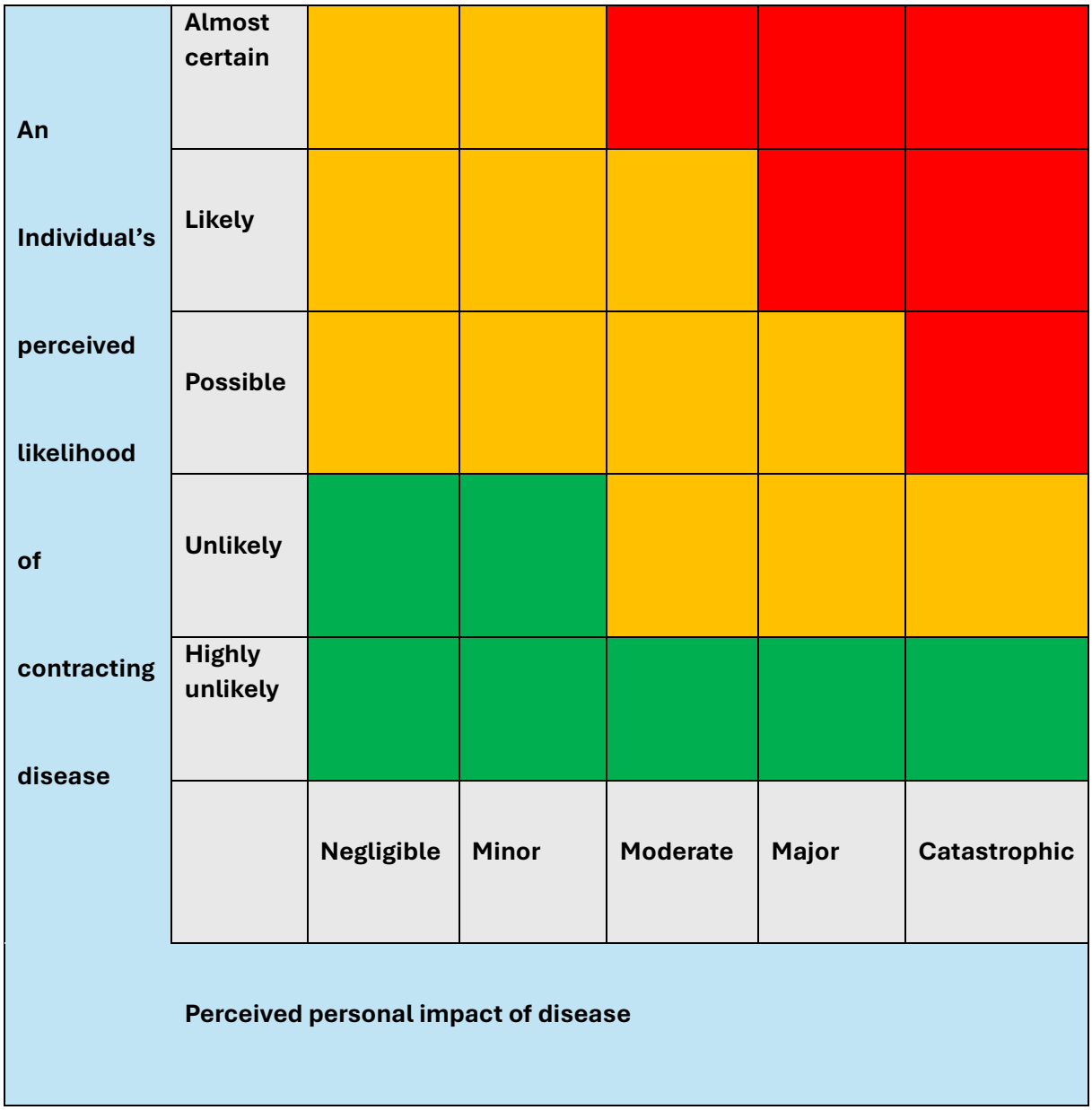
The components earlier described as contributors to the dynamic risk assessment were further echoed by paramedics within the qualitative aspect of this study. It was reported how they would often take the decision to not use PPE, particularly masks, in a variety of circumstances. These would include instances where the patient was deemed time critical due to the nature of their presentation and required either rapid intervention or transport to hospital. A particular circumstance that was repeatedly cited as a source where non-adherence had or would occur was when in the presence of critically ill paediatric cases, thus showing how paramedics within this select sample would prioritise this patient group's needs over their own based on age. This is an interesting observation as age is not a factor in the NHS Major Incident Triage tool (MITT) (2023) and likely has origins lying within more deep-rooted

psychological theories involving personal and professional identity (Hill et al., 2023; Fadjukoff et al., 2016)

An additional contributor to this decision to not adhere to PPE policy was when it was felt that communication became too significantly impeded, particularly involving breaking bad news to relatives. It was felt that mask use dehumanised the care provided, presenting a barrier to the 'softer' skills of communication, deemed vital in these circumstances. This was further highlighted when discussions were had around patients who might feel stigmatised or frightened. Other examples included the impedance of effective clinical assessment; a sentiment echoed within wider literature (Houghton et al 2020). The conscious decision made by paramedics to not wear appropriate PPE, and ultimately not protect their own health and safety, was based upon their dynamic risk assessment, informed by the individual's perception of personal risk, an assumption supported within the thematic analysis (see section 6.2.5). The perception of risk has been deemed a key aspect of PPE compliance. Vaccination status, mistrust in PPE effectiveness, or lack of understanding of the seriousness of COVID-19 in paramedics contribute to higher levels of non-adherence. Contrastingly, concern regarding the protection of family members, perceived vulnerability of themselves and crew mates, trust in PPE effectiveness and an appreciation of the severity of the pandemic and disease transmission through asymptomatic means were all motivating factors to adhere more rigidly to PPE protocols, captured both in the data within this thesis and wider literature (Neves et al., 2020, Millington et al., 2022).

Risk matrices are used within healthcare organisations as a useful tool to illustrate, identify, and evaluate risk and inform guideline productions (Lemmens et al., 2022). A proposed risk matrix regarding healthcare workers' assessment of their own risk regarding COVID-19 and their probability of adhering to PPE guidelines was generated as part of the first literature review (see section 3.1.1), and is presented within Figure 7.1. This was created following careful scrutiny of the relevant literature and

consideration of the emerging themes that arose following completion of this literature review. The concepts held within this risk matrix can be adapted to be used for other diseases that might pose a risk of nosocomial transmission.



Key:

	Highly likely to adhere to PPE protocols
	Likely will adhere most of the time
	Might frequently not adhere

Figure 7.1 Proposed risk matrix relevant to HCP's adherence to PPE.

Using tools such as this during fit testing as part of a risk assessment strategy could support organisations in their delivery of guidance that is tailored to an individual's circumstances. This could then inform methods of dissemination of guidelines through educational programmes targeting high-risk individuals. The concepts held within this matrix are furthered by the limited evidence available around this topic, in which it has been highlighted how knowledge gaps, along with a lack of belief in the effectiveness of PPE, are closely linked to higher levels of non-adherence to PPE policies by healthcare workers (Haji et al 2020.; Houghton et al., 2020).

Behaviours in healthcare settings often become habitual. Literature exploring this specifically found that over half of healthcare workers reported deviation or modification of routine practice became too challenging to maintain over prolonged periods (Tien et al., 2021). Cultural influences also exist within organisations; these might support or discourage adherence. It has been captured both in the thematic analysis and wider literature that those staff who witnessed role modelling behaviours, such as colleagues' persistent maintenance of high professional standards, or those who felt supported in doing the right thing by their managers, were more likely to adhere to policy. In contrast, when senior figures or role models are seen breaking the rules, it can negatively influence others and undermine adherence. (Houghton et al, 2020.

7.5 Considerations for organisations and implications for clinical practice

The findings of this thesis have notable implications for healthcare systems should they face future pandemics. With a suggestion that chest compressions may generate aerosols within this thesis and the broader literature, but without a definitive answer, alongside paramedic testimonies describing voluntary and conscious non-adherence to PPE policy and perceptions that masks provide inadequate protection

during CPR, organisations face significant challenges in ensuring their staff and patients are adequately protected from respiratory disease transmission (Shrimpton et al., 2024). Further research in this area is needed, as noted earlier in this chapter. Thematic analysis of interview data has demonstrated how the practical, day-to-day application of PPE policies and usage frequently deviated from the guidance recommended. This disparity raises important considerations of human factors and highlights that any future PPE guidance must address the gap between prescribed 'work as guided' and the actual, routine paramedic practice or 'work as done' (Royal College of Obstetricians and Gynaecologists, 2024).

The underlying science of human factors focuses on understanding individuals and how they interact with various elements of a system. It was developed to effectively design systems that are safe and supportive of their users, providing environments that promote physical and emotional well-being. For workplaces to create an environment where their employees feel psychologically motivated and fulfilled, organisations must support the fulfilment of several key basic needs for each individual (Rutherford, 2022). These needs are encapsulated within Maslow's hierarchy of needs, illustrated in Figure 7.2.

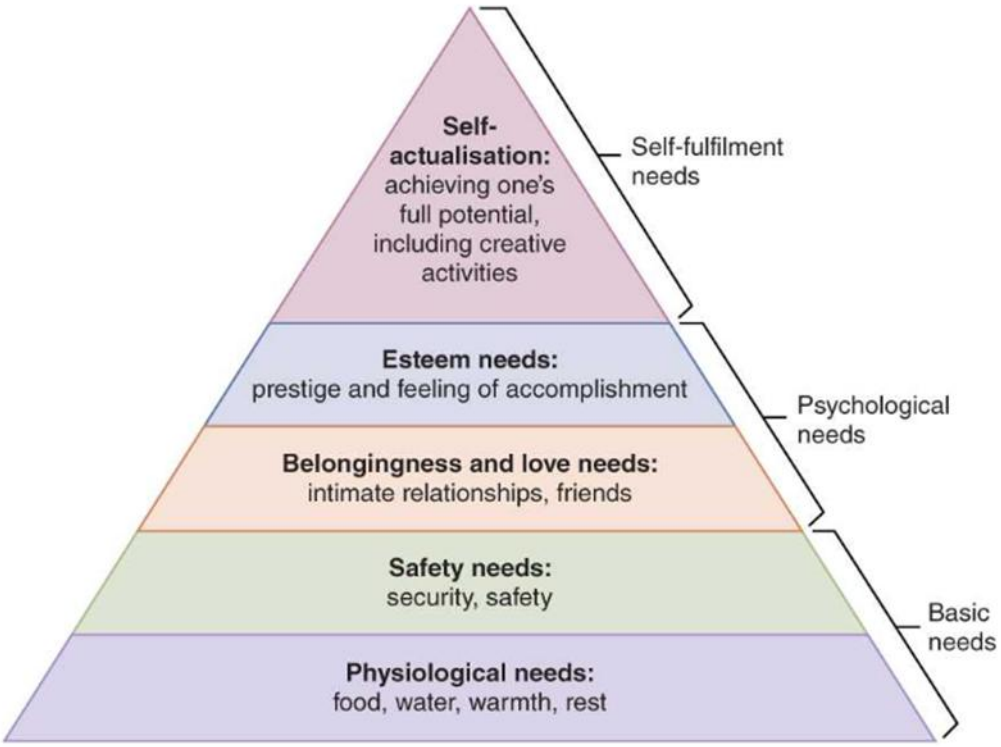


Figure 7.2 Maslow's Hierarchy of Needs taken from Rutherford (2022).

This tool has been widely applied in healthcare settings to provide a framework for better identifying and understanding human motivation and behaviour. Criticism has been directed towards this theory concerning its potential oversimplification of the complexities of human behaviour (King-Hill, 2015). However, it offers a broad framework to structure the discussion. Maslow's Hierarchy of Needs (1943) proposes that human needs can be arranged into a five-tier pyramid, with basic physiological needs such as the basic human need for food and water lying at its foundation, followed by safety, love and belonging, esteem, and culminating in self-actualisation. According to the model, individuals must satisfy lower-level needs before effectively pursuing higher-level psychological or self-fulfilment goals. Applying it to the introduction of PPE during the pandemic reveals how crucial aspects of the pyramid were adversely affected, particularly the needs associated with 'physiological needs' and 'safety needs', which are essential for maintaining personal well-being. Organisations that fail to address these fundamental elements can cause increased stress among individuals, which, in turn, may impair their

ability to make complex decisions. Issues such as reduced dexterity, communication when leading a team, clinical decision-making, and clinical examination have all been noted as negatively impacted. This could be a direct result of PPE creating a barrier, as initially suspected; however, in this context, it may also have indirectly arisen from individuals not meeting their physiological or safety needs. For instance, several participants reported experiencing overheating and dehydration (physiological needs). Similarly, many participants voiced significant concerns regarding their safety (safety needs). Although this provides an explanation for the various difficulties paramedics described in Workstream 1 when delivering patient care while wearing PPE, it does not account for the broader complexities associated with adherence and compliance. Factors affecting adherence to PPE policy in this context may be short-term or long-term, and workplace culture significantly influences both aspects.

Self-determination theory (SDT) is a valuable framework for exploring this in greater detail and is considered to be more flexible and context-dependent than Maslow's hierarchy (Ng et al., 2012). SDT is a psychological theory of human motivation that focuses on the degree to which an individual's behaviour is self-motivated and self-determined. It identifies three basic psychological needs—autonomy, competence, and relatedness, which are described as being essential for fostering intrinsic motivation and well-being (Deci & Ryan, 1985). SDT examines intrinsic and extrinsic motivators that can influence individuals' behaviour, emphasising autonomy, motivation, workplace culture, and perceived competence (Ackerman, 2024). Paramedics reported that a lack of transparency concerning the sharing of guidance and its underlying evidence base fostered mistrust. Instances of a negative workplace culture were also noted, where senior colleagues or managers were not perceived to lead by example. These factors contribute to individual non-adherence to policy. SDT supports this notion, underscoring that those who feel informed of the facts, backed by their organisation, and part of an inclusive culture that prioritises safety will be more likely to comply with guidance (Ng et al., 2012). These considerations are crucial for future protocols (Carayon et al., 2014).

7.5.1 Strengthening Paramedic Practice Through the Matrix Framework, and implications Future Pandemics

The proposed risk matrix (Figure 7.1) provides a practical mechanism for strengthening both paramedic practice and the education that underpins it when the profession is required to operate under comparable conditions to those experienced during COVID-19 in future pandemics. The findings of this thesis highlight that adherence to respiratory protection is shaped not only by individual behaviour, but by the convergence of behavioural, procedural, organisational and environmental pressures, and is catalysed by the paramedic role identity as lifesaver. Embedding these four domains explicitly within paramedic education—particularly within dynamic risk assessment training, clinical leadership development, and scenario-based simulation—would enable clinicians to better recognise how these interacting pressures influence their decisions during high-risk, time-critical situations.

When the findings of this thesis are viewed through this proposed matrix, it becomes clear that PPE adherence cannot be understood as a binary individual choice or through the threat of punitive measures. Rather, the behavioural domain reflects the motivational tensions identified through self-determination theory; the procedural domain captures ongoing uncertainty surrounding AGP classification; the organisational domain encompasses policy instability, trust, and supervisory influence; and the environmental domain acknowledges the physical constraints unique to prehospital care. Integrating these dimensions provides a clearer foundation for designing future PPE guidance, for preparing clinicians to anticipate risk, and for supporting them to maintain adherence under operational pressure.

Applying the matrix to future pandemic planning would allow organisations to anticipate where non-adherence is most likely to emerge and to design responses that are proportionate, evidence-informed and operationally realistic. For example, during the early stages of COVID-19, behavioural fatigue,

procedural ambiguity and organisational instability converged to shape paramedic decision-making in ways seldom captured in national policy. Workstream 1 demonstrated that, for many paramedics, instances of non-adherence were not acts of insubordination, but conscious, patient-centred adaptations intended to preserve communication, empathy, and enhance technical performance in situations where PPE was perceived to compromise care. This interpretation reframes non-adherence as a signal of system strain rather than individual failure, and highlights the need for education, guidance, and organisational support that acknowledge the realities of prehospital work. The matrix therefore offers more than a descriptive synthesis of findings; it provides a structured, forward-looking approach for translating these findings into actionable improvements in education, policy design and the everyday delivery of safe, sustainable paramedic practice.

Finally, in the context of future pandemics, the matrix presented within this thesis offers a practical preparedness tool for ambulance services, enabling paramedic education, leadership and organisational policy to anticipate predictable points of strain and to support safe, patient-centred practice under prolonged conditions of uncertainty as was in during the COVID-19 pandemic.

7.6.1 Specific recommendations

- **Clarity and standardisation of PPE Guidance**

Advocate for clearer and standardised PPE guidelines across healthcare organisations in prehospital settings. This strategy would help reduce the confusion and inconsistencies paramedics experienced during the pandemic, which impacted their ability to make informed decisions and might have jeopardised safety and patient care.

- **Ambulance Purpose-Designed PPE**

Encourage the development of PPE specifically designed for the prehospital environment. The current equipment frequently fails to address the physical demands and environmental variations faced by paramedics, leading to discomfort, limited mobility, and potential risks to safety and care quality.

- **Organisational Support**

Highlight the necessity of ongoing organisational support for paramedics, including acknowledgement of their moral and psychological challenges. Support systems should enhance autonomy, competence, and connectedness, in accordance with relevant psychological theory, to improve well-being and adherence to policy.

- **Realistic PPE Policies**

Suggest revising PPE policies to incorporate contextual flexibility, especially during emergencies. Inflexible protocols can hinder timely interventions; policies should reflect the realities of prehospital care and enable clinicians to exercise professional judgement in high-pressure situations.

- **Further Research**

Urge for more focused research on the aerosol-generating potential of procedures crucial to advanced life support and the resuscitation of cardiac arrest patients, specifically chest compressions and defibrillation. Strong evidence is essential to guide appropriate PPE guidelines and minimise the risk of infection while ensuring the continuity of critical care.

Chapter 8: Conclusion

The purpose of this thesis was to explore and inform the paramedic dynamic risk assessment when applied to the context of delivering resuscitative care to patients in cardiac arrest at scenes where respiratory disease, specifically COVID-19, was suspected. The content has provided valuable insight into the paramedic dynamic risk assessment in this context, illustrating how this is a highly complex process. Inevitable tension arises between the paramedics' desire to adhere to prescribed PPE protocols and the deeply ingrained professional ethos they possess, whereby they frequently view themselves as caregivers and lifesavers, first and foremost, particularly in cases involving vulnerable patient populations, such as critically ill children.

The qualitative findings demonstrate that in most instances, non-adherence is less a matter of negligence and more a reflection of the influence of role identity and the moral imperative to provide immediate care, even in the presence of potential catastrophic personal risk. This must also be considered alongside the lack of clear guidance disseminated at the time, which also lacked any offered evidence base or rationale in many circumstances. Paramedics described how they remained cognisant of the risk posed to vulnerable colleagues and their own families should they become infected with the SARS-CoV-2 virus. These competing obligations influenced their adherence, highlighting a dynamic, context-specific approach to risk that balances professional duty with personal responsibility. An impossible position ensues, whereby they might be forced to choose between adhering to PPE protocols to minimise risk to themselves or their loved ones, yet responding instinctively to critically ill patients where immediate intervention was perceived as morally non-negotiable. The societal valorisation of healthcare workers during the COVID-19 pandemic, exemplified by public campaigns such as Clap for Heroes, further compounded this distress. While presumed to be intended as a gesture of gratitude, it

also reinforced an expectation of self-sacrifice, exacerbating internal conflict and likely deepening the psychological burden felt by paramedics.

The quantitative analysis of aerosol generation during resuscitation, while inconclusive due to the many confounding variables, offered important contributions to the ongoing discourse on transmission risks in emergency care settings. The suggestive link between chest compressions and increased aerosolisation, albeit captured within a limited case study format, thereby requiring further investigation, reinforces the need for dynamic, context-sensitive risk assessment strategies that account for both infection control and the operational realities of prehospital care.

Taken together, these findings advocate for a more reflexive and adaptive approach to dynamic risk assessment, one that acknowledges the realities of paramedic practice. Policy and training interventions should move beyond the rigid enforcement of PPE adherence and instead seek to engage with the lived experiences of paramedics, fostering strategies that align infection control with the professional values and situational exigencies that define emergency care. The development of PPE designed explicitly for prehospital care delivery would further support this recommendation. Future research should build upon this foundation and explore how risk assessment frameworks might integrate the technical dimensions of aerosol risk and the human factors that shape frontline decision-making in time-critical situations.

References

Abdel Wahed, W.Y., Hefzy, E.M., Ahmed, M.I., Hamed, N.S., 2020. Assessment of knowledge, attitudes, and perception of health care workers regarding COVID-19, a cross-sectional study from Egypt. J Community Health. Vol. 45(6):1242–1251. Accessed [online] from https://doi.org/10.1007/s10900-020-00882-0 on 3/5/23.

Ackerman, C. E., 2024. Self Determination Theory and How It Explains Motivation. Positive Psychology. Accessed [online] from https://positivepsychology.com/self-determination-theory/ 21/02/25.

Ai, T., Melikov, A.K., 2018. Airborne spread of expiratory droplet nuclei between the occupants of indoor environments: A review. Internation Journal of Indoor Environment and health. Accessed [online] from https://doi.org/10.1111/ina.12465 on 11/4/24.

Al Muharraq, E.H., 2021. The psychological impact of coronavirus disease 2019 on nurses in Saudi Arabia and their coping strategies. SAGE Open Nurs. Vol. 7:1–10. https://doi.org/10.1177/23779608211011322

Alacahan, Ö.F., Güllüoğlu, A.N., Karagöz, N., 2023. Occupational safety perceptions of prehospital emergency health services employees: A sample of Sivas central district. Work. 2023;76(4):1441-1453. doi: 10.3233/WOR-220425. PMID: 37393470.

Alene, M., Ysimaw, L., Assemie, M. A., Ketema, D. B., Mengist, B., Kassie, B., Birhan, T. Y., 2021. Magnitude of asymptomatic COVID-19 cases throughout the course of infection: A systematic review and meta-analysis. PLOS ONE. Accessed [online] from ttps://doi.org/10.1371/journal.pone.0249090 on 11/3/22.

Allemang, B., Sitter, K., Dimitropoulos, G., 2021. Pragmatism as a paradigm for patient-oriented research. Health Expectations. Volume 25. Issue 1. P 38-47. Accessed [online] from https://doi.org/10.1111/hex.13384 on 2/2/23.

Alonso, M., Endo, Y., 2001. Dispersion of aerosol particles undergoing Brownian motion. Journal of Physics A: Mathematical and general. Vol. 34. Accessed [online] from https://iopscience.iop.org/article/10.1088/0305-4470/34/49/301/pdf on 8/8/24.

Almufarrij, I., Munro, K.J., 2021. One year on: an updated systematic review of SARS-CoV-2, COVID-19 and audio-vestibular symptoms. International Journal of Audiology. P1-11. Accessed [online] from https://doi.org/10.1080/14992027.2021.1896793 on 8/3/22.

Alrawashdeh, H.M., Al-Tammemi, A.B., Alzawahreh, M.K. et al. 2021. Occupational burnout and job satisfaction among physicians in times of COVID-19 crisis: a convergent parallel mixed method study. BMC Public Health. Vol. 21(1):811. https://doi.org/10.1186/s12889-021-10897-4

Antman, E. M., 2008. Time Is Muscle: Translation Into Practice. Journal of American College of Cardiology. Vol. 52. Issue 15. PP1216-1221.

Arimany-Manso, J., Martin-Fumado, C., 2020. Medico-legal issues regarding from the COVID-19 pandemic. Medicina Clinica. Vol. 155. Issue 8. PP344-346. Accessed [online] from https://doi.org/10.1016/j.medcle.2020.06.014 on 24/5/24.

Ashbury, S., Jacobs, E., 2014. Dynamic Risk Assessment: The practical guide to making risk-based decisions with 3-level management model. Routledge publications.

Ashraf, A. M., Peres, S. C., Sasangohar, F., et al. 2022. Investigating a new classification to describe the differences between Work-As-Imagined and Work-As-Done. Vol. 66. Issue 1. Accessed [online] from https://doi.org/10.1177/10711813226613 on 24/4/24.

Atkinson, J., Chartier, Y., Pessoa-Silva, C. L., et al... 2009. Natural Ventilation for Infection Control in Health-Care Settings. World Health Organization. National Library of Medicine. Accessed [online] from https://www.ncbi.nlm.nih.gov/books/NBK143281/ on 24/5/24.

Atzrodt, C.L., Maknojia, I., McCarthy, R.D.P. et al. 2020. A guide to COVID-19: a global pandemic caused by the novel coronavirus SARS-CoV-2. FEBS J. Vol. 287(17):3633–3650. https://doi.org/10.1111/febs.15375

Bajimaya, S., Frankl, T., Hayashi, T. & Takimoto, T. 2017. Cholesterol is required for stability and infectivity of influenza A and respiratory syncytial viruses. Virology 510, 234–241.

Bajpai, N. (2011). Business Research Methods. Pearson Education India. Accessed [online] via https://research-methodology.net/research-philosophy/ on 27/12/23.

Baldwin, S., George, J., 2021. Qualitative study of UK health professionals' experiences of working at the point of care during the COVID-19 pandemic. BMJ Open. Vol. 11. Issue 9. Accessed [online] from https://pubmed.ncbi.nlm.nih.gov/34489298/ on 24/4/24.

Bamforth, K., Rae, P., Maben, J., Lloyd, H., Pearce, S., 2023. Perceptions of healthcare professionals' psychological wellbeing at work and the link to patients' experiences of care: A scoping review. International Journal of nursing Studies Advances. Vol. 5. Accessed [online] from https://doi.org/10.1016/j.ijnsa.2023.100148 on 27/10/24.

Bandhala Rajan, M., Kumar, M. P., Bhardwaj, A., 2020. The trend of cutaneous lesions during COVID-19 pandemic: lessons from a meta-analysis and systematic review. International Journal of Dermatology. Volume 59, issue 11. P1358-1370.

Bandura, A., 1989. Human agency in social cognitive theory. American psychologist, 44 (9), 1175.

Bar-On, Y.M., Flamholz, A., Phillips, R., Milo R., 2020. Science forum: SARS-CoV-2 (COVID-19) by the numbers. Elife. 2020;9:e57309. https://doi.org/10.7554/eLife.57309

Bardhan, M., Ray, I., Roy, S., Bhatt P., Patel, S., Asri, S., Shariff, S., Shree, A., Mitra, S., Roy, P., Anand, A., 2023. 2023. Emerging zoonotic diseases and COVID-19 pandemic: global Perspective and Indian Scenario. Vol. 85. Issue 8. PP3997-4004. Accessed [online] from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10406085/ on 08/10/23.

Barros, A. J., Sifri, C. D., Bell, T. D., et al. 2021. Effectiveness of Elastomeric Half-Mask Respirators vs N95 Filtering Facepiece Respirators During Simulated Resuscitation, A Nonrandomized Controlled Trial. JAMA Netw Open. 2021;4(3):e211564. doi:10.1001/jamanetworkopen.2021.1564.

Batson, C. D., 2011. Empathy and altruism. In Altruism in humans (pp. 71–98). Oxford University Press.

Beauchamp, M. R., Crawford, K. L., Jackson, B., 2019. Social cognitive theory and physical activity: Mechanisms of behavior change, critique, and legacy. Vol. 42. PP110-117. Accessed [online] from https://doi.org/10.1016/j.psychsport.2018.11.009 on 20/1/24.

Beebe, R., Myers, J. C., 2010. Professional paramedic, volume I: Foundations of paramedic care Cengage Learning, Clifton Park NY.

Belle, B., 2019. Evaluation of gravimetric sampler bias, effect on measured concentration, and proposal for the use of harmonised performance based dust sampler for exposure assessment. International Journal of mining Science and Technology. Vol. 29, issue 3. PP445-452.

Berk, L. E., 2017. Child Development. Pearson.

Bernhard, W., 2016. Lung surfactant: Function and composition in the context of development and respiratory physiology. Annals of Anatomy. Vol. 208. PP146-150. doi: 10.1016/j.aanat.2016.08.003

Bielski, K., Szarpak, A., Jaguszewski, M. J., Kopiec, T., Smereka, J., Gaecka, A., Wolak, P., Nowak-Starz, G., Chmielewski, J., Rafique, Z., Peacock, F. W., Szarpak, L., 2021, The Influence of COVID-19 on Out-Hospital Cardiac Arrest Survival Outcomes: An Updated Systematic Review and Meta-Analysis. Journal of Clinical Medicine, Vol. 27. Accessed [online] from https://pubmed.ncbi.nlm.nih.gov/34884289/ on 22/11/23.

Biesta GJJ, Burbules NC. 2003. Pragmatism and Educational Research. Rowman & Littlefield Publishers, Inc.; 2003.

Biesta, G., 2010. Pragmatism and the philosophical foundations of methods mixed-methods research. In: TASHAKKORI, A. & TEDDLIE, C. (eds.) SAGE Handbook of Mixed-methods in Social & Behavioural Research. Second ed. Thousand Oaks, CA: Sage

Billings, J., Ching, B.C.F., Gkofa, V. et al. 2021. Experiences of frontline healthcare workers and their views about support during COVID-19 and previous pandemics: a systematic review and qualitative meta-synthesis. BMC Health Serv Res 21, 923. https://doi.org/10.1186/s12913-021-06917-z

Bischoff, W. E., Swett, K., Leng, I. & Peters, T. R. 2013. Exposure to influenza virus aerosols during routine patient care. Journal of Infectious Diseases. Vol. 207, pp1037–1046.

Bitan, Y., & Jaffe, E., 2017. Studying Paramedics Working Environment in a Trauma Scene. Proceedings of the International Symposium on Human Factors and Ergonomics in Health Care, 6(1), 109-110. https://doi.org/10.1177/2327857917061024

Blummer, B. & Kenton, J.M., 2014. Improving student information search: a metacognitive approach. Oxford: Chandos Publishing. PP110 – 120.

Bolton, G., Delderfield, R., 2018. Reflective practice: Writing and professional development. SAGE Publications.

Booth, A., Reed, A. B., Ponzo, S., Yassaee, A., Aral, M., Plans, D., Labrique, A., Mohan, D., 2021. Population risk factors for severe disease and mortality in COVID-19: A global systematic review and meta-analysis. PLOS ONE. Accessed [online] from https://doi.org/10.1371/journal.pone.0247461 on 12/4/22.

Bourdeau, M., 2018. Auguste Comte. Metaphysics Research Lab, Stanford Accessed [online] from https://plato.stanford.edu/archives/sum2018/entries/comte/ on 3/1/24.

Brannick, T., Coghlan, D., 2007. In defense of being 'native': The case for insider academic research. Organizational Research Methods, 10(1), 59–74.

Braun. V., Clarke, V., 2022. Thematic Analysis: A Practical Guide. SAGE Publishing. Chapter 2: Taking an initial lay of the land. PP35-36.

Braun, V., Clarke, V., Hayfield, N., Davey, L., Jenkinson, E. 2022. Doing Reflexive Thematic Analysis. In: Bager-Charleson, S., McBeath, A. (eds) Supporting Research in Counselling and Psychotherapy . Palgrave Macmillan, Cham. https://doi.org/10.1007/978-3-031-13942-0_2

Braun, M., Koger, F., Klingelhofer, D., Muller, R., Groneberg, D. A., 2019. Particulate Matter Emissions of Four Different Cigarette Types of One Popular Brand: Influence of Tobacco Strength and Additives. International Journal of Environmental Research and Public Health. Vol. 16, issue 2. Accessd [online] from https://doi.org/10.3390%2Fijerph16020263 22/8/24.

Bravata, D. M., Watts, S. A., Keefer, A. L., Madhusudhan, D. K., Taylor, K. T., Clark, D. M., et al. 2020. Prevalence, predictors, and treatment of impostor syndrome: a systematic review. Journal of General Internal Medicine. 35, 1252–1275. Accessed [online] from https://doi.org/10.1007%2Fs11606-019-05364-1 on 4/6/24.

Bray, J., 2020, Bystander CPR in the COVID-19 pandemic. Resus Plus. ttps://doi.org/10.1016/j.resplu.2020.100041

Brinkrolf, P., Metelmann, B., Metelmann, C., Baumgarten, M., Scharte, C., Zarbock, A., Hahnenkamp, K., Bohn, A., 2021. One out of three bystanders of out-of-hospital cardiac arrests shows signs of pathological psychological processing weeks after the incident - results from structured telephone interviews. Scand J Trauma Resusc Emerg Med. 2021 Sep 8;29(1):131. doi: 10.1186/s13049-021-00945-8. PMID: 34496942; PMCID: PMC8425096.

British Heart Foundation (BHF). 2023. Information and support: Cardiac Arrest. Accessed [online] from https://www.bhf.org.uk/informationsupport/conditions/cardiac-arrest on 18/10/23.

British Medical Association (BMA). 2022. BMA COVID Review 2: The impact of the pandemic on the medical profession. Accessed [online] from https://www.bma.org.uk/media/5620/20220141-bma-covid-review-report-2-the-impact-of-the-pandemic-on-the-medical-profession-final.pdf on 15/11/2023.

British Medical Association (BMA). 2023. Report: The public health response by UK governments to COVID-19. Accessed [online] from https://www.bma.org.uk/advice-and-support/covid-19/what-the-bma-is-doing/the-public-health-response-by-uk-governments-to-covid-19 on 10/10/23.

British Medical Journal (BMJ) Best Practice. 2022. Coronavirus disease 2019 (COVID-19). Accessed [online] from https://bestpractice.bmj.com/topics/en-gb/3000201 on 8/3/22.

Brown, E., Chan, L.M., 2020. Should chest compressions be considered an aerosol-generating procedure? A literature review in response to recent guidelines on personal protective equipment for

patients with suspected COVID-19. Clin Med (Lond). 20(5):e154–e159. https://doi.org/10.7861/clinmed.2020-0258

Brown, J., Gregson, F. K. A., Shrimpton, A., Cook, T. M., Bzdek, B. R., Reid, J. P., Pickering, A. E., 2020. A quantitative evaluation of aerosol generation during tracheal intubation and extubation. Anaesthesia. Vol. 76. PP 182-188. Accessed [online] from https://doi.org/10.1111/anae.15292 on 28/3/24.

Brown, J., Gregson, F.K.A., Shrimpton, A. et al. 2021. A quantitative evaluation of aerosol generation during tracheal intubation and extubation. Anaesthesia. Vol. 76(2):174–181. https://doi.org/10.1111/anae.15292

Brown, P., Newham, R., Hewison, A., 2020.To explore the experience of research nurses who obtain consent from adults in emergency settings to participate in clinical trials, either prospectively or post enrolment. J Clin Nurs. Vol. 29 (15):3054–6

Bryman, A. 2006. Integrating quantitative and qualitative research: How is it done? Qualitative Research, 6(1), 97-113. https://doi.org/10.1177/1468794106058877

Buckley, D., Budzyna, D., 2023. The Whole Child: Development in the Early Years. PP32-35. Accessed [online] from https://rotel.pressbooks.pub/whole-child/ on 20/1/24.

Burton, E., Aladkhen, J., O'Donnell, C., Masterson, S., Merwick, A., McCarthy, V. J. C., Kearney, P. M., Buckley, C. M., 2022. HRB Open Research. Vol. 5. Issue 24. Accessed [online] from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9266003/ from 20/11/23.

Butchard, P., Balogun, B., 2024. What is the proposed WHO Pandemic Preparedness Treaty? House of Commons Library. Accessed [online] from https://commonslibrary.parliament.uk/research-briefings/cbp-9550/ on 28/5/24.

Byrne, D., 2021. A worked example of Braun and Clarke's approach to reflexive thematic analysis. Quality & Quantity. Vol. 56. PP1391-1412. Accessed [online] from https://link.springer.com/article/10.1007/s11135-021-01182-y on 30/3/24.

Caggiari, S., Bader, D., Packman, Z., Robinson, J., Tranka, S., Bohning, D., Worsley, P., 2023. Retrospective evaluation of factors affecting successful fit testing of respiratory protective equipment during the early phase of COVID-19. BMJ Open. Accessed [online] from https://doi.org/10.1136%2Fbmjopen-2022-065068 on 21/3/24.

Campbell, D.T. & Fiske, D.W. (1959). Convergent and discriminant validation by the multitrait-multimethod matrix. Psychological Bulletin, 56: 81-105.

Carayon, P., Xie, A., Kianfar, S., 2014. Human Factors and ergonomics as a patient safety practice. BMJ Quality Interaction. Vol. 23. PP196-205.

Card, N. A., 2011. Toward a relationship perspective on aggression among schoolchildren: Integrating social cognitive and interdependence theories. Psychology of Violence, 1(3), 188–201. https://doi.org/10.1037/a0023711 accessed [online] 20/1/24.

Centre for disease control and prevention (CDC) 2005. Frequently asked questions about SARS. Accessed [online] from https://archive.cdc.gov/#/details?url=https://www.cdc.gov/sars/about/faq.html on 10/2/2023.

Chalumeau, M., Bidet, P., Lina, G. et al. 2005. Transmission of Panton[1]Valentine leukocidin-producing Staphylococcus aureus to a physician during resuscitation of a child. Clin Infect Dis. Vol. 41(3):e29–30. https://doi.org/10.1086/431762

Chandrasekharan, P., Vento, M., Trevisanuto, D. et al. 2020. Neonatal resuscitation and post resuscitation care of infants born to mothers with suspected or confirmed SARS-CoV-2 infection. Am J Perinatol. Vol. 37(8):813–824. https://doi.org/10.1055/s-0040-1709688

Chapman, H.J., Veras-Estévez, B.A., Pomeranz, J.L., Pérez-Then, E.N., Marcelino, B., Lauzardo, M., 2017. Perceived barriers to adherence to tuberculosis infection control measures among health care workers in the Dominican Republic. MEDICC Rev. Vol.19(1):16–22. https://doi.org/10.37757/MR2017.V19.N1.4

Charmaz, K., 2014. Constructing Grounded Theory 2nd Edition. Sage Publications.

Chartered Society of Physiotherapists, 2020, Information paper: Duty of care. PD101. Practice and Development. Accessed [online] from https://www.csp.org.uk/system/files/publication_files/Duty%20of%20Care%202021.pdf 20/10/23.

Chen, F., Zang, Y., Liu, Y., Wang, X., Lin, X., 2021. Dispatched nurses' experiences of wearing full gear personal protective equipment to care for COVID-19 patients in China – a descriptive qualitative study. Journal of clinical nursing. Vol. 30. Issue 13/14. Pp 2001 – 2014.

[1]Chen, C.H., Yang, P.H., Kuo, F.L., Yeh, I.J., Su, C.Y., 2021. Experience of 2003 SARS has a negative psychological impact on healthcare workers in the COVID-19 pandemic: a cross-sectional study. Sao Paulo Med J. Vol. 139(1):65–71. https://doi.org/10.1590/1516-3180.2020.0516.r1.10122020

Cheruku, S., Dave, S., Goff, K., Park, C., Ebeling, C., Cohen, L., Styrvoky, K., Choi, C., Anand, V., Kershaw, C., 2020. Cardiopulmonary Resuscitation in Intensive Care Unit Patients With Coronavirus Disease 2019. Journal of Cardiothoracic and vascular anesthesia. Vol. 34. Issue 10. PP2595-2603.

Chew-Graham, C. A., May, C. R. & Perry, M. S., 2002. Qualitative research and the problem of judgement: Lessons from interviewing fellow professionals. Family Practice, 19(3), 285–289

Chinchilla, J., Vazquez, A., Gomez, A., 2022. Strongly fused individuals feel viscerally responsible to self-sacrifice. British Journal of SocialPsychology. Vol. 61, issue 4, PP1067-1085. Accessed [online] from https://doi.org/10.1111/bjso.12526 on 9/11/23.

Christian, M.D., Loutfy, M., McDonald, L.C. et al., 2004. Possible SARS coronavirus transmission during cardiopulmonary resuscitation. Emerg Infect Dis. Vol. 10(2):287–293. https://doi.org/10.3201/eid1002.030700

Chrousos, G. P., Mentis, A. A., Dardiotis, E., 2020. Focusing on the Neuro-Psycho-Biological and Evolutionary Underpinnings of the Imposter Syndrome. Frontiers in Psychology. Vol. 11. Accessed [online] from https://doi.org/10.3389/fpsyg.2020.01553 on 4/6/24.

Chugtai, A. A., Khan, W., 2020. Journal Infection & Public Health, volume 12 on page 522. Accessed [online] from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7102706/ on 19/10/2023.

Çiriş Yildiz, C., Ulaşli Kaban, H., Tanriverdi, F.Ş.. 2022. COVID-19 pandemic and personal protective equipment: Evaluation of equipment comfort and user attitude. Arch Environ Occup Health. Vol. 77(1):1–8. https://doi.org/10.1080/19338244.2020.1828247

Clerkin, K. J., Friend, Raikhelkar, J., Sayer, G., Griffin, J. M., Masoumi, A., Jain, S. S., Burkhoff, D., Kumaraih, D., Rabbani, L., Schwartz, A., Uriel, N., 2020. COVID-19 and cardiovascular disease. Circulation. Issue 141. P1648-1655.

College of Paramedics (CoP), 2023. Paramedic Career Framework 2023 5th Edition. PP 4 – 10.

College of Paramedics. 2024. Not all paramedics wear green. Accessed [online] from https://collegeofparamedics.co.uk/COP/Become_a_Paramedic/COP/BecomeAParamedic/Become_a_Paramedic.aspx?hkey=f10838de-b67f-44a0-83b7-8140d8cdba83 on 25/4/24.

Cooke M. W., Wilson S. 1999. Obstacles to research in prehospital care. Prehospital Immediate Care, 3, 149-151.

Corbin, J., Strauss, A., 2015. Basics of qualitative research: Techniques and procedures for developing grounded theory (4th edition). Sage.

Couper, K., Taylor-Phillips, S., Grove, A., Freeman, K., Osokogu, O., Court, R., Mehrabian, A., Morley, P. T., Nolan, Soar, J., Perkins, G. D., 2020. COVID-19 in cardiac arrest and infection risk to rescuers: A systematic review. Resuscitation. Vol. 151. PP59-66 accessed [online} from https://doi.org/10.1016/j.resuscitation.2020.04.022 5/3/23.

Cox, C. L., 2020. 'Healthcare Heroes': problems with media focus on heroism from healthcare workers during the COVID-19 pandemic. Journal of Medical Ethics. Vol. 46. PP510-513.

Coyer, F., Coleman, K., Hocking, K., Leong, T., Levido, A., Barakat Johnson, M., 2020. Maintaining skin health and integrity for staff wearing personal protective equipment for prolonged periods: a practical tip sheet. Wound Practice and Research. Vol. 28(2):75–83. https://doi.org/10.33235/wpr.28.2.75-83

Craig, P., Dieppe, P., Macintyre, S., Michie, S., Nazareth, I., & Petticrew, M., 2008, Developing and evaluating complex interventions: The new Medical Research Council guidance. BMJ, 337, a1655.

Creswell, J. W., Clark, V. L. P., 2011. Designing and conducting mixed-methods research. SAGE publishing Ltd.

Creswell, J. W., Clark, V. L. P., 2022. Designing and conducting mixed-methods research. Designing and conducting mixed-methods research (4th ed.). SAGE Publications.

Creswell, J. W., 2015. A concise introduction to Mixed-methods Research. SAGE. Pp 2 – 3.

Creswell, J. W., Klassen, A. C., Clarke, V. L. P., Smith, K. C., 2010. Best practices for Mixed-methods Research in the Health Sciences. Office of behavioural and Social Sciences Research (OBSSR). Accessed [online] from https://obssr.od.nih.gov/sites/obssr/files/Best_Practices_for_Mixed_Methods_Research_the_nature_and_design_of_mixed_methods_research.pdf on 6/1/24.

Creta, M., Sagnelli, C., Calentano, G., Napolitano, L., La Rocca, R., Capece, M., Califano, G., Calogero, A., Sica, A., et al. 2021. SARS-CoV-2 infection affects the lower urinary tract and male genital system: A systematic review. Journal of Medical Virology. Vol. 93, issue 5, PP3133-3142. Accessed [online] from https://pubmed.ncbi.nlm.nih.gov/33595134/ on 12/12/2022.

Crotty, M., 1998. The foundations of social research: Meaning and perspective in the research process. London, England: Sage.

Cruickshank, J., 2012. Positioning positivism, critical realism and social constructionism in the health sciences: a philosophical orientation. Nursing Inquiry. Vol. 19. Issue 1. PP71-82.

Cummings, D. A. t., Radonovich, L. J., Gorse, G. J., Gaydos, C. A., Bessesen, m. T., Brown, A. C., Gibert, C. L., Hitchings, M. D. T., Lessler, J., Nyquist, A., Rattigan, S. M., et al. 2021. Clinical Infectious Diseases. Vol. 6;73(11):e4428-e4432. Accessed [online] from https://doi.org/10.1093/cid/ciaa900 on 3/4/24.

Davidhizar, R., 1983. Critique of the health-belief model. Journal of Advanced Nursing. Vol. 8. Issue 6. PP467-72. Accessed [online] from https://doi.org/10.1111/j.1365-2648.1983.tb00473.x on 18/1/24.

de Waal, F.B., 2008. Putting the altruism back into altruism: the evolution of empathy. Annu Rev Psychol. 59:279-300. doi: 10.1146/annurev.psych.59.103006.093625. PMID: 17550343.

Deci, E. L., & Ryan, R. M. (1985). Intrinsic motivation and self-determination in human behavior. Springer. https://doi.org/10.1007/978-1-4899-2271-7

DeGarmo, D. S., Kitson, G. C., 1996. Identity relevance and disruption as predictors of psychological distress for widowed and divorced women. J. Marriage Fam. Vol. 58:983–997. Accessed [online] from https://www.jstor.org/stable/353985 on 24/5/24.

Dejonckheere, M., Vaughn, L. M., 2019. Semi structured interviewing in primary care research: a balance of relationship. Family medicine and community health. Vol. 7. Accessed [online] from http://dx.doi.org/10.1136/fmch-2018-000057 on 26/4/22.

Dejoy, D. M., 1996. Theoretical models of health behaviour and workplace self-protective behaviour. Journal of Safety Research. Vol. 27. Issue 2. PP61-72. Accessed [online] from https://psycnet.apa.org/doi/10.1016/0022-4375(96)00007-2 on 24/1/24.

Dempsey, B., Madan, I., Stevelink, S. A. M., Lamb, D., 2024. Long COVID among healthcare workers: a narrative review of definitions, prevalence, symptoms, risk factors and impacts, British Medical Bulletin, Volume 151, Issue 1, September 2024, Pages 16–35, https://doi.org/10.1093/bmb/ldae008

Dempster, P., Hutchinson, A., Oldland, E., Bouchoucha, S. L., 2021. Australian emergency nurses' experiences of working with personal protective equipment during the COVID-19 pandemic. A qualitative study, Australasian Emergency Care, Volume 27, Issue 1, Pages 63-70, ISSN 2588-994X, https://doi.org/10.1016/j.auec.2023.08.003.

Dominick, P. G., Squires, P., Cervone, D., 2010. Back to Persons: On Social-Cognitive Processes and Products of Leadership Development Experiences. Industrial and Organised Psychology. Issue 3. PP33-37. Accessed [online] from https://www.cambridge.org/core/journals/industrial-and-organizational-psychology/article/abs/back-to-persons-on-socialcognitive-processes-and-products-of-leadership-development-experiences/F11A573DA4BA29BC934AC30EBACE01B0 on 20/1/24.

Donnelly, E.A., Siebert, D., Siebert, C. 2015. Development of the Emergency Medical Services Role Identity Scale (EMS-RIS) Soc. Work Health Care. Issue 54. PP212–233.

Dos Santos J.A., Normando, A.G.C., Carvalho da Silva, R.L., Acevedo, A.C., De Luca Canto, G., Sugaya, N., Santos-Silva, A.R., Guerra, E.N.S., 2021. Oral Manifestations in Patients with COVID-19: A 6-Month Update. J Dent Res. Vol. 100(12):1321-1329. doi: 10.1177/00220345211029637. Epub 2021 Jul 29. PMID: 34324825.

Drisko, J. W., 2024. Transferability and Generalization in Qualitative Research. Research on Social Work and Practice. Accessed [online] from https://doi.org/10.1177/10497315241256560 on 17/8/24.

Drossinos, Y., Weber, T. P., Stilianakis, N. I., 2021. Droplets and aerosols: An artificial dichotomy in respiratory virus transmission. Health Science Report. Vol. 4, issue 2. Accessed [online] from https://doi.org/10.1002/hsr2.275 on 02/02/24.

Eaton, G., Mahtani, K., Catterall, M., 2018. The evolving role of paramedics - a NICE problem to have? Journal of health services research and policy. Vol. 23. Issue 3. PP193-195.

Edwards, D.A., Ausiello, D., Salzman, J., et al. 2021. Exhaled aerosol increases with COVID-19 infection, age, and obesity. Proc Natl Acad Sci U S A. Vol. 118(8):e2021830118. https://doi.org/10.1073/pnas.2021830118. Erratum in: Proc Natl Acad Sci U S A. 2021;118(27)

Elliott, R., Crowe, L., Pollock, W., Hammond, N. E., 2023. The impact of the COVID-19 pandemic on critical care healthcare professionals' work practices and wellbeing: A qualitative study. Australian Critical Care. Accessed [online] from https://linkinghub.elsevier.com/retrieve/pii/S1036731422002028 on 12/5/24.

Elliot, R., Fischer, C. T., Rennie, D. L., 1999. Evolving guidelines for publication of qualitative research studies in psychology and related fields. Br J Clin Psychol. 1999 Sep;38(3):215-29. doi: 10.1348/014466599162782. Erratum in: Br J Clin Psychol 2000 Mar;39 Pt 1:10. PMID: 10532145.

Elman, C., Gerring, J., Mahoney, J., 2020. The Production of Knowledge. Enhancing Progress in Social Science. Cambridge University Press.

Erbaş, G.S., Botsali, A., Erden, N., et al. 2022. COVID-19-related oral mucosa lesions among confirmed SARS-CoV-2 patients: a systematic review. International journal of dermatology. Volume 61, issue 1. P20-32.

Esseili, M.A.,2023. Great escape: how infectious SARS-CoV-2 avoids inactivation by gastric acidity and intestinal bileGut. Vol.72. PP808-810.

Etheridge, J. C., Sinyard, R. D., Brindle, M. E., 2023. Chapter 90 – Implementation Research. Translational Surgery. Elsevier Inc. PP 563 – 573.

Evans, B. C., Coon, D. W., Ume, E., et al. 2011. Use of Theoretical Frameworks as a Pragmatic Guide for Mixed-methods Studies: A Methodological Necessity? Vol. 5. Issue 4. Accessed [online] from https://doi.org/10.1177/1558689811412972 on 17/01/2024.

Fadjukoff, P., Pulkkinen, L., & Kokko, K., 2016. Identity Formation in Adulthood: A Longitudinal Study from Age 27 to 50. Identity, 16(1), 8–23. https://doi.org/10.1080/15283488.2015.1121820

Faul, F., Erdfelder, E., Lang, A., & Buchner, A. (2007). G*Power 3: A flexible statistical power analysis program for the social, behavioral, and biomedical sciences. Behavior Research Methods, 39(2), 175-191. doi:10.3758/bf03193146

Fernandopulle, N., 2021. To what extent does hierarchical leadership affect health care outcomes? Medical Journal of the Islamic Republic of Iran. Vol. 35. Accessed [online] from https://doi.org/10.47176%2Fmjiri.35.117 on 4/6/24.

Fetters & Molina-Azorin (2016). The Journal of Mixed-methods Research Starts a New Decade: Principles for Bringing in the New and Divesting of the Old Language of the Field. The Journal of Mixed-methods Research. Vol. 11. Issue 1. Accessed [online] from https://doi.org/10.1177/1558689816682092 on 27/12/23.

Fetters, M . D., Curry, L. A., Creswell, J. W., 2013. Achieving Integration in Mixed-methods Designs—Principles and Practices. Health Services Research. Vol. 48. Issue 6, part 2. PP2134-2156.

Fink, J. B., Ehrmann, S., Li, J., Dailey, P., McKiernan, P., Darquenne, C., Martin, A. R., Rothen-Rutishausser, B., Kuehl, P. J., Haussermann, S., MacLoughlin, R., Smaldone, G. C., Muellinger, B., Corcoran, T. E., Dhand, R., (2020), Reducing Aerosol-Related Risk of Transmission in the Era of COVID-19: An Interim Guidance Endorsed by the International Society of Aerosols in Medicine. Journal of Aerosol Medicine and Pulmonary drug delivery. Volume 33. Number 6. Pp 300 – 304.

Fisher, J.D., Fisher, W. A., Misovich, S. J., Kimble, D.L., Malloy, T.E., 1996. Changing AIDS risk behavior: effects of an intervention emphasizing AIDS risk reduction information, motivation, and behavioral skills in a college student population. Health Psychology. Vol. 15, issue 2. PP114-123.

Fitzpatrick, A., Wood, F., Shepherd, V. 2022. Trials using deferred consent in the emergency setting: a systematic review and narrative synthesis of stakeholders' attitudes. Trials 23, 411. https://doi.org/10.1186/s13063-022-06304-x

Flateau, C., Noel, C., Bonnafoux, A., Fuentes, E., de Pontfarcy, A., Diamantis, S., (2021). Psychological impact of the SARS-CoV-2 outbreak on the staff of a French hospital. Infectious diseases now. Volume 51. PP 187 – 193.

Francis, J.J., Johnston, M., Robertson, C., Glidewell, L., Entwistle, V., Eccles, M. P., Grimshaw, J. M., 2010. What is an adequate sample size? Operationalising data saturation for theory-based interview studies. Psychology and health, vol. 25, issue 10, PP1229-1245.

Friedrich, M. G., Cooper, L. T., 2021. What we (don't) know about myocardial injury after COVID-19. 2021. European Heart Journal. Volume 42. Issue 19. Pages 1879–1882.

Furness, S., Hanson, L., Spier, J., 2021. Archetypal meanings of being a paramedic: A hermeneutic review. Australasian Emergency Care. Vol. 24. Issue 2. PP135-140.

Galovski, T., Blanchard, E. B., 2002. Psychological characteristics of aggressive drivers with and without intermittent explosive disorder. Behaviour Research and therapy. Vol. 40. Issue 10. PP1157-1168. Accessed [online] from https://doi.org/10.1016/S0005-7967(01)00083-3 on 24/4/24.

Galloway, A., 2005. Non-probability sampling. Encyclopaedia of Social Measurement. E;sevier. P859-864.

Gao, J., Wang, J., Zhu, Y., Yu, J., 2013. Validation of an information–motivation–behavioral skills model of self-care among Chinese adults with type 2 diabetes. BMC Public Health. Accessed [online] from https://bmcpublichealth.biomedcentral.com/articles/10.1186/1471-2458-13-100 on 17/1/24.

Ghazali, D. A., Ouersighni, A., Gay, M., Audebault, V., Pavlovsky, T., Casalino, E., 2020. Feedback to Prepare EMS Teams to Manage Infected Patients with COVID-19: A Case Series. Prehospital disaster medicine. Vol. 35. Issue 4. PP451-453.

Given, L. M., 2017. It's a New Year…So Let's Stop the Paradigm Wars. Editorial. International Journal of Qualitative methods. SAGE Journals. Accessed [online] from https://doi.org/10.1177/160940691769264 on 3/1/24.

Goerlich-Dobre, K., Lamm, C., Pripfl, J., Habel, U., Votinov, M., 2015. The left amygdala: A shared substrate of alexithymia and empathy. NeuroImage. Vol. 122. PP20-32. Accessed [online] from https://doi.org/10.1016/j.neuroimage.2015.08.014 on 24/5/24.

Gómez, Á., 2020. What doesn't kill us makes us stronger: the COVID-19 pandemic transforms anonymous citizens into devoted actors. Int. J. Soc. Psychol. 35, 611–617. doi: 10.1080/02134748.2020.1783838

Gordon, J.M., Magbee, T., Yoder, L.H., 2021. The experiences of critical care nurses caring for patients with COVID-19 during the 2020 pandemic: a qualitative study. Appl Nurs Res. Vol. 59:151418.https://doi.org/10.1016/j.apnr.2021.151418

Goto, Y., Jingushi, N., Hiraiwa, H., Ogawa, H., Sakai, Y., Kasugai, D., Tanaka, T., et al. 2021. The protective effect of tight-fitting powered air-purifying respirators during chest compressions. The American Journal of Emergency Medicine. Vol. 49. PP172-177. Accessed [online] from https://doi.org/10.1016/j.ajem.2021.06.012 pm 8/11/23.

Gough, B., Madill, A., 2012. Subjectivity in psychological science: From problem to prospect. Psychological Methods, 17(3), 374–384. https://doi.org/10.1037/a0029313

Goyal, A., Chhabra, L., Sciammarella, J.C. et al. Defibrillation. Treasure Island (FL): StatPearls Publishing. 2023. https://www.ncbi.nlm.nih.gov/books/NBK499899/ (accessed 8 March 2023)

Grant, M. C., Geoghegan, L., Arbyn, M., et al. 2020. The prevalence of symptoms in 24,410 adults infected by the novel coronavirus (SARS-COV-2; COVID-19): A systematic review and meta-analysis of 148 studies from 9 countries. PLoS One. Accessed [online] from https://doi.org/10.1371/journal.pone.0234765 on 8/3/22.

Green, C. F., Davidson, C. S., Panlilo, A. L., Jensen, P. A., Jin, Y., Gibbs, S. G., Scarpino, P. V., 2012. Effectiveness of selected surgical masks in arresting vegetative cells and endospores when worn by simulated contagious patients. Infection Control and hospital epidemiology. Vol. 33(5):487-94. doi: 10.1086/665321.

Greene, J. C., 2007. Mixing methods in social inquiry. San Francisco, CA: Jossey-Bass.

Greene, J. C., 2015. Preserving distinctions within the multimethod and mixed-methods research merger. In Hesse-Biber S., Johnson B. (Eds.), The Oxford handbook of multimethod and mixed-methods research inquiry (pp. 606-615). New York, NY: Oxford University Press.Hunter, D. J., McCallum, J., Howes, D., 2019. Defining Exploratory-Descriptive Qualitative (EDQ) research and considering its application to healthcare. Journal of Nursing and Health Care (JNHC). Vol.4 No.1. Accessed [online] from http://dl6.globalstf.org/index.php/jnhc/article/view/1975/1978 on 27/12/23.

Green, L. W., (1974), Toward cost-benefit evaluations of health education: Some concepts, methods, and examples. Health Education Monographs 2(Suppl. 1): 34–64.

Green, L. W., Kreuter, M. W., (1991). Health Promotion Planning: An Educational and Environmental Approach. Mountain View, CA: Mayfield Publishing.

Greenhalgh, T., & Papoutsi, C., 2018. Studying complexity in health services research: Desperately seeking an overdue paradigm shift. BMC Medicine, 16, 95.

Gregson, F. K. A., Sheikh, S., Archer, J., Symons, H. E., Walker, J. S., Haddrell, A. E., 2021. Analytical challenges when sampling and characterising exhaled aerosol. Aerosol Science and Technology. Vol. 56. Issue 2. Accessed [online] from https://doi.org/10.1080/02786826.2021.1990207 on 29/3/24.

Gregson, F. K. A., Shrimpton, A.J., Hamilton, F. the AERATOR group, et al, 2022, Identification of the source events for aerosol generation during oesophago-gastro-duodenoscopy. Gut 2022;71:871-878.

Guan, W-J., Ni, Z-y, Hu, Y., Liang, W-H, Ou, C-q, He, J-x, Lio, L., Shan, H., Lei, C-L., Hui, S. S. C., Du, B., Li, L-J., et al 2020. Clinical characteristics of Coronavirus Disease 2019 in China. The New England Journal of Medicine. Volume 382. P1708-1720.

Guba, E. G., Lincoln, Y. S., 1982. Epistemological and methodological bases of naturalistic inquiry. Education Technology Research and Development. Vol. 30. PP233-252. Accessed [online] from https://doi.org/10.1007/BF02765185 on 18/8/24.

Guo, J., Lv, M., Liu, Z., Qin, T., Qiu, H., Zhang, L., Lu, J., Hu, L., Yang, W., Zhou, D., 2024. Comprehensive performance evaluation of six bioaerosol samplers based on an aerosol wind tunnel. Environmental International. Vol. 183. Accessed [online] from https://doi.org/10.1016/j.envint.2023.108402 on 10/08/24.

Gupta, V., Eames, C., Golding, L. et al. 2023. Understanding the identity of lived experience researchers and providers: a conceptual framework and systematic narrative review. Res Involv Engagem 9, 26. https://doi.org/10.1186/s40900-023-00439-0

Gutterman, T. C., Plano Clark, V. P., Molina-Azorin, J. F., et al. 2023. Terminology and Mixed-methods Research: A Persistent Challenge. Journal of Mixed-methods Research. Vol. 18. Issue 1. Accessed [online] from https://doi.org/10.1177/15586898231217855 on 15/1/24.

Haiko, K., Anderson, J. V., Bakkerud, M., Christiansen, C. R., Rand, K., Staff, T., 2021. A retrospective survey study of paramedic students' exposure to SARS-CoV-2, participation in the COVID-19 pandemic response, and health-related quality of life. Scandinavian Journal of trauma, Resuscitation and Emergency medicine. Vol. 29. Issue 153 accessed [online] from https://doi.org/10.1186/s13049-021-00967-2 on 8/11/23.

Haji, J. Y., Subramaniam, A., Kumar, P., Ramanathan, K., Rajamani, A., 2020 State of Personal Protective Equipment Practice in Indian Intensive Care Units amidst COVID-19 Pandemic: A Nationwide Survey. Indian journal of critical care medicine. Vol. 24, issue 9. Pp809 – 816.

Hallingberg, B., Turley, R., Segrott, J., Wight, D., Craig, P., Moore, L., Murphy, S., Robling, M., Simpson, S.A., Moore, G. G. 2018. Exploratory studies to decide whether and how to proceed with full-scale evaluations of public health interventions: a systematic review of guidance. Pilot Feasibility Stud. 2018 May 28;4:104. doi: 10.1186/s40814-018-0290-8. PMID: 29854417; PMCID: PMC5971430.

Hampson, T., McKinley, J., 2023. Problems posing as solutions: Criticising pragmatism as a paradigm for mixed research. Research in Education. Vol. 116. Issue 1. Accessed [online] from https://doi-org.ezproxy.herts.ac.uk/10.1177/00345237231160085 on 4/1/24.

Hanefield, J., Powell-Jackson, T., Balabanova, D., 2017. Understanding and measuring quality of care: dealing with complexity. Bull World Health Organ. 2017 May 1;95(5):368-374. doi: 10.2471/BLT.16.179309. Epub 2017 Mar 20. PMID: 28479638; PMCID: PMC5418826.

Hao, Y., Wang, Y., Wang, M., Zhou, L., Shi, J., Cao, J., Wang, D., 2022. The origins of COVID-19 pandemic: A brief overview. Transboundary and emerging diseases. Accessed [online] from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9874793/pdf/TBED-9999-0.pdf 4/2/23.

Harris, A. W., Kudenchuk, P. J., 2018. Cardiopulmonary resuscitation: the science behind the hands. Heart. Vol. 104. Issue 13. PP1056-1061.

Harrison, R., Jones, B., Gardner, P. et al. 2021. Quality assessment with diverse studies (QuADS): an appraisal tool for methodological and reporting quality in systematic reviews of mixed- or multi-method studies. BMC Health Serv Res 21, 144. https://doi.org/10.1186/s12913-021-06122-y

Health and Care Professions Council (HCPC), 2023. Paramedics: The standards of proficiency for paramedics. Accessed [online] from https://www.hcpc-uk.org/standards/standards-of-proficiency/paramedics/ on 10/9/23.

Health Education England (HEE), 2017, Multi-professional framework for advanced clinical practice in England. Accessed [online] from https://www.hee.nhs.uk/sites/default/files/documents/multi-professionalframeworkforadvancedclinicalpracticeinengland.pdf on 6/11/23.

Health Education England (HEE). 2020. What do I need to know about Fit Testing for FFP3 (and FFP2/N95), Respiratory Protective Equipment for Dental Practice? Safety Bulletin. Accessed [online] from https://www.england.nhs.uk/south/wp-content/uploads/sites/6/2020/07/hee-fit-testing-overview.pdf on 20/5/24.

Health and Safety Executive (HSE), 2023, Health and Safety at Work etc Act 1974, accessed [online] from https://www.hse.gov.uk/legislation/hswa.htm on 17/10/23.

Health and Safety Executive (HSE), 2022, Personal protective equipment (PPE) at work regulations from 6 April 2022, accessed [online] from https://www.hse.gov.uk/ppe/ppe-regulations-2022.htm from 02/11/23.

Health and Safety Executive (HSE), 2009, Health and safety law (leaflet), accessed [online] from https://www.hse.gov.uk/pubns/books/lawleaflet.htm on 02/11/23.

Health and Safety Executive (HSE) 2019. Guidance on respiratory protective equipment (RPE)

fit testing. Accessed [online] from https://www.hse.gov.uk/pubns/indg479.pdf on 4/4/24.

Her Majesty's (HM) Government, 2023, National Risk Register 2023 Edition, accessed [online] from https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1175834/2023_NATIONAL_RISK_REGISTER_NRR.pdf on 15/11/23.

Hesse-Biber, S. N., 2010. Mixed-methods research: Merging theory with practice. The Guilford Press.

Higginson, R., Jones, B., Kerr, T., Ridley, A., 2020. Paramedic use of PPE and testing during the COVID-19 pandemic. Journal of Paramedic Practice. Accessed [online] https://www.paramedicpractice.com/features/article/paramedic-use-of-ppe-and-testing-during-the-covid-19-pandemic on 18/11/23.

Hill, L., Eaton, G., 2023. Exploring paramedic professional identity. Br Paramed J. 2023 Dec 1;8(3):42-51. doi: 10.29045/14784726.2023.12.8.3.42. PMID: 38046791; PMCID: PMC10690486.

Hodkinson, M., 2022, Air ambulance outcomes of out-of-hospital cardiac arrest seen in the pandemic, Journal of Paramedic Practice. Accessed [online] from https://www.paramedicpractice.com/features/article/air-ambulance-outcomes-of-out-of-hospital-cardiac-arrest-seen-in-the-pandemic on 28/10/23.

Hoernke, K., Djellouli, N., Andrews, L., Lewis-Jackson, S., Manby, L., Martin, S., Vanderslott, S., Vindrola-Padros, C., 2021. Frontline healthcare workers' experiences with personal protective equipment during the COVID-19 pandemic in the UK: a rapid qualitative appraisal. BMJ Open. Accessed [online] from https://doi.org/10.1136%2Fbmjopen-2020-046199 on 21/5/24.

Hollnagel, E., 2015. Resilient Health Care: Vol. 2, 1st Edition. CRC Press. Chapter: 'Why is work-as Imagined different from work-as done?

Holmes, C. H., Goldstein, S. A., Rasmussen, A. L., Robertson, D. L., Crits-Christoph, A., Wertheim, J. O., Anthony, S. J., Barclay, W. S., Boni, M. F., Doherty, P. C., Farra, J., Geoghegan, J. L., Jiang, X., Leibowitz, J. L., Neil, S. J. D., Skern, T., Weiss, S. R., Worobey, M., Anderson, K. G., Garry, R. F., Rambaut, A., 2021. The origins of SARS-CoV-2: A critical review. Cell Press OpenAccess. Accessed online from https://doi.org/10.1016/j.cell.2021.08.017 on 2/3/22.

Hon, C-Y., Danyluk, Q., Bryce, E., Jansenn, B., Neudorf, M., Yassi, A., Shen, H., Astrakianakis, G., 2017. Comparison of qualitative and quantitative fit-testing results for three commonly used respirators in the healthcare sector. Journal of Occupational and Environmental hygiene. Vol. 14, issue 3. PP 175-179. Accessed [online] from https://doi.org/10.1080/15459624.2016.1237030 on 21/5/24.

Houghton, C., Meskell, P., Delaney, H., Smalle, M., Glenton, C., Booth, A., Chan, X. H. S., Devane, D., Biesty, L. M., 2020. Barriers and facilitators to healthcare workers' adherence with infection prevention and control (IPC) guidelines for respiratory infectious diseases: a rapid qualitative evidence synthesis (review). Cochrane Database of systematic reviews. Accessed [online] from https://www.cochranelibrary.com/cdsr/doi/10.1002/14651858.CD013582/full on 19/8/2021.

Howe, A., 2023. Crimes of Passion Since Shakespeare: Red Mist Rage Unmasked. 1st Edition. Routledge publishing. Accessed [online] from https://doi.org/10.4324/9781003301974 on 24/4/24.

Hsu, C. H., Tiba, M. H., Boehman, A. L., McCracken, B. M., Leander, D. C., Francalancia, S. C., Pickell, Z., Sanderson, T. H., Ward, K. R., Neumar, R. W., 2021. Aerosol generation during chest compression and defibrillation in a swine cardiac arrest model. Resuscitation. Vol. 159. PP28-34. Accessed [online] from https://doi.org/10.1016/j.resuscitation.2020.12.004 on 5/3/24.

[1]Hsu, A., Sasson, C., Kudenchuk, P.J. et al. 2021. interim guidance to health care providers for basic and advanced cardiac life support in adults, children, and neonates with suspected or confirmed COVID-19. Circ Cardiovasc Qual Outcomes. Vol 14(10):e008396. https://doi.org/10.1161/CIRCOUTCOMES.121.008396

Huang, Y., Pei, J., Nielsen, P. V., Bonthoux, F., Lechene, S., Keller, F., Wu, S., Xu, C., Cao, Z., 2021, Chapter 4 - Experimental techniques. Industrial Ventilation Design Guidebook (2nd Edition). Academic Press. PP185-277.

Huecker, M. R., Shreffler, J., McKeny, P T., Davis, D., 2023. Imposter Phenomenon. Stat Pearls. Accessed [online] https://www.ncbi.nlm.nih.gov/books/NBK585058/ on 12/5/24.

Hung, T-Y., Wen, C-S., Yu, S-H., Chen, Y-C., Chen, H-L., Chen, W-L., Wu, C-C., Lin, C-L., Hu, S-C., Lin, T., 2023. A comparative analysis of aerosol exposure and prevention strategies in bystander, pre-hospital, and inpatient cardiopulmonary resuscitation using simulation manikins. Scientific Reports. Vol. 13. Article number 12552. Accessed [online] from https://www.nature.com/articles/s41598-023-39726-x on 20/4/24.

Hunter, D., McCallum, J. and Howes, D., 2019. Defining Exploratory-Descriptive Qualitative (EDQ) research and considering its application to healthcare. Journal of Nursing and Health Care. Volume 4, issue 1.

Hwang, S. Y., Yoon, H., Yoon, A., Kim, T., Lee, G., Jung, K. Y., Park, J. H., Shin, T. G., Cha, W. C., Sim, M. S., Kim, S., 2020. N95 filtering facepiece respirators do not reliably afford respiratory protection during chest compression: A simulation study. American Journal of Emergency Medicine. Vol. 38, issue 1. PP12-17. Accessed [online] from https://doi.org/10.1016/j.ajem.2019.03.041 on 4/6/24.

Iqbal, F. M., Lam, K., Sounderajah, V., Clarke, J. M., Ashrafian, H., 2021. Characteristics and predictors of acute and chronic post-COVID syndrome: A systematic review and meta-analysis. eClinical Medicine – part of the Lancet Discovery Science. Accessed [online] from https://doi.org/10.1016/j.eclinm.2021.100899 on 14/3/22.

Jackson, T., Deibert, D., Wyatt, G. et al. 2020. Classification of aerosol[1]generating procedures: a rapid systematic review. BMJ Open Respir Res. Vol. 7(1):e000730. https://doi.org/10.1136/bmjresp-2020-000730

Jafar, A. J. N., 2018. What is positionality and should it be expressed in quantitative studies? Emergency Medicine Journal, 35(5), 323–324. Accessed [online] from https://doi.org/10.1136/emermed-2017-207158 on 21/1/24.

Jamieson, M. K., Govaart, G. H., Pownall, M., 2023. Reflexivity in quantitative research: A rationale and beginner's guide. Social and Personality Psychology Compass. Vol. 17. Issue 4. Accessed [online] from https://doi.org/10.1111/spc3.12735 on 10/4/24.

Jarvis, M. C., 2020. Aerosol Transmission of SARS-CoV-2: Physical Principles and Implications. Sec. Infectious Diseases – Surveillance, Prevention and Treatment. Volume 8. Accessed [online] from https://doi.org/10.3389/fpubh.2020.590041 on 2/8/24.

Jefferson, T., Dooley, L., Ferroni, E., Al-Ansary, L. A., Van Driel, M. L., Bawazeer, G. A., Jones, M. A., Hoffman, T. C., Clark, J., Beller, E. M., Glasziou, P. P., Conly, J. M., 2023. Physical interventions to interrupt

or reduce the spread of respiratory viruses/ Cochrane Database of Systematic Reviews. Issue 1. Art. No.: CD006207. DOI: 10.1002/14651858.CD006207.pub6. Accessed 08 November 2024.

Jinkerson, J. D., 2016. Defining and assessing moral injury: A syndrome perspective. Traumatology, volume 22, issue 2, PP122–130. Accessed [online] from https://doi-org.ezproxy.herts.ac.uk/10.1037/trm0000069 on 24/4/24.

John, S.A., Walsh, J.L., Weinhardt, L.S., 2017. The Information-Motivation-Behavioral Skills Model Revisited: A Network-Perspective Structural Equation Model Within a Public Sexually Transmitted Infection Clinic Sample of Hazardous Alcohol Users. AIDS Behav. 2017 Apr;21(4):1208-1218. doi: 10.1007/s10461-016-1446-2. PMID: 27260181; PMCID: PMC5136346.

Johnson, B., Gray, R., 2010. A history of philosophical and theoretical issues for mixed-methods research. In A. Tashakkori & C. Teddlie (eds.), SAGE Handbook of Mixed-methods in Social & Behavioural Research. 2nd ed. Thousand Oaks, CA: SAGE Publications, pp. 69-94.

Johnson, R. B., Onwuegbuzie, A. J., 2004. Mixed-methods Research: A research whose time has come. Educational Researcher. Sage Journals. Vol. 33. Issue 7. Accessed [online] from https://doi-org.ezproxy.herts.ac.uk/10.3102/0013189X033007014 on 3/1/24.

Johnson, R. B., Onwuegbuzie, A. J., Turner, L.A. 2007. Toward a Definition of Mixed-methods Research. Journal of Mixed-methods Research, 1, 112-133. Accessed [online] at https://doi.org/10.1177/1558689806298224 on 4/1/24.

Johnston, T., Acker, J., 2016, Using a Sociological Approach to Answering Questions about Paramedic Professionalism and Identity. Australasian Journal of Paramedicine. 2016;13:1-8. doi:10.33151/ajp.13.1.301

Joint Royal Colleges Ambulance Liaison Committee (JRCALC). 2022. JRCALC Guidelines: Duty of care. Accessed [online] from https://jrcalcplusweb.co.uk/guidelines/G0077 on 15/3/23.

Joint Royal Colleges Ambulance Liaison (JRCALC), 2023. Duty of Care. Accessed [online] from https://jrcalcplusweb.co.uk/guidelines/G0077 on 29/10/23.

Jose, S., Cyriac, M.C., Dhandapani, M., 2021. Health Problems and Skin Damages Caused by Personal Protective Equipment: Experience of Frontline Nurses Caring for Critical COVID-19 Patients in Intensive Care Units. Indian J Crit Care Med. Feb;25(2):134-139. doi: 10.5005/jp-journals-10071-23713. PMID: 33707889; PMCID: PMC7922454.

Jost, D., Minh, P.D., Galinou, N., Alhanati, L., Dumas, F., Lemoine, F., Tourtier, J-P. 2015. What is the incidence of regurgitation during an out-of-hospital cardiac arrest? Observational study Resuscitation. Issue 96, Vol70.

Kalita, S., Gogoi, B., Khaund, G. et al. 2022. Optimizing airway surgery in COVID 19 era. Indian J tolaryngol Head Neck Surg. Vol. 74(suppl 2):3370–3377. https://doi.org/10.1007/s12070-020-02326-6

Kashetsky, N., Mukovozov, I.M., Bergman, J. 2021. Chilblain-like lesions (CLL) associated with COVID-19 ("COVID toes"): a systematic review. Journal of Cutan Med Surg. Volume 25, issue 6. P627-633

Kaushik, V., Walsh, C.A., 2019. Pragmatism as a research paradigm and its implications for social work research. Soc Sci. 2019;8(255):1-17.

Kaur, K., Kelly, K. E., 2023. Performance evaluation of the Alphasense OPC-N3 and Plantower PMS5003 sensor in measuring dust events in the Salt Lake Valley, Utah. Atmospheric Measurement Techniques. Volume 6, issue 10. Accessed [online] from https://doi.org/10.5194/amt-16-2455-2023 on 10/8/24.

Keith, C.H., Derrick, J.C. 1960. Measurement of the particle size distribution and concentration of cigarette smoke by the “conifuge” Journal. Colloid Science. Vol 15, PP340–356. doi: 10.1016/0095-8522(60)90037-4

Kent V Griffiths, 2001, Case Page, practical law, accessed [online] from https://uk.practicallaw.thomsonreuters.com/D-014-3278?transitionType=Default&contextData=(sc.Default) on 01/11/23.

Key, T., Mathai, N. J., Venkatesan, A. S., Farnell, D., Mohanty, K., (2020) Personal protective equipment during the Covid-19 crisis: a snapshot and recommendations from the frontline of a university teaching hospital, British journal of orthopaedics. Vol. 1, no. 5, pp131 – 136

Kiger, M., Varpio, L., 2020. Thematic analysis of qualitative data: AMEE Guide No. 131. Medical teacher. Vol 8. PP846-854. Accessed [online] from https://doi.org/10.1080/0142159x.2020.1755030 on 9/10/23.,

Kim, W.Y., Choi, W., Park, S.W. et al. 2015. Nosocomial transmission of severe fever with thrombocytopenia syndrome in Korea. Clin Infect Dis. Vol. 60(11):1681–1683. https://doi.org/10.1093/cid/civ128

Kim, J., Jang, J., Kim, B., Lee, K., 2022. Effect of the PRECEDE-PROCEED model on health programs: a systematic review and meta-analysis. Systematic reviews. Accessed [online] from https://systematicreviewsjournal.biomedcentral.com/articles/10.1186/s13643-022-02092-2 on 27/10/24.

King-Hill, S., 2015, Critical analysis of Maslow's hierarchy of need. The STeP Journal Student Teacher Perspectives, vol. 2, no. 4, pp. 54-57.

Klein, T. A., Tadi, P., (2023). EMS Scene Safety. StatPearls. National Library of Medicine. Accessed [online] from https://www.ncbi.nlm.nih.gov/books/NBK557615/ on 22/11/2023.

Klompas, M., Baker, M., Rhee, C., 2020. What is an Aerosol Generating Procedure? JAMA Surg. Vol. 156. Issue 2. PP 113-114. Accessed [online] from https://doi.org/10.1001/jamasurg.2020.6643 20/3/22.

Knoblauch, H., 2021. Reflexive methodology and the empirical theory of science. Historical Social Research / Historische Sozialforschung, 46(2), 59–79. Accessed [online] from https://www.jstor.org/stable/27032972 on 20/1/24.

Kuhn, T., 1962. The structure of scientific revolutions (2nd ed.). Chicago, IL: University of Chicago Press.

Kulkarni, A. P., Singh, Y., Garg, H., Jha, S., 2020. Cardiopulmonary Resuscitation during COVID-19 Pandemic: Outcomes, Risks, and Protective Strategies for the Healthcare Workers and Ethical Considerations. Indian Journal of Critical care Medicine. Vol. 24. Issue 9. PP868-872.

Knobloch, J. K., Franke, G., Knoblock, M. J., Knobling, B., Kampf, G., 2023. Overview of tight fit and infection prevention benefits of respirators (filtering face pieces). The Journal of Hopsital Infection. Vol. 134. PP89-96. Accessed [online] from https://doi.org/10.1016/j.jhin.2023.01.009 on 24/3/24.

Krajnc, A. P., Pirker, L., Centa, U. G., Gradisek, A., Mekjavic, I. B., Godnic, M., Cebasek, M., Bregnant, T., Remskar, M., 2021. Size- and Time-Dependent Particle Removal Efficiency of Face Masks and Improvised Respiratory Protection Equipment Used during the COVID-19 Pandemic. MDPI open access. Accessed [online] from https://doi.org/10.3390/s21051567 on 24/5/24.

Kursumovic, E., Lennane, S., Cook, T. M., 2020. Deaths in healthcare workers due to COVID-19: the need for robust data and analysis. Anaesthesia, vol. 75, issue 8, PP989-992. Accessed [online] from https://doi.org/10.1111/anae.15116 on 10/11/24.

Kvale S. Interviews: an introduction to qualitative research interviewing. Thousand Oaks, CA: Sage, 1996.

Laue, M., Kauter, A., Hoffmann, T., Möller, L., Michel, J., Nitsche, A., 2021. Morphometry of SARS-CoV and SARS-CoV-2 particles in ultrathin plastic sections of infected Vero cell cultures. Sci Rep. Vol. 11(1):3515. https://doi.org/10.1038/s41598-021-82852-7

Lawes, E. G., Baskett, P.J., 1987. Pulmonary aspiration during unsuccessful cardiopulmonary resuscitation. J Intensive Care Med; 13: 379–82.

Leary, A., 2022. The Principles of Advanced Level Practice, Health Education England. Accessed [online] from https://www.hee.nhs.uk/sites/default/files/documents/The%20Principles%20of%20Enhanced%20Level%20Practice.pdf on 10/10/24.

Lee, S. A., Grinshpun, S. A., Adhikari, A. et al. 2005. Laboratory and field evaluation of a new personal sampling system for assessing the protection provided by the N95 filtering facepiece respirators against particles. Annal of Occupational Hygiene. Vol 49. PP245–57.

Lee, B. U., 2020. Minimum Sizes of Respiratory Particles Carrying SARS-CoV-2 and the Possibility of Aerosol Generation. Internation Journal of Environmental Research and Public Health. Vol. 17. Issue 19. PP6960. Accessed [online] from https://doi.org/10.3390%2Fijerph17196960 on 24/4/24.

Lemmens, S. M. P., Van Balen, V. A. L., Roselaers, Y. C., M., Scheepers, H., C. J., Spaanerman, M. E., A., 2022. The risk matrix approach: a helpful tool weighing probability and impact when deciding on preventive and diagnostic interventions. BMC Health Services Research. Vol. 22. Article 218. Accessed [online] from https://link.springer.com/article/10.1186/s12913-022-07484-7 on 19/4/24.

Lentz, L. M., Smith-MacDonald, L., Malloy, D., Carleton, R. N., Bremault-Phillips, S., 2021. Frontiers in Psychology. Vol. 12. Accessed [online] from https://doi.org/10.3389/fpsyg.2021.639781 on 24/4/24.

Lobarto, R. M., 2021. Collective Rituals in Times of the COVID-19 Quarantine: The Relationship between Collective Applause and Identity Fusion. Studia Psychologica, 3(3), 279–290. https://doi.org/10.31577/sp.2021.03.827

Loeb, M., McGeer, A., Henry, B. et al. 2004. SARS among critical care nurses, Toronto. Emerg Infect Dis. Vol. 10(2):251–255. https://doi.org/10.3201/eid1002.030838

Loeb, M., Dafoe, N., Mahony, J., John, M., Sarabia, A., Glavin, V., Webby, R., Smieja, M., Earn, D. J. D., Chong, S., Webb, A., Walter, S. D., 2009. Surgical mask vs N95 respirator for preventing influenza among health care workers: a randomized trial. JAMA. Vol. 302(17):1865-71. doi: 10.1001/jama.2009.1466.

Leong, Y. C., Cheskes, S., Drennan, I. R., Buick, J. E., Latchmansingh, R. G., Verbeek, P. R., 2020. Clinical considerations for out-of-hospital cardiac arrest management during COVID-19. Resuscitation Plus. Accessed [online] from https://doi.org/10.1016/j.resplu.2020.100027on 1/2/22.

Leung, N. H., Zhou, J., Chu, D. K. W., Yu, H., Lindsley, W. G., et al. 2016. Quantification of influenza virus RNA in aerosols in patient rooms. PLoS ONE 11, accessed [online] from https://doi.org/10.1371/journal.pone.0148669 on 1/8/24.

Leung, N. H. L., 2021. Transmissibility and transmission of respiratory viruses. Nature Reviews Microbiology. Vol. 19. PP528-545.

Levac, D., Colquhoun, H. & O'Brien, K.K. 2010. Scoping studies: advancing the methodology. Implementation Sci 5, 69. https://doi.org/10.1186/1748-5908-5-69

Li, K. K. W., Joussen, A. M., Kwan, J. K. C., Steel, D. H. W., 2020. FFP3, FFP2, N95, surgical masks and respirators: what should we be wearing for ophthalmic surgery in the COVID-19 pandemic? Graefe's Archive for Clinical and Experimental Ophthalmology. Issue 258. PP 1587-1589. Accessed [online] from https://doi.org/10.1007%2Fs00417-020-04751-3 on 19/4/24.

Li, F., Jiang, T., Shi, T. et al. 2021. Factors that affect the duration of wearing disposable personal protective equipment by healthcare professionals in Wuhan during treatment of COVID-19 patients: an epidemiological study. Nurs Health Sci. Vol. 23(1):245–254. https://doi.org/10.1111/nhs.12814

Lier, M., Nessler, S., Stadelmann, C., Pressler, M., Saager, L., Moerer, O., Roessler, M., Meissner, K., Winkler, M. S., 2021. High class filtering facepiece (FFP) are fundamental and effective in protection of emergency health care workers: an observational cohort study in a German community. Scandinavian Journal of Trauma, Resuscitation and emergency medicine. Vol. 29. Issue 1. Accessed [online] from https://doi.org/10.1186/s13049-021-00969-0 on 8/11/24.

Lim, C.S., See, B., Liang Teo, D.C., Qing Tan, M.S., Hassan, N., Tee, A., 2023. Risk Perception and Psychosocial Impact During the Early Period of the COVID-19 Pandemic on Healthcare Workers. BJPsych Open. 2023 Jul 7;9(Suppl 1):S57–8. doi: 10.1192/bjo.2023.205. PMCID: PMC10345860.

Lin, L. W., DuCanto, J., Hsu, C-Y., Su, Y-C., Huang, C-C., Hung, S-W., 2022. Compromised cardiopulmonary resuscitation quality due to regurgitation during endotracheal intubation: a randomised crossover manikin simulation study. BMC Emergency Medicine. Volume 22, Article number: 124. Accessed [online] from https://bmcemergmed.biomedcentral.com/articles/10.1186/s12873-022-00662-0 on 10/5/24.

Lindsley, W.G., Blachere, F.M., Thewlis, R.E., et al. 2010. Measurements of airborne influenza virus in aerosol particles from human coughs. PLoS ONE. 5: Accessed [online] from https://doi.org/10.1371/journal.pone.0015100 on 12/4/24.

Lindsley, W. H., Green, B. J., Blachered, F. M., Martin, S. B., Law, B. F., Jensen, P. A., Schafer, M. P., 2017. Sampling and characterization of bioaerosols. NIOSH Manual of Analytical Methods (NMAM), 5th Edition. Accessed [online] from https://www.cdc.gov/niosh/nmam/pdf/chapter-ba.pdf on 30/08/2024.

Liu, W., Tang, F., Fang, L., De Vlas, S. J., Ma, H., Zhou, J., Looman, C. W. N., Richardus, J. H., Cao, W., 2009. Risk factors for SARS infection among hospital healthcare workers in Beijing: a case control study. Tropical Medicine and International Health. Vol. 14. Issue 1. PP52-59. Accessed [online] from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7169729/ on 10/4/24.

Lobato, R. M., Sainz, M., 2021. Collective Rituals in Times of the COVID-19 Quarantine: The Relationship between Collective Applause and Identity Fusion. Studia Psychologica. Vol. 63. No. 3. PP279-290. Accessed [online] from https://doi.org/10.31577/sp.2021.03.827 on 25/4/24.

MacDannold, R., Bobrow, B.J., Chikani, V., Silver, A., Spaite, D.W., Vadeboncoeur, T., 2018. Quantification of ventilation volumes produced by compressions during emergency department cardiopulmonary resuscitation. Am J Emerg Med. Vol. 36(9):1640–1644. https://doi.org/10.1016/j.ajem.2018.06.057

MacIntyre, C. R., Chugtai, A. A., Rahman, B., Peng, Y., Zhang, Y., Seale, H., Wang, X., Wang, Q., 2017. The efficacy of medical masks and respirators against respiratory infection in healthcare workers. Influenza & other respiratory viruses. Vol. 11, issue 6. PP511-517. https://doi.org/10.1111/irv.12474

Mahroum, N., Seida, I., Esirgun, S. N., Bragazzi, N. L., 2022. The COVID-19 pandemic – How many times were we warned before? European Journal of Internal Medicine. Vol. 105. Accessed [online] https://doi.org/10.1016/j.ejim.2022.07.009 on 23/10/24.

Malik, M., Peirce, J., Wert, M.V., Wood, C., Burhanullah, H., Swartz, K., 2021. Psychological first aid well-being support rounds for frontline healthcare workers during COVID-19. Front Psychiatry. Vol. 12:669009. https://doi.org/10.3389/fpsyt.2021.669009

Manthorpe, J., Iliffe, S., Gillen, P., Moriarty, J., Mallett, J., Schroder, H., Currie, D., Ravalier, J., McFadden, P., 2022. Clapping for carers in the Covid-19 crisis: Carers' reflections in a UK survey. Health and Social Care within the community. Vol. 30. Issue 4. PP1442-1449. Accessed [online] from https://doi.org/10.1111%2Fhsc.13474 1/6/24.

Manzoor, A., 2021. Designs of Mixed method Research. Research Anthology on Developing Critical Thinking Skills in Students. IGI Global. Accessed [online] from https://www.irma-international.org/viewtitle/269892/?isxn=9781799830221 on 28/12/23.

Martha, D., Sousa, V. D., Mendes, I. A. C., 2007. An overview of research designs relevant to nursing: Part 3: Mixed and multiple methods. Rev. Latino-Am. Enfermagem 15 (5). Accessed [online] from https://doi.org/10.1590/S0104-11692007000500025 on 12/9/22.

Martin, T. C. S., Curtin, G., Martin, N. K., Torriani, F. J., 2024. Annual N95 respirator fit-testing: an unnecessary burden on healthcare. Infection Control and Hospital Epidemiology. Vol. 45. PP250 – 252. Accessed [online] from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC10877532/pdf/S0899823X23001873a.pdf on 2/9/24.

Maslow, A. H., 1943. A theory of human motivation. Psychological Review, 50(4), 370–396. https://doi.org/10.1037/h0054346

Masuda, Y., Teoh, S. E., Yeo, J. W., et al. 2022. Variation in community and ambulance care processes for out-of-hospital cardiac arrest during the COVID-19 pandemic: a systematic review and meta-analysis. Scientific Reports. Vol. 12. Article 800. Accessed [online] from https://www.nature.com/articles/s41598-021-04749-9 on 20/11/23.

Mateu, M. G., 2013. Assembly, stability and dynamics of virus capsids. Archives of biochemistry and Biophysics. Issue 531. PP 65–79. Accessed [online] from https://doi.org/10.1016/j.abb.2012.10.015 on 01/08/2024. .

Mausz, J., Donnelly, E. A., Moll, S., Harms, S., McConnell, M., 2022. Role Identity, Dissonance, and Distress among Paramedics. International Journal of Environmental Research and Public Health. Vol. 19. Issue 4. Accessed [online] from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8871672/#B18-ijerph-19-02115 on 12/5/24.

Maxwell J. A., Mittapalli K., 2010. Realism as a stance for mixed method research. In Tashakkori A., Teddlie C. (Eds.), Handbook of mixed-methods in social & behavioral research (2nd ed., pp. 145–168). Thousand Oaks, CA: Sage.

McCloskey, M. S., Phan, K. L., Angstadt, M., Fettich, K. C., Keedy, S., Coccaro, E. F., 2016. Amygdala hyperactivation to angry faces in intermittent explosive disorder. Journal of Psychiatric Research. Vol. 79. PP34-41. accessed [online] from https://doi.org/10.1016/j.jpsychires.2016.04.006 on 24/5/24.

McConnell, D., 2020. Balancing the duty to treat with the duty to family in the context of the COVID-19 pandemic. J Med Ethics. 2020 Jun;46(6):360-363. doi: 10.1136/medethics-2020-106250. Epub 2020 Apr 24. PMID: 32332154; PMCID: PMC7211094.

McKellar, K., Sillence, E., 2020. Current Research on Sexual Health and Teenagers. Teenagers, Sexual Health Information, and the Digital Age. Elsevier Inc. PP5-23. Accessed [online] from https://doi.org/10.1016/B978-0-12-816969-8.00002-3 on 18/1/24.

McLeod, S., 2024. Relevance of Reliability and Validity in Qualitative Research. Simply Psychology. Accessed [online] from https://www.simplypsychology.org/reliability-and-validity-in-qualitative-research.html on 01/02/2025.

McManamny, T. et al., 2014. Mixed-methods and its application in prehospital research: a systematic review. Journal of Mixed-methods Research. Vol. 9. Issue 3. Accessed [online] from https://doi.org/10.1177/1558689813520408 on 28/12/23.

McManamny, T., Ortega, M., Munro, S., Jennings, P., Whitley, G. A., 2023. A pre-hospital mixed-methods systematic review protocol. British Paramedic Journal. Sep 1;8(2):38-43. doi: 10.29045/14784726.2023.9.8.2.38.

Merrified, K. A., Gamble, W. C., Yu, J. J., 2015. Using social cognitive theory to understand meta-parenting in parents of young children. Family Science. Vol. 6. Issue 1. Accessed [online] from https://doi.org/10.1080/19424620.2015.1076495 on 20/1/24.

Mertens, D. M., Bledsoe, K. L., Sullivan M., Wilson A., 2010. Utilization of mixed-methods for transformative purposes. In Tashakkori A., Teddlie C. (Eds.), Handbook of mixed-methods in social & behavioral research (2nd ed., pp. 193–214). Thousand Oaks, CA: Sage.

Mertens, D. M., 2012. What Comes First? The Paradigm or the Approach? Journal of Mixed method Research. Vol. 6. Issue 4. PP255-257. Accessed [online] from https://doi.org/10.1177/1558689812461574 on 3/1/24.

Messeri, A., Bonafede, M., Pietrafesa, E. et al. 2021. A web survey to evaluate the thermal stress associated with personal protective equipment among healthcare workers during the Covid-19 pandemic in Italy. Int J Environ Res Public Health. Vol.18(8):3861. https://doi.org/10.3390/ijerph18083861

Meyer, A. N.D., Giardina, T. D., Khawaja, L., Singh, H., 2021. Patient and clinician experiences of uncertainty in the diagnostic process: Current understanding and future directions. Patient Education and Counselling. Vol. 104. Issue 11. PP2606 – 2615. https://doi.org/10.1016/j.pec.2021.07.028

Mik-Meyer, N., 2020. Multimethod qualitative research. Qualitative Research. London. SAGE, pp. 357-374. Accessed [online] from https://www.researchgate.net/publication/348651286_Multimethod_qualitative_research on 12/9/22.

Millington, T., Chilcott, R. P., Williams, J., 2022. Experiences of personal protective equipment and reasons for non-compliance. Journal of Paramedic Practice. Vol. 14. Issue 10. Accessed [online] from https://www.paramedicpractice.com/content/features/experiences-of-personal-protective-equipment-and-reasons-for-non-compliance/ on 21/5/24.

Mills, A. J., Durepos, G., & Wiebe, E. (Eds.), 2010. Encyclopaedia of case study research: L-Z; index (Vol. 1). Sage.

Mitchell, G., 2021. Clap for Heroes: Nurses say they do not want return of applause. Nursing Times. Accessed [online] from https://www.nursingtimes.net/news/coronavirus/clap-for-heroes-nurses-say-they-do-not-want-return-of-applause-07-01-2021/ on 25/5/24.

Mitri, M., Fadel, F. A., Juvelekian, G., 2021. Resilience in Health Care: Surviving a Coinciding Pandemic, a Major Deadly Disaster, and an Economic Collapse: What Did We Learn? CHEST Journal. Vol. 160. Issue 5. PP1986-1988. Accessed [online] from https://doi.org/10.1016/j.chest.2021.06.056 on 28/5/24.

Misumi, M., Nishiura, H., 2021. Long-term dynamics of Norovirus transmission in Japan, 2005–2019. Peer Journal. Accessed [online] from https://peerj.com/articles/11769/ on 12/5/24.

Mobley, C. C., Sandobval, V. A., 2008. Prevention in Clinical Oral Health Care. Chapter 10 - Integrating Risk and Health-Promotion Counselling. Mosby Publishing. PP122-133.

Montgomery, C. M., Humphreys, S., McCulloch, C., Docherty, A. B., Sturdy, S., Pattison, N., 2021. Critical care work during COVID-19: a qualitative study of staff experiences in the UK. BMJ Open. Volume 11. Issue 5. Accessed [online] from DOI: 10.1136/bmjopen-2020-048124 on 8/4/22.

Monzani, A., Ragazzoni, L., Della Corte, F., Rabbone, I., Franc, J.M., 2020. COVID-19 pandemic: perspective from Italian pediatric emergency physicians. Disaster Med Public Health Prep. Vol. 14(5):648–651. https://doi.org/10.1017/dmp.2020.198

Morawska, L., Johnson, G. R., Ristovski, Z. D., Hargreaves, M., Mengersen, K., Corbett, S., Chao, C. Y. H., Li, Y., Katoshevski, D., 2009. Size distribution and sites of origin of droplets expelled from the human respiratory tract during expiratory activities. Journal of Aerosol Science. Vol. 40. Issue 3. PP 256 – 269. Accessed [online] from https://doi.org/10.1016/j.jaerosci.2008.11.002 on 10/4/24.

Morgan, D. L., 2014. Pragmatism as a paradigm for social research. Qualitative Inquiry. Vol. 20, issue 8, pp1045-1053.

Morse, J., 2003. Principles of mixed-methods and multimethod research design. Handbook of mixed-methods in social & behavioural research. Thousand Oaks: Sage. Pp 189-208

Morse, J.M., 2015, Critical analysis of strategies for determining rigor in qualitative inquiry.

Qualitative health research, vol. 25, issue 9, PP1212-1222.

Moscati, R., 2002. Protection of human subjects in prehospital research. Prehospital Emergency Care, 6(Suppl. 2), S18-S23.

Mueller, A. V., Eden, M. J., Oakes, J. M., Bellini, C., Fernandez, L. A., 2020. Quantitative Method for Comparative Assessment of Particle Removal Efficiency of Fabric Masks as Alternatives to Standard Surgical Masks for PPE. Matter. Vo. 3. Issue 3. PP950-962. Accessed [online] from https://doi.org/10.1016/j.matt.2020.07.006 on 27/1/24.

Muharraq, E. H. (2021). The Psychological Impact of Coronavirus Disease 2019 on Nurses in Saudi Arabia and Their Coping Strategies. SAGE open nursing. Volume 7. PP 1-10.

Munn, Z., Peters, M.D.J., Stern, C., Tufanaru, C., McArthur, A., Aromataris, E., 2018. Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. BMC Med Res Methodol. Vol. 18(1):143. https://doi.org/10.1186/s12874-018-0611-x

Munthe-Kaas, H., Nøkleby, H., Lewin, S. et al. 2020. The TRANSFER Approach for assessing the transferability of systematic review findings. BMC Med Res Methodol 20, 11. https://doi.org/10.1186/s12874-019-0834-5

Murcot, P., Williams, B., Morgans, A., Boyle, M., 2014. Community perceptions of the professional status of the paramedic discipline. International Journal of Paramed Practice, vol. 4 issue 1. PP13-18

Mutiawati, E., Syahrul, S., Fahriani, M., et al. 2020. Global prevalence and pathogenesis of headache in COVID-19: a systematic review and meta-analysis. Accessed [online] from https://doi.org/10.12688/f1000research.27334.1 on 8/3/2022.

Nam, H.S., Yeon, M.Y., Park, J.W., Hong, J.Y., Son, J.W. 2015. Healthcare worker infected with Middle East Respiratory Syndrome during cardiopulmonary resuscitation in Korea. Epidemiol Health. Vol. 39:e2017052. https://doi.org/10.4178/epih.e2017052

Nasiri, N., Sharifi, H., Bazrafshan, A., et al. 2021. Ocular manifestations of COVID-19: a systematic review and meta-analysis. Journal of Ophthalmic Visual Research. Volume 16, issue 1. P103-112.

National Ambulance Resilience Unit (NARU), 2015, National Ambulance Service Command and Control Guidance. V.1.2 October 2015. Accessed from https://naru.org.uk/wp-content/uploads/2016/09/NARU-CC-GUIDANCE-V.1.2.OCT-2015jm.pdf on 18/10/23.

National Ambulance Resilience Unit (NARU). 2021. The Duty of Care of ambulance responders. Accessed [online] from https://naru.s3.eu-west-2.amazonaws.com/wp-content/uploads/2021/09/03212218/DutyofCareBreifingNoteApril21.pdf on 1/4/24.

National Ambulance Resilience Unit (NARU), 2023. Hazardous Area Response Team (HART). Accessed [online] from https://naru.org.uk/the-interoperable-capabilities/hart/ on 18/1/23.

National Ambulance Service Infection Prevention & Control Group (NASIPCG) 2023. IPC Guidance for Seasonal Respiratory Infections (SRIs) in health and care settings Winter 2023/2024: POSITION STATEMENT – 13/10/2023. Association of Ambulance Chief Executives. Accessed [online] from https://aacesite.s3.eu-west-2.amazonaws.com/wp-content/uploads/2023/10/04103724/NASIPCG-Position-Winter-Guidance-FINAL-13-Oct-2023.pdf on 24/4/24.

National Ambulance Service Infection Prevention & Control Group (NASIPCG), 2022. IPC Guidance changes to the Seasonal Respiratory Infections (SRIs) in health and care setting update April 2022 POSITION STATEMENT – 14/04/22. Accessed [online] from https://aace.org.uk/wp-content/uploads/2022/04/NASIPCCG-position-statement-guidance-14422-FINAL_.pdf on 2/11/23.

National Health Service England (NHSE). 2022. A rapid review of aerosol generating procedures (AGPs). A rapid review of aerosol generating procedures (AGPs). Accessed [online] from https://tinyurl.com/mry9trkj (accessed 24 March 2023) 3/2/22.

National Health Service England (NHSE). 2025. A just culture guide. Accessed [online] from https://www.england.nhs.uk/patient-safety/patient-safety-culture/a-just-culture-guide/ on 2/2/25.

National Health Service England (NHSE), 2020, COVID-19 Ambulance Case Transport Response Service Framework. Accessed [online] https://www.england.nhs.uk/coronavirus/documents/covid-19-ambulance-case-transport-response-service-framework/ from 18/11/23.

National Health Service (NHS) Major Incident Triage Tool (MITT), 2023. Accessed [online] from https://www.england.nhs.uk/long-read/nhs-major-incident-triage-tool-mitt/ on 22/10/24.

National Health Service England (NHSE) National infection prevention and control manual (NIPCM) for England. 2024. Accessed [online] from https://www.england.nhs.uk/national-infection-prevention-and-control-manual-nipcm-for-england/ on 11/10/23.

National Patient Safety Alert. NHS. 2021. Infection risk when using FFP3 respirators with valves or Powered Air Purifying Respirators (PAPRs) during surgical and invasive procedures. Reference number: NatPSA/2021/009/NHSPS. Accessed [online] from https://www.england.nhs.uk/wp-content/uploads/2021/08/NatPSA-vented-masks-hoods-FINAL.pdf on 10/5/24.

National Ambulance Service Infection Prevention & Control Group (NASIPCG) (2022), NHS England Health Care Service Recovery IPC Guidance changes to the Seasonal Respiratory Infections (SRIs) in health and care setting update April 2022 POSITION STATEMENT – 14/04/22 , accessed [online] from https://aace.org.uk/wp-content/uploads/2022/04/NASIPCCG-position-statement-guidance-14422-FINAL_.pdf 15/3/23

National Institute for Health and Care Excellence (NICE). 2024. Cardiac Arrest – out of hospital: What is the Prognosis? Accessed [online] from https://cks.nice.org.uk/topics/cardiac-arrest-out-of-hospital-care/background-information/prognosis/#:~:text=Immediate%20initiation%20of%20CPR%20can,to%20hospital%20discharge%20by%2010%25 on 10/4/24.

Naylor, D., 2019. Tackling 'imposter syndrome': working with third sector leaders. The Kingsfund: Blog. Accessed [online] from https://www.kingsfund.org.uk/insight-and-analysis/blogs/tackling-imposter-syndrome on 10/5/24.

Nazaroff, W.W., Klepeis, N.E., 2003. Indoor Environment: Airborne Particles and Settled Dust. Environmental Tobacco Smoke Particles. Wiley-VCH Verlag GmbH & Co. KG; Weinheim, Germany. PP. 245–274.

New and Emerging Respiratory Virus Threats Advisory Group (NERVTAG), 2020, NERVTAG consensus statement on Cardiopulmonary Resuscitation (CPR) as an AGP. Accessed [online] from https://www.gov.uk/government/publications/wuhan-novel-coronavirus-infection-prevention-and-control/phe-statement-regarding-nervtag-review-and-consensus-on-cardiopulmonary-resuscitation-as-an-aerosol-generating-procedure-agp--2 on 20/11/23.

Neves, H., Souza, A., Medeiros, M., Munari, D., Ribeiro, L., Tipple, A., 2011. Safety of Nursing Staff and Determinants of Adherence to Personal Protective Equipment. Rev. Latino-Am. Enfermagem. Volume 19. Issue 2. PP 354 – 361.

Ng, J. Y. Y., Ntoumanis, N., Thøgersen-Ntoumani, C., Deci, E. L., Ryan, R. M., Duda, J. L., & Williams, G. C. 2012. Self-Determination Theory Applied to Health Contexts: A Meta-Analysis. Perspectives on Psychological Science, 7(4), 325-340. https://doi.org/10.1177/1745691612447309

Nguyen, L, H., Drew, D. A., Graham, M. S., Joshi, A. D., Guo, C., et al 2020.Risk of COVID-19 among front-line health-care workers and the general community: a prospective cohort study. The Lancet. Vol. 5. Issue 9. PP475-483. Accessed [online] from https://www.thelancet.com/journals/lanpub/article/PIIS2468-2667(20)30164-X/fulltext on 10/11/23.

Nolan, J., Soar, J., Eikeland, H., 2006. The chain of survival. Resuscitation. Vol. 71(3):270–271. https://doi.org/10.1016/j.resuscitation.2006.09.001

Nomali, M., Mehrdad, N., Heidari, M. E., Ayati, A., Yadegar, A., Payab, M., Olyaeemanesh, A., Larijani, B., 2023. Challenges and solutions in clinical research during the COVID-19 pandemic: A narrative review. Health Science Report. Vol. 6(8):e1482. doi: 10.1002/hsr2.1482

Nursing and Midwifery Council (NMC), 2018, Standards of proficiency for registered nurses, accessed [online] from https://www.nmc.org.uk/standards/standards-for-nurses/standards-of-proficiency-for-registered-nurses/ on 10/10/23.

Oboza, P., Ogarek, N., Olszanecka-Glinianowicz, M., Kocelak, P., 2023. The main causes of death in patients with COVID-19. European review for medical and pharmacological sciences. Vol. 27 (5). PP2165-2172.

O'Cathain, A., Murphy, E., Nicholl, J., 2009. The quality of mixed-methods studies in health services research. Journal of Health Services Research and Policy. Vol. 13. PP 92-98.

O'Connor, S., O'Connor, P. F., Feng, H. A., Ashley, K., 2014. Gravimetric Analysis of Particulate Matter using Air Samplers Housing Internal Filtration Capsules. Gefahrst Reinhalt Luft, vol. 74, issue 10. PP403-410.

Olasveengen, T.M., Semeraro, F., Ristagno, G., et al. 2021. European Resuscitation Council Guidelines 2021: basic life support. Resuscitation. Vol. 161:98–114. https://doi.org/10.1016/j.resuscitation.2021.02.009

Olmos-Vega, F. M., 2022. A practical guide to reflexivity in qualitative research: AMEE Guide No. 149. Medical teacher. Vol. 45. Issue 3. PP241-251.

Onwuegbuzie, A. J., Mallette, M. H. Mallette, K. M. 2022. A 41-Year History of Mixed-methods Research in Education: A Mixed-methods Bibliometric Study of Published Works from 1980 to 2021. Journal of Mixed-methods Studies. Vol. 6. Accessed [online] from https://doi.org/10.59455/jomes.2022.6.2 on 27/12/23.

Orasanu, J. M., 2001. Decision Making (Naturalistic), Psychology of, International Encyclopedia of the Social & Behavioral Science. Pergamon, PP 3300-3304, ISBN 9780080430768, https://doi.org/10.1016/B0-08-043076-7/01611-9.

Orji, R., Vassileva, J., Mandryk, R., 2012. Towards an Effective Health Interventions Design: An Extension of the Health Belief Model. Online Journal of Public Health Informatics. Vol. 4. Issue 3. Accessed [online] from https://doi.org/10.5210%2Fojphi.v4i3.4321 on 18/1/24.

Ott, M., Milazzo, A., Liebau, S., Jaki, C., Schilling, T., Krohn, A., Heymer, J. 2020. Exploration of strategies to reduce aerosol-spread during chest compressions: a simulation and cadaver model. Resuscitation. Vol. 152:192–198. https://doi.org/10.1016/j.resuscitation.2020.05.012

Páez, D., Rimé, B., Basabe, N., Wlodarczyk, A., & Zumeta, L. 2015. Psychosocial effects of perceived emotional synchrony in collective gatherings. Journal of Personality and Social Psychology, 108, 711–729. https://doi.org/10.1037/pspi0000014 24/5/24.

Paiano, M., Jaques, A.E., Nacamura, P.A.B., Salci, M.A., Radovanovic, C.A.T., Carreira, L., 2020. Mental health of healthcare professionals in China during the new coronavirus pandemic: an integrative review. Rev Bras Enferm. Vol. 73(suppl 2):e20200338. https://doi.org/10.1590/0034-7167-2020-0338

Papazoglou, K., Blumberg, D. M., and Schlosser, M. 2020. A brief discussion of effective ways to teach potentially life-saving psychology. Salus J. 8, 2–10.

Pan, Y., Detection and characterization of biological and other organic-carbon aerosol particles in atmosphere using fluorescence. Journal of Qualitative Spectroscopy and Radiative Transfer. Vol. 150. PP12-35. Accessed [online] from https://doi.org/10.1016/j.jqsrt.2014.06.007 on 30/08/24.

Park, H. S., Hwang, S. Y., Lee, G., Park, J. E., Kim, T., Shin, T. G., Sim, M. S., Jo, I. J., Kim, S., Yoon, H., 2021. Are loose-fitting powered air-purifying respirators safe during chest compression? A simulation study. The American Journal of Emergency Medicine. Vol. 44. PP235-240. Accessed [online] https://doi.org/10.1016/j.ajem.2020.03.054 at 08/11/24.

Payne, D., Peache, M., 2021. Aerosol-generating procedures in home care. British Journal of Community Nursing. Volume 26. No. 2. PP76 – 80. Accessed [online] from https://doi.org/10.12968/bjcn.2021.26.2.76 on 21/4/23

Perkins, J., Hamilton, M., Canniff, C., Gannon, C., Illsely, M., Murray, P., Scribbins, K., Stockwell, M., Wilson, J., Gallagher, A., (2021) Resuscitation during the pandemic: Optional obligation? Or supererogation? Clinical Ethics. Pp 1 – 7

Personal protective equipment (PPE) at work regulations, 1992. Do employers have to provide personal protective equipment (PPE)? Accessed [online] at https://www.hse.gov.uk/contact/faqs/ppe.htm#:~:text=Employers%20should%2C%20therefore%2C%20provide%20appropriate,adequately%20controlled%20by%20other%20means on 15/10/23.

Personal protective equipment (PPE) at work regulations amended, 2022. Accessed [online] at https://www.hse.gov.uk/ppe/ppe-regulations-2022.htm#duties on 15/10/23.

Peters, M. D. J., Godfrey, C. M., Khalil, H., McInerney, P., Parker, D., & Soares, C. B. 2015. Guidance for conducting systematic scoping reviews. International Journal of Evidence-Based Healthcare, 13(3), 141–146. https://doi.org/10.1097/XEB.0000000000000050

Peterson, J., Pearce, P.F., Ferguson, L.A., Langford, C.A., 2017. Understanding scoping reviews: definition, purpose, and process. J Am Assoc Nurse Pract. Vol. 29(1):12–16. https://doi.org/10.1002/2327-6924.12380

Pilbery, R., Lethbridge, K., (2019). Ambulance care essentials. Chapter 6: Health and Safety, Section 2: Risk assessment. Class publishing.

Porter, C. M., 2016. Revisiting Precede–Proceed: A leading model for ecological and ethical health promotion. Health Education Journal. Vol. 75. Issue 6. Accessed [online] from https://doi.org/10.1177/0017896915619645 on 24/1/24.

Prince, S. E., Chen, H., Tong, H., Bernsten, J., Masood, S., Zeman, K. L., Clapp, P. W., Bennett, W. D., Samet, J. M., 2021. Assessing the effect of beard hair lengths on face masks used as personal protective equipment during the COVID-19 pandemic. Journal of Exposure Science & Environmental Epidemiology. Accessed [online] from https://www.nature.com/articles/s41370-021-00337-1 on 3/4/24.

Public Health England (PHE), 2020. Press release: New personal protective equipment (PPE) guidance for NHS teams. Accessed [online] from https://www.gov.uk/government/news/new-personal-protective-equipment-ppe-guidance-for-nhs-teams 18/11/23.

Public Health England (PHE), 2022. PHE statement regarding NERVTAG review and consensus on cardiopulmonary resuscitation as an aerosol generating procedure (AGP) *withdrawn 27 May 2022*, accessed [online] from https://tinyurl.com/yhaesxn3 on 8 March 2023.

Raboud, J., Shigayeva, A., McGeer, A. et al. 2010. Risk factors for SARS transmission from patients requiring intubation: a multicentre investigation in Toronto, Canada. PLoS One. Vol. 5(5):e10717. https://doi.org/10.1371/journal.pone.0010717

Rabin, S., Kika, N., Lamb, D., Murphy, D., Stevelink, S. A. M., Williamson, Williamson, V., Wessley, S., Greenberg, N., 2023. Moral Injuries in Healthcare Workers: What Causes Them and What to Do About Them? Journal of Healthcare Leadership. Vol. 15. PP153-160. Accessed [online] from https://doi.org/10.2147%2FJHL.S396659 on 13/8/24.

Radonovich, L. J., Simberkoff, M. S., Bessesen, M. T., Brown, A. C., Cummings, D. A. T., Gaydos, C. A. Los, J. G., Krosche, A. E., Gibert, C. L., Gorse, G. J., Nyquist, A., Reich, N. G., Rodriguez-Barradas, M. C., Price, C. S., Peri, T. M., 2019. N95 Respirators vs Medical Masks for Preventing Influenza Among Health Care Personnel: A Randomized Clinical Trial. JAMA. Vol. 322(9):824-833. doi: 10.1001/jama.2019.11645.

Rahimi, S., Khatooni, M., 2024. Saturation in qualitative research: An evolutionary concept analysis. International Journal of Nursing Studies Advances. Vol. 6. Accessed [online] from https://doi.org/10.1016/j.ijnsa.2024.100174 on 0/8/24.

Raleigh, V., 2022. Deaths from Covid-19 (coronavirus): how are they counted and what do they show? The Kings Fund. Accessed [online] from https://www.kingsfund.org.uk/publications/deaths-covid-19?gclid=EAIaIQobChMIyurV77LGggMVhYuDBx1WHQlPEAAYAiAAEgKewfD_BwE on 8/10/23.

Rao, H., Mancini, D., Tong, A. et al. 2021. Frontline interdisciplinary clinician perspectives on caring for patients with COVID-19: a qualitative study. BMJ Open. Vol. 11(5):e048712. https://doi.org/10.1136/bmjopen-2021-048712

Rengasamy, S., Zhuang, Z., Niezgoda, G., Walbert, G., Lawrence, R., Boutin, B., Hudnall, J., Monaghan, W. P., Bergman, M., Miller, C., Harris, J., Coffey, C., (2018). A comparison of total inward leakage measured using sodium chloride (NaCl) and corn oil aerosol methods for air-purifying respirators. Journal of Occupational and Environmental Hygiene. Vol. 15. Issue 8. PP616-627.

Rammohan, R., Varadarajan, V., Mohanty, K., 2020. Unmasking problems due to disposable FFP3 masks: Snapshot survey on FFP3 masks usage by frontline healthcare professionals during COVID-19 pandemic. British Orthopaedic Association. Accessed [online] from https://www.boa.ac.uk/resource/unmasking-problems-due-to-disposable-ffp3-masks-snapshot-survey-on-ffp3-masks-usage-by-frontline-healthcare-professionals-during-covid-19-pandemic.html on 24/5/24.

Rashis, M., Gale, C. P., Curzen, N., Ludman, P., Bedler, M., et al. 2020. Impact of Coronavirus Disease 2019 Pandemic on the Incidence and Management of Out-of-Hospital Cardiac Arrest in Patients Presenting with Acute Myocardial Infarction in England. Journal of the American Heart Association. Vol. 9. No. 22. Accessed [online] from https://www.ahajournals.org/doi/10.1161/JAHA.120.018379 on 17/11/23.

Raveendran, A., Renjith V. R., Madhu, G., 2022, A comprehensive review on dynamic risk analysis methodologies, Journal of Loss Prevention in the Process Industries, Volume 76, 104734, ISSN 0950-4230, https://doi.org/10.1016/j.jlp.2022.104734.

Rees, N., Smythe, L., Hogan, C., Williams, J., 2021 Paramedics experiences of providing care in Wales (UK) during the 2020 COVID-19 pandemic (PECC-19): a qualitative study using evolved grounded theory. BMJ open, volume 11, pp 1 – 14.

Reeve, C., Pashen, D., Mumme, H., De La Rue, S., Cheffins, T., 2008, Expanding the role of paramedics in northern Queensland: An evaluation of population health training. The Australian Journal of Rural health. Accessed [online] from https://doi-org.ezproxy.herts.ac.uk/10.1111/j.1440-1584.2008.01018.x on 22/11/23.

Resuscitation Council UK (RCUK). 2021. Guidance for safer handling during cardiopulmonary resuscitation in healthcare settings. Pp 5. Accessed [online] from

https://www.resus.org.uk/sites/default/files/2021-06/Guidance%20for%20safer%20handling%202021.pdf on 19/5/24.

Resuscitation Council United Kingdom (RCUK), 2020. Resuscitation Council UK Statement on COVID-19 in relation to CPR and resuscitation in acute hospital settings, accessed [online] from https://www.resus.org.uk/sites/default/files/2020-06/FINAL%20Resuscitation%20Council%20UK%20Statement%20on%20COVID-19%20in%20relation%20to%20CPR%20and%20resuscitation%20in%20healthcare%20settings.pdf on 22/11/23.

[1]Resuscitation Council UK (RCUK), 2020. Updated RCUK Statement on PHE PPE Guidance by Professor Jonathan Wyllie, RCUK President:20 April 2020, accessed [online] from https://www.resus.org.uk/sites/default/files/2020-06/Updated%20RCUK%20Statement%20on%20PHE%20PPE%20Guidance%2020042020.pdf on 28/8/24.

Resuscitation Council UK (RCUK), 2024. Who we are. Accessed [online] from https://www.resus.org.uk/about-us/who-we-are on 28/8/24.

Resuscitation Council UK (RCUK). 2022. Guidance: COVID-19. Accessed [online] from https://www.resus.org.uk/library/additional-guidance/guidance-covid-19 on 24/4/24.

Riyapan, S., Chantanakomes, J., Roongsaenthong, P., Tianwibool, P., Wittayachamankul, B., Supasaovapak, J., Pansiritanachot, W., 2022. Impact of the COVID-19 outbreak on out-of-hospital cardiac arrest management and outcomes in a low-resource emergency medical service system: a perspective from Thailand. International Journal of Emergency medicine. Vol. 15. Article no. 26. Accessed [online] from https://intjem.biomedcentral.com/articles/10.1186/s12245-022-00429-1 on 15/10/23.

Roberts, W., Filmore, M. T., 2017, Curbing the DUI offender's self-efficacy to drink and drive: A laboratory study. Drug and Alcohol Dependence. Vol. 172. PP73.

Robinson, R.S. 2014. Purposive Sampling. In: Michalos, A.C. (eds) Encyclopaedia of Quality of Life and Well-Being Research. Springer, Dordrecht. https://doi.org/10.1007/978-94-007-0753-5_2337

Robinson, S., 2022. Ethics part 1: what do paramedics owe patients? Journal of Paramedic Practice. Vol. 14, issue 3. Accessed [online] from https://doi-org.ezproxy.herts.ac.uk/10.12968/jpar.2022.14.3.102 on 31/08/24.

Rojo-Rojo, A., Pujalte-Jesus, M. J., Hernandez-Sanchez, E., Melendreras-Ruiz, R., Garcia-Mendez, J. A., Munoz-Rubio, G. M., Leal-Costa, C., Diaz-Agea, J. L., 2022. Risk of Dehydration Due to Sweating While Wearing Personal 2 Protective Equipment in COVID-19 Clinical Care: A Pilot Study. Healthcare (Basel). Vol. 10. Issue 2. Accessed [online] from https://doi.org/10.3390%2Fhealthcare10020267 on 20/4/24.

Rolfe, G., Freshwater, D., Jasper, M. 2001. Critical reflection in nursing and the helping professions: a user's guide. Basingstoke: Palgrave Macmillan.

Rollings, L., 2020. FFP3 respirator face fit testing - what is it all about? British Dental Journal. Vol. 229. Issue 2. PP 112-114. Accessed [online] from https://doi.org/10.1038%2Fs41415-020-1850-x on 20/5/24.

Rongkavilit, C., Near-King, S., Kalijee, L. M., Panthong, A., Koken, J. A., Bunupuradah, T., Parsons, J. Y., 2010. Applying the Information-Motivation-Behavioral Skills Model in Medication Adherence Among Thai Youth Living with HIV: A Qualitative Study. AIDS patient care and STDs. Vol. 24. Issue 12. PP787-794.

Royal College of Emergency Medicine (2020). PPE Fatigue. Safety Flash Card. Accessed [online] from https://www.rcem.ac.uk/docs/Safety/RCEM%20Safety%20Flash%20- %20PPE%20importance.pdf on the 18/8/21.

Royal College of Obstetricians and Gynaecologists. 2024. Work as imagined versus work as done. Accessed [online] from https://www.rcog.org.uk/about-us/quality-improvement-clinical-audit-and-research-projects/each-baby-counts-learn-support/safety-thinking-toolkit/work-as-imagined-versus-work-as-done/#:~:text=Work%2Das%2Ddone%20is%20the,%2C%20procedures%2C%20standards%20and%20guidelines. On 20/4/24.

Royal College of Nursing (RCN). 2023. Personal protective equipment (PPE) and COVID-19 [online] from https://tinyurl.com/3v77nwu5 accessed 24 March 2023.

[1]Royal College of Nursing (RCN), 2023, Duty of Care. Accessed [online] from https://www.rcn.org.uk/Get-Help/RCN-advice/duty-of-care on 22/11/2023.

Runder, D. P., Harland, K. K., Van Heukelom, P., Faine, B., O'Shaughnessy, P., Mohr, N. M., (2021). The "double eights mask brace" improves the fit and protection of a basic surgical mask amidst COVID-19 pandemic. Journal of the American College of Emergency Physicians Open. Accessed [online] from https://doi.org/10.1002%2Femp2.12335 on 27/1/24.

Rutherford, G., 2022. Human Factors in paramedic Practice. Class Professional Publishing. Chapter 7. PP76-80.

Saha, B., Wong, C. M., Parks, R. J., 2015. The adenovirus genome contributes to the structural stability of the virion. Viruses. Issue 6, PP3563–3583.

Santrock, J., 2013. Children (12th ed.). McGraw Hill

Sandelowski, M., 2000, Whatever happened to qualitative description? Res Nurs Health. Aug;23(4):334-40. doi: 10.1002/1098-240x(200008)23:4<334::aid-nur9>3.0.co;2-g. PMID: 10940958.

Saver, J. L., 2005. Time is brain – quantified. Stroke. Vol. 37. No. 1. PP263-266.

Schoonenboom, J., Johnson, R. B., 2017. How to Construct a Mixed-methods Research Design. Kolner Zeitshrift Fur Soziologie Und Sozialpsychologie. Vol. 69. PP107-131. Accessed [online] from https://doi.org/10.1007%2Fs11577-017-0454-1 on 5/1/24.

Schunk, D. H., 2012. Social cognitive theory. Part 2. General Theories of Human Motivation.

Schwandt, T. A., 2000. Three Epistemological Stances for Qualitative Inquiry. In Handbook of Qualitative Research (pp. 189-213). SAGE Publications.

Scquizzato, T., D'Amico, F., Rocchi, M., Saracino, M., Stella, F., Landoni, G., Zangrillo, A., (2021). Impact of COVID-19 pandemic on out-of-hospital cardiac arrest system-of-care: A systematic review and meta-analysis. Prehospital Emergency care. Accessed [online] from https://doi.org/10.1080/10903127.2021.1967535 on 14/9/21

Scottish Ambulance Service (2015). Risk Assessment documentation. Accessed [online] from https://www.scottishambulance.com/media/trrp0zur/gen-ra-008-rtc-incident.pdf pm 28/12/23.

Seto, W. H., Tsang, D., Yung, R. W. H., Ching, T. Y., Ng, T. K., Ho, M., Peiris, J. S. M., 2003. Effectiveness of precautions against droplets and contact in prevention of nosocomial transmission of severe acute respiratory syndrome (SARS). The Lancet. Vo. 3, accessed [online] from https://doi.org/10.1016/s0140-6736(03)13168-6 on 28/8/24.

Sfantou, D. F., Laliotis, A., Patelarou, A. E., Sifaki-Pistolla, D., Matalliotakis, M., Patelarou, E., 2017, Importance of Leadership Style towards Quality of Care Measures in Healthcare Settings: A Systematic Review. Healthcare. Vol. 5. Issue 4. Accessed [online] from https://doi.org/10.3390/healthcare5040073 on 4/6/24.

Shanks, S., van Schalkwyk, M. C., Cunningham, A. A., 2022. A call to prioritise prevention: Action is needed to reduce the risk of zoonotic disease emergence. The Lancet. Vol. 23. Accessed [online] from https://doi.org/10.1016/j.lanepe.2022.100506 on 10/10/24.

Shao, F., 2020. Cardiopulmonary resuscitation of inpatients with severe COVID-19 pneumonia: The Wuhan experience. Resuscitation. Vol. 152. PP 95-96. Accessed [online] from https://doi.org/10.1016%2Fj.resuscitation.2020.05.009 on 10/4/24.

Shao, S. C., Lai, C. C., Chen, Y. H., et al. 2021. Prevalence, incidence and mortality of delirium in patients with COVID-19: A systematic review and meta-analysis. Age & Ageing. Volume 11, issue 50(5). P1445-1453.

Shin, N., Velmurugun, K., Su, C., Bauer, A. K., Tsai, C. S. J., 2019. Assessment of fine particles released during paper printing and shredding processes. Environmental Science: Processes & Impacts. Issue 8. Accessed [online] from https://doi.org/10.1039/C9EM00015A on 30/08/24.

Shin, H., Oh, J., Lim, T. H., Kang, H., et al. 2017. Comparing the protective performances of 3 types of N95 filtering facepiece respirators during chest compressions: A randomized simulation study. Medicine. Vol. 96, issue 42. Accessed [online] from https://journals.lww.com/md-journal/fulltext/2017/10200/comparing_the_protective_performances_of_3_types.73.aspx on 8/11/24.

Shrimpton, A. J., Brown, V., Vasallo, J., Nolan, J. P., Soar, J., Hamilton, F., Cook, T. M., Bzdek, B. R., Reid, J. P., Makepeace, C. H., et al. 2024. A quantitative evaluation of aerosol generation during cardiopulmonary resuscitation. Anaesthesia. Vol. 79. PP 156-167. Accessed [online] from https://associationofanaesthetists-publications.onlinelibrary.wiley.com/doi/epdf/10.1111/anae.16162 on 27/8/24.

Shrimpton, A. J., Gregson, F. K. A., Brown, J. M., Cook, T. M., Bzdek, B. R., Hamilton, F., Reid, J. P., Pickering, A. E., 2021. A quantitative evaluation of aerosol generation during supraglottic airway insertion and removal. Vol. 76. Issue 12. PP 1577 – 1584. Accessed [online] from https://doi.org/10.1111/anae.15542 on 28/3/24.

[1]Shrimpton, A. J., Brown, J. M.,Cook, T. M., Penfold, C. M., Reid, J. P., Pickering, A. E., 2022. Quantitative evaluation of aerosol generation from upper airway suctioning assessed during tracheal intubation and extubation sequences in anaesthetized patients. Vol. 124, PP13-21. Accessed [online] from https://doi.org/10.1016/j.jhin.2022.02.021 on 28/3/24.

[2]Shrimpton, A. J., Brown, J. M., Gregson, F. K. A., Cook, T. M., Scott, D. A., McGain, F., Humphries, R. S., Dhillon, R. S., Reid, J. P., Hamilton, F., Bzdek, B. R, Pickering, A. E., 2022. Quantitative evaluation of

aerosol generation during manual facemask ventilation. Anaesthesia. Vol. 77, issue 1. PP22-27. Accessed [online] from https://doi.org/10.1111/anae.15599 on 27/3/24.

Shrimpton, A. J., O'Farrell, G. O., Howes, H. M., Craven, R., Duffen, A. R., Cook, T. M., Reid, J. P., Brown, J. M., Pickering, A. E., 2023. A quantitative evaluation of aerosol generation during awake tracheal intubation. Anaesthesia. Vol. 78. Issue 5. PP587-597. Accessed [online] from https://doi.org/10.1111/anae.15968 on 10/3/24.

Shurlock, J., Rudd, J., Jeanes, A. et al. 2021.Communication in the intensive care unit during COVID-19: early experience with the Nightingale Communication Method. Int J Qual Health Care. Vol. 33(1):mzaa162. https://doi.org/10.1093/intqhc/mzaa162

Sibson, L., 2011. A Duty of Care. Journal of Paramedic Practice. Vol. 3. Issue 11. Accessed [online] from https://www.paramedicpractice.com/content/opinion/a-duty-of-care/ on 21/4/25.

Sietsema, M., Hamza, H., Brosseau, L. M., 2023. Simulated workplace protection factor study of a quarter-facepiece elastomeric respirator. Vol. 20. Issue 1. Accessed [online] from https://doi.org/10.1080/15459624.2022.2145014 on 2/2/24.

Silva, J. D., 2021. Producing 'good enough' automated transcripts securely: Extending Bokhove and Downey (2018) to address security concerns. Methodological Innovations. Vol. 14. Issue 1. Accessed [online] from https://doi.org/10.1177/2059799120987766 on 24/5/24.

Silverberg, S. L., Ritchie, L. M., Gobat, N., Murthy, S., (2021). COVID-19 infection prevention and control procedures and institutional trust: Perceptions of Canadian intensive care and emergency department nurses. Springer publications. Accessed [online] from https://link.springer.com/article/10.1007%2Fs12630-021-02028-9 on 19/8/2021.

Simons, R.W., Rea, T.D., Becker, L.J., Eisenberg, M.S., 2007. The incidence and significance of emesis associated with out-of-hospital cardiac arrest. Resuscitation. Vol. 74, issue 3, pp427–31.

Sipkins, T. A., Corbin, J. C., Oldershaw, A., Smallwood, G. J., 2022. Particle filtration efficiency measured using sodium chloride and polystyrene latex sphere test methods. Nature. Accessed [online] from https://www.nature.com/articles/s41597-022-01860-y#Tab1 on 30/1/24.

Siriwardena, A. N., Whitley, G. A., 2022. Prehospital Research: Methods and Practice. Class Publishing Ltd. P153 – 165.

Smith, J. D., MacDougall, C. C., Johnstone, J., Copes, R. A., Schwartz, B., Garber, G. E., 2016. Effectiveness of N95 respirators versus surgical masks in protecting health care workers from acute respiratory infection: a systematic review and meta-analysis. CMAJ Canadian Medical Association Journal, May 17;188(8):567-574. doi: 10.1503/cmaj.150835. Epub 2016 Mar 7. PMID: 26952529; PMCID: PMC4868605.

Smith, J., Noble, H., 2025. Understanding sources of bias in research. Evidence-Based Nursing Published Online First: doi: 10.1136/ebnurs-2024-104231

Snooks, H., & Hutchings, H. 2001. Research in pre-hospital care: A time to change the landscape. Emergency Medicine Journal, 18(4), 230–231.

Spicknall, I. H., Koopman, J. S., Nicas, M., Pujol, J. M., Li, S., Eisenberg, J. N. S., 2010. Informing Optimal Environmental Influenza Interventions: How the Host, Agent, and Environment Alter Dominant Routes of Transmission. PLOS Computational Biology. Accessd [online] from https://doi.org/10.1371/journal.pcbi.1000969 30/08/24.

Soar, J., Böttiger, B.W., Carli, P. et al. 2021. European Resuscitation Council Guidelines 2021: adult advanced life support. Resuscitation. Vol. 161:115–151. https://doi.org/10.1016/j.resuscitation. 2021.02.010. Erratum in: Resuscitation. 2021;167:105–106

Song, Y., Zhang, L., Wang, W., 2022. An Analysis of the Effect of Personal Protective Equipment (PPE) Training Based on the Information–Motivation–Behavior Skills Model in the Practice of COVID-19 PPE Application. Infection and Drug Resistance. Vol. 15. PP4829-4835. Accessed [online] from https://doi.org/10.2147%2FIDR.S366049 om 14/1/24.

Song, W.J., Hui, C.K.M., Hull, J.H., et al. 2021. Confronting COVID-19-associated cough and the post-COVID syndrome: role of viral neurotropism, neuroinflammation, and neuroimmune responses. Lancet Respiratory Medicine. Volume 9, issue 5. P533-544.

Stafford, H., (2023). Pre-hospital Advanced Life Support (ALS) – OSCE Guide. Geeky Medics. Accessed [online] from https://geekymedics.com/pre-hospital-advanced-life-support-als-osce-guide/#:~:text=Initial%20patient%20assessment%20should%20always,to%20be%20free%20from%20hazards on n 22/11/23.

Stalmeijer, R.E., Brown, M.E.L., O'Brien, B.C., 2024. How to discuss transferability of qualitative research in health professions education. Clin Teach. Dec;21(6):e13762. doi: 10.1111/tct.13762. Epub 2024 Mar 18. PMID: 38497107.

Stavropulou, A., Roovithis, M., Sigala, E., Moudatsou, M., Fasoi, G., Papageorgiou, D., Koukouli, S., 2022. Healthcare. Volume 10. Issue 8. Accessed [online] from https://www.mdpi.com/2227-9032/10/8/1406 on 22/11/23.

Staymates, M., 2020. Flow visualization of an N95 respirator with and without an exhalation valve using schlieren imaging and light scattering. Physics of Fluids. Vol. 32. Issue 11. Accessed [online] from https://doi.org/10.1063/5.0031996 on 10/0/24.

Swaminathan, R., Mukundadura, B.P., Prasad, S., 2022. Impact of enhanced personal protective equipment on the physical and mental well-being of healthcare workers during COVID-19. Postgrad Med J. Vol. 98(1157):231–233. https://doi.org/10.1136/postgradmedj-2020-139150

Swann, W. B., Jr., Gómez, A., Dovidio, J. F., Hart, S., & Jetten, J., 2010. Dying and killing for one's group. Fusion moderates responses to intergroup versions of the trolley problem. Psychological Science,

21(open in a new window)(8(open in a new window)), 1176–1183. https://doi.org/10.1177/0956797610376656

Swann, W. B., Jr., Buhrmester, M., Gómez, Á., Jetten, J., Bastian, B., Vázquez, A., et al, 2014. What makes a group worth dying for? Identity fusion fosters perception of familial ties, promoting self-sacrifice. Journal of Personality and Social Psychology, Vol. 106, PP912–926.

Tangherlini, T. R., 2000. Heroes and lies: Storytelling tactics among paramedics. Folklore. Vol.111. PP43–66.

Taniguchi, T., Omi, W., Inaba, H., 2007. Attitudes toward the performance of bystander cardiopulmonary resuscitation in Japan. Resuscitation. Vol. 75(1):82–87

Tariq, R., Saha, S., Furqan, F., et al. 2020. Prevalence and mortality of COVID-19 patients with gastrointestinal symptoms: a systematic review and meta-analysis. Mayo Clin Proc. Volume 95. Issue 8. P1632-1648

Tasa, K., Taggar, S., Seijits, G. H., 2007. The development of collective efficacy in teams: A multilevel and longitudinal perspective. Journal of Applied Psychology, 92(1), 17–27. https://doi.org/10.1037/0021-9010.92.1.17 accessed 20/1/24.

Tashakkori, A., Newman, I., 2010. Mixed-methods. International Encyclopaedia of Education (3rd Edition). Elsevier. PP514-520. Accessed [online] from https://doi.org/10.1016/B978-0-08-044894-7.00287-6 on 4/1/24.

Teddlie, C., Tashakkori, A., 2003. Major issues and controversies in the use of mixed-methods in the social and behavioral sciences. In Tashakkori A., Teddlie C. (Eds.), Handbook of mixed-methods in social and behavioral research (pp. 3–50). Sage Publications.

Teddlie, C., Tashakkori, A. 2010. Overview of contemporary issues in mixed-methods research. Handbook of mixed-methods in social and behavioural research, 2, 1-41

Teddlie, C., Tashakkori, A., 2012. Common "Core" Characteristics of Mixed-methods Research: A Review of Critical Issues and Call for Greater Convergence. Vol. 56. Issue 6. Accessed [online] via https://doi-org.ezproxy.herts.ac.uk/10.1177/0002764211433795 on 28/12/23.

Teleman, M. D., Boudville, I. C., Heng, B., H., Zhu, D., Leo, Y. S., 2004. Factors associated with transmission of severe acute respiratory syndrome among health-care workers in Singapore. Epidemiology and infection. Vol. 132. PP979-803. Accessed [online] from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2870165/pdf/15473141.pdf on 28/8/24.

Terry, M., Freedberg, D., Morris, M., 2017. An alternative consent process for minimal risk research in the ICU. Crit Care Med. Vol 45 (9):1450–6.

The National Personal Protective Technology Laboratory (NPPTL), 2020. Respirator Exhalation Valve Research. Accessed [online] from https://www.cdc.gov/niosh/npptl/respirators/exhalationvalve/default.html on 1/9/24.

Thoits, P.A., 2012. Role-Identity Salience, Purpose and Meaning in Life, and Well-Being among Volunteers. Soc. Psychol. Q. Vol. 75. PP360–384. doi: 10.1177/0190272512459662.

Thoits, P.A., 2011. Mechanisms linking social ties and support to physical and mental health. J. Health Soc. Behav. Vol. 52, PP145–161. Doi: 10.1177/0022146510395592.

Tien, T. Q., Tuyet-Hanh, T. T., Linh, T. N. Q., Phuc, H. H., Nhu, H. V., 2021. COVID-19 prevention among Vietnamese Healthcare Workers in 2020. Health Services Insight. Safe. Volume 14. PP 1-7.

Tight, M., 2023. Saturation: An Overworked and Misunderstood Concept? Qualitative Inquiry. Vol. 30. Issue 7. Accessed [online] from https://doi.org/10.1177/10778004231183948 10/8/24.

Toerien, M., Shaw, R., Reuber, M., & Strong, P., 2009. The research–clinical divide: Bridging the gap in research involvement for healthcare professionals. BMJ, Vol. 339, b2684.

Tran, K., Cimon, K., Severn, M., Pessoa-Silva, CL., Conly, J., 2012. Aerosol generating procedures and risk of transmission of acute respiratory infections to healthcare workers: a systematic review. PLoS One. Vol. 7(4):e35797. https://doi.org/10.1371/journal.pone.0035797

Tricco, A.C., Lillie, E., Zarin, W. et al., 2018. PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. Ann Intern Med. Vol. 169(7):467–473. https://doi.org/10.7326/M18-0850

Tsung, E.W.K., 2016. The Philosophy of Management Research. Routledge. Accessed [online] via https://research-methodology.net/research-philosophy/ on 27/12/23.

United Nations Office for Disaster Risk Reduction (UNDRR), 2024. Disaster Risk. Accessed [online] from https://www.undrr.org/terminology/disaster-risk#:~:text=Acceptable%20risk%2C%20or%20tolerable%20risk,cultural%2C%20technical%20and%20environmental%20conditions on 23/3/24.

UK Health Security Agency, 2022. [Withdrawn] Infection prevention and control for seasonal respiratory infections in health and care settings (including SARS-CoV-2) for winter 2021 to 2022 - Appendix for UK ambulance services. Accessed [online] from https://www.gov.uk/government/publications/covid-19-guidance-for-ambulance-trusts/covid-19-guidance-for-ambulance-trusts#PPElevels 3/6/23.

University of Hull, 2024. Reflective writing: Rolfe. Accessed [online] from https://libguides.hull.ac.uk/reflectivewriting/rolfe on 6/1/24.

Vasileiou, K., Barnett, J., Thorpe, S., Young, T., 2018. Characterising and justifying sample size sufficiency in interview-based studies: systematic analysis of qualitative health research over a 15-year period.

BMC Medical Research Methodology. Volume 18, Article number: 148. Accessed [online] from https://bmcmedresmethodol.biomedcentral.com/articles/10.1186/s12874-018-0594-7 on 31/8/22.

Vilcek, S., 2020. SARS-CoV-2: Zoonotic origin of pandemic coronavirus. Acta Virologica. Vol. 64. Issue 3. PP281 – 287.

Vindrola-Padros, C., Andrews, L., Dowrick, A. et al. 2020. Perceptions and experiences of healthcare workers during the COVID-19 pandemic in the UK. BMJ Open. Vol. 10(11):e040503. https://doi.org/10.1136/bmjopen-2020-040503

Virkkunen, I., Ryyanen, S., Kujala, S., Vuori, A., Piilnen, A., Kaaria, J-P., Kahara, V., Pettila, V., Yli-Hankala, A., 2007. Emesis in sudden cardiac arrest. Resuscitation. Vol. 75. Issue 2. P389.

Wahad, W. Y., Hefzy, E. M., Ahmed, M. I., Hamed, N. S., 2020, Assessment of Knowledge, Attitudes, and Perception of Health Care Workers Regarding COVID-19, A Cross-Sectional Study from Egypt. Journal of community Health. Accessed [online] from https://doi.org/10.1007/s10900-020-00882-0 on 16/8/2021.

Wakefield, M. K., Williams, D. R., Le Menestrel, S., Flaubert, J. L., 2021. The Future of Nursing 2020-2030 Charting a Path to Achieve Health Equity. National Academy of Sciences. Accessed [online] from https://www.ncbi.nlm.nih.gov/books/NBK573914/pdf/Bookshelf_NBK573914.pdf on 21/4/25.

Wang, H., Liu, Y., Hu, K. et al., 2020. Healthcare workers' stress when caring for COVID-19 patients: an altruistic perspective. Nurs Ethics. Vol. 27(7):1490–1500. https://doi.org/10.1177/ 0969733020934146

[1]Wang, C.C., Prather, K.A., Sznitman, J. et al., 2021. Airborne transmission of respiratory viruses. Science. Vol. 373(6558):eabd9149. https://doi.org/10.1126/science.abd9149

Wankhade, P., 2011. Performance measurement and the UK emergency ambulance service: Unintended consequences of the ambulance response time targets. International Journal of Public Sector management. Vol. 24. No. 5. PP384-402.

Whitley, G.A., Munro, S., Hemingway, P., Law, G.R., Siriwardena, A.N., Cooke, D., Quinn, T., 2020. Mixed-methods in pre-hospital research: understanding complex clinical problems. Br Paramed J. Dec 1;5(3):44-51. doi: 10.29045/14784726.2020.12.5.3.44. PMID: 33456396; PMCID: PMC7783957.

Wilding, A., 2019. Paradigm Wars: Selecting a Philosophical Side When Considering a Research Design. SAGE publications. Accessed [online] from https://doi.org/10.4135/9781526477002 on 3/1/24

Wilkinson, E., 2024. Covid inquiry: What we have learnt about Wales's response? BMJ. Accessd [online] from https://doi.org/10.1136/bmj.q608 on 26/5/24.

Wilkinson, S., 1988. The role of reflexivity in feminist psychology. Women's Studies International Forum. Vol. 11. Issue 5. PP493-502.

Williams, S. L., 1995. Self-efficacy, anxiety, and phobic disorders. Self-Efficacy, Adapatation, and Adjustment. PP769-107. Accessed [online] from https://link.springer.com/chapter/10.1007/978-1-4419-6868-5_3 20/1/24.

Wilson, C., Janes, G., Williams, J., 2022. Identity, positionality and reflexivity: relevance and application to research paramedics. British Paramedic Journal. Vol. 7. Issue 2. PP43-49.

Wong, P., Gk, S., Lim, W. Y., 2020. COVID-19 and cardiopulmonary resuscitation: an N95 respirator mask may not be adequate. British Journal of Anaesthesia. Accessed [online] from https://doi.org/10.1016/j.bja.2020.05.008 on 21/5/24.

World Health Organisation (WHO), 2020. Rationale use of personal protective equipment (PPE) for coronavirus disease (COVID-19). Interim guidance. 19th March 2020. Accessed [online] from https://iris.who.int/bitstream/handle/10665/331498/WHO-2019-nCoV-IPCPPE_use-2020.2-eng.pdf on 16/10/2023.

World Health Organization (WHO), 2021. Health and Care Worker Deaths during COVID-19. Accessed [online] from https://www.who.int/news/item/20-10-2021-health-and-care-worker-deaths-during-covid-19.

[1]World Health Organisation, 2021. WHO-convened Global Study of Origins of SARS-CoV-2: China Part Joint WHO-China Study 14 January-10 February 2021 Joint Report. Accessed [online] from https://www.who.int/publications/i/item/who-convened-global-study-of-origins-of-sars-cov-2-china-part on 9/3/22.

[2]World Health Organisation (WHO), 2021. Infection prevention and control during health care when coronavirus disease (COVID-19) is suspected or confirmed. Interim guidance. Accessed [online] from https://tinyurl.com/27rsya3k 8 March 2023.

World Health Organisation (WHO), 2022. Coronavirus disease (COVID-19) pandemic. https://www.who.int/europe/emergencies/situations/covid-19 (accessed 21 September 2022)

World Health Organization (WHO) Coronavirus dashboard, 2025, Accessed [online] from https://data.who.int/dashboards/covid19/deaths?n=o on 25/01/2025.

Xia, W., Fu, L., Liao, H., Yang, C., Guo, H., Bian, Z., 2020. The physical and psychological effects of personal protective equipment on health care workers in Wuhan, China: a cross-sectional survey study. J Emerg Nurs. Vol. 46(6):791–801.e7. https://doi.org/10.1016/j.jen.2020.08.004

Xie, Y., Wang, Z., Liao, H., Marley, G., Wu, D., Tang, W., 2020. Epidemiologic, clinical, and laboratory findings of the COVID-19 in the current pandemic: systematic review and meta-analysis. BMC Infectious Diseases. Volume 20. Accessed [online] from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7457225/ on 8/3/2022.

Xu, W., Zammit, K., 2020. Applying Thematic Analysis to Education: A Hybrid Approach to Interpreting Data in Practitioner Research. International Journal of Qualitative Methods, 19. https://doi.org/10.1177/1609406920918810

Yildiz, C. C., Kaban, H. U., Tanriverdi, F. S., (2020). COVID-19 pandemic and personal protective equipment: Evaluation of equipment comfort and user attitude. Archives of Environmental & Occupational Health. Accessed [online] from https://doi.org/10.1080/19338244.2020.1828247 on 16/8/2021.

Yin, W., Cao, W., Zhou, G., Wang, L., Sun, J., Zhu, A., Wang, Z., Zhou, Y., Liu, X., Li, Y., Zhong, N., Zhao, J., Liu, L., Ran, P., 2021, Analysis of pathological changes in the epithelium in COVID-19 patient airways. ERJ Open Research.Vol. 7, issue 2, Accessed [online] from https://doi.org/10.1183%2F23120541.00690-2020 on 1/8/24.

Younas, A., Fàbregues, S., & Creswell, J. W., 2023. Generating metainferences in mixed-methods research: A worked example in convergent mixed-methods designs. Methodological Innovations, 16(3), 276-291. https://doi.org/10.1177/20597991231188121

Yuan, N., Yang, W.X., Lu, J.L., Lv, Z.H., 2021. Investigation of adverse reactions in healthcare personnel working in level 3 barrier protection PPE to treat COVID-19. Postgrad Med J. Vol. 97(1148):351–354. https://doi.org/10.1136/postgradmedj-2020-137854

Zaichik, L. I., Alipchenkov, V. M., 2008. The effect of Brownian motion on collisions between aerosol particles in turbulent flow. Heat and Mass Transfer and Physical Gasdynamics. Volume 46. PP 502–511. Accessed [online] from https://link.springer.com/article/10.1134/S0018151X08040093 on 2/8/24.

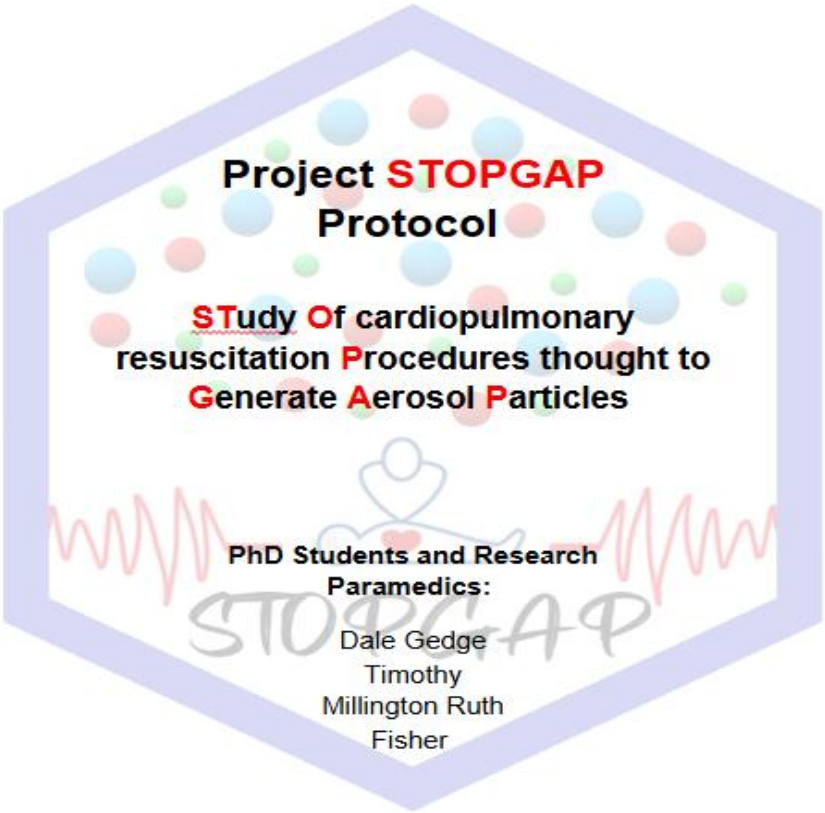
Zhou, Y., Farrell, 2023. Understanding Responses to Conflicting Advice on COVID-19. Health Communication. Vol. 39. Issue 8. Accessed [online] from https://doi.org/10.1080/10410236.2023.2227429 on 3/4/24.

Zhu, Y., Hinds, W. C., 2022. Aerosol Technology: Properties, Behaviour, and Measurement of Airborne Particles, 3rd Edition. Wiley Publishing.

ZOE 2021. COVID Symptom Study. What are the new top 5 COVID symptoms? Accessed [online] from https://covid.joinzoe.com/post/new-top-5-covid-symptoms on 8/3/2022.

Appendices

Appendix 1: STOPGAP Protocol



Supervisors:

Professor Julia Williams
Professor Robert Chilcott

Glossary 4

1. Introduction 6

1.1. Background and Study Rationale 6

2. Study Objectives 7

2.1. Primary Objectives 7

2.2. Secondary Objectives 8

3. Investigational Plan 8

3.1. Study Design 8

3.2. Overview 9

3.3. Study Procedures 11

3.3.1. Patient Screening and Point of Enrolment 11

3.3.2. Resuscitative Procedures 12

3.3.3. Return of spontaneous circulation (ROSC) 13

3.3.4. Recognition of Life Extinct (ROLE) 14

3.3.5. Follow-up 14

3.3.6. Patient Withdrawal 14

3.3.7. Device 15

4. Patient Population 16

4.1. Patient Inclusion Criteria 16

4.2. Patient Exclusion Criteria 17

5. Evaluation of Safety 17

5.1. Adverse Event Definitions 17

5.2. Adverse Event Assessments 18

5.3. Serious and Adverse Events Reporting 18

6. Risk Evaluation 19

6.1. Potential Risks and Methods to Minimize Risks 19

7. Statistical Considerations 21

7.1. Randomisation 21

7.2. Statistical Analysis 21

8. Data and Quality Management 22

9. Adherence to Protocol 25

10. Protocol Amendment 25

11. Reporting 26

12. Publication Policy 26

References 27

Appendix 1. Overview of work packages for project STOPGAP 28

Appendix 2. Work Package 1 – Clinical – Out-of-Hospital setting protocol 29

Appendix 3a. Work Package 1 – Clinical – Out-of-hospital Setting Participant Information Leaflet 30

Appendix 3b. Work Package 2 – Clinical – ED Setting Participant Information Leaflet 31

Appendix 3c. Work Package 1 and 2 – Clinical – Post-ROSC Participant Information Leaflet 32

Appendix 3d. Work Package 1 and 2 – Clinical – Healthcare Professional Information Leaflet 33

Appendix 4. Resuscitation Council UK Advanced Life Support Algorithm 34

Appendix 5a. Work Package 1 – Clinical – Out-of-Hospital Setting Data Collection Form 35

Appendix 5b. Work Package 2 – Clinical – ED Setting Data Collection Form 37

Appendix 6. Summary of Completed Data Collection Forms 39

Glossary

ALS	Advanced Life Support
ANOVA	Analysis of variance
BVM	Bag valve mask
CPR	Cardiopulmonary resuscitation
DMP	Data Management Plan
DNACPR	Do Not Attempt Cardiopulmonary Resuscitation
ECDA	Ethics Committee with Delegated Authority
ED	Emergency Department
EOC	Emergency and Operations Centre
FFP	Filtering Face-piece
HCPC	The Health and Care Professions Council
HCID	Highly Contagious Infectious Disease
HRA	Health Research Authority
MRC	Medical Research Council
OHCA	Out of Hospital Cardiac Arrest
OPC	Optical Particle Counter
PIL	Participant Information Leaflet
PPE	Personal Protective Equipment
PPIE	Patient and Public Involvement and Engagement
REC	Research Ethics Committee
ReSPECT	Recommended Summary Plan for Emergency Care and Treatment
ROLE	Recognition of Life Extinct
ROSC	Return of Spontaneous Circulation
STOPGAP	Study of cardiopulmonary resuscitation procedures thought to generate aerosol particles
TBC	To be confirmed
UH	University of Hertfordshire
UHRA	University of Hertfordshire Research Archive

USB Universal Serial Bus

WP Work Package

CONFIDENTIAL STOPGAP

1. INTRODUCTION

1.1. BACKGROUND & STUDY RATIONALE

A cardiac arrest describes an event when a person's heart stops, and they are no longer breathing. The key to survival is prompt action by healthcare workers or members of the public. These prompt actions grouped together are classified as cardiopulmonary resuscitation (CPR).

- Prior to the pandemic advice was to intervene straight away. Since COVID-19 this has changed, and we now think about the risk of the responder catching COVID-19 from the patient. For the public, this led to recommendations to cover the patient's nose/mouth with a cloth before starting compression-only CPR, avoiding the provision of mouth-to-mouth. For healthcare professionals, the advice was to put on medium-level (Level 2) personal protective equipment (PPE) mask, place a disconnected oxygen mask on the patient and start chest compressions until someone wearing a higher level of PPE (Level 3) takes over. Only then could full CPR begin. Guidance has varied throughout the pandemic. The Resuscitation Council UK currently recommend that, for those working in healthcare settings, FFP3 masks or respirators, along with eye protection, should be worn when performing chest compressions on suspected or confirmed COVID-19 patients.

There is considerable debate in the current literature and various professional bodies regarding the level of risk to the responder posed by the various medical procedures carried out during a resuscitation attempt. The consensus is that the earlier evidence is of low quality, with contemporary evidence casting doubt on the previously perceived high-risk procedures such as endotracheal intubation – so the responder finds themselves with a dilemma; an inadequate level of PPE may put them at higher risk of contracting COVID-19, but a higher level of PPE may delay their response and therefore reduce the chance of survival of the patient. For every minute without CPR, the patient's chances of survival decrease by 7-10% so seconds do matter.

Risks arising from exposure to aerosols generated during CPR of patients infected with SARS-COV-2 are largely unknown. Correspondingly, guidance for clinical professionals and lay responders has been based on a highly conservative approach involving revised clinical procedures (e.g., withdrawal of manual ventilation during initial stages of CPR), the introduction of different levels of PPE and, now in this pandemic, ad hoc interventions such as the use of towels/cloths placed over the face of patients.

Quantification of the extent and particle size distribution of aerosols during individual elements of resuscitation procedures (chest compression, bag-valve-mask ventilation, defibrillation, oropharyngeal/nasopharyngeal suctioning, intubation and supraglottic airway insertion) would provide the critical evidence required to effectively address these public health issues during this current, and any future pandemics involving infectious pathogens. The primary objective being to develop evidence-based guidance for CPR, that delivers optimal patient care, while ensuring the safety of emergency responders and appropriate utilisation of limited resources e.g., level 3 PPE.

The proposal's multi-method design incorporates a clinical component (investigating CPR aerosol generation during a resuscitation of out-of-hospital cardiac arrest patients, as well as during an arrest within an emergency department (ED)), that will form a laboratory-based study (within a climate-controlled exposure chamber) to evaluate ad hoc interventions (patient facial coverings) and standard NHS respiratory PPE. Quantification and characterisation of aerosols will be performed using a high-resolution particle size

analysers. The aim of the clinical studies will be to determine the contribution of each CPR procedure (chest compressions, bag-valve-mask ventilation, defibrillation, oropharyngeal/nasopharyngeal suctioning, intubation and supraglottic airway insertion) to aerosol generation within the working clinical environment.

We will carry out research in two different clinical settings, to determine whether there is a different level of risk in the out-of-hospital environment compared to a more controlled in-hospital environment. Following comprehensive review of the literature no studies were identified that captured real time aerosol data measured during active resuscitation of patients in cardiac arrest. To address this, two work packages have been designed. Work Package 1 (out-of-hospital) will involve capturing aerosol data during an active resuscitation attempt of patients in cardiac arrest, something not previously recorded within literature. Work Package 2 (ED) will similarly record aerosols during an active resuscitation attempt within a resuscitation bay located in an ED. This second work package provides the opportunity to record baseline data both prior to, and following cessation of, the resuscitation event, something not provided by the out-of-hospital arm.

The resulting data will facilitate the development of a laboratory model to replicate the aerosol concentration recorded in the real-world settings using a non-infectious simulate (solvated salt particles) to assess the effectiveness of fabrics (t-shirt, tea towel, bathroom towel; dry or humid conditions), a non-rebreather mask (without oxygen), and a standard fluid repellent FFP2 face mask. The outcome of the laboratory studies will be to validate the necessity of level 2 and 3 respiratory protection and what, if anything, should be placed over the patient's face to limit aerosol being exhaled while they are being resuscitated.

A panel of lay people have kindly assisted the research team throughout the project to ensure that views of patients, families and the public are represented. We have also referred to guidance published in 2020, designed to inform the recruitment and consent in studies involving critically ill patients. The guidance primarily aligns with findings of the Perspectives Study which researched the views of 1400 stakeholders (including patients, family members and healthcare professionals) in 14 hospitals in England, between 2017-2019.

2. STUDY OBJECTIVES

2.1. Primary Objectives

To document aerosol data recorded throughout active resuscitation of patients in cardiac arrest.

To establish whether the following procedures within cardiopulmonary resuscitation generate aerosols:

- Bag-valve mask ventilation
- Chest compressions
- Defibrillation

- Oropharyngeal/nasopharyngeal suctioning
- Insertion of a supraglottic airway
- Endotracheal Intubation

2.2. Secondary Objectives

To establish what the distribution of aerosol size is from these procedures in a controlled environment.

To determine whether placing a cloth over the patient's face reduce the number of aerosols being exhaled into the physical space adequately for responders to safely deliver effective chest compressions.

To determine whether placing a non-rebreathing mask with no oxygen attached to the patient's face reduce the number of aerosols being exhaled into the space required for responders to safely deliver effective chest compressions.

To determine whether it is safe for emergency responders who are first on scene to commence chest compressions wearing a level 2 water repellent mask.

3. INVESTIGATIONAL PLAN

3.1. Study Design

STOPGAP will use a multi-method design and consist of three work packages; two in the clinical setting and a subsequent laboratory-based investigation, as outlined in Appendix 1.

Work Package 1 - Clinical - Out-of-hospital setting

Work Package 1 aims to collect real-time data of aerosol particles exhaled by patients being resuscitated. As an observational study, there will be no deviation from usual care delivered to the patient during an out-of-hospital cardiac arrest. The characterisation of the aerosol particles in Work Package 1 will be based on a maximum of 36 resuscitation events and, in combination with the outcomes from Work Package 2, will facilitate the development of a laboratory-based model of aerosol generation for subsequent Work Package 3.

Work Package 1 and 2 can be run concurrently. Data collection is planned to start in May 2023, being mindful that the winter months often see additional operational pressures both in and out-of-hospital. We expect the data collection phase of Work Package 1 and 2 to last approximately 8 weeks.

Work Package 2 - Clinical – ED setting

This work package aims to collect, through similar, non-invasive means to Work Package 1, aerosols created during resuscitation of patients in cardiac arrest within a designated resus

bay within an ED. The patient may have deteriorated and experienced a cardiac arrest in the department or have been brought in by ambulance with the resuscitation still in progress.

A maximum of 36 participants will be required. The outcomes are similar to Work Package 1, with the added benefit of being in a controlled environment in which baseline aerosol measurements can be taken prior to, and following cessation of, the resuscitation event.

The sample size was calculated using peer-reviewed, open-access software (G*Power, v3.1.9.6). Further details relating to the power calculation can be found in section 7.2.

3.2. Overview

Work Package 1 - Clinical - Out-of-hospital setting

The research paramedics team will be assigned to 999 calls identified as a cardiac arrest in the Emergency and Operations Centre (EOC) within a reasonable distance of their location. The research paramedics will attend these calls either as a responding clinician or as a supernumerary researcher attached to a critical care team.

The Work Package 1 protocol flowchart (in Appendix 2) details the scenarios that may occur as a responding clinician, with regards to resource allocation and at what times it is appropriate to begin data collection. Ultimately, the research paramedic will act in the best interests of the patient and only step away from a clinical role (and begin data collection) when sufficient numbers and grade of clinician are present at the scene.

If appropriate to do so, the research paramedic will position a sampling tube (1.8cm diameter) at a standardised location (targeting 20cm approximately, but not exceeding 100cm) immediately near the patient's mouth opening, connect it to the aerosol analyser, and record the chronology and timings of the treatment provided. The research paramedic will remain positioned away from the patient to eliminate the possibility of interference with patient care. The analysing equipment, a miniature optical particle counter (OPC),



will be set up following a dynamic risk assessment of the environment so that it is as close to the patient as possible, whilst not obstructing the resuscitation attempt in any way. Data relating to relative humidity and temperature will also be recorded.

Due to the time-critical nature of a cardiac arrest incident and the significant stress and upset placed upon family members during this time, a waiver of consent will facilitate patient enrolment. A participant information leaflet (PIL – Appendix 3a) will be given to family members upon request, with details of the study, contact details of the research team and information on withdrawing from the study. This approach will ensure that the research does not place an additional burden of stress on family members.

Work Package 2 – Clinical – ED setting

Work Package 2 aims to characterise particle size and concentration of aerosols created during resuscitation within the more controlled environment of a resus bay, within an emergency department. Baseline data will be recorded prior to the resuscitation attempt and following its cessation if time allows but as a minimum baseline data will be collected once in a 24-hour period during the study time. The aim being to differentiate between the aerosols produced during each procedure of resuscitation. The research paramedics will attend the daily meeting within the department to explain their role and make the resuscitation team aware of the alerting process. During the working shift, the research paramedic will be based in a nearby department of the hospital, contactable by an Alertive messaging system. The research paramedic will be alerted of any incoming cardiac arrests, following the pre-alert call made by the ambulance crew, and any cardiac arrests occurring in the department as a result of a deteriorating patient.
It is anticipated the ELPI+, pump and sampling tubing will be permanently situated within a designated resus bay. The Research Paramedic will switch the EPLI+ on at the beginning of their shift and follow an assigned process to zero the machinery. They will be required to activate the pump once a cardiac arrest patient is known to be inbound – typically this will be through a pre-alerted telephone call from the ambulance service. The sampling tubing will be positioned in proximity to the head of the patient with care taken to not interfere with the resuscitation attempt. The exact positioning of the sampling tube will be identified through collaborative partnership with local policy makers and is expected to be via a ceiling mount, suspending the sample tubing above the patient (aiming to be no further then 100cm away from the mouth). As this work package is based within an ED it provides opportunity to analyse the environmental aerosols before any procedures have been performed. This will provide the research team with valuable 'baseline' data and enable any spikes in aerosols to be identified during the resuscitation attempt. To ascertain if these spikes are attributed to a specific procedure, it will be important to keep a log of all resuscitation activities. The research team will produce a scribed log recorded as part of normal practice in any cardiac arrest resuscitation, but they will add additional data relevant to the study. Data relating to relative humidity and temperature will also be recorded. Similar to Work Package 1, a waiver of consent will be sought and whilst challenge from relatives is less likely than in WP1 due to restricted access to the resuscitation area of ED, a PIL will be issued upon request (Appendix 3b).

Work Package 3 will take place in the laboratory setting, using the data obtained during Work Packages 1 and 2. Tests carried out during simulation will include those that determine the effect of covering a patient's face (via use of a mannequin) with various types of fabrics or with a non-rebreather mask without oxygen during a resuscitation attempt. We will also investigate the efficacy of level 2 and level 3 masks that emergency responders are expected to wear when carrying out cardiopulmonary resuscitation. Collectively, data derived from Work Packages 1 and 2 will provide evidence to accurately reproduce the quantity and particle distribution of aerosols arising from individual resuscitation procedures within the laboratory during these simulations.

3.3. STUDY PROCEDURES

3.3.1. Patient Screening & Point of Enrolment

Work Package 1 - Clinical - Out-of-hospital

setting

All 'code 09' calls will be screened in real-time by the research team, whilst on duty in the host Trust via computer aided dispatch (CAD) system.

When an appropriate '09' call is identified, the research paramedic/team on duty will self-deploy in liaison with the EOC and respond in a blue light vehicle to the address of the call. Whilst on duty, the research team will be identified to the EOC as acting in a research capacity at the start of their shift to avoid confusion.

Should the critical care paramedic, with whom the research paramedic is working with, is the first clinician(s) on scene at a confirmed cardiac arrest, or life-threatening emergency, the research paramedic will assist in providing lifesaving/life-supporting care as a registered paramedic, until additional resource(s) arrive on scene. At this point, the research paramedic will hand over care of the patient to an appropriately qualified clinician.
When the critical care paramedic has adequate support on scene, the research paramedic will set up the device for data collection. The research paramedic will also begin a written log of events. In the event that the call is identified as unsuitable for inclusion on arrival, providing no clinical assistance is required, the research paramedic will excuse themselves and depart to avoid detracting from patient care.

When in attendance at scenes of cardiac arrests, the research paramedic will not interfere with resuscitation efforts unless absolutely necessary, for example, if unsafe practice is identified, or there are no other paramedics on scene.

All screened calls will be recorded in a 'screening log', with reasons for exclusion or non-attendance. In addition, the following characteristics will be recorded for each attended call:

Participant: sex, age, body habitus and diagnosis of co-morbidities

Cardiac arrest: time of arrest (if known), assumed aetiology, initial cardiac arrest rhythm.

Work Package 2 – Clinical – ED

'Pre-alert' is a term used within emergency and prehospital care to describe a phone call from a pre-hospital resource to a receiving ED, notifying them of an inbound, critically ill, patient. It allows the resus team time to ready their response and prepare adequate resources. All cardiac arrest patients brought in by ambulance should have a pre-alert call from the ambulance crew. As part of the dissemination strategy to resus staff, the inclusion and exclusion criteria shall be highlighted. A pre-alert call will enable ED staff aware of the inclusion criteria of STOPGAP to identify patients eligible for the study and begin preparations. A reference document will be situated with the pre-alert phone within ED, as a

reminder for staff of the inclusion and exclusion criteria, along with the alerting process. It is important that these preparations do not take precedence over usual patient care and so should only be carried out if adequate time and resources are available. A screening log will be kept by the research team throughout.

Not all ED cardiac arrests are brought in by ambulance. Those patients that deteriorate to the point of experiencing a cardiac arrest elsewhere in the department will be brought into resus. If adequate time and resources are available these patients should be screened and included in the study. The research team are senior ED clinicians and so appreciate that, often, appropriate resources will not be available immediately at point of cardiac arrest, therefore the data collection process should only begin once optimal resources are present to meet the patients care needs. Data collection should not impact care in any way. The Research paramedic will be based in ED for 8 weeks to be present at all eligible arrests and will take a wholly observational role collecting data.

3.3.2. Resuscitative Procedures

Work Package 1 - Clinical – Out-of-hospital setting

As the research team will be attending real-time active cardiac arrests with ongoing resuscitation attempts, the procedures will follow the Resuscitation Council UK Advanced Life Support Algorithm, shown in Appendix 4.

As a passive observer, the research paramedic should not be involved in the provision of care unless absolutely necessary. However, if the research paramedic is the first on-scene at a cardiac arrest, they will initiate CPR upon recognition of an absence of pulse and respiratory effort and continue until assistance arrives.

The research paramedic will observe resuscitative efforts, and record the following information:

- Time of initial call
- Time CPR is initiated by Ambulance responders
- Any bystander CPR?
- CPR mechanism (mechanical or manual)
- Cardiac arrest rhythm
- Drugs administered
- Airway patency
- Capnography at rhythm check
- Shocks delivered and joules
- Number of people in the room/immediate area, and mask/PPE status
- Environment features, including in/outdoors, ventilation, approximate room size

Work Package 2 – Clinical – ED

As per Work Package 1, the Research Paramedic will be present in an observational role and will be recording data throughout the resuscitation attempt. Similar information will be

documented including:

information:

- Time of pre alert call if appropriate
- CPR mechanism (mechanical or manual)
- Cardiac arrest rhythm
- Drugs administered
- Airway patency
- Capnography at rhythm check
- Shocks delivered and joules
- Number of people in the room/immediate area, and mask/PPE status
- Environment features, including footfall and transient attenders to the arrest

3.3.3. Return of spontaneous circulation (ROSC)

ROSC will be defined as having taken place when chest compressions are discontinued and post-resuscitation care begins, due to the presence of a palpable carotid pulse consistent with a life-sustaining cardiac rhythm during a rhythm check, or signs of life, such as spontaneous breathing, or movement.

Work Package 1 - Clinical – Out-of-hospital setting

If a ROSC is identified during an OHCA, the research paramedic will note the time of the ROSC, and pause data collection, immediately ensuring that their presence and the equipment are not obstructing the extrication of the patient or the egress route.

If the patient subsequently re-arrests, the research paramedic will record the time and resume data collection. Re-arrests will be defined as the absence of palpable carotid pulse and respiratory efforts resulting in the need for ALS to continue. The decision to do so will be made by the clinicians directly involved in the resuscitative efforts.

Work Package 2 - Clinical – ED

Re-arrest definition as per Work Package 1. This decision will be made by the resuscitation team leader.

3.3.4. Recognition of Life Extinct (ROLE)

Work Package 1 - Clinical - Out-of-hospital setting

Recognition of life extinct, or ROLE, is a decision made by clinicians on-scene during an OHCA to discontinue resuscitative efforts, often on the grounds of futility, patient wishes, or the presence of an advanced directive, ReSPECT form or DNACPR. At the termination of resuscitative efforts, the patient will be recognised as deceased.

If a ROLE decision is made, data collection will cease at the time that resuscitative efforts are terminated, and the research paramedic will depart from scene out of respect for the resuscitation team and provide their loved ones with privacy and dignity. Prior to departure, the research paramedic will provide the relevant details to the cardiac arrest team leader for inclusion on paperwork as being present.

Work Package 2 - Clinical – ED

Similarly, to Work Package 1, the decision to terminate resuscitation attempts will be made by the resuscitation team. Data collection will cease, and the direct care team will make arrangements for family members to spend time with their loved one. The research will have no impact on these arrangements.

3.3.5. Follow-Up

There are three anticipated possible outcomes of the cardiac arrests attended:
a) the participant is resuscitated, survives, and recovers to a point where they have the capacity to give consent.
b) the participant is resuscitated, and survives, but is not able to provide consent due to lack of capacity due to infirmity.
c) the participant dies.

At the request of the HRA REC, the team will seek to obtain consent from any participant that is resuscitated and survives, recovering sufficiently that they are able to give consent to the inclusion of their data within the study. In order to facilitate the follow up of these potential participants, their name and date of birth will be collected, as will the ambulance CAD incident reference number. Consent for survivors will be sought at the earliest appropriate point. Due to the condition of participants and the potential impact of revisiting a significant and distressing event to loved ones, it would be inappropriate to follow up with participants that have died, or have not recovered sufficiently that they are able to independently give consent for the inclusion of their data.

3.3.6. Patient Withdrawal

Work Package 1 - Clinical - Out-of-hospital setting

Whilst consent for participation is not being obtained contemporaneously in Work Package 1, if the research paramedic is approached and/or challenged by the patient's loved ones or the Ambulance responders on scene, they can be provided with a PIL. The aim of providing a PIL will be to facilitate the provision of relevant information at a time that is appropriate for them. If objections to the research paramedic's presence are raised, or they are asked to leave, the observation and data collection will be terminated, and the research paramedic will depart.

In order to minimise ambiguity and provide responders with information, local awareness will be raised within host Trusts via local bulletins and posters, prior to the commencement of the study period(s). During this time, they will be able to seek further information and provide feedback to the research team.

Work Package 2 - Clinical – ED setting

As with Work Package 1, it is not envisaged that families or on-lookers will be present to approach the research team. In the unlikely event that this occurs, similarly to work package 1, a PIL will be issued.

3.3.7. Devices

Work Package 1 will use an Optical Particle Counter (OPC) to analyse aerosol data, specifically an Alphaphase OPC-N3. This portable, robust particle analyser is able to measure particles from 0.35µm via an attached sampling tube. The OPC-N3 particle monitor itself is small, measuring only 75mm by 63.5mm. The OPC and its corresponding power source are easily transportable in light, hand-held carriers. The manufacturer advocates its versatility, describing how it can accurately record particle data in a variety of settings, including clean rooms or more heavily polluted environments, all characteristics meaning it is ideally suited for out-of-hospital research projects such as this.

The Dekati ELPI+ particle analyser will be used for the purposes of data collection in Work Package 2, within the ED. Able to detect particles between 0.006 and 10µm, the ELPI+ collects real-time second-by-second air samples via a sampling tube, which can vary in length to meet the needs of the research. The ELPI+ is attached via a length of exhaust tubing to a pump, which draws in the air samples. The pump is fitted with a silencer, to minimise the impact of additional noise. With the silencer fitted, the noise produced is significantly less than that of an air or oxygen-driven nebuliser, even in an enclosed space. The two instruments will produce broadly comparable data, albeit that the hospital-based instrument will provide higher resolution: both will provide a breakdown of particle concentration at different particle sizes, but the higher resolution (hospital) instrument will allow more particle sizes to be analysed. The range of particle sizes is the same between the two instruments. A bridging study will be performed in our laboratory to characterise any differences in measured particle concentration, so that the experimental data obtained within the hospital and domestic environments can be directly compared.

During Work Package 2 (ED), the ELPI+ will be zeroed at the start of the shift, and subsequently left on standby until required. The research paramedic will revisit the equipment every 2-3 hours to ensure the machine remains ready for immediate data collection.

During Work Package 1 (out-of-hospital), the OPC will be zeroed at the beginning of the shift, to avoid delays and distractions from patient care. The OPC will be powered by a light, portable battery pack whilst in deployment to avoid the need for additional cables and trip hazards.

Estimated weight of Work Package 2 equipment, as shown in Figure 1 is:

- Dekati ELPI+ particle analyser – 22kg
- Pump with silencer – 25kg

Transportation of equipment will be determined in line with safe moving and handling limits and procedures to prevent injury to the research team or others that may come into contact with it.

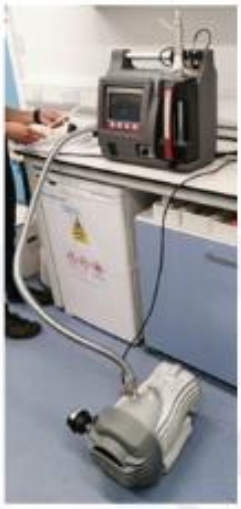


Figure 1. Dekati ELPI+ particle analyser and pump, with silencer attached (Image courtesy of RM Fisher).

4. PATIENT POPULATION

4.1. PATIENT INCLUSION CRITERIA

Work Package 1 - Clinical – Out-of-hospital setting

- >16 years old
- Out-of-hospital cardiac arrest, including overdose, hypothermia, pulmonary embolism, atraumatic major haemorrhage.
- Scene deemed appropriate following dynamic risk assessment.

Work Package 2 - Clinical – ED setting

- >16 years old
- Confirmed cardiac arrest, including overdose, hypothermia, pulmonary embolism, atraumatic major haemorrhage.

- Environment deemed appropriate following dynamic risk assessment.

4.2. PATIENT EXCLUSION CRITERIA

Work Package 1 - Clinical - Out-of-hospital setting

- <16 years old
- Tracheostomy in situ
- Circumstances surrounding cardiac arrest that require police investigation.
- DNACPR / end of life directives in place
- OHCA due to drowning (dry or wet)
- OHCA secondary to smoke inhalation / house fires
- Multi-patient incidents
- Public places – following researcher led dynamic risk assessment
- Research impedes resus attempt
- Resuscitation not commenced based on futility, e.g., decomposition / putrefaction / rigor mortis
- Family request
- Scene deemed unsafe
- Crew request
- Return of spontaneous circulation (ROSC)
- Institutionalized patients – prison, secure mental health facilities, nursing homes or care homes
- Patient with surgical airway in situ

Work Package 2 - Clinical - ED setting

- <16 years old
- Tracheostomy in situ
- Circumstances surrounding cardiac arrest that require police investigation.
- DNACPR / end of life directives in place
- Research impedes resus attempt
- Family request
- ED clinician request
- Return of spontaneous circulation (ROSC)
- Institutionalized patients – prison, secure mental health facilities, nursing homes or care homes
- Patient with surgical airway in situ

5. EVALUATION OF SAFETY

5.1. ADVERSE EVENT DEFINITIONS

- Research equipment induced injury or impedance of resuscitation attempt.

Potentially the presence of the researchers and /or the associated equipment might create a

hazard or obstruction to the resuscitation attempt. The research paramedics shall draw upon their experience in cardiac arrest scene management to ensure both they themselves and the equipment are positioned in such a way to maintain a safe and practical working environment and does not obstruct any rescue attempt.

- Witness to unsafe practice or inappropriate professional behaviour.

Defined as inappropriate clinical practice with or without harm to the patient, public or staff. Typically, this might involve drug administration errors or patient mismanagement but can take many different guises of varying severity. Out-of-hospital and secondary care facilities have systems in place for such occurrences including escalation to senior management and completion of appropriate reporting tools, e.g., Datix. The research team are senior clinicians who are well versed in using such systems as part of their continued professional development in maintenance of their professional body membership. These systems shall be followed as cited below.

5.2. ADVERSE EVENT ASSESSMENTS

Research paramedics involved in STOPGAP are bound by their professional obligation to meet and uphold the highest standards of patient and public safety and any actions deemed to compromise this must be reported through the appropriate channels. Assessment of patient care shall be done continually throughout the research process through direct observation of clinical practice.

5.3. SERIOUS AND ADVERSE EVENTS REPORTING

The research team has an appreciation of the evolving and unpredictable nature of out-of-hospital resuscitation attempts and so, should the unlikely event of an accident occur, the research attempt shall be immediately stopped, with the research paramedic reverting to a clinical role. After the resuscitation attempt has been completed and away from the scene of the cardiac arrest the research paramedic shall conduct a team debrief to investigate the incident further. It then shall be escalated via appropriate reporting channels, i.e., Datix, and the research team shall arrange a serious case review with the supervisory team and ambulance service clinical leads. No further research shall be conducted until this process has been completed. Similar channels shall be utilised should the research paramedics bear witness to unsafe practice.

6. RISK EVALUATION

6.1. POTENTIAL RISKS AND METHODS TO MINIMIZE RISK

The following areas of risk have been highlighted for each arm of the STOPGAP study:

Work Package 1 - Clinical - Out-of-hospital setting

- Information governance
- Impedance of resuscitation attempt
- Family distress
- Research equipment causing trip hazard
- Staff well being
- Consent of patients who do not have capacity
- Infection control
- Staff awareness and familiarisation

Information governance - It is appreciated that access to confidential patient records shall be required by the research team and handling of such data must be approached with the utmost sensitivity and professionalism. The researchers involved in this study are experienced senior clinicians registered with the Health and Care Professions Council (HCPC) and extensively use data of this nature in their clinical roles. It is a legal requirement that they stay up to date with information governance practices to meet expected professional standards. To minimise risks, minimal demographic patient data shall be recorded in addition to aerosol data; age, sex, body habitus, co-morbidities, and cardiac arrest characteristics (i.e., aetiology). This shall be stored on password secure laptops with no identifying patient information.

Impedance of the resuscitation attempt – When a patient suffers a cardiac arrest time is of the essence to restart their heart and potentially save their life. In a recent PPIE workshop, conducted by the research team, a concern was raised regarding collection of data impeding the resuscitation process. This concern was addressed by referencing the out-of-hospital research protocol. The researchers involved in STOPGAP are experienced paramedics with extensive Advanced Life Support (ALS) skills. The protocol for the out-of-hospital arm has been designed to utilise their skills as part of the rescue attempt. Research paramedics shall attend all included cardiac arrests incidents as a clinician first and a researcher second, meaning they shall begin, lead, or assist the resuscitation efforts until such point that there is an appropriate team of rescuers on scene. They then shall withdraw and begin research efforts in agreement with the resuscitation team. Researchers involved in STOPGAP are widely versed in cardiac arrest management and shall draw upon this experience to reach decisions as to when it is appropriate to begin the research process. 'Dynamic risk assessment' is a tool engrained in paramedic training and involves the continued review of scene management to ensure optimal care and safety. Dynamic risk assessment shall be conducted throughout the rescue attempt and at any point should it be felt the researcher's clinical expertise would best address the patient's need, the research process shall be halted, and the researcher will revert to their clinical role. It is a fundamental aspect of this trial that any decisions regarding data collection are made with the patients' best interests at its heart.

Family distress – This was another consideration raised within the PPIE workshop and has been discussed in depth by the research team from the early stages of designing protocols. Cardiac arrest is often a highly stressful event for family members to witness, provoking extreme emotions, particularly in the out-of-hospital setting. The resuscitation procedures are often upsetting to observe, and this can be a time of great uncertainty and confusion for the family. Approaching family members at this time to explain the research process has been deemed inappropriate by the research team. To ensure family members remain informed, and to support them in their grieving process, a patient information leaflet has been created. This contains a plain English overview of the study as well as contact details of the research team should they wish to discuss further or withdraw from the research. It also has useful links to supportive services.

Research equipment causing trip hazard – As with any resuscitation attempt, scene safety is of paramount importance. The researchers shall draw upon their experience in cardiac arrest scene management to ensure the position of the equipment maintains a safe and practical working environment and does not obstruct any rescue attempt. Dynamic risk assessments shall be conducted throughout, and should it be felt the equipment poses a risk, at any point, it shall be removed, and the research halted. It then shall be escalated via appropriate reporting channels, i.e., Datix, as described in section 5.3. Research shall be stopped pending this review.

Staff wellbeing – Attending cardiac arrests can be traumatic emotional events for responders and has been linked to post traumatic stress disorder, depression, and anxiety (Hasselqvist-Ax et al., 2019; Petrie et al., 2018). To help mitigate this the research team, of which one member is a mental health advocate within an ambulance service trust, has compiled a health care professional's information leaflet which signposts staff to appropriate supportive organisations, via contact details i.e., websites and phone numbers. It also contains information regarding the study.

Consent of incapacitated patients – Thorough review of the principles of consent has concluded that deferral of consent would be potentially insensitive to the patient and their family. As a result, a waiver of consent is being requested to avoid undue distress to those affected for the time of the cardiac arrest. To allow participants to withdraw from the study, should they wish, the patient information leaflet highlighted earlier in this section includes contact details of the research team. This channel of communication shall remain open until publication of the data allowing for families to follow-up on any points of concern through the study. Furthermore, any participant that survives and is able to give consent for data to be included in the study will be followed up by the research team to enable them to do so if they wish.

Infection control - The research team are aware of the risk COVID-19 having all worked in front-line, patient facing, roles throughout the pandemic. As a result, they are well versed in infection control practices that minimize the risk of transmission. Their presence in both arms of the study minimally increases this risk. However, adhering to trust policies and including lateral flow testing prior to entering any health care facility, vigilance for symptoms of illness, the use of enhanced PPE and their experiences as front-line clinicians will mitigate this.

Staff awareness and familiarisation - Through working closely with the Research and Development and operational Teams at the host sites for both work packages, the research paramedics will be seeking to actively promote the study with the staff that may encounter them during data collection. In addition, the research paramedics will be seeking to actively

engage with operational staff to address any concerns or queries and support them throughout the data collection period. Staff engagement methods will include, but are not limited to, attendance at daily huddles, publication of study details in local newsletters etc explaining the role of the research paramedics at the scene.

Work Package 2 - Clinical – ED setting

- Information governance
- Research equipment causing trip hazard
- Staff well being
- Consent of patients who do not have capacity
- Dignity in death

Information governance – The ED arm of this trial will require additional patient demographic data to be stored such as BMI, comorbidities, and differential diagnoses prior to arrest. This will require access to confidential patient data. Strict adherence to information governance principles shall ensure appropriate use and storage of this data.

Research equipment causing a trip hazard – The data shall be collected in an active resus bay during a resuscitation attempt. Equipment shall be placed in collaborative decision making with the clinical care team and safety of staff and patients remains the absolute priority. Should there be any issues, similar protocols to the out-of-hospital arm shall be followed, namely, cessation of research, Datix reporting and supervisory case review.

Staff wellbeing – The research team appreciate the immense stresses imposed on emergency departments and a member of the research team will ensure the resus team are happy with planned research activities. Any objections raised on the day shall be discussed with the resuscitation team leader, with their say being final.

Consent of patients who do not have capacity – As per Work Package 1 - a waiver of consent is being requested to avoid undue distress to families. However, any participant that survives and is able to give consent after the event to have their data included in the study will be followed up by the research team to enable them to do so if they wish.

Dignity in death – The researchers are experienced, senior clinicians and endeavour to maintain the highest standards professionally and will follow departmental policies and procedures throughout.

7. STATISTICAL CONSIDERATIONS

7.1. RANDOMISATION

Work Package 1 - Clinical - Out-of-hospital setting

As an opportunistic observational study, no randomisation will take place.

Work Package 2 – Clinical – ED setting

As an opportunistic observational study, no randomisation will take place.

7.2. STATISTICAL ANALYSIS

The primary outcome measure for the study will be the particle number concentration and particle mass concentration measured during the six CPR procedures.

The data will be analysed to determine distribution ("parametric" or "non-parametric") using a standard test such as the Anderson-Darling or D'agostino-Pearson omnibus normality test. Appropriate descriptive statistics, dependent on normality, will be applied to the data collected to ascertain changes in aerosol generation alongside the timings of the recorded procedures. Standard statistical tests will not be used, owing to the clinical settings not being conducive with establishment of a control group.

8. DATA AND QUALITY MANAGEMENT

A data management plan (DMP) is a living document and will therefore be continuously updated throughout the project lifecycle to reflect the evolving workings of the project.

Data Overview

Pre-existing data:

Medical records, patient report forms

Data capture:

An ELPI+ particle analyser, and similar more portable device (OPC), will be used to collect air samples and determine the volume and size of aerosol particles being generated during CPR. In addition, data collection forms, as shown in Appendix 5a and Appendix 5b, will be used to record participant-specific data and each procedure performed. In carrying out the data collection, patient confidentiality will be maintained, as required by the Common Law Duty of Confidentiality.

Type(s): quantitative data

Format(s): DAT, XLXS, DOCX, PDF

Expected quantity: 90+ datasets.

Expected size: 500MB.

Data Curation

Data integrity:

File names will be generated using the following format - 'Date (YYYY-MM-DD) - WP (1 or 2) researcher initials - unique participant identifier (UPI #), ELPI / documents.

E.g., *2021-09-18 – WP1 TM – UPI 4 ELPI.dat or 2021-09-18 – WP2 DG – UPI 4 documents.pdf*

Metadata:

Metadata will be provided in the form of PDF or word documents with details as to the timings and type of data collected for each file generated.

Security and Storage

Anonymisation measures:

All participants will be allocated a random unique participant identifier at the point of enrolment. The participant will be referred to in documentation and data collection by their unique participant identifier.

Data storage:

Following recruitment, each participant will be allocated a unique identifying code which will be used on all data produced by that participant. Consent forms will be stored separately from data at the University of Hertfordshire. In addition, this project will comply with the Medical Research Council's Guidelines on Personal Information in Medical Research 2000.

Electronic data will be held on a secure network and personal information and data in paper form will be stored in locked filing cabinets on a secure site. Only the research team will have access to the data and participant information. Only anonymised data will be stored at UH. All data will be stored in the manner described for a period of 5 years, which complies with Section 5.2 of the Medical Research Council's (MRC) Good Research Practice (MRC Good Ethics Series) which states that: "Research records relating to clinical or public health studies should be retained for 20 years to allow for longer follow-up if necessary."

Data security:

The data will be kept on the University OneDrive system and will be kept by the collecting researcher. The researcher will utilise 'Exchange File' to provide the members of the team with access to the files, and a restricted R: drive page will be requested for the STOPGAP project to ensure data security.

There is a risk of data loss or failure to capture on the USB drive used to collect the raw files direct from the ELPI+, while a Secure Digital (SD) card will be used in the device used during work package 1. The files on the SD card and USB drive will be named by the analysers and will be completely anonymous. The data will be transferred to the OneDrive system as soon as practicable following termination of data collection to prevent avoidable data loss.

Data Archiving and Preservation

Archiving:

The original data files will be deleted from the USB drive originally used to capture the data immediately following its transfer to the OneDrive system.

Original copies of paper documents will be destroyed securely following conversion to electronic copy and storage on the OneDrive system to prevent loss.

Preservation:

Following completion of the STOPGAP project, data in XLSX format and associated metadata will be uploaded to the University of Hertfordshire Research Archive (UHRA) for preservation.

All data will be stored in the manner described for a period of 5 years, which complies with Section 5.2 of the Medical Research Council's (MRC) Good Research Practice (MRC Good Ethics Series) which states that: "Research records relating to clinical or public health studies should be retained for 20 years to allow for longer follow-up if necessary."

Data Sharing

Availability:

All data will be anonymised at point of participant enrolment. Data will be able to be shared freely at conclusion of STOPGAP project. No sensitive information will be shared.

Location of dataset(s):
Datasets will be stored in the UHRA repository, although can be provided if directly requested from research team.

Responsibilities and Resourcing

Roles and responsibilities for data management:

This DMP has been authored by Ruth Fisher, Dale Gedge, and Timothy Millington, who also have responsibility for data collection, handling, and management. Professor Julia Williams and Professor Robert Chilcott will also have access to the data and will be overseeing its collection and use within the PhD studies associated with STOPGAP.

Review:

Date of next review - 6th May 2023 by Ruth Fisher, Dale Gedge, and Timothy Millington.

Legal obligations and considerations:

Civil Contingencies Act 2004

Common Law Duty of Confidentiality

Data Protection Act 1998

Data Protection (Processing of Sensitive Personal Data) Order 2000

Access to Health Records Act 1990

Freedom of Information Act 2000

Health and Safety at Work Act 1974

Human Rights Act 1998

HCPC Standards of Conduct, Performance and Ethics

9. ADHERENCE TO PROTOCOL

Deviation from the protocol will be considered acceptable without amendment where necessary to ensure participant, public, emergency responder and/or researcher health and safety. All deviations are to be recorded in detail with justification, for review by the research team and supervisors, and any significant deviations will be reported to the Ethics Committee where appropriate.

10. PROTOCOL AMENDMENT

The principal research team may consider and implement amendments to protocol if agreed by all members of the research team. Amendments are also to be approved by supervisory team prior to implementation and referred to the HRA and REC if required.

11. REPORTING

Site liaisons and/or direct-care teams will be informed via a weekly briefing of patients that have been enrolled to the study. The research team will take responsibility for completing all reports and forms in a complete and timely manner. The research team will record the completion of relevant data collection forms on a summary document, shown in Appendix 6.

Reports completed by the research team will include all serious adverse events, device issues, changes to the protocol or ethical approval, and deviations from the protocol with justifications.

12. PUBLICATION POLICY

On completion of the study, data will be incorporated within 3 PhD theses and will be published upon completion within the British Library.

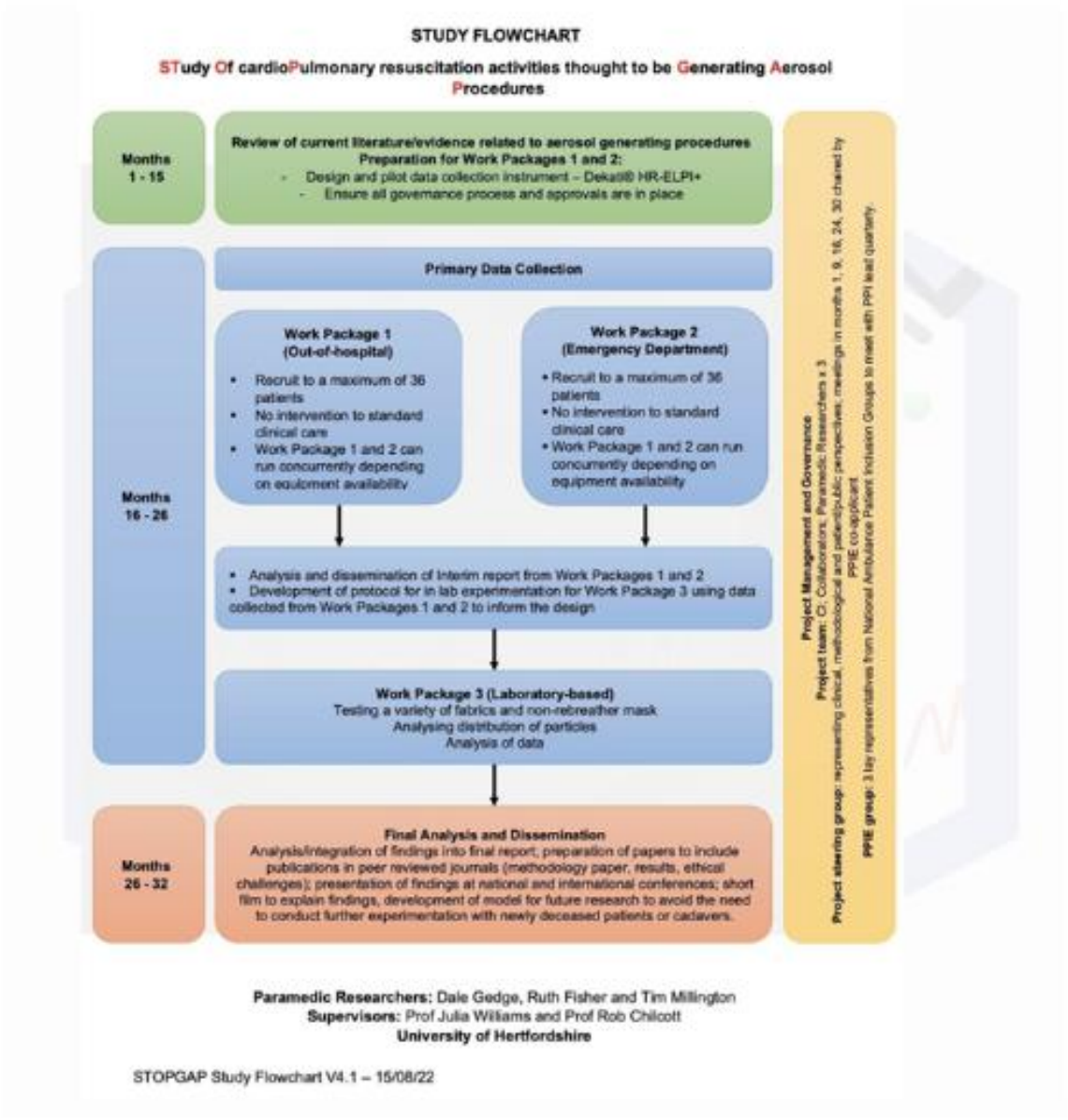
Additional publications may also be made via relevant national and international emergency care, resuscitation, infection prevention and control, and prehospital care journals. In addition, the results from the study may be presented at relevant conferences and symposiums.

A report detailing a summary of findings will be provided to the host sites following completion of the study and subsequent data analysis.

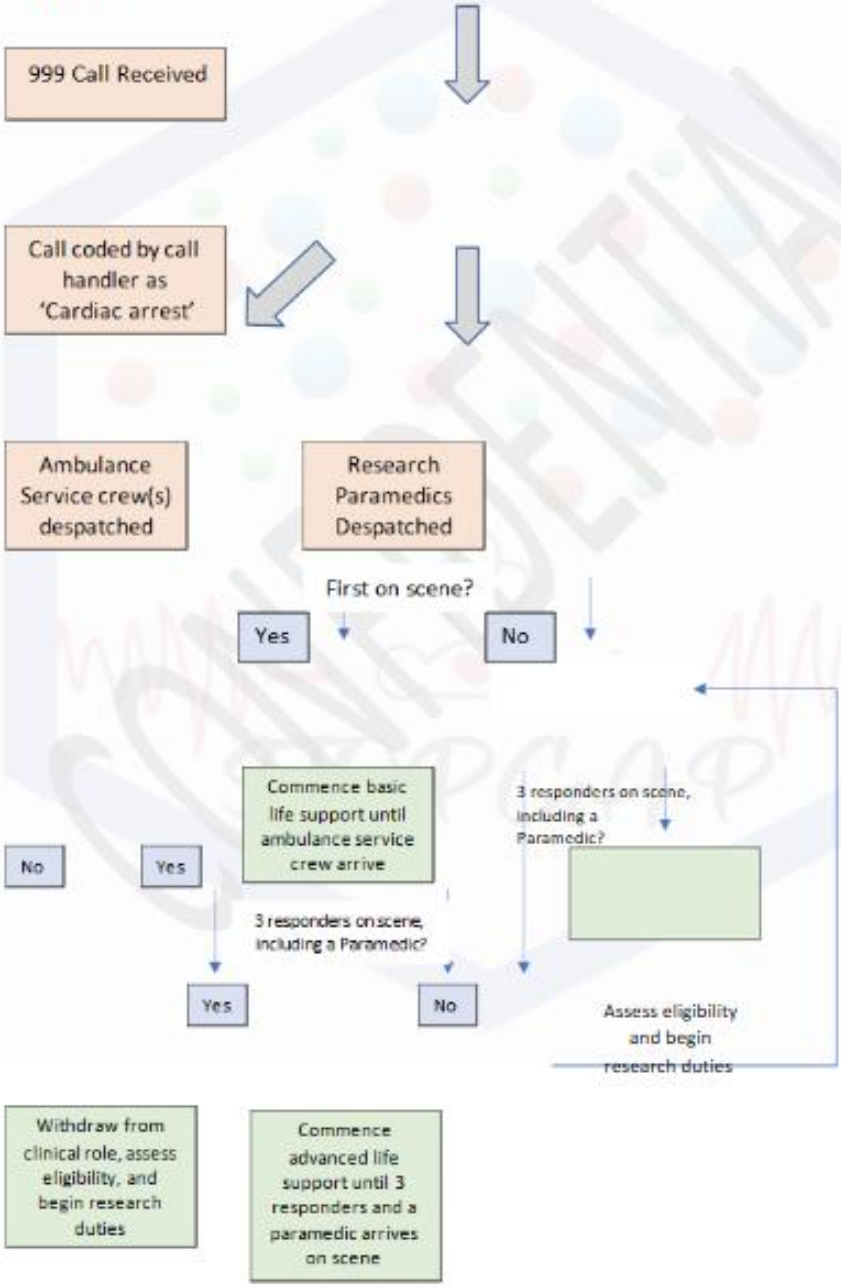
References

Hasselqvist-Ax, I., Nordberg, P., Svensson, L., Hollenberg, J., & Joelsson-Alm, E. (2019). Experiences among firefighters and police officers of responding to out-of-hospital cardiac arrest in a dual dispatch programme in Sweden: an interview study. *BMJ Open*, *9*(11), e030895. https://doi.org/10.1136/bmjopen-2019-030895

Petrie, C., Milligan-Saville, J., Gayed, A., Deady, M., Phelps, A., Dell, L., Forbes, D., Bryant, R.A., Calvo, R.A., Glozier, N., & Harvey, S.B. (2018). Prevelance of PTSD and common mental disorders amongst ambulance personnel: a systematic review and meta analysis. *Soc Psychiatry Psychiatr Epidemiol*, *53*(9). 897-909. DOI: 10.1007/s00127018-1539-5


STUDY FLOWCHART
STudy Of cardioPulmonary resuscitation activities thought to be Generating Aerosol Procedures
Months 1 - 15
Review of current literature/evidence related to aerosol generating procedures
Preparation for Work Packages 1 and 2:
- Design and pilot data collection instrument – Dekati® HR-ELPI+
- Ensure all governance process and approvals are in place
Months 16 - 26
Primary Data Collection
Work Package 1 (Out-of-hospital)
• Recruit to a maximum of 36 patients
• No intervention to standard clinical care
• Work Package 1 and 2 can run concurrently depending on equipment availability
Work Package 2 (Emergency Department)
• Recruit to a maximum of 36 patients
• No intervention to standard clinical care
• Work Package 1 and 2 can run concurrently depending on equipment availability
• Analysis and dissemination of Interim report from Work Packages 1 and 2
• Development of protocol for in lab experimentation for Work Package 3 using data collected from Work Packages 1 and 2 to inform the design
Work Package 3 (Laboratory-based)
Testing a variety of fabrics and non-rebreather mask
Analysing distribution of particles
Analysis of data
Months 26 - 32
Final Analysis and Dissemination
Analysis/integration of findings into final report; preparation of papers to include publications in peer reviewed journals (methodology paper, results, ethical challenges); presentation of findings at national and international conferences; short film to explain findings, development of model for future research to avoid the need to conduct further experimentation with newly deceased patients or cadavers.
Project Management and Governance
Project team: CI, Collaborators, Paramedic Researchers x 3
Project steering group: representing clinical, methodological and patient/public perspectives; meetings in months 1, 9, 16, 24, 30 chaired by PPIE co-applicant
PPIE group: 3 lay representatives from National Ambulance Patient Inclusion Groups to meet with PPI lead quarterly.
Paramedic Researchers: Dale Gedge, Ruth Fisher and Tim Millington
Supervisors: Prof Julia Williams and Prof Rob Chilcott
University of Hertfordshire
STOPGAP Study Flowchart V4.1 – 15/08/22

APPENDIX 2. Work Package 1 – Clinical – Out-of-hospital setting flowchart for research initiation



Appendix 3a. Work Package 1 – Clinical – Out-of-hospital Setting Participant Information Leaflet

Useful contacts for additional support

Age UK	0800 678 1774
Cruse Bereavement Care Helpline	0808 808 1677
Mind (mental health support)	0300 123 3393 | **Text** 86463
Samaritans	116 123
Silver Line (support for older people)	0800 4 70 80 90
Government website	**www.gov.uk/after-a-death**
National Survivor User Network	**www.nsun.org.uk**
Advocacy Fatal Domestic Abuse	07768 386 922 | **www.aafda.org.uk**
Sands	0808 164 3332 | **www.sands.org.uk**
Support after Suicide Partnership	**www.supportaftersuicide.org.uk**

Contact and Concerns
We wish to thank you for taking the time to read this leaflet, and if you have any further questions or concerns, please speak with, or contact the STOPGAP research team directly at ProjectSTOPGAP@gmail.com.

Although we hope it is not the case, if you have any complaints or concerns about any aspect of the way you have been approached or treated during the course of this study, please write to the University's Secretary and Registrar at the following address:

Secretary and Registrar
University of Hertfordshire
College Lane,
Hatfield
Herts AL10 9AB



Figure 1. The equipment being used by the researchers.

Trust Logo

Project STOPGAP

STudy Of cardiopulmonary resuscitation Procedures thought to Generate Aerosol Particles

Participant Information Leaflet

Your local Ambulance Service / Emergency Department (ED) is supporting the University of Hertfordshire and the College of Paramedics in the study of aerosol particles generated during cardiopulmonary resuscitation (CPR) when someone's heart stops. This leaflet is to provide you with information related to why the research is being done and how the research is being conducted.
Please take the time to read this information when it is convenient for you to do so - We know that this may be a difficult and distressing time.

Q. What is a cardiac arrest?
A cardiac arrest describes an event when a person's heart stops and they are no longer breathing. Prompt action by healthcare workers or members of the public is key to survival. These actions grouped together are classified as CPR.

Q. What are aerosols and why are they important in a cardiac arrest?
Aerosols can be thought of as fine mist (like that produced from a deodorant can), but are not visible to the naked eye. Particles are generated by different forces acting within the respiratory tract and lungs and are broadly split into two categories; '***droplets***' and '***aerosols***'. Droplets are often visible and are much larger than aerosols.
Droplets are affected by gravity once they have left the body, falling, and settling on surfaces. Droplets can contain live virus which can then be easily transmitted to other people, hence hand hygiene is so important. Aerosols, being much smaller than droplets, will remain suspended in the air and can be inhaled by another person in that environment. As aerosols are 'floating' in the atmosphere, typical loose fitting face coverings are not thought to offer adequate protection to the wearer so a higher level of protection would be required.

University of Hertfordshire UH V3.3 17.04.23 College of paramedics

Q. What is the purpose of the STOPGAP project?

There is considerable debate in current literature and between various professional bodies regarding the risk to a responder who may be carrying out CPR activities. The general consensus is that the current evidence is of low quality – so the responder finds themselves with a dilemma; an inadequate level of personal protective equipment (PPE) may put them at higher risk of the transmission of a communicable disease, such as coronavirus, but a higher level of PPE may delay their response and therefore reduce the chance of survival of the patient. For every minutes without CPR, the patient's chances of survival decrease by 7-10% so seconds really do matter.

During the first wave of COVID-19, evidence showed that the outcomes for patients experiencing cardiac arrest attended to by the ambulance service were poorer than in the same period pre-COVID-19. Since COVID-19, the risk to the first responder of a cardiac arrest has been considered, with different advice, compared to pre-COVID-19, now given to both healthcare workers and members of the public. This new advice is likely to delay commencement of CPR and may have contributed to the worsening outcomes for patient's suffering a cardiac arrest since the COVID-19 pandemic.

The new advice has been given as result of a perceived risk to the responder of exposure to coronaviruses and other communicable respiratory viruses and infections via aerosols generated during procedures carried out as part of CPR. Our research investigates which CPR procedures are aerosol generating and therefore which procedures justify a delay in the first responder commencing CPR, in order to put on a higher level of PPE and adequately protect the responder, whilst optimising the chances of survival for the patient.

Q. How will the research affect the care participants receive?

The researchers will sample the air in the environment around patients receiving CPR from Ambulance Service responders to see what aerosols are generated during a resuscitation attempt. The sampling will not interfere with the delivery of care, nor will our presence influence decisions to undertake any procedures. The delivery of care will remain the priority of researchers throughout the project.

Q. Is this project being conducted anywhere else?

Yes — research for the project is being conducted in both Ambulance Services and local EDs.

Q. How will participants' information be used?
Limited personal information is being collected from participants for the purposes of this research, including gender, age and a history of specific medical conditions, where possible. Data will be stored on a secure network for 5 years. The information that will be collected by researchers will be related to the air in the environment, and will be used to inform further research relating to different PPE levels for healthcare workers, as well as mitigation strategies to reduce aerosol generation from patients. Following on from the data collection in the out-of-hospital and ED settings, research is expected to take place within a laboratory, with mannequins and simulations based on the findings of the real-time studies.

Q. Is it possible to opt-out of being involved in this research?
Yes — while all support for the project is greatly appreciated, any consultee and/or individual who does not wish to be involved will be fully supported to do so by the research team and their direct-care providers. Opting out or withdrawal of consent will not have an impact on care that the individual receives at any time.

Q. Who has reviewed the project?
The project has been reviewed by a Health Research Authority (HRA) research ethics committee (REC).

Q. Who will be conducting the research for the project?
Project STOPGAP is being conducted by 3 paramedics as a component of their PhDs, funded by the University of Hertfordshire and the College of Paramedics.

Glossary	
COVID-19	SARS-CoV-2, or sudden acute respiratory syndrome coronavirus 2 virus
CPR	Cardiopulmonary Resuscitation
HRA	Health Research Authority
ED	Emergency Department
PPE	Personal Protective Equipment
REC	Research Ethics Committee
STOPGAP	Study of cardiopulmonary resuscitation activities thought to generate aerosol particles

Appendix 3b. Work Package 2 – Clinical – Emergency Department Participant Information Leaflet

Useful contacts for additional support

Age UK	0800 678 1774
Cruse Bereavement Care Helpline	0808 808 1677
Mind (mental health support)	0300 123 3393 | **Text** 86463
Samaritans	116 123
Silver Line (support for older people)	0800 4 70 80 90
Government website	**www.gov.uk/after-a-death**
National Survivor User Network	**www.nsun.org.uk**
Advocacy Fatal Domestic Abuse	07768 386 922 | **www.aafda.org.uk**
Sands	0808 164 3332 | **www.sands.org.uk**
Support after Suicide Partnership	**www.supportaftersuicide.org.uk**

Contact and Concerns
We wish to thank you for taking the time to read this leaflet, and if you have any further questions or concerns, please speak with, or contact the STOPGAP research team directly at ProjectSTOPGAP@gmail.com.

Although we hope it is not the case, if you have any complaints or concerns about any aspect of the way you have been approached or treated during the course of this study, please write to the University's Secretary and Registrar at the following address:

Secretary and Registrar
University of Hertfordshire
College Lane,
Hatfield
Herts AL10 9AB



Figure 1. The equipment being used by the researchers.

Trust Logo

Project STOPGAP

STudy Of cardiopulmonary resuscitation Procedures thought to Generate Aerosol Particles

Participant Information Leaflet

Your local Ambulance Service / Emergency Department (ED) is supporting the University of Hertfordshire and the College of Paramedics in the study of aerosol particles generated during cardiopulmonary resuscitation (CPR) when someone's heart stops. This leaflet is to provide you with information related to why the research is being done and how the research is being conducted.
Please take the time to read this information when it is convenient for you to do so - We know that this may be a difficult and distressing time.

Q. What is a cardiac arrest?
A cardiac arrest describes an event when a person's heart stops and they are no longer breathing. Prompt action by healthcare workers or members of the public is key to survival. These actions grouped together are classified as CPR.

Q. What are aerosols and why are they important in a cardiac arrest?
Aerosols can be thought of as fine mist (like that produced from a deodorant can), but are not visible to the naked eye. Particles are generated by different forces acting within the respiratory tract and lungs and are broadly split into two categories; '***droplets***' and '***aerosols***'. Droplets are often visible and are much larger than aerosols.
Droplets are affected by gravity once they have left the body, falling, and settling on surfaces. Droplets can contain live virus which can then be easily transmitted to other people, hence hand hygiene is so important. Aerosols, being much smaller than droplets, will remain suspended in the air and can be inhaled by another person in that environment. As aerosols are 'floating' in the atmosphere, typical loose fitting face coverings are not thought to offer adequate protection to the wearer so a higher level of protection would be required.

University of Hertfordshire UH V3.3 17.04.23 College of paramedics

Q. What is the purpose of the STOPGAP project?

There is considerable debate in current literature and between various professional bodies regarding the risk to a responder who may be carrying out CPR activities. The general consensus is that the current evidence is of low quality – so the responder finds themselves with a dilemma; an inadequate level of personal protective equipment (PPE) may put them at higher risk of the transmission of a communicable disease, such as coronavirus, but a higher level of PPE may delay their response and therefore reduce the chance of survival of the patient. For every minutes without CPR, the patient's chances of survival decrease by 7-10% so seconds really do matter.

During the first wave of COVID-19, evidence showed that the outcomes for patients experiencing cardiac arrest attended to by the ambulance service were poorer than in the same period pre-COVID-19. Since COVID-19, the risk to the first responder of a cardiac arrest has been considered, with different advice, compared to pre-COVID-19, now given to both healthcare workers and members of the public. This new advice is likely to delay commencement of CPR and may have contributed to the worsening outcomes for patient's suffering a cardiac arrest since the COVID-19 pandemic.

The new advice has been given as result of a perceived risk to the responder of exposure to coronaviruses and other communicable respiratory viruses and infections via aerosols generated during procedures carried out as part of CPR. Our research investigates which CPR procedures are aerosol generating and therefore which procedures justify a delay in the first responder commencing CPR, in order to put on a higher level of PPE and adequately protect the responder, whilst optimising the chances of survival for the patient.

Q. How will the research affect the care participants receive?

The researchers will sample the air in the environment around patients receiving CPR within the emergency department to see what aerosols are generated during a resuscitation attempt. The sampling will not interfere with the delivery of care, nor will our presence influence decisions to undertake any procedures. The delivery of care will remain the priority of researchers throughout the project.

Q. Is this project being conducted anywhere else?

Yes — research for the project is being conducted in both Ambulance Services and local EDs.

Q. How will participants' information be used?
Limited personal information is being collected from participants for the purposes of this research, including gender, age and a history of specific medical conditions, where possible. Data will be stored on a secure network for 5 years. The information that will be collected by researchers will be related to the air in the environment, and will be used to inform further research relating to different PPE levels for healthcare workers, as well as mitigation strategies to reduce aerosol generation from patients. Following on from the data collection in the out-of-hospital and ED settings, research is expected to take place within a laboratory, with mannequins and simulations based on the findings of the real-time studies.

Q. Is it possible to opt-out of being involved in this research?
Yes — while all support for the project is greatly appreciated, any consultee and/or individual who does not wish to be involved will be fully supported to do so by the research team and their direct-care providers. Opting out or withdrawal of consent will not have an impact on care that the individual receives at any time.

Q. Who has reviewed the project?
The project has been reviewed by a Health Research Authority (HRA) research ethics committee (REC).

Q. Who will be conducting the research for the project?
Project STOPGAP is being conducted by 3 paramedics as a component of their PhDs, funded by the University of Hertfordshire and the College of Paramedics.

Glossary	
COVID-19	SARS-CoV-2, or sudden acute respiratory syndrome coronavirus 2 virus
CPR	Cardiopulmonary Resuscitation
HRA	Health Research Authority
ED	Emergency Department
PPE	Personal Protective Equipment
REC	Research Ethics Committee
STOPGAP	Study of cardiopulmonary resuscitation activities thought to generate aerosol particles

Appendix 3c. Work Package 1 and 2 – Clinical – Post-ROSC Participant Information Leaflet

Useful contacts for additional support

Age UK	0800 678 1774
Mind (mental health support)	0300 123 3393 | **Text** 86463
Samaritans	116 123
Silver Line (support for older people)	0800 4 70 80 90
National Survivor User Network	**www.nsun.org.uk**

Contact and Concerns
We wish to thank you for taking the time to read this leaflet, and if you have any further questions or concerns, please speak with, or contact the STOPGAP research team directly at ProjectSTOPGAP@gmail.com.

Although we hope it is not the case, if you have any complaints or concerns about any aspect of the way you have been approached or treated during the course of this study, please write to the University's Secretary and Registrar at the following address:

Secretary and Registrar,
University of Hertfordshire
College Lane,
Hatfield
Herts AL10 9AB





Figure 1 (*left*). The equipment being used by researchers with the Ambulance Service

Figure 2 (*right*). The equipment used by researchers in the Emergency Dept.

Trust Logo

Project STOPGAP

STudy Of cardiopulmonary resuscitation Procedures thought to Generate Aerosol Particles

Participant Information Leaflet

Your local Ambulance Service / Emergency Department (ED) is supporting the University of Hertfordshire and the College of Paramedics in the study of aerosol particles generated during cardiopulmonary resuscitation (CPR) when someone's heart stops. This leaflet is to provide you with information related to why the research is being done and how the research was conducted, as you will have been involved during your recent healthcare contact.
Please take the time to read this information when it is convenient for you to do so - We know that this may be a difficult and distressing time.

Q. What is a cardiac arrest?
A cardiac arrest describes an event when a person's heart stops and they are no longer breathing. Prompt action by healthcare workers or members of the public is key to survival. These actions grouped together are classified as CPR.

Q. What are aerosols and why are they important in a cardiac arrest?
Aerosols can be thought of as fine mist (like that produced from a deodorant can), but are not visible to the naked eye. Particles are generated by different forces acting within the respiratory tract and lungs and are broadly split into two categories; "**droplets**" and "**aerosols**". Droplets are often visible and are much larger than aerosols.
Droplets are affected by gravity once they have left the body, falling, and settling on surfaces. Droplets can contain live virus which can then be easily transmitted to other people, hence hand hygiene is so important. Aerosols, being much smaller than droplets, will remain suspended in the air and can be inhaled by another person in that environment. As aerosols are 'floating' in the atmosphere, typical loose fitting face coverings are not thought to offer adequate protection to the wearer so a higher level of protection would be required.

University of Hertfordshire UH V1.2 17.4.23 College of paramedics

Q. What is the purpose of the STOPGAP project?

There is considerable debate in current literature and between various professional bodies regarding the risk to a responder who may be carrying out CPR activities. The general consensus is that the current evidence is of low quality – so the responder finds themselves with a dilemma; an inadequate level of personal protective equipment (PPE) may put them at higher risk of the transmission of a communicable disease, such as coronavirus, but a higher level of PPE may delay their response and therefore reduce the chance of survival of the patient. For every minutes without CPR, the patient's chances of survival decrease by 7-10% so seconds really do matter.

During the first wave of COVID-19, evidence showed that the outcomes for patients experiencing cardiac arrest attended to by the ambulance service were poorer than in the same period pre-COVID-19. Since COVID-19, the risk to the first responder of a cardiac arrest has been considered, with different advice, compared to pre-COVID-19, now given to both healthcare workers and members of the public. This new advice is likely to delay commencement of CPR and may have contributed to the worsening outcomes for patient's suffering a cardiac arrest since the COVID-19 pandemic.

The new advice has been given as result of a perceived risk to the responder of exposure to coronaviruses and other communicable respiratory viruses and infections via aerosols generated during procedures carried out as part of CPR. Our research investigates which CPR procedures are aerosol generating and therefore which procedures justify a delay in the first responder commencing CPR, in order to put on a higher level of PPE and adequately protect the responder, whilst optimising the chances of survival for the patient.

Q. How will the research have affected the care participants receive?

The researchers will have sampled the air around patients whilst they were receiving CPR from healthcare responders to identify what aerosols were generated during a resuscitation attempt. The sampling did not interfere with the delivery of care, nor did their presence influence decisions to undertake any procedures. The delivery of care remained the priority of researchers throughout the project.

Q. Is this project being conducted anywhere else?

Yes — research for the project is being conducted in both Ambulance Services and local EDs.

Q. How will participants' information be used?
Limited personal information was collected from participants for the purposes of this research, including gender, age and a history of specific medical conditions, where possible. Data will be stored on a secure network for 5 years.
The information that was collected by researchers is related to the air in the environment, and will be used to inform further research relating to different PPE levels for healthcare workers, as well as mitigation strategies to reduce aerosol generation from patients. Following on from the data collection in the out-of-hospital and ED settings, research is expected to take place within a laboratory, with mannequins and simulations based on the findings of the real-time studies.

Q. Is it possible to opt-out of being involved in this research?
Yes — while all support for the project is greatly appreciated, any consultee and/or individual who does not wish for their data to be included will be fully supported by the research team and their direct-care providers. Opting out or withdrawal of consent will not have an impact on care that the individual receives at any time. Opting out of involvement will result in your data being removed from the study, and securely destroyed.

Q. Who has reviewed the project?
The project has been reviewed by a Health Research Authority (HRA) research ethics committee (REC).

Q. Who will be conducting the research for the project?
Project STOPGAP is being conducted by 3 paramedics as a component of their PhDs, funded by the University of Hertfordshire and the College of Paramedics.

Glossary	
COVID-19	SARS-CoV-2, or sudden acute respiratory syndrome coronavirus 2 virus
CPR	Cardiopulmonary Resuscitation
HRA	Health Research Authority
ED	Emergency Department
PPE	Personal Protective Equipment
REC	Research Ethics Committee
STOPGAP	Study of cardiopulmonary resuscitation activities thought to generate aerosol particles

Appendix 3d. Work Package 1 and 2 – Clinical – Healthcare Professional Information Leaflets

Useful contacts for additional support

Mind (mental health support)	0300 123 3393 | **Text** 86463
Samaritans	116 123
Government website	**www.gov.uk/after-a-death**
National Survivor User Network	**www.nsun.org.uk**
Support after Suicide Partnership	**www.supportaftersuicide.org.uk**
The Ambulance Staff Charity (TASC)	02477 987 922 | **theasc.org.uk**

Contact and Concerns
We wish to thank you for taking the time to read this leaflet, and if you have any further questions or concerns, please speak with, or contact the STOPGAP research team directly at ProjectSTOPGAP@gmail.com.

Although we hope it is not the case, if you have any complaints or concerns about any aspect of the way you have been approached or treated during the course of this study, please write to the University's Secretary and Registrar at the following address:

Secretary and Registrar,
University of Hertfordshire
College Lane,
Hatfield
Herts AL10 9AB





Figure 1 (left). The equipment being used by researchers with the Ambulance Service

Figure 2 (right). The equipment used by researchers in the ED.

Trust Logo

Project STOPGAP

STudy Of cardiopulmonary resuscitation Procedures thought to Generate Aerosol Particles

Healthcare Professional Information Leaflet

Your local Ambulance Service / Emergency Department (ED) is supporting the University of Hertfordshire and the College of Paramedics in the study of aerosol particles generated during cardiopulmonary resuscitation (CPR). This leaflet is to provide you with information related to why the research is being done and how the research is being conducted.

Q. Is this project being conducted anywhere else?
Yes — research for the project is being conducted in both Ambulance Services and local EDs.

Q. Who has reviewed the project?
The project has been reviewed by a Health Research Authority (HRA) research ethics committee (REC).

Q. Who will be conducting the research for the project?
Project STOPGAP is being conducted by 3 paramedics as a component of their PhDs, funded by the University of Hertfordshire and the College of Paramedics.

Q. Can my patients opt-out of being involved in this project?
Yes — while all support for the project is greatly appreciated, any consultee and/or individual who does not wish to be involved will be fully supported to do so by the research team and their direct-care providers. Opting out or withdrawal of consent will not have an impact on care that the individual receives at any time. Consent will not be directly sought from the patient's family at the time to avoid undue distress to those affected. However, the decision to opt out or withdraw from the project are still fully supported. The waiver of consent has been reviewed by the HRA research ethics committee. For survivors, we will seek permission to include their data within the research at an appropriate time after the event and will not use this data unless consent is gained.

University of Hertfordshire UH V3.3 17.04.23 COLLEGE OF paramedics

Q. What are aerosols and why are they important in a cardiac arrest?

Aerosols can be thought of as fine mist (like that produced from a deodorant can), but are not visible to the naked eye. Particles are generated by different forces acting within the respiratory tract and lungs and are broadly split into two categories; '**droplets**' and '**aerosols**'. Droplets are often visible and are much larger than aerosols.

Droplets are affected by gravity once they have left the body, falling, and settling on surfaces. Droplets can contain live virus which can then be easily transmitted to other people, hence hand hygiene is so important. Aerosols, being much smaller than droplets, will remain suspended in the air and can be inhaled by another person in that environment. As aerosols are 'floating' in the atmosphere, typical loose fitting face coverings are not thought to offer adequate protection to the wearer so a higher level of protection would be required.

Q. What is the purpose of the STOPGAP project?

There is considerable debate in current literature and between various professional bodies regarding the risk to a responder who may be carrying out CPR activities. The general consensus is that the current evidence is of low quality – so the responder finds themselves with a dilemma; an inadequate level of personal protective equipment (PPE) may put them at higher risk of the transmission of a communicable disease, such as coronavirus, but a higher level of PPE may delay their response and therefore reduce the chance of survival of the patient. For every minutes without CPR, the patient's chances of survival decrease by 7-10% so seconds really do matter.

During the first wave of COVID-19, evidence showed that the outcomes for patients experiencing cardiac arrest attended to by the ambulance service were poorer than in the same period pre-COVID-19. Since COVID-19, the risk to the first responder of a cardiac arrest has been considered, with different advice, compared to pre-COVID-19, now given to both healthcare workers and members of the public. This new advice is likely to delay commencement of CPR and may have contributed to the worsening outcomes for patient's suffering a cardiac arrest since the COVID-19 pandemic.

The new advice has been given as result of a perceived risk to the responder of exposure to coronaviruses and other communicable respiratory viruses and infections via aerosols generated during procedures carried out as part of CPR. Our research investigates which CPR procedures are aerosol generating and therefore which procedures justify a delay in the first responder commencing CPR, in order to put on a higher level of PPE and adequately protect the responder, whilst optimising the chances of survival for the patient.

Q. How will the research affect the care that participants receive?

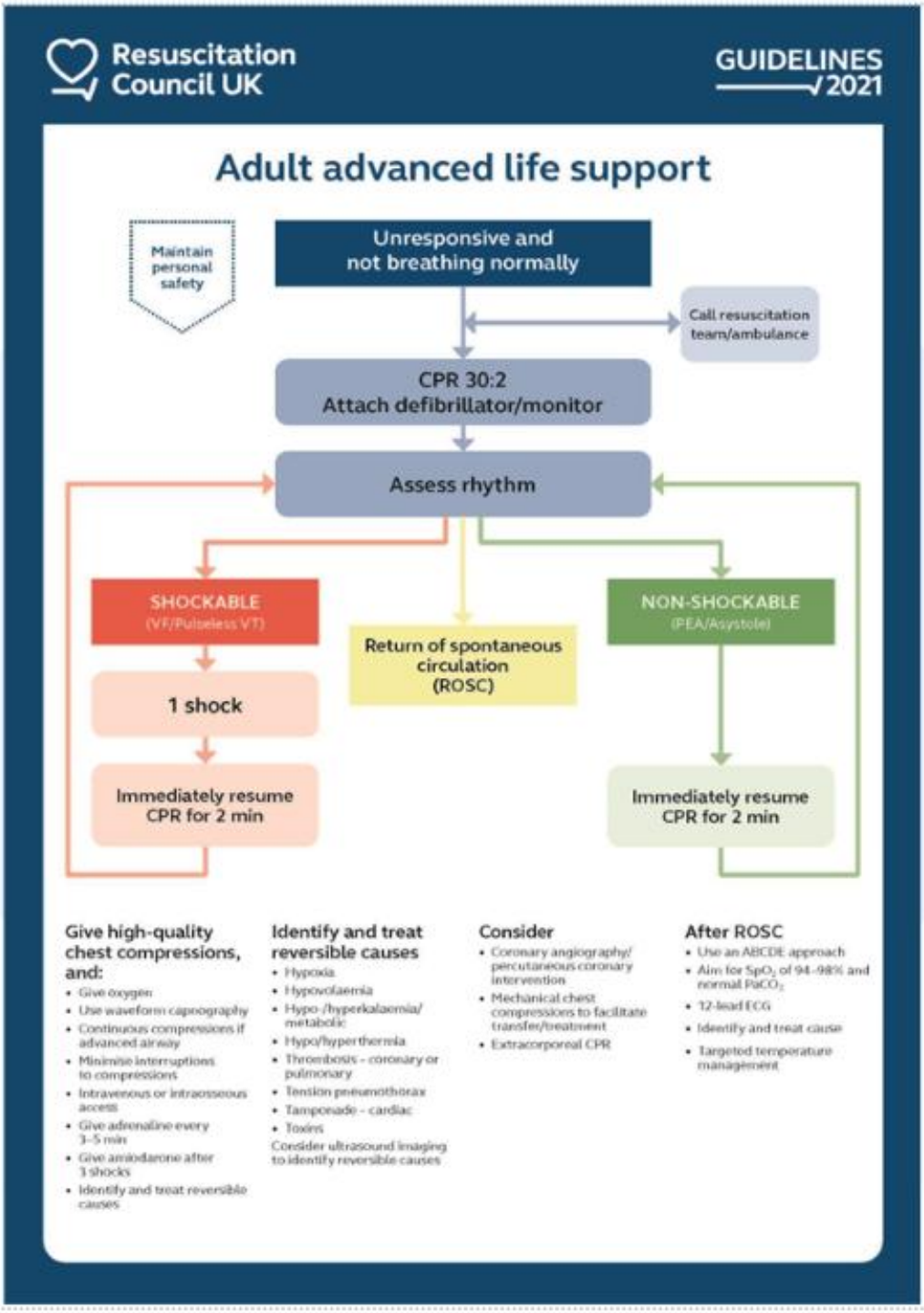
The researchers will sample the air in the environment around patients receiving CPR from Ambulance Service responders and clinicians within the Emergency Department to see what aerosols are generated during a resuscitation attempt. The sampling will not interfere with the delivery of care, nor will our presence influence decisions to undertake any procedures. The delivery of care will remain the priority of researchers throughout the project.

Q. How will participants' information be used?

Limited personal information is being collected from participants for the purposes of this research, including gender and age in order to identify them during data collection, as well as a confirmed history of specific medical conditions.

The information that will be collected by researchers will be related to the air in the environment, and will be used to inform further research relating to different PPE levels for healthcare workers, as well as mitigation strategies to reduce aerosol generation from patients. Following on from the data collection in the out-of-hospital and ED settings, research is expected to take place within a laboratory, with mannequins and simulations based on the findings of the real-time studies.

Glossary	
COVID-19	SARS-CoV-2, or sudden acute respiratory syndrome coronavirus 2 virus
CPR	Cardiopulmonary Resuscitation
HRA	Health Research Authority
ED	Emergency Department
PPE	Personal Protective Equipment
REC	Research Ethics Committee
STOPGAP	Study of cardiopulmonary resuscitation activities thought to generate aerosol particles


Resuscitation Council UK
GUIDELINES 2021
Adult advanced life support
Maintain personal safety
Unresponsive and not breathing normally
Call resuscitation team/ambulance
CPR 30:2
Attach defibrillator/monitor
Assess rhythm
SHOCKABLE
(VF/Pulseless VT)
1 shock
Immediately resume CPR for 2 min
Return of spontaneous circulation (ROSC)
NON-SHOCKABLE
(PEA/Asystole)
Immediately resume CPR for 2 min
Give high-quality chest compressions, and:
• Give oxygen
• Use waveform capnography
• Continuous compressions if advanced airway
• Minimise interruptions to compressions
• Intravenous or intraosseous access
• Give adrenaline every 3–5 min
• Give amiodarone after 3 shocks
• Identify and treat reversible causes
Identify and treat reversible causes
• Hypoxia
• Hypovolaemia
• Hypo-/hyperkalaemia/ metabolic
• Hypo/hyperthermia
• Thrombosis - coronary or pulmonary
• Tension pneumothorax
• Tamponade - cardiac
• Toxins
Consider ultrasound imaging to identify reversible causes
Consider
• Coronary angiography/ percutaneous coronary intervention
• Mechanical chest compressions to facilitate transfer/treatment
• Extracorporeal CPR
After ROSC
• Use an ABCDE approach
• Aim for SpO_2 of 94–98% and normal $PaCO_2$
• 12-lead ECG
• Identify and treat cause
• Targeted temperature management

Work Package 1 - Clinical - Out-of-Hospital Setting

Host Trust		Participant identifier	

Participant Information	
Sex	
Age	
Height	

Co-morbidities *(Delete as appropriate)*		
	Obesity	
	Hypertension	
Lung disease *	Heart disease / Heart failure	** incl chronic obstructive pulmonary disease (COPD), asthma, interstitial lung disease (ILD), cancer*
Kidney disease	Diabetes	

Cardiac Arrest Details		
Time of arrest (if known)		
Initial cardiac arrest rhythm		
ROSC / ROLE?		
Time of initial call		
Time CPR is initiated by Ambulance responder		
Any bystander CPR?		
CPR mechanism	Manual	Mechanical
Cardiac arrest rhythm		
Airway patency		
Capnography at rhythm check		
Shocks delivered and joulage	Shocks	Joulage
Number of people in the room/immediate area and mask/PPE status		
Environment features (incl. in/outdoors, ventilation, approximate room size)		

V3.1 11.04.23

Procedure Times and Details		
Bag-valve-mask ventilation		
Chest compressions		
Defibrillation		
Oropharyngeal/ nasopharyngeal suctioning		
Supraglottic airway insertion		
Endotracheal intubation		
Notes:		

V3.1 11.04.23

Appendix 5b. Work Package 2 – Clinical – Emergency Department Setting Data Collection Form

Work Package 2 - Clinical - ED			
Host Trust		**Participant identifier**	Pre-populated

Participant Information	
Sex	
Age	
Height	

Co-morbidities *(Delete as appropriate)*	Obesity
	Hypertension
Lung disease *	Heart disease / Heart failure
Kidney disease	Diabetes

** incl chronic obstructive pulmonary disease (COPD), asthma, interstitial lung disease (ILD), cancer*

Cardiac Arrest Details		
Time of arrest (if known)		
Initial cardiac arrest rhythm		
ROSC / ROLE?		Time:
Time of initial call		
Time CPR initiated by Ambulance responder		
Any bystander CPR?		
Time of ED arrival		
CPR mechanism	Manual	Mechanical
Cardiac arrest rhythm		
Airway patency		
Capnography at rhythm check		
Shocks delivered and joulage	Shocks	Joulage
Number of people within Resus Team		
Location within ED		

V3.1 11.04.23

Procedure Times and Details		
Bag-valve-mask ventilation		
Chest compressions		
Defibrillation		
Oropharyngeal/ nasopharyngeal suctioning		
Supraglottic airway insertion		
Endotracheal intubation		
Notes:		

Appendix 6. Summary of Completed Data Collection Forms

Summary of Completed Data Collection Forms			Work Package 1 - Clinical – Out-of-hospital Setting		
Date	Incident identifier	Data collection form completed?	Date form completed	Form scanned?	Researcher initials

Summary of Completed Data Collection Forms			Work Package 2 - Clinical – Emergency Department Setting		
Date	**Participant identifier**	**Data collection form completed?**	**Date form completed**	**Form scanned?**	**Researcher initials**

V1.1 15.08.22

Research

Experiences of personal protective equipment and reasons for non-compliance

Timothy Ian Millington (Corresponding Author), Emergency Medicine Advanced Clinical Practitioner, Rotherham NHS Foundation Trust; and Paramedic Researcher, University of Hertfordshire; **Robert P Chilcott,** Head of Toxicology; University of Hertfordshire; **Julia Williams,** Professor of Paramedic Science and Associate Dean—Research; University of Hertfordshire, UK.
Email: Timothy.millington@nhs.net

Abstract

Background: The COVID-19 pandemic created challenges in prehospital care. Paramedics have been required to adhere to strict protocols regarding infection control and the use of personal protective equipment (PPE). These protocols have evolved as the pandemic progressed. Understanding the experiences of paramedics in using PPE and their reasons behind not adhering to recommended guidelines should improve the limited evidence base and assist healthcare organisations to form tailored PPE guidance, enabling better protection of paramedics. **Aim:** This study aimed to analyse evidence on paramedics' experiences of using PPE and explore the reasons behind non-compliance to inform PPE policies. **Methods:** Searches of five key databases identified papers relating to frontline practitioners' experiences of using PPE; frontline was defined as working in patient-facing roles in prehospital, emergency department or critical care settings. Articles were then subject to thematic analysis as part of this narrative review. **Results:** Three themes emerged: physical and emotional wellbeing; impact on patient care and clinical effectiveness; and PPE fatigue. The evidence explores health professionals' experiences of working in this difficult environment but very little data exist regarding the impact of PPE, specifically on UK paramedics or their reasons for not adhering to PPE protocols. **Conclusion:** PPE affects wearers in a variety of ways. Factors behind non-adherence are multifactorial. A paucity of literature exists regarding paramedics' experiences of using PPE.

Key words
● Personal and protective equipment (PPE) ● Paramedicine ● Experiences ● Protocols ● COVID-19 ● Pandemic

Accepted for publication: 25 August 2022

COVID-19, the respiratory disease caused by SARS-CoV-2, led to the World Health Organization (WHO) declaring a pandemic in March 2020 (WHO, 2022). COVID-19 has a variety of symptoms, which have changed as the virus mutated and understanding of the disease deepened. Significant mortality has been seen in particular demographic groups. Many patients are asymptomatic, compounding difficulties in infection control and prevention of disease transmission (Atzrodt et al, 2020; Fink et al, 2020).

Health professionals are still required to adhere to strict protocols regarding the use of personal protective equipment (PPE), particularly when in proximity to medical procedures thought to generate aerosols. This is because SARS-CoV-2 is primarily transmitted through respiratory particles in the form of droplets, aerosols or fomites (Leong et al, 2020).

Infection control guidelines have been variable and contradictory in some instances. It remains recommended that PPE be worn when caring for patients to provide a protective barrier, shielding the wearer from exposure with external contaminants. Level 2 PPE was initially recommended for use with all patients regardless of COVID-19 status, with level 3 PPE reserved for use in patients who were suspected of or had been confirmed as being COVID-19 positive (*Figure 1*).

Studies have explored health professionals' general experiences of working during the pandemic and highlights the new challenges COVID-19 has presented; however, very little research has explored the impact of PPE on prehospital care or paramedics specifically (Chen et al, 2021a; Hoernke et al, 2021; Rees et al, 2021).

A deeper understanding of how the wearing of PPE impacts paramedics, with a focus on their reasons when they might not adhere to PPE policies, would improve the limited data that are available and help inform healthcare strategies in

© 2022 MA Healthcare Ltd

the future. Contemporary literature on this matter would provide healthcare organisations with tools to create evidence-based PPE guidance. The overall result would be better protection for health professionals who continue to be at risk from coronavirus and any other transmissible, potentially lethal, pathogens.

Aim

The aim of this review is to investigate paramedics' experiences of using PPE in order to better understand factors contributing to their non-adherence of PPE policy.

A preliminary literature search highlighted a dearth of evidence on this so the population was expanded to explore frontline health professionals' experiences of using PPE. Frontline was defined as working in patient-facing roles in critical care units, emergency departments or ambulance services.

Prehospital care poses its own set of unique challenges. However it was felt there were enough similarities with other frontline specialities to warrant their inclusion in this study to address the lack of paramedic-specific literature.

Methods

After a preliminary literature search identified a paucity of literature specifically involving paramedic or prehospital health workers' experiences when using PPE, an adapted literature search exploring frontline health professionals' perspectives was conducted. This involved the use of key words and phrases, boolean operators and MeSH terminology relevant to the topic.

Four databases were searched (*Table 1*): PubMed, CINAHL, Cochrane and Medline. Key search terms included combinations of 'PPE', 'Mask*', 'protective equipment', 'COVID-19', 'SARS-CoV-2', 'corona*', 'healthcare', 'workers', 'professionals', 'frontline', 'ambulance', 'emergency', 'critical care' and 'intensive'.

All literature obtained using the search terms and exclusion criteria below were then subject to title and abstract review to identify papers of relevance. These then underwent further screening by a solo researcher. Duplicates and foreign language papers without a readily available translation were excluded. Appropriate papers were subject to full text review and thematic analysis. Relevant papers were included as part of the review with relevance defined as articles that specifically discussed either experiences of frontline health professionals with PPE or health professionals' non-compliance with PPE. No date parameters were set.

Inclusion criteria

- English language or readily available translation
- Any discussion regarding paramedic, emergency department or critical care health workers' experiences of PPE
- Any focus on non-adherence to PPE in settings related to the frontline.

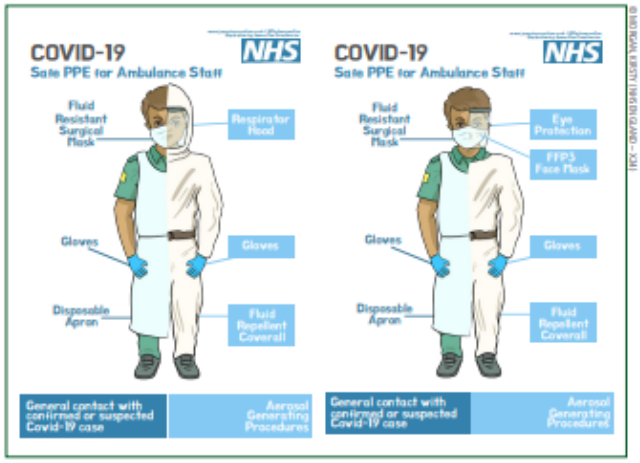


Figure 1. Recommended PPE from East Midlands Ambulance Service NHS Trust issued at the start of the pandemic

Exclusion criteria

- No English language version available
- No discussion regarding paramedic, emergency department or critical care health workers' experiences of PPE
- No focus on non-adherence to PPE in settings related to the frontline.

Results

Thirty-one papers of interest met the inclusion criteria and were included in the review (*Figure 2*; *Table 1*). Systematic literature searching principles were used that were aligned to Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) (Tricco et al, 2018).

Literature that focused on the proposed line of inquiry highlighted in the research questions was analysed, namely frontline health workers' experiences of wearing PPE when caring for patients, with a lens on the reasons behind non-adherence. This enabled identification of themes to be identified to structure the discussion.

Discussion

PPE is vital to counter the transmission of infectious diseases. The image of frontline health professionals caring for COVID-19 patients wearing enhanced PPE has become arguably one of the defining images of the pandemic.

© 2022 MA Healthcare Ltd

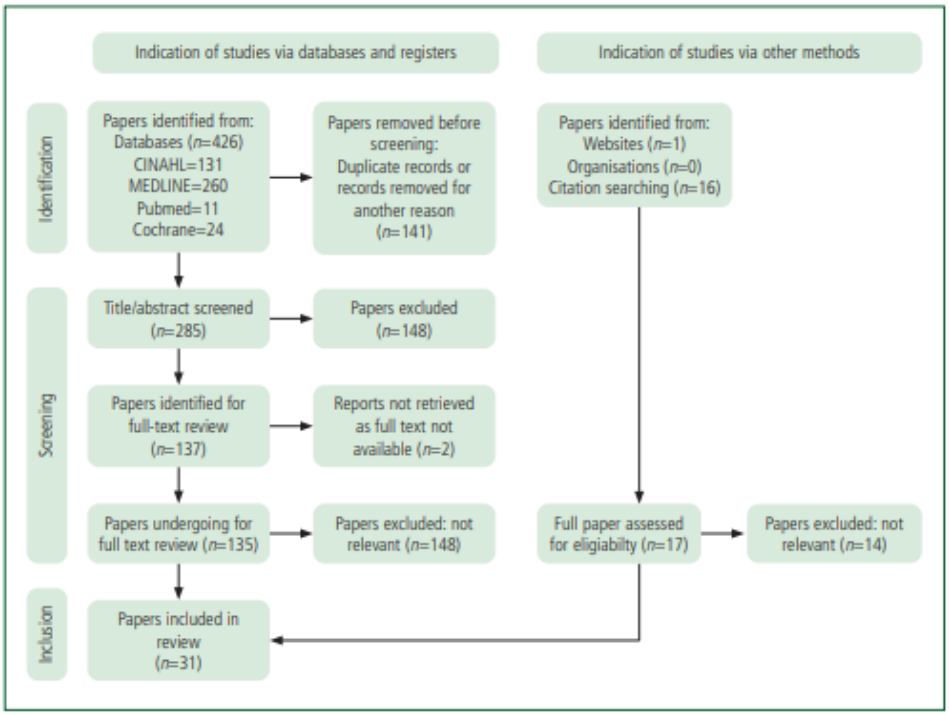


Figure 2. PRISMA diagram of search strategy

Table 1. Results yielded from searches

Source	Results
CINAHL plus	131
Medline	260
PubMed	11
Cochrane	24
Citation searches	16

The use of PPE is not without consequence, however. Themes were identified following review of the literature regarding its effect on physical and emotional wellbeing as well as the impact wearing PPE can have on patient care and clinical effectiveness (*Figure 3*).

Theme 1. Physical and emotional wellbeing

Hoernke et al's (2021) qualitative study investigating frontline healthcare workers' experiences of PPE, perhaps the most relevant article that exists in relation to the clinical questions, offers valuable insight. Data obtained through their semistructured interviews were collected at three stages during the first wave of the COVID-19 pandemic and illustrated the views of health professionals based within the UK. Interview findings were then triangulated with policy and media review literature. The authors grouped their findings into three key themes: 'PPE guidance', 'PPE supply' and 'challenges in care delivery'. Frontline health professionals included in the study had a variety of secondary and primary care roles; however, the sample consisted of predominately doctors based in critical care departments and the perspectives of prehospital health professionals were not captured.

Hoernke et al (2021) found that a lack of clear, consistent PPE guidance resulted in feelings of confusion and mistrust in policies. This ultimately led to health professionals losing confidence in PPE effectiveness. Concern regarding PPE reuse and procurement issues led to health professionals becoming distressed and anxious about passing infection on to family members. Adjectives such as terrified, angry and upset were all associated with health professionals' concerns regarding the lack of PPE available (Gordon et al, 2021).

© 2022 MA Healthcare Ltd

This negative tone towards PPE was echoed in prehospital care. Rees et al (2021) found Welsh paramedics were concerned over being issued inappropriate PPE and confusing guidelines raising anxiety among prehospital staff. Rees et al (2021) used evolved grounded theory to explore Welsh paramedics' experiences in providing care during the pandemic, gaining a broad insight into their experiences over this period. They captured paramedics' feelings of increased anxiety regarding the quality of the PPE being issued and being overwhelmed by numerous changes to clinical guidelines or PPE protocols. However, Rees et al's (2021) study did not focus on PPE's impact but gathered a more general view of pandemic prehospital working.

The sentiment of health professionals who feared infecting loved ones was frequently cited within other qualitative research that explored the experiences of health professionals working in patient-facing roles during the COVID-19 pandemic. Indeed, this was repeatedly highlighted as a key factor influencing an individual's adherence to PPE guidance (Abdel Wahed et al, 2020; Key et al, 2020; Al Muharraq, 2021; Flateau et al, 2021).

More than half of the health professionals questioned in a review of PPE used in Turkish hospitals reported that wearing PPE was associated with increased incidences of sleep disturbance and feelings of being overwhelmed. Stress and anxiety brought on by donning PPE were hypothesised to be a cause of these symptoms and thought to contribute to the high levels of burnout seen in frontline healthcare professionals (Alrawashdeh et al, 2021; Çiriş Yildiz et al, 2022). Çiriş Yildiz et al's (2022) evaluation of PPE's effects on the wearer included 27 paramedics (4.5% of the overall sample).

Gordon et al (2021) captured similar findings in their qualitative study through interviews with critical care nursing staff. Participants attributed anxiety and sleep disturbances to prolonged PPE use, a finding aligned with Swaminathan et al's (2022) survey of hospital-based doctors and nurses, which found PPE was linked to anxiety, depression and somnolence. Their single-centre, cross-sectional study assessed mental and physical wellbeing, using a visual analogue scale, found significant scores of ≥7 or more were reported by 27.8% of respondents regarding PPE-associated anxiety, 19.5% concerning PPE-related depression and 40.3% regarding PPE-attributed somnolence.

The use of enhanced PPE creates practical obstacles to performing simple yet essential tasks such as taking regular toilet breaks, eating or drinking fluids (Paiano et al, 2020; Vindrola-Padros et al, 2020). This is confounded when supply issues cause additional pressures, pushing the wearer to prolong item use because supplies are limited.

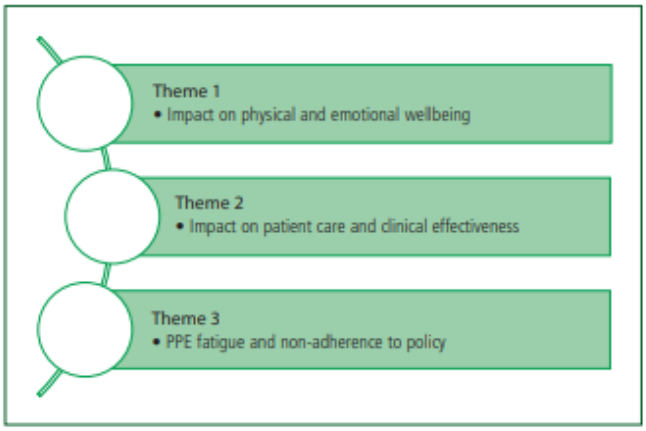


Figure 3. Summary of themes arising from the literature review

The introduction of additional plastic layers on top of clothing, such as hoods and double gowns, can lead to overheating when performing physically demanding tasks such as chest compressions. The PPE used while caring for COVID-19 patients has been reported to have twice the evaporative resistance of scrubs alone, and this is postulated to increase more than tenfold when used in conjunction with sealed head and neck hoods. Prolonged use and physical activity lead to overheating (Messeri et al, 2021).

Health professionals who were fasting during Ramadan reported feeling particularly anxious and vulnerable to adverse events when wearing PPE (Vindrola-Padros et al, 2020). The combination of overheating and restricted oral intake puts health professionals at risk of developing symptoms of dehydration, including headaches, light-headedness and even syncope.

Further adverse effects reported included dyspnoea, hyperthermia and exacerbations of gastrointestinal and skin conditions (Chen et al, 2021a; Gordon et al, 2021; Hoernke et al, 2021; Li et al, 2021).

It has been reported that hospital-based health professionals preferred full-body disposable gowns to plastic aprons because of their perceived breathability (Swaminathan et al, 2022).

Additionally, a survey of hospital-based health professionals in Wuhan, China, found that immediately on doffing PPE, significant numbers reported symptoms of palpitations (27.3%), chest discomfort and shortness of breath (33.0%) or nausea or vomiting (16.8%) (Xia et al, 2020).

The weight and bulky nature of PPE, particularly eye protection and certain respirators, can have

© 2022 MA Healthcare Ltd

implications for the wearer's physical health. Headaches attributed to the tight bands required to maintain an effective seal when using face masks, respirators and goggles have been reported (Chen et al, 2021b). Skin was particularly vulnerable to the adverse effects of prolonged PPE use. Pressure damage to the skin and soft tissues of the face, nose and ears was a common area of concern and frequently reported by health professionals, particularly on social media platforms, after extended periods of PPE use (Coyer et al, 2020).

Retro-auricular pain was reported in 81.8% of 297 health professionals surveyed regarding their PPE experiences in Wuhan (Xia et al, 2020). The effects over time of sweating, pressure and overheating can lead to dermatological conditions such as dermatitis, pruritus, acne, friction burns, dry skin, skin indentation and rashes, with male health professionals more prone to skin erosion than their female counterparts (Xia et al, 2020; Yuan et al, 2021).

Variation in levels of discomfort experienced by health professionals has been found when comparing them by role as well as by sex, with hospital doctors and GPs reporting PPE wearing to be more uncomfortable than other groups of health professionals; prehospital perspectives were not included in this survey (Messeri et al, 2021).

Theme 2. Patient care and clinical effectiveness

The widespread adoption of enhanced PPE across all healthcare settings created barriers to the delivery of patient care (Hoernke et al, 2021). Health professionals reported significant impedance in clinical performance. Examples obtained through qualitative means described several issues.

The application and removal of PPE delayed timely patient care. Double-gloving hindered the identification of subtle signs involved when performing a detailed patient examination, for example when palpating pulses or identifying veins for intravenous cannulation.

Additionally, communication, both verbal and non-verbal, was detrimentally impacted when eye protection fogged, and masks and respirators impeded this (Hoernke et al, 2021). These findings were underpinned by Montgomery et al (2021) and Monzani et al (2020), who conducted qualitative research into critical care staff and paediatric emergency physicians respectively. The detrimental impact of PPE on patient examination and interactions were reiterated, described by Monzani et al (2020) as the biggest challenge facing clinicians.

PPE use impeded teamwork when attempting to identify roles, particularly seniority, during time-critical procedures such as intubation. Fogging of eye protection was highlighted as a common complaint within the literature (Wang et al, 2020; Xia et al, 2020; Swaminathan et al, 2022).

Additionally, PPE reduced manual dexterity, resulting in difficulties when attempting procedures requiring several members of staff, such as proning or rolling patients in critical care units. Health professionals described experiencing diminished senses (Montgomery et al, 2021).

Similarly, Messeri et al (2021), noted prolonged use of headgear was linked to statistically significant impairment of cognitive reasoning.

The nature of respiratory disease requires patients as well as staff to adhere to strict PPE protocols, limiting the ability of clinicians to gauge visual clues as to patients' condition from the end of the bed (Montgomery et al, 2021).

Rao et al (2021) investigated the experiences of health professionals in the US including five paramedics, and found less time was spent with patients to minimise the workers' risks of exposure of COVID-19.

Considering these points alongside the physician's concerns raised in Monzani et al's (2020) study regarding PPE leading to increased framing bias when formulating potential differential diagnoses, as well as Hoernke et al (2021) finding that junior staff were less likely to seek senior advice when in enhanced PPE because they were unable to leave isolation bays, one can envisage how the use of PPE creates an environment ripe for potential diagnostic errors and patient mismanagement.

Communication between patients and health professionals, particularly building the rapport that is crucial for effective care, became depersonalised by the introduction of PPE and was a source of significant frustration to caregivers (Malik et al, 2021; Rao et al, 2021; Shurlock et al, 2021).

Hoernke et al (2021) reported that health professionals felt they were viewed as intimidating to patients when donned in PPE. This was particularly the case with patients who usually rely on lip reading because of a hearing impairment. Similarly, interactions could be disorientating for delirious patients, who previously might have been comforted through non-verbal communication techniques such as hand-holding or facial expressions.

Rao et al (2021) went further by describing a stripping away of a key principle of patient care, namely human interaction, highlighting health professionals' frustrations at not being able to convey empathy or compassion because of PPE blocking their usual means of expressing this. Care would become more paternalistic, with patients often not being involved in discussions regarding

© 2022 MA Healthcare Ltd

their treatment options. Concerningly, health professionals have reported overcoming these frustrations, particularly when breaking bad news, by removing their masks (Rao et al, 2021).

Theme 3. PPE fatigue and non-adherence to PPE protocols

PPE fatigue is a contemporary term coined by the Royal College of Emergency Medicine (RCEM) throughout the initial stages of the pandemic in their safety flash card, which has subsequently been withdrawn. This was designed to help protect health professionals from infection through a visual reminder to maintain high standards regarding personal protection.

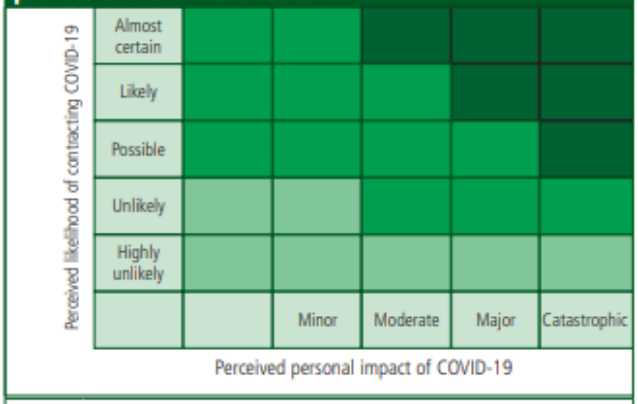
The term subsequently featured on various online articles but is not clearly defined in the reviewed literature. While there is no formal definition of PPE fatigue in the literature, the use of the word 'fatigue' suggests forgetfulness or carelessness through tiredness. The literature investigating health professionals' adherence to PPE echoes this, describing both forgetfulness and carelessness as major contributors to practitioner non-compliance (Neves et al, 2011; Çiriş Yildiz et al, 2022). Increased workloads directly impact health professional fatigue (Chapman et al, 2017). Nursing staff have described how unrealistic workloads had detrimental impacts on adherence to infection control guidelines (Houghton et al, 2020).

Various reasons have been captured within qualitative literature regarding non-adherence to PPE protocols. The literature identified through the search strategy in the present study predominately captured perspectives of hospital-based nursing staff. Discomfort, supply issues and effects on the ability to deliver good-quality patient care were frequently cited as causes for non-compliance (Li et al, 2021, Silverberg et al, 2021, Çiriş Yildiz et al, 2022). Health professionals who found PPE particularly uncomfortable, understandably, chose to wear it for shorter time periods (Li et al, 2021). Health professionals have reported choosing not to use PPE, particularly masks, if they felt it made their patients feel stigmatised or frightened (Houghton et al, 2020).

This could stem in part from an individual's view of personal risk. Perception of risk has been deemed a key aspect in PPE compliance, with concern regarding the protection of family members being a motivating factor (Neves et al, 2011).

Risk matrices are used within NHS organisations to illustrate, identify and evaluate risk. A proposed matrix regarding health professionals' assessment of their own risk regarding COVID-19 and their probability to adhere to PPE guidelines was generated by the lead author, giving consideration to the points raised within this review (*Table 2*).

Table 2. Proposed risk matrix relevant to health professionals' adherence to PPE



Key	
	Highly likely to adhere to PPE protocols
	Likely will adhere most of the time
	Might frequently not adhere

Using tools such as this during performance reviews could enable health professionals with a low personal perception of their own risk to be identified and aid delivery of more targeted educational programmes.

The concepts on which the matrix is based are supported by evidence (albeit limited) showing that non-adherence to PPE can arise from knowledge gaps or a lack of belief in its effectiveness (Haji et al, 2020; Houghton et al, 2020).

Ultimately, behaviour—particularly in healthcare settings—can be habitual. In a Vietnamese study, more than half of health professionals sampled reported finding modifications to their methods of working because of COVID-19 too difficult to maintain in the long term (Tien et al, 2021).

Finally, this review identified points regarding cultural influences within organisations, with staff who saw colleagues repeatedly maintaining high standards or who felt supported by managers more likely to maintain adherence to PPE policy (Houghton et al, 2020).

Conclusion

There is a clear paucity of literature specifically exploring the experiences of UK paramedics when using PPE. No evidence was found relating to this population or the reasons behind non-adherence. Looking more broadly to include other frontline health professionals shows there is a dearth of evidence on this matter.

© 2022 MA Healthcare Ltd

Key Points

- Healthcare workers found their physical and mental wellbeing affected by the use of personal protective equipment (PPE)
- PPE acted as a barrier to effective communication, impeding both verbal and non-verbal communication
- Healthcare workers suspect patient care to be negatively impacted by PPE
- An individual's perception of their own risk could influence their likelihood of adherence to PPE guidelines

Understanding the experiences of practitioners working in other healthcare settings can help to illustrate paramedics' experiences working in this new, challenging environment. However, the unique nature of prehospital healthcare means that, to properly understand how PPE has impacted paramedics, further research is required.

There is no current formal understanding of non-adherence to PPE policies, particularly regarding paramedics. The limited literature available consists of anecdotal reports and hypotheses that are not evidence-based.

Common themes emerged on analysis of broader contextual data showing PPE to affect both caregiver and care recipient negatively, causing detriment to their physical and emotional health as well as to the quality of care provided.

Further research is needed to explore paramedics' experiences of non-adherence specifically to fill the existing gaps in knowledge on this topic. JPP

Conflict of interest: None.

References

Abdel Wahed WY, Hefzy EM, Ahmed MI, Hamed NS. Assessment of knowledge, attitudes, and perception of health care workers regarding COVID-19, a cross-sectional study from Egypt. J Community Health. 2020;45(6):1242–1251. https://doi.org/10.1007/s10900-020-00882-0

Al Muharraq EH. The psychological impact of coronavirus disease 2019 on nurses in Saudi Arabia and their coping strategies. SAGE Open Nurs. 2021;7:1–10. https://doi.org/10.1177/23779608211011322

Alrawashdeh HM, Al-Tammemi AB, Alzawahreh MK et al. Occupational burnout and job satisfaction among physicians in times of COVID-19 crisis: a convergent parallel mixed-method study. BMC Public Health. 2021;21(1):811. https://doi.org/10.1186/s12889-021-10897-4

Atzrodt CL, Maknojia I, McCarthy RDP et al. A guide to COVID-19: a global pandemic caused by the novel coronavirus SARS-CoV-2. FEBS J. 2020;287(17):3633–3650. https://doi.org/10.1111/febs.15375

Chapman HJ, Veras-Estévez BA, Pomeranz JL, Pérez-Then EN, Marcelino B, Lauzardo M. Perceived barriers to adherence to tuberculosis infection control measures among health care workers in the Dominican Republic. MEDICC Rev. 2017;19(1):16–22. https://doi.org/10.37757/MR2017.V19.N1.4

Chen CH, Yang PH, Kuo FL, Yeh IJ, Su CY. Experience of 2003 SARS has a negative psychological impact on healthcare workers in the COVID-19 pandemic: a cross-sectional study. Sao Paulo Med J. 2021a;139(1):65–71. https://doi.org/10.1590/1516-3180.2020.0516.r1.10122020

Chen F, Zang Y, Liu Y, Wang X, Lin X. Dispatched nurses' experience of wearing full gear personal protective equipment to care for COVID-19 patients in China—a descriptive qualitative study. J Clin Nurs. 2021b;30(13–14):2001–2014. https://doi.org/10.1111/jocn.15753

Çiriş Yildiz C, Ulaşli Kahan H, Tanriverdi FŞ. COVID-19 pandemic and personal protective equipment: Evaluation of equipment comfort and user attitude. Arch Environ Occup Health. 2022;77(1):1–8. https://doi.org/10.1080/19338244.2020.1828247

Coyer F, Coleman K, Hocking K, Leong T, Levido A, Barakat-Johnson M. Maintaining skin health and integrity for staff wearing personal protective equipment for prolonged periods: a practical tip sheet. Wound Practice and Research. 2020;28(2):75–83. https://doi.org/10.33235/wpr.28.2.75-83

Fink JB, Ehrmann S, Li J et al. Reducing aerosol-related risk of transmission in the era of COVID-19: an interim guidance endorsed by the International Society of Aerosols in Medicine. J Aerosol Med Pulm Drug Deliv. 2020;33(6):300–304. https://doi.org/10.1089/jamp.2020.1615

Flateau C, Noël C, Bonnafoux A, Fuentes E, de Pontfarcy A, Diamantis S. Psychological impact of the SARS-CoV-2 outbreak on the staff of a French hospital. Infect Dis Now. 2021;51(2):187–193. https://doi.org/10.1016/j.idnow.2021.01.007

Gordon JM, Magbee T, Yoder LH. The experiences of critical care nurses caring for patients with COVID-19 during the 2020 pandemic: a qualitative study. Appl Nurs Res. 2021;59:151418. https://doi.org/10.1016/j.apnr.2021.151418

Haji JY, Subramaniam A, Kumar P, Ramanathan K, Rajamani A. State of personal protective equipment practice in Indian intensive care units amidst COVID-19 pandemic: a nationwide survey. Indian J Crit Care Med. 2020;24(9):809–816. https://doi.

CPD Reflection Questions

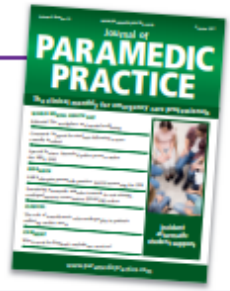
- Reflecting on times you may have experienced non-adherence to personal protective equipment (PPE) guidelines, what factors do you feel contributed to this?
- From your understanding of the transmission of respiratory disease, how does PPE protect both you and the patient?
- Thinking more broadly, COVID-19 aside, what are your feelings regarding PPE use in the future? Does it have a place in protecting health workers and patients from other contagious diseases?

© 2022 MA Healthcare Ltd

org/10.5005/jp-journals-10071-23550
Hoernke K, Djellouli N, Andrews L et al. Frontline healthcare workers' experiences with personal protective equipment during the COVID-19 pandemic in the UK: a rapid qualitative appraisal. BMJ Open. 2021;11(1):e046199. https://doi.org/10.1136/bmjopen-2020-046199
Houghton C, Meskell P, Delaney H et al. Barriers and facilitators to healthcare workers' adherence with infection prevention and control (IPC) guidelines for respiratory infectious diseases: a rapid qualitative evidence synthesis. Cochrane Database Syst Rev. 2020;4(4):CD013582. https://doi.org/10.1002/14651858.CD013582
Key T, Mathai NJ, Venkatesan AS, Farnell D, Mohanty K. Personal protective equipment during the COVID-19 crisis: a snapshot and recommendations from the frontline of a university teaching hospital. Bone Jt Open. 2020;1(5):131–136. https://doi.org/10.1302/2633-1462.15.BJO-2020-0027.R1
Leong YC, Cheskes S, Drennan IR, Buick JE, Latchmansingh RG, Verbeek PR. Clinical considerations for out-of-hospital cardiac arrest management during COVID-19. Resusc Plus. 2020;4:100027. https://doi.org/10.1016/j.resplu.2020.100027
Li F, Jiang T, Shi T et al. Factors that affect the duration of wearing disposable personal protective equipment by healthcare professionals in Wuhan during treatment of COVID-19 patients: an epidemiological study. Nurs Health Sci. 2021;23(1):245–254. https://doi.org/10.1111/nhs.12814
Malik M, Peirce J, Wert MV, Wood C, Burhanullah H, Swartz K. Psychological first aid well-being support rounds for frontline healthcare workers during COVID-19. Front Psychiatry. 2021;12:669009. https://doi.org/10.3389/fpsyt.2021.669009
Messeri A, Bonafede M, Pietrafesa E et al. A web survey to evaluate the thermal stress associated with personal protective equipment among healthcare workers during the Covid-19 pandemic in Italy. Int J Environ Res Public Health. 2021;18(8):3861. https://doi.org/10.3390/ijerph18083861
Montgomery CM, Humphreys S, McCulloch C, Docherty AB, Sturdy S, Pattison N. Critical care work during COVID-19: a qualitative study of staff experiences in the UK. BMJ Open. 2021;11(5):e048124. https://doi.org/10.1136/bmjopen-2020-048124
Monzani A, Ragazzoni L, Della Corte F, Rabbone I, Franc JM. COVID-19 pandemic: perspective from Italian pediatric emergency physicians. Disaster Med Public Health Prep. 2020;14(5):648–651. https://doi.org/10.1017/dmp.2020.198
Neves HC, Souza AC, Medeiros M, Munari DB, Ribeiro LC, Tipple AF. Safety of nursing staff and determinants of adherence to personal protective equipment. Rev Lat Am Enfermagem. 2011;19(2):354–361. https://doi.org/10.1590/S0104-11692011000200018
Paiano M, Jaques AE, Nacamura PAB, Salci MA, Radovanovic CAT, Carreira L. Mental health of healthcare professionals in China during the new coronavirus pandemic: an integrative review. Rev Bras Enferm. 2020;73(suppl 2):e20200338. https://doi.org/10.1590/0034-7167-2020-0338
Rao H, Mancini D, Tong A et al. Frontline interdisciplinary clinician perspectives on caring for patients with COVID-19: a qualitative study. BMJ Open. 2021;11(5):e048712. https://doi.org/10.1136/bmjopen-2021-048712
Rees N, Smythe L, Hogan C, Williams J. Paramedic experiences of providing care in Wales (UK) during the 2020 COVID-19 pandemic (PECC-19): a qualitative study using evolved grounded theory. BMJ Open. 2021;11(6):e048677. https://doi.org/10.1136/bmjopen-2021-048677
Shurlock J, Rudd J, Jeanes A et al. Communication in the intensive care unit during COVID-19: early experience with the Nightingale Communication Method. Int J Qual Health Care. 2021;33(1):mzaa162. https://doi.org/10.1093/intqhc/mzaa162
Silverberg SL, Puchalski Ritchie LM, Gobat N, Murthy S. COVID-19 infection prevention and control procedures and institutional trust: perceptions of Canadian intensive care and emergency department nurses. Can J Anaesth. 2021;68(8):1165–1175. https://doi.org/10.1007/s12630-021-02028-9
Swaminathan R, Mukundadura BP, Prasad S. Impact of enhanced personal protective equipment on the physical and mental well-being of healthcare workers during COVID-19. Postgrad Med J. 2022;98(1157):231–233. https://doi.org/10.1136/postgradmedj-2020-139150
Tien TQ, Tuyet-Hanh TT, Linh TNQ, Hai Phuc H, Van Nhu H. Knowledge, attitudes, and practices regarding COVID-19 prevention among Vietnamese healthcare workers in 2020. Health Serv Insights. 2021;14:11786329211019225. https://doi.org/10.1177/11786329211019225
Tricco AC, Lillie E, Zarin W et al. PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. Ann Int Med. 2018;169(7):P467–473
Vindrola-Padros C, Andrews L, Dowrick A et al. Perceptions and experiences of healthcare workers during the COVID-19 pandemic in the UK. BMJ Open. 2020;10(11):e040503. https://doi.org/10.1136/bmjopen-2020-040503
Wang H, Liu Y, Hu K et al. Healthcare workers' stress when caring for COVID-19 patients: an altruistic perspective. Nurs Ethics. 2020; 27(7):1490–1500. https://doi.org/10.1177/0969733020934146
World Health Organization. Coronavirus disease (COVID-19) pandemic. 2022. https://www.who.int/europe/emergencies/situations/covid-19 (accessed 21 September 2022)
Xia W, Fu L, Liao H, Yang C, Guo H, Bian Z. The physical and psychological effects of personal protective equipment on health care workers in Wuhan, China: a cross-sectional survey study. J Emerg Nurs. 2020;46(6):791–801.e7. https://doi.org/10.1016/j.jen.2020.08.004
Yuan N, Yang WX, Lu JL, Lv ZH. Investigation of adverse reactions in healthcare personnel working in level 3 barrier protection PPE to treat COVID-19. Postgrad Med J. 2021;97(1148):351–354. https://doi.org/10.1136/postgradmedj-2020-137854

Write for IPP

International Paramedic Practice (IPP) is our quarterly online publication targeted at Paramedics around the world. Write to us with your ideas and discuss with the editor how your article might be published in the next issue of IPP.



Journal of Paramedic Practice CPD

jpp@markallengroup.com

© 2022 MA Healthcare Ltd

Appendix 3: Published .pdf of literature review 2

Chest compressions and defibrillation as aerosol-generating procedures

Timothy Ian Millington, Consultant Paramedic, Yorkshire Ambulance Service NHS Trust, Wakefield, UK; University of Hertfordshire, Hatfield, UK; **Robert P Chilcott**, Head of Toxicology, University of Hertfordshire, Hatfield, UK; **Julia Williams**, Professor of Paramedic Science; Associate Dean – Research; University of Hertfordshire, Hatfield, UK. **Email:** Timothy.millington@nhs.net

Abstract

SARS-CoV-2 is a highly contagious respiratory pathogen associated with significant mortality in certain patient populations. Patients may be asymptomatic, which causes problems regarding infection control and prevention. Health professionals are required to adhere to strict protocols regarding infection control and personal protective equipment (PPE), particularly when engaging in resuscitation activities thought to be aerosol-generating procedures (AGPs). While adherence to enhanced PPE protocols can delay life-saving interventions, non-adherence may put responders at risk. The aim of this scoping literature review was to establish if chest compressions and defibrillation should be classified as AGPs. Following application of systematic literature search criteria, a limited selection of studies was identified in relation to chest compressions and defibrillation as AGPs. An assumption that endotracheal intubation posed a high risk of nosocomial transmission was noted. Emerging evidence suggests that endotracheal intubation produces fewer aerosol particles than coughing so could be classed as a low-risk-procedure. Because of the lack of adequate prospective studies investigating chest compressions and defibrillation as AGPs, there is a clear need to perform further, well-controlled studies to better understand the aerosol-generating potential of chest compressions and defibrillation.

Key words

● Chest compressions ● Defibrillation ● Aerosols ● Aerosol-generating procedures ● COVID-19 ● SARS-CoV-2 ● Cardiopulmonary resuscitation ● Transmission ● Nosocomial

Accepted for publication: 15 July 2022

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) belongs to a family of highly contagious respiratory coronaviruses and is associated with high levels of mortality in certain patient populations (Chandrasekharan et al, 2020; Cheruku et al, 2020). Disease presentation, in the form of COVID-19, typically involves cough, pyrexia and dyspnoea; however, symptomology may be highly variable, with asymptomatic patients creating problems regarding infection control and prevention (Atzrodt et al, 2020; Fink et al, 2020). A pandemic was declared by the World Health Organization (WHO) in March 2020 and the resulting global disruption remains ongoing (Kalita et al, 2022). As of 7 July 2022, COVID-19 has been responsible for over 6.8 million deaths worldwide (WHO, 2023).

It is postulated that COVID-19's route of transmission is through respiratory droplets, bioaerosols and fomites (Fink et al, 2020). As a result, health professionals are required to adhere to strict protocols regarding infection control and personal protective equipment (PPE), particularly when in proximity to medical activities thought to be aerosol-generating procedures (AGPs) (Leong et al, 2020). During the early stages of the pandemic, advice issued regarding appropriate levels of PPE was inconsistent (Hoernke et al, 2021).

Definitions of AGPs are often derived from theoretical hypotheses rather than evidence-based quantification, with transmission risk thought to be associated with forced air aerosolising virus-containing moisture within infected airways (Klompas et al, 2021).

Cardiac arrest survival depends upon the effective delivery of rapid, sequential interventions, conceptualised as the chain of survival (Nolan et al, 2006). Basic life support and defibrillation play crucial roles within this approach. Timely administration of chest compressions is promoted in both basic and advanced life support algorithms (Olasveengen et al, 2021; Soar et al, 2021). The intent is to mimic the actions of the heart, affecting intrathoracic pressure in such a way as to manually assist blood flow and sustain some level of end-

© 2023 MA Healthcare Ltd

Downloaded from magonlinelibrary.com by 147.197.131.042 on April 12, 2023.

organ perfusion (Harris et al, 2018; Leong et al, 2020; Soar et al, 2021). Defibrillation concerns the application of an electrical current that acts on the heart to terminate ventricular dysrhythmias not consistent with a perfusing blood pressure. When done promptly, both chest compressions and defibrillation can contribute to survival after cardiac arrest (Nolan et al, 2006; Goyal et al, 2023).

Evidence regarding chest compressions and defibrillation specifically regarding whether they are AGPs is scant, with the limited data available inconclusive. This is partly because the multifaceted nature of resuscitative efforts means drawing specific conclusions is difficult (Couper at al, 2020). Furthermore, there are significant ethical considerations regarding conducting research in this area.

This paucity of literature has led to conflicting guidelines from various professional bodies regarding appropriate levels of PPE required when responding to patients in cardiac arrest, raising ethical and medico-legal questions regarding health professionals' responsibilities (Cheruku et al, 2020; Payne and Peache, 2021; Perkins et al, 2021).

The application of PPE with adherence to enhanced PPE protocols will delay the delivery of life-saving interventions; however, deciding not to use PPE potentially puts the rescuer at risk. COVID-19 infection rates among health professionals remain high despite enhanced PPE protocols and mortality is disproportionately high among health workers compared to the general population (Key et al, 2020; Haji et al, 2020). Clarity regarding AGPs in resuscitation will improve the limited literature regarding this matter and help to inform future healthcare strategies, better protecting health professionals who continue to remain at risk of COVID-19.

Clinical questions

This review aimed to answer the following questions:

- Should chest compressions be classified as an AGP?
- Should defibrillation be classified as an AGP?

Methodology

Scoping reviews offer flexibility when reviewing literature that spans multiple, diverse methodologies and allow a broad overview of a topic to be created. As such, they have been described as an appropriate alternative to traditional systematic reviews when tackling limited evidence obtained using differing methodologies (Peterson et al, 2017; Munn et al, 2018).

A literature search was performed using systematic principles aligned to Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) (Tricco et al, 2018). Five key databases were searched: PubMed, Cumulative Index to Nursing and Allied Health Literature (CINAHL), SCOPUS, the Cochrane Library and MEDLINE. Key search terms included combinations of 'AGP', 'aerosol', 'droplet', 'bioaerosol', 'defib*', 'CPR', 'resus*', 'compression', 'transm*', 'COVID*', 'SARS', 'coronavirus', 'ebola' and 'airborne'. Boolean operators and MeSH terminology were also used.

Identified articles were subject to title and abstract analysis to obtain relevant papers and were screened using inclusion and exclusion criteria. Duplicates and foreign language papers without a translation into English were excluded. The remaining papers then underwent full text review. Relevant papers were included as part of the review with relevance defined as articles that specifically discussed either chest compressions or defibrillation as a source of transmission of disease or potential AGP. Grey literature and searches of reference lists also highlighted papers of interest and were again included for full-text review. Following full analysis, findings were chartered in a table with common findings and themes were colour-coded. All of this was undertaken by a solo researcher.

Inclusion criteria

The following were considered regarding inclusion:

- Any time: no date restrictions were applied after a pilot literature search found research was scarce
- In the English language or with a translation readily available
- Any discussion regarding chest compressions or defibrillation as potential AGPs
- Focus on nosocomial transmission of respiratory disease during resuscitation.

Exclusion criteria

The following exclusion criteria were applied:

- No readily available English language version
- No discussion regarding chest compression or defibrillation as AGP
- No focus on nosocomial transmission.

Results

The search strategy identified 13 papers specifically discussing chest compressions or defibrillation as possible AGPs/sources of nosocomial infection (*Figure 1*). Literature dates ranged from 2004 to 2021 and were predominately retrospective in nature. Only two prospective papers were identified.

© 2023 MA Healthcare Ltd

Downloaded from magonlinelibrary.com by 147.197.131.042 on April 12, 2023.

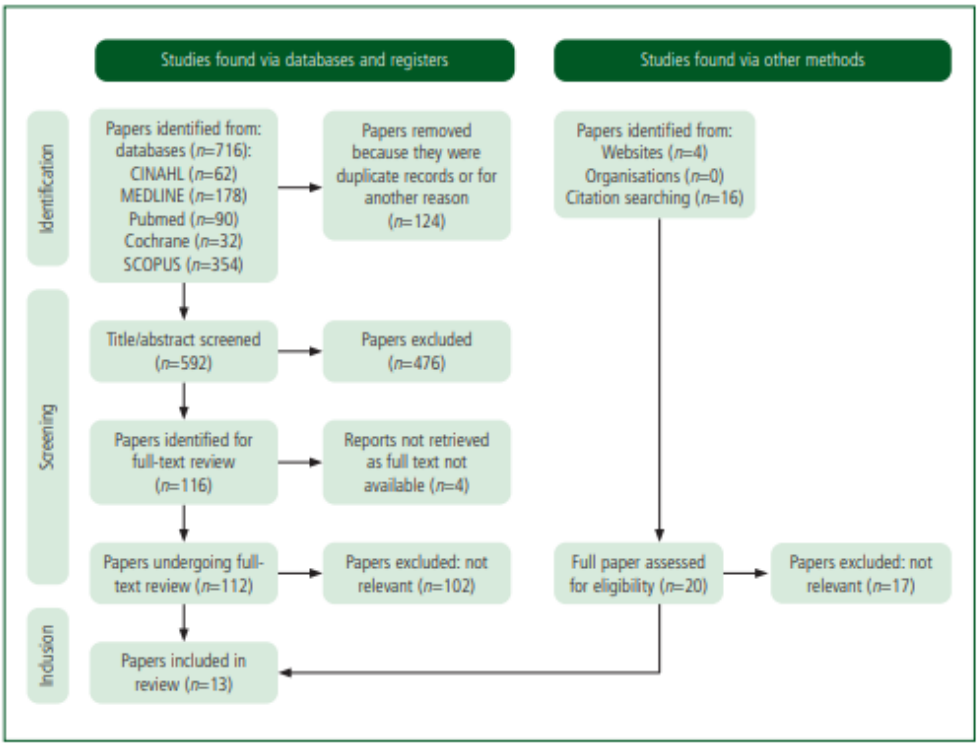


Figure 1. PRISMA–ScR search results (Tricco et al, 2018)

Evidence identified through the search criteria consisted of case reviews, retrospective cohort studies and systematic reviews (*Table 1*).

Case study and retrospective cohort study data showed that SARS-CoV-2 was not the first coronavirus to present a threat to health workers treating critically ill patients. Similar concerns regarding nosocomial transmission during resuscitation were raised during SARS and Middle East respiratory syndrome (MERS) outbreaks in Canada and Saudi Arabia respectively (Christian et al, 2004; Loeb et al, 2004; Raboud et al, 2010; Nam et al, 2017). Similarly, in an outbreak of severe fever with thrombocytopenia syndrome (not caused by a coronavirus) in South Korea, four out of seven health professionals involved in cardiopulmonary resuscitation (CPR), wearing varying levels of PPE, subsequently contracted the disease (Kim et al, 2015).

The search identified three notable systematic reviews, which were included in this review. A consistent finding across all three was that chest compressions and defibrillation were thought to pose a low risk of transmission of respiratory disease compared to the perceived higher risk procedure of endotracheal intubation (Tran et al, 2012; Brown and Chan, 2020; Couper et al, 2020).

Prospective studies used animal or cadaver models to investigate chest compressions and defibrillation as potential AGPs. A pilot study by Hsu et al (2021a) involved induced cardiac arrest in three Yorkshire swine which then underwent chest compressions and defibrillation while attached to an aerosol analyser. No difference was seen in the level of aerosols generated by chest compressions alone, but significantly larger aerosols were observed immediately after chest compressions were initiated following defibrillation. The limitations of the study design are apparent, particularly with regards to sample size and anatomical differences between pigs and humans. The authors also conceded they had neglected to measure humidity, temperature and air flow, all of which are known to influence aerosol dispersion. Furthermore, the equipment used by Hsu et al (2021a) measured aerosols with particles that measured <10µm, therefore not gaining an understanding of aerosols with larger particles that might be created.

© 2023 MA Healthcare Ltd

Downloaded from magonlinelibrary.com by 147.197.131.042 on April 12, 2023.

Table 1. Results yielded from searches

Author (year) Country	Methodology	Results/outcomes	Chest compressions as an AGP	Defibrillation as an AGP
Loeb et al (2004) Canada	Retrospective cohort study	Three nurses performed chest compressions on SARS patients; none contracted the disease	Low risk	Low risk
Brown and Chan (2020) UK	Literature review	Limited evidence included in the review. Transmission potentially from compressions	Inconclusive	Not investigated
Chalumeau et al (2005) France	Case study	Transmission of Panton-Valentine leukocidin-producing *Staphylococcus aureus* during resuscitation of child to one health professional	Inconclusive	Not investigated
Christian et al (2004) Canada	Case report	One of nine health professionals infected with SARS during resuscitation attempt	Inconclusive: suspected	Not investigated
Liu et al (2009) China	Case control study	Chest compressions associated with increased risk (33%) of health professional SARS infection	Strongly suspected	Not discussed
Raboud et al (2010) Canada	Retrospective cohort study	Twenty-six of 697 health professionals investigated were infected during resuscitation of SARS patients	Potentially high risk	Potentially high risk
Tran et al (2012) Canada	Systematic review	Reviewed evidence of very low quality following GRADE. Intubation associated with transmission. Findings not generalisable	Low risk	Low risk
Kim et al (2015) Korea	Case study	Four out of seven health professionals involved in CPR of patient with severe fever with thrombocytopenia syndrome.	Inconclusive: suspected	Inconclusive; suspected
Nam et al (2017) Korea	Case study	Health professional contraction of MERS during CPR. Exact route of transmission unclear	CPR high risk	Not discussed
Couper et al (2020) UK	Systematic review	Evidence was lacking but significant caution is advised when drawing conclusions	Inconclusive: suspected	Inconclusive: suspected
Jackson et al (2020) UK	Rapid systematic review	89% of literature classified CPR as an AGP, 5% as possibly AGP and 7% as not an AGP	Inconclusive: suspected	Inconclusive: suspected
Ott et al (2020) Germany	Simulation	Chest compression shown as AGP in a mannequin and cadaver model	High risk	Not investigated
Hsu et al (2021a) US	Pilot study: simulated animal model	Chest compressions following defibrillation created increased aerosols. Compressions alone did not	Compressions alone not AGP	Compressions plus defibrillation AGP

Key: evidence for an AGP: green: in favour; red: against; grey: not investigated; pink: inconclusive; blue: inconclusive but suspected AGP
AGP: aerosol-generating procedure; CPR: cardiopulmonary resuscitation; GRADE: Grading of Recommendations, Assessment, Development and Evaluation; MERS: Middle East respiratory syndrome; SARS: severe acute respiratory syndrome

© 2023 MA Healthcare Ltd

Ott et al (2020) concluded that chest compressions were a potential AGP from using ultraviolet-sensitive detergent in their mannequin and cadaver simulation models. Their study design involved filling the lungs and airways of mannequins and cadavers with nebulised detergent, then using periodic, ultraviolet-sensitive photography to track aerosol dispersion during chest compressions. This methodology meant aerosol distribution could be estimated; however, size and quantity were not measurable. Limitations were cited as an inability to translate aerosol

Downloaded from magonlinelibrary.com by 147.197.131.042 on April 12, 2023.

dispersion into risk of infection, likely because of the inability to quantify aerosol volume or mass, as well as man-made aerosols not being truly representative of what might be seen in real life.

Ambiguity of language

Inconsistencies regarding terminology, specifically regarding CPR, were noted.

CPR traditionally comprises chest compressions and assisted ventilations, either via mouth-to-mouth or bag-valve mask ventilations. Guidelines have been adapted to encourage compression-only CPR due to the reluctance of lay people to perform assisted ventilations. Partly due to a lack of understanding of the techniques involved or, more notably, fear of disease transmission through mouth-to-mouth ventilation (Taniguchi et al, 2007)—a fear exacerbated through the pandemic (Bray, 2020).

This ambiguity of language regarding CPR seen throughout the literature meant it was difficult to draw specific conclusions regarding chest compressions as a possible AGP.

Discussion

This review of the limited literature has demonstrated a pressing need for clarity to better understand aerosol production during resuscitation procedures. There was a paucity of evidence regarding chest compressions and defibrillation as potential AGPs, with no study offering definitive, conclusive findings. This dearth of evidence has led to contradictory guidelines being produced, with documented confusion among health professionals and reported feelings of mistrust in policies. The effect is that health professionals could potentially not be complying with PPE guidelines, putting themselves and others at risk (Cheruku et al, 2020; Houghton et al, 2020; Payne and Peache, 2021; Perkins et al, 2021).

Retrospective evidence analysed within this review suggests the risk of contracting respiratory disease through chest compressions and defibrillation is low. However, data contributing to this viewpoint have been demonstrated to be of poor quality in various systematic reviews, with caution repeatedly urged within the literature should one wish to draw definitive conclusions.

Uncertainty has arisen because of the multiple confounding variables and significant biases associated with retrospective data. Resuscitation of patients in cardiac events inevitably involves multiple procedures performed simultaneously, which means that case review data cannot be used to pinpoint the specific point of nosocomial transmission.

A general assumption exists within literature that nosocomial transmission in a resuscitative attempt originates from being in close proximity to the airway, with transmission often presumed to be a result of endotracheal intubation, which is perceived as a high-risk procedure (Tran et al, 2012; Brown and Chan, 2020; Couper et al, 2020).

Emerging literature casts doubt on the validity of this assumption. Recently published quantitative studies have shown elective intubation to produce very few aerosols—significantly fewer than coughing (Brown et al, 2021). Similar findings have been demonstrated during insertion and removal of supraglottic airways (Shrimpton et al, 2021). These findings have led to calls for reviews of which procedures should be defined as an AGP. When considering these findings in relation to prehospital working, a point of consideration in both studies is the environment in which the investigated intervention occurred.

Both Brown et al (2021) and Shrimpton et al (2021) investigated aerosol production in the controlled environment of hospital theatres. Routine practice would involve prior assessment and grading of airways. Similarly, patients would be fully anaesthetised, making no respiratory effort and kept nil by mouth before the procedure. In the case of Shrimpton et al (2021), patients with difficult airways were excluded from the study. These safety and screening measures would not be afforded to the prehospital rescuer. Prehospital patients do not present fully anaesthetised so could potentially make a respiratory effort at any moment, further complicating matters. As such, this is an area that would benefit from further investigation.

No studies were identified that had attempted to record real-time aerosol data during active emergency resuscitation in human subjects and very little data exist investigating size, volume or distribution of aerosols generated by these procedures. The two prospective studies identified via the search strategy suggest chest compressions and defibrillation are potential AGPs. However, both were subject to significant limitations. Although innovative in their study design, the use of small sample sizes impacted their findings. Methodological techniques that were not reflective of true resuscitative events meant that generalised conclusions were impossible. Both studies conceded this point, highlighting the need for further research (Ott et al, 2020; Hsu et al, 2021a).

With no definitive, evidence-based answer regarding defibrillation or chest compressions being aerosol generating or, more importantly, whether these procedures pose a risk of transmission of respiratory disease to health professionals, one must consider their respective risk in relation to the nature of respiratory viral transmission and aerosol production.

© 2023 MA Healthcare Ltd

Downloaded from magonlinelibrary.com by 147.197.131.042 on April 12, 2023.

Respiratory aerosol particles and droplets have historically been defined as being under 5µm and droplets exceeding this are arbitrarily cut off. Droplets follow a ballistic trajectory whereas aerosols remain suspended in the air, akin to smoke. It has since emerged, through advances in aerosol-measuring technology, that this might be over simplistic. Particles of up to 100µm have been found to remain suspended in air for up to 5 seconds. SARS-CoV-2 measures approximately 0.1µm, with aerosol particles of under 5µm or more able to carry virions (Bar-On et al, 2020; Lee, 2020; Wang et al, 2021). These measurements have implications when considering what appropriate levels of PPE would be.

People create respiratory particles, both droplets and aerosols, through the turbulence of exhaled air passing over moist, mucous-lined airways. This air force liberates aerosols that are then exhaled, coughed or sneezed from the airway (Edwards et al, 2021). Once aerosolised, particles are then subject to the effects of temperature and humidity, which can further alter their size and aerodynamic properties, as does the speed at which they leave the airway (Drossinos et al, 2021; Klompas et al, 2021).

Physiological conditions that alter the surface tension and viscoelasticity of the mucous-lined airways can increase the propensity for respiratory particle generation, in which surfactant properties play a crucial role. Factors such as age, weight, diet and COVID-19 infection can change lung surfactant properties and lead to a greater production of droplets and aerosols (Edwards et al, 2021). The force of compressing a patient's chest to manually affect intrathoracic pressure, as seen during chest compressions, has been demonstrated to create an expiratory passive tidal volume as high as 45.8ml (McDannold et al, 2018). Similarly, defibrillation causes a violent muscular contraction. One can thus see how chest compressions or defibrillation might lead to production of respiratory aerosols and be a risk factor in the transmission of respiratory disease.

On 28 September 2021, Public Health England (PHE) released its updated interpretation of the New and Emerging Respiratory Virus Threats Advisory Group (NERVTAG) review, examining the evidence regarding chest compressions and defibrillation as AGPs. This was reviewed on 14 April 2022 but later withdrawn in May 2022. Within this document PHE published the following quote from NERVTAG:

'It is biologically plausible that chest compressions could generate an aerosol, but only in the same way that an exhalation breath would do. No other mechanism exists to generate an aerosol other than compressing the chest and an expiration breath, much like a cough, is not currently recognised as a high-risk event or an AGP.' (PHE, 2022)

Table 2. World Health Organization list of aerosol-generating procedures

Medical	Dental
Tracheal intubation	Any procedure involving spray-generating equipment e.g. three-way air/water spray and dental cleaning
Non-invasive ventilation (bilevel positive airway pressure/continuous positive airway pressure)	Tooth polishing
Tracheotomy	Periodontal treatment using ultrasonic scaler
Cardiopulmonary resuscitation	Procedures involving high- or low-speed handpieces
Manual ventilation before intubation	Direct or indirect restoration and polishing
Bronchoscopy	Cementation of crowns or bridges
Sputum induction using nebulised hypertonic saline	Mechanical endodontic treatment
Autopsy procedures	Surgical tooth extractions and implant placement

Source: World Health Organization (2021)

This is caveated with a suggestion that health organisations may wish to use higher levels of PPE for staff tasked with the delivery of chest compressions. PHE has since been replaced by the UK Health Security Agency and Office for Health Improvement and Disparities. More recently, NHS England (NHSE) published a rapid review of AGPs in June 2022, in which chest compressions or defibrillation are not mentioned (NHSE, 2022). Interestingly the Resuscitation Council UK (RCUK) advised members of the public to not delay chest compressions on out-of-hospital cardiac arrest patients. Both RCUK and the Royal College of Nursing (RCN) advocate higher levels of PPE (FFP3 masks or respirators) for health care workers performing chest compressions for suspected or confirmed COVID-19 (RCUK, 2022; RCN, 2023). The RCN takes a different stance with regards to how it advises its members when faced with cardiac arrest patients outside of hospital.

'…conduct a risk assessment and use their professional judgement to decide whether or not to provide Basic Life Support CPR; taking

© 2023 MA Healthcare Ltd

Downloaded from magonlinelibrary.com by 147.197.131.042 on April 12, 2023.

Key Points

- There is very limited evidence available regarding chest compressions and defibrillation as potential aerosol-generating procedures (AGPs)
- Health organisations disagree over whether chest compressions are AGPs
- Evidence suggests the physiological mechanism involved in both chest compression and defibrillation could plausibly increase respiratory aerosols
- There is urgent need for future studies investigating procedures of resuscitation as AGPs

into consideration the individual needing CPR, the current situation, the environment and their own safety, local policy, and any knowledge of the individual.' (RCN, 2023)

Similarly, the American Heart Association (Hsu et al, 2021b), in an attempt to address rising mortality rates seen in patients experiencing an out-of-hospital cardiac arrest, recommend there be no delay in compression or defibrillation in regions where vaccinations have been widely distributed. This is in contrast to the WHO's (2021) stance; CPR remains on its list of AGPs, alongside tracheal intubation, manual ventilation and non-invasive ventilation. *Table 2* shows the WHO's (2021) full list of AGPs.

Without formal quantification of aerosols during real-time resuscitation with a focus on chest compressions and defibrillation specifically, disagreement and debate regarding the most appropriate course of action will remain.

Conclusions

The evidence base regarding chest compressions and defibrillation as possible AGPs is highly limited and subject to multiple confounding factors and biases. Literature suggests chest compressions and defibrillation to be of low risk of transmission of respiratory diseases. This is partly because, during a cardiac arrest, these procedures occur simultaneously to the perceived high-risk procedures associated with airway management.

Literature repeatedly theorises the origin of nosocomial transmission during a resuscitation attempt to be airway management procedures, specifically endotracheal intubation. Emerging evidence in controlled hospital settings suggests elective intubation and supraglottic airway insertion might not be as high risk as initially thought, generating fewer aerosols than coughing (Brown et al, 2021; Klompas et al, 2021; Shrimpton et al, 2021).

It is a recommendation from this review that urgent research is carried out to establish which procedures of resuscitation generate aerosols, with clarity required regarding chest compressions and defibrillation, specifically to reassure rescuers and benefit patients in cardiac arrest. JPP

Conflict of interest: The author is part of a trial entitled STOPGAP: STudy Of cardioPulmonary resuscitation activities thought to Generate Aerosol Particles

References

Atzrodt CL, Maknojia I, McCarthy RDP et al. A guide to COVID-19: a global pandemic caused by the novel coronavirus SARS-CoV-2. FEBS J. 2020;287(17):3633–3650. https://doi.org/10.1111/febs.15375

Bar-On YM, Flamholz A, Phillips R, Milo R. Science forum: SARS-CoV-2 (COVID-19) by the numbers. Elife. 2020;9:e57309. https://doi.org/10.7554/eLife.57309

Bray J. Bystander CPR in the COVID-19 pandemic. Resus Plus. 2020. https://doi.org/10.1016/j.resplu.2020.100041

Brown E, Chan LM. Should chest compressions be considered an aerosol-generating procedure? A literature review in response to recent guidelines on personal protective equipment for patients with suspected COVID-19. Clin Med (Lond). 2020; 20(5):e154–e159. https://doi.org/10.7861/clinmed.2020-0258

Brown J, Gregson FKA, Shrimpton A et al. A quantitative evaluation of aerosol generation during tracheal intubation and extubation. Anaesthesia. 2021;76(2):174–181. https://doi.org/10.1111/anae.15292

Chalumeau M, Bidet P, Lina G et al. Transmission of Panton-Valentine leukocidin-producing Staphylococcus aureus to a physician during resuscitation of a child. Clin Infect Dis. 2005;41(3):e29–30. https://doi.org/10.1086/431762

Chandrasekharan P, Vento M, Trevisanuto D et al. Neonatal resuscitation and postresuscitation care of infants born to mothers with suspected or confirmed SARS-CoV-2 infection. Am J Perinatol. 2020;37(8):813–824. https://doi.org/10.1055/s-0040-1709688

Cheruku S, Dave S, Goff K et al. Cardiopulmonary

CPD Reflection Questions

- Considering the size of aerosol particles discussed in this review, what are the implications with respect to personal protective equipment?
- Which procedures of resuscitation do you feel pose the greatest risk and why?
- Given current knowledge, do you feel chest compressions should be considered an aerosol-generating procedure? What is your rationale?

© 2023 MA Healthcare Ltd

Downloaded from magonlinelibrary.com by 147.197.131.042 on April 12, 2023.

resuscitation in intensive care unit patients with coronavirus disease 2019. J Cardiothorac Vasc Anesth. 2020;34(10):2595–2603. https://doi.org/10.1053/j.jvca.2020.06.008

Christian MD, Loutfy M, McDonald LC et al. Possible SARS coronavirus transmission during cardiopulmonary resuscitation. Emerg Infect Dis. 2004;10(2):287–293. https://doi.org/10.3201/eid1002.030700

Couper K, Taylor-Phillips S, Grove A et al. COVID-19 in cardiac arrest and infection risk to rescuers: a systematic review. Resuscitation. 2020;151:59–66. https://doi.org/10.1016/j.resuscitation.2020.04.022

Drossinos Y, Weber TP, Stilianakis NI. Droplets and aerosols: an artificial dichotomy in respiratory virus transmission. Health Sci Rep. 2021;4(2):e275. https://doi.org/10.1002/hsr2.275

Edwards DA, Ausiello D, Salzman J et al. Exhaled aerosol increases with COVID-19 infection, age, and obesity. Proc Natl Acad Sci U S A. 2021;118(8):e2021830118. https://doi.org/10.1073/pnas.2021830118. Erratum in: Proc Natl Acad Sci U S A. 2021;118(27)

Fink JB, Ehrmann S, Li J et al. Reducing aerosol-related risk of transmission in the era of COVID-19: an interim guidance endorsed by the international society of aerosols in medicine. J Aerosol Med Pulm Drug Deliv. 2020;33(6):300–304. https://doi.org/10.1089/jamp.2020.1615

Goyal A, Chhabra L, Sciammarella JC et al. Defibrillation. Treasure Island (FL): StatPearls Publishing. 2023. https://www.ncbi.nlm.nih.gov/books/NBK499899/ (accessed 8 March 2023)

Haji JY, Subramaniam A, Kumar P, Ramanathan K, Rajamani A. State of personal protective equipment practice in Indian intensive care units amidst COVID-19 pandemic: a nationwide survey. Indian J Crit Care Med. 2020;24(9):809–816. https://doi.org/10.5005/jp-journals-10071-23550

Harris AW, Kudenchuk PJ. Cardiopulmonary resuscitation: the science behind the hands. Heart. 2018;104(13):1056–1061. https://doi.org/10.1136/heartjnl-2017-312696

Hoernke K, Djellouli N, Andrews L et al. Frontline healthcare workers' experiences with personal protective equipment during the COVID-19 pandemic in the UK: a rapid qualitative appraisal. BMJ Open. 2021;11(1):e046199. https://doi.org/10.1136/bmjopen-2020-046199

Houghton C, Meskell P, Delaney H et al. Barriers and facilitators to healthcare workers' adherence with infection prevention and control (IPC) guidelines for respiratory infectious diseases: a rapid qualitative evidence synthesis. Cochrane Database Syst Rev. 2020;4(4):CD013582. https://doi.org/10.1002/14651858.CD013582

Hsu CH, Tiba MH, Boehman AL et al. Aerosol generation during chest compression and defibrillation in a swine cardiac arrest model. Resuscitation. 2021a;159:28–34. https://doi.org/10.1016/j.resuscitation.2020.12.004

Hsu A, Sasson C, Kudenchuk PJ et al. 2021 interim guidance to health care providers for basic and advanced cardiac life support in adults, children, and neonates with suspected or confirmed COVID-19. Circ Cardiovasc Qual Outcomes. 2021b;14(10):e008396. https://doi.org/10.1161/CIRCOUTCOMES.121.008396

Jackson T, Deibert D, Wyatt G et al. Classification of aerosol-generating procedures: a rapid systematic review. BMJ Open Respir Res. 2020;7(1):e000730. https://doi.org/10.1136/bmjresp-2020-000730

Kalita S, Gogoi B, Khaund G et al. Optimizing airway surgery in COVID 19 era. Indian J Otolaryngol Head Neck Surg. 2022; 74(suppl 2):3370–3377. https://doi.org/10.1007/s12070-020-02326-6

Key T, Mathai NJ, Venkatesan AS, Farnell D, Mohanty K. Personal protective equipment during the COVID-19 crisis: a snapshot and recommendations from the frontline of a university teaching hospital. Bone Jt Open. 2020;1(5):131–136. https://doi.org/10.1302/2633-1462.15.BJO-2020-0027.R1

Kim WY, Choi W, Park SW et al. Nosocomial transmission of severe fever with thrombocytopenia syndrome in Korea. Clin Infect Dis. 2015;60(11):1681–1683. https://doi.org/10.1093/cid/civ128

Klompas M, Baker M, Rhee C. What is an aerosol-generating procedure? JAMA Surg. 2021;156(2):113–114. https://doi.org/10.1001/jamasurg.2020.6643

Laue M, Kauter A, Hoffmann T, Möller L, Michel J, Nitsche A. Morphometry of SARS-CoV and SARS-CoV-2 particles in ultrathin plastic sections of infected Vero cell cultures. Sci Rep. 2021;11(1):3515. https://doi.org/10.1038/s41598-021-82852-7

Lee BU. Minimum sizes of respiratory particles carrying SARS-CoV-2 and the possibility of aerosol generation. Int J Environ Res Public Health. 2020;17(19):6960. https://doi.org/10.3390/ijerph17196960. Erratum in: Int J Environ Res Public Health. 2021;18(22)

Liu E, Tang F, Fang LQ et al. Risk factors for SARS infection among hospital healthcare workers in Beijing: a case control study. Trop Med Int Health 2009;14(suppl 1):52–59

Leong YC, Cheskes S, Drennan IR, Buick JE, Latchmansingh RG, Verbeek PR. Clinical considerations for out-of-hospital cardiac arrest management during COVID-19. Resusc Plus. 2020;4: 100027. https://doi.org/10.1016/j.resplu.2020.100027

Loeb M, McGeer A, Henry B et al. SARS among critical care nurses, Toronto. Emerg Infect Dis. 2004;10(2):251–255. https://doi.org/10.3201/eid1002.030838

McDannold R, Bobrow BJ, Chikani V, Silver A, Spaite DW, Vadeboncoeur T. Quantification of ventilation volumes produced by compressions during emergency department cardiopulmonary resuscitation. Am J Emerg Med. 2018;36(9):1640–1644. https://doi.org/10.1016/j.ajem.2018.06.057

Munn Z, Peters MDJ, Stern C, Tufanaru C, McArthur A, Aromataris E. Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. BMC Med Res Methodol. 2018;18(1):143. https://doi.org/10.1186/s12874-018-0611-x

NHS England. A rapid review of aerosol generating procedures (AGPs). A rapid review of aerosol generating procedures (AGPs). 2022. https://tinyurl.com/mry9trkj (accessed 24 March 2023)

Nam HS, Yeon MY, Park JW, Hong JY, Son JW. Healthcare worker infected with Middle East Respiratory Syndrome during cardiopulmonary resuscitation in Korea, 2015. Epidemiol Health. 2017;39:e2017052. https://doi.org/10.4178/epih.e2017052

Nolan J, Soar J, Eikeland H. The chain of survival. Resuscitation. 2006;71(3):270–271. https://doi.org/10.1016/j.resuscitation.2006.09.001

Olasveengen TM, Semeraro F, Ristagno G et al. European Resuscitation Council Guidelines 2021: basic life support. Resuscitation. 2021;161:98–114. https://doi.org/10.1016/j.resuscitation.2021.02.009

Ott M, Milazzo A, Liebau S, Jaki C, Schilling T, Krohn A, Heymer J. Exploration of strategies to reduce aerosol-spread during chest compressions: a simulation and cadaver model. Resuscitation. 2020;152:192–198. https://doi.org/10.1016/j.resuscitation.2020.05.012

Payne D, Peache M. Aerosol-generating procedures in home care. Br J Community Nurs. 2021;26(2):76–80. https://doi.org/10.12968/bjcn.2021.26.2.76

Perkins J, Hamilton M, Canniff C et al. Resuscitation during the pandemic: optional obligation? Or supererogation? Clin Ethics. 2021;16(2):74–80. https://doi.org/10.1177/1477750920946684

Peterson J, Pearce PF, Ferguson LA, Langford CA. Understanding scoping reviews: definition, purpose, and

© 2023 MA Healthcare Ltd

Downloaded from magonlinelibrary.com by 147.197.131.042 on April 12, 2023.

process. J Am Assoc Nurse Pract. 2017;29(1):12–16. https://doi.org/10.1002/2327-6924.12380

Public Health England. PHE statement regarding NERVTAG review and consensus on cardiopulmonary resuscitation as an aerosol generating procedure (AGP). 2022. https://tinyurl.com/yhaesxn3 (accessed 8 March 2023)

Raboud J, Shigayeva A, McGeer A et al. Risk factors for SARS transmission from patients requiring intubation: a multicentre investigation in Toronto, Canada. PLoS One. 2010;5(5):e10717. https://doi.org/10.1371/journal.pone.0010717

Resuscitation Council UK. Guidance: COVID-19. 2022. https://www.resus.org.uk/library/additional-guidance/ (accessed 24 March 2023)

Royal College of Nursing. Personal protective equipment (PPE) and COVID-19. 2023. https://tinyurl.com/3v77nwu5 (accessed 24 March 2023)

Shrimpton AJ, Gregson FKA, Brown JM et al. A quantitative evaluation of aerosol generation during supraglottic airway insertion and removal. Anaesthesia. 2021;76(12):1577–1584. https://doi.org/10.1111/anae.15542

Soar J, Böttiger BW, Carli P et al. European Resuscitation Council Guidelines 2021: adult advanced life support. Resuscitation. 2021;161:115–151. https://doi.org/10.1016/j.resuscitation.2021.02.010. Erratum in: Resuscitation. 2021;167:105–106

Taniguchi T, Omi W, Inaba H. Attitudes toward the performance of bystander cardiopulmonary resuscitation in Japan. Resuscitation. 2007;75(1):82–87

Tran K, Cimon K, Severn M, Pessoa-Silva CL, Conly J. Aerosol generating procedures and risk of transmission of acute respiratory infections to healthcare workers: a systematic review. PLoS One. 2012;7(4):e35797. https://doi.org/10.1371/journal.pone.0035797

Tricco AC, Lillie E, Zarin W et al. PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. Ann Intern Med. 2018;169(7):467–473. https://doi.org/10.7326/M18-0850

Wang CC, Prather KA, Sznitman J et al. Airborne transmission of respiratory viruses. Science. 2021;373(6558):eabd9149. https://doi.org/10.1126/science.abd9149

World Health Organization. Infection prevention and control during health care when coronavirus disease (COVID-19) is suspected or confirmed. Interim guidance. 2021. https://tinyurl.com/27rsya3k (8 March 2023

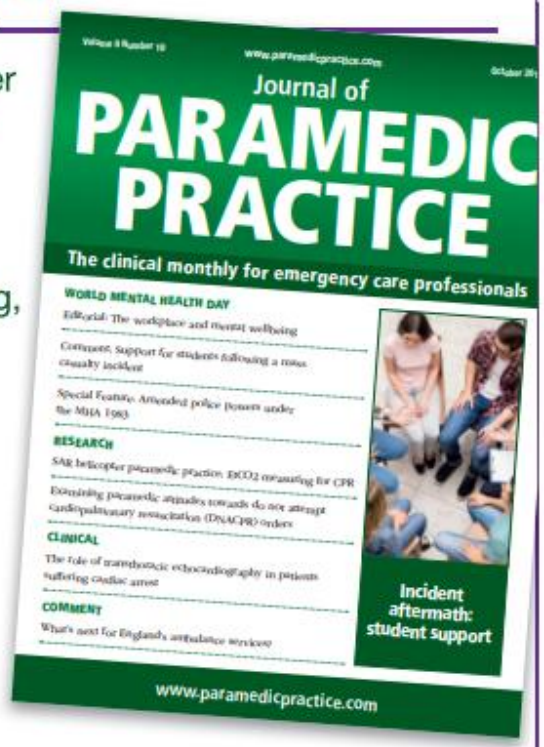
World Health Organization. WHO Coronavirus (COVID-19) Dashboard. 2023. https://covid19.who.int/ (8 March 2023)

Become a Reviewer

The JPP is seeking dedicated peer reviewers to provide constructive feedback on articles submitted across a variety of areas in paramedic practice. If you have experience reviewing or publishing, and would like to be considered for the JPP Review Panel, email the editor with your CV and register your interest.

jpp@markallengroup.com

Journal of PARAMEDIC PRACTICE CPD



© 2023 MA Healthcare Ltd

Downloaded from magonlinelibrary.com by 147.197.131.042 on April 12, 2023.

Appendix 4: Literature Review 2: Data Extraction Table

Author / Year	Country / Setting	Design / Sample	Participants	Key findings	Critique / Limitations
Loeb et al., 2004	Canada / Hospital (SARS)	Retrospective cohort	Critical care nurses	No infections after compressions; suggests low transmission risk	Retrospective; confounded by airway procedures; unclear exposure pathways
Brown & Chan, 2020	UK / Global evidence	Narrative review	N/A	Suggests possible transmission during CPR; limited evidence	Non-systematic; weak underlying evidence; cannot isolate CPR effects
Chalumeau et al., 2005	France / Paediatric ED	Case study	Single physician	Transmission of S. aureus during CPR	Single case; non-viral pathogen; no AGP measurement
Christian et al., 2004	Canada / Hospital (SARS)	Case report	Mixed clinicians (n=9)	One infection during CPR event	Retrospective, likely due to ETT
Liu et al., 2009	China / SARS hospitals	Case-control	Hospital HCWs	Chest compressions associated with higher infection odds	Recall bias; simultaneous airway procedures; non-UK setting
Raboud et al., 2010	Canada / SARS	Retrospective cohort	697 HCWs	26 infections associated with resuscitation activities	Confounded by intubation; documentation gaps; cannot isolate compressions
Tran et al., 2012	Canada / Multisite	Systematic review	Hospital HCWs	Low-quality evidence; CPR low certainty; intubation highest risk	Very weak primary studies; outdated PPE contexts; no prehospital relevance
Kim et al., 2015	Korea / SFTS outbreak	Case report	7 clinicians	Four clinicians infected during CPR	Non-coronavirus; unclear route; mixed PPE; no aerosol measurement
Nam et al., 2017	Korea / Hospital (MERS)	Case report	Single clinician	Infection occurred during CPR	Single case; cannot attribute to compressions; low generalisability
Couper et al., 2020	UK / Global COVID-19 evidence	Systematic review	Hospital HCWs	Evidence inconclusive; CPR classified as 'suspected' AGP	Weak evidence base; multiple confounders; no prospective studies
Jackson et al., 2020	UK / Global	Rapid systematic review	Mixed clinicians	CPR widely classified as AGP across literature	Rapid methods; included opinion pieces
Ott et al., 2020	Germany / Simulation + cadaver	Experimental	Mannequin + cadaver	Compressions caused fluorescent aerosol spread	Artificial conditions; poor ecological validity
Loeb et al., 2004	Canada / Hospital (SARS)	Retrospective cohort	Critical care nurses	No infections after compressions; suggests low transmission risk	Retrospective; confounded by airway procedures; unclear exposure pathways

Appendix 5: Literature Review 1: Data Extraction table

Author / Year	Country / Setting	Design & Sample	Participants	Key findings	Critique / Limitations
Hoernke et al., 2021	UK, frontline hospital	Rapid qualitative appraisal; n=159	ED staff; doctors, nurses	Confusion around PPE guidance; anxiety; supply issues	No paramedics; rapid design; UK-only
Rees et al., 2021	Wales, UK / ambulance service	Grounded theory; n=20	Paramedics / ambulance staff	Poor PPE quality; guidance overload; fear of family exposure	Small sample; not focussed on PPE experiences / non-adherence so limited generalisability
Gordon et al., 2021	USA / Critical care nurses only in single hospital	Qualitative interviews; ICU nurses	Critical care nurses	PPE linked to fear, anxiety, reduced connection with patients	Narrow sample, no prehospital staff discussion, limited non-adherence exploration.
Chen et al., 2021a	Taiwan / multiple hospital departments	Cross-sectional; n≈400	Hospital clinicians	SARS experience linked to psychological impact	Hospital only sample, captures a single moment in time.
Chen et al., 2021b	China / wards caring for COVID-19 patients	Qualitative	Nurses	Physical burden, skin damage	Nurse only insights, ward only discussion, no exploration of non-adherence
Xia et al., 2020	Wuhan, China / Hospitals	Cross-sectional; n=297	Mixed clinicians, no paramedics	Headaches, shortness of breath, skin issues	Self-reported = recall bias. No ED or prehospital staff.
Montgomery et al., 2021	UK / critical care	Qualitative; n≈60	Critical care staff	PPE impaired communication and situational awareness	Limited applicability to prehospital
Monzani et al., 2020	Italy / paediatric ED	Qualitative	Emergency physicians	PPE created diagnostic bias and impaired assessment	Physician-focused with no adherence discussion.
Malik et al., 2021	USA / hospitals	Mixed methods	Hospital clinicians	PPE linked to emotional exhaustion	PPE not primary focus - primary aim was wellbeing
Swaminathan et al., 2022	India / hospital wards & EDs	Cross-sectional	Doctors and nurses	PPE associated with anxiety and depression	Secondary care focus, PPE not primary focus.
Alrawashdeh et al., 2021	Jordan / hospital wards	Mixed methods	Physicians	Burnout linked to PPE factors	Physician-heavy, focus on burn out.
Çiriş Yildiz et al., 2022	Turkey / multiple hospitals	Cross-sectional	Mixed clinicians incl. 4.5% paramedics	Comfort issues linked to non-adherence	Few paramedics, design limited exploration of adherence behaviour
Rao et al., 2021	USA / ED	Qualitative	ED clinicians (incl. paramedics)	PPE reduced rapport, empathy; some removed masks for communication	Small paramedic subset, PPE not sole focus, ED setting differs to prehospital

Appendix 6: Protocol Workstream 1

Insights into paramedic experiences using personal protective equipment (PPE) during the COVID-19 pandemic

PROTOCOL

Tim Millington

TABLE OF CONTENTS

1. Introduction

1.1. Background and Study Rationale

1.2 Aims

2. Study Objectives

2.1. Primary research objectives

2.2. Secondary research objectives

3. Investigational Plan

3.1. Research Design & Rationale

3.2. Outline of methods and setting

3.3. Sampling Strategy & Recruitment

4. Patient Population

4.1. Patient Inclusion Criteria

4.2. Patient Exclusion Criteria

5. Evaluation of Safety

5.1. Adverse Event Definitions

5.2. Adverse Event Assessments

5.3. Adverse Events Reporting

5.4. Serious Adverse Event Reporting

6. Risk Evaluation

6.1. Potential Risks

6.2. Methods to Minimise Risks

7. Statistical Considerations

7.1 Statistical Analysis

8. Data and Quality Management

9. Adherence to Protocol

10. Protocol Amendment

11. Reporting

12. Publication Policy

13. References

1. Introduction

1.1 Background & study rationale

Infection with SARS-CoV-2 virus results in COVID-19, a contagious respiratory disease associated with significant mortality in specific patient populations (Cheruku et al 2020, Chandrasekharan

et al 2020). Presentation typically involves cough, pyrexia, and dyspnoea however symptoms can vary, with patients often asymptomatic, creating great challenges in infection control and prevention (Atzrodt et al 2020, Fink et al 2020). A pandemic was declared by the World Health Organisation (WHO) in March 2020 and the resulting global disruption remains ongoing (Kalita et al 2020). It is postulated that transmission occurs through a combination of respiratory droplets, bioaerosols and fomites (Fink et al 2020). As a result, healthcare professionals (HCPs) are required to adhere to strict protocols regarding infection control and personal protective equipment (PPE), particularly when in proximity of medical procedures thought to be aerosol generating procedures (AGPs) (Leong et al 2020).

PPE is vital to counter the threat of nosocomial transmission of infectious diseases in order to keep HCPs safe. The image of frontline HCPs wearing enhanced PPE has become, arguably, one of the defining images of the pandemic. The use of PPE is not without consequence however, with themes emerging in the literature regarding its impact on physical and emotional well-being, as well as the effect its use can have on patient care and clinical effectiveness (Hoernke et al 2021, Rees et al 2021). Studies have explored HCPs' perceptions of working in this new and challenging environment, however, to date, very limited data exist exploring the impact of PPE specifically on paramedics, with a paucity of literature presently published investigating perspective of paramedics working in patient facing roles in the UK (Chen et al 2021, Hoernke et al 2021, Rees et al 2021).

It is anticipated a deeper understanding of how protective measures impact rescuers, particularly with regards to factors leading to non-adherence, will improve the understanding and help to inform future healthcare strategies, protecting HCPs, who continue to remain at risk in the fight against COVID-19.

PPE fatigue is a contemporary term adopted as part of the Royal College of Emergency Medicine's (RCEM) safety flash card, designed to help protect HCPs through visual reminder to maintain high standards regarding their own personal protection (RCEM 2020) (see figure 1). The term has subsequently featured in various online articles; however, it lacks clear definition within the reviewed literature. The use of the word fatigue suggests forgetfulness or carelessness through tiredness. Literature investigating HCPs adherence to PPE echo this sentiment, describing both forgetfulness and carelessness as major contributors to HCP non-compliance (Neves et al 2011, Yildiz et al 2020). Increased workloads directly impact HCP fatigue (Chapman et al 2017). Houghton et al (2020) found nursing staff described unrealistic workloads had detrimental impacts on adherence to infection prevention and control guidelines.

Various reasons have been captured within qualitative literature regarding non-adherence to PPE protocols, literature that predominately captured perspectives of hospital based nursing staff, with no ambulance insight on this matter identified through the utilised search strategy. Discomfort, supply, and ability to deliver quality patient care were frequently cited as causes for non-compliance (Li et al 2020, Silverberg et al 2021, Yildiz et al 2020). HCPs who found PPE particularly uncomfortable, understandably, chose to wear it for shorter time periods (Li et al 2020). One might say admirably but worryingly nevertheless, HCPs have reported choosing not to use PPE, particularly masks, if they felt it made their patients feel stigmatised or frightened (Houghton et al 2020). This could be, in part due to individuals view of personal risk of disease. The perception of risk has been deemed a key aspect in determining PPE compliance, with concern regarding the protection of family members being a motivating factor (Neves et al 2020). Conversely, knowledge gaps or a lack of belief in PPE effectiveness led to increased levels of non-adherence (Haji et a 2020, Houghton et al 2020). Ultimately, behaviour, particularly in healthcare settings can be habitual, evidence by 56.4% of HCPs in a Vietnamese study, reported modifying their working practices too challenging, and so fell back to their previous method (Tien et al 2021). Finally, interesting points were raised regarding the cultural influence within organisations, with

staff who saw colleagues maintaining high standards or who felt supported by managers more likely to maintain adherence to PPE policy (Houghton et al 2020).

Figure 1: RCEM Safety Flash card. (RCEM 2020).



1.2 Aims:

To investigate patient-facing paramedics' experiences of using PPE during the COVID-19 pandemic, to better understand factors contributing to non-adherence of PPE policy.

2. STUDY OBJECTIVE

2.1. Primary Research Question

- How has the use of PPE impacted patient facing paramedics in the UK working during the COVID-19 pandemic?

2.2. Secondary Research Question

- What contributes to staff non-adherence to PPE policies?
- How do HCPs define PPE fatigue?

3. INVESTIGATIONAL PLAN

3.1. Research Design & Rationale

Semi-structured interviews will be utilised as part of this exploratory research design to capture the perspectives of patient facing, paramedics investigating their experiences of using PPE, with a particular focus on their views regarding non-adherence. Using an exploratory approach is an appropriate research design to explore phenomena within healthcare in which there exists little, or no, understanding (Hunter et al 2019). Semi-structured Interviews are widely accepted within literature as an appropriate research tool in qualitative research, particularly when collecting new exploratory data and enables experiences, thoughts, and perceptions to be explored (DeJonckheere et al 2019). To act as an incentive to assist the recruitment process a certificate thanking participant for their participation shall be offered (See appendix 3).

3.2: Outline of methods and setting

Overview: Following receipt of consent from participants, semi-structured interviews will be carried out over Microsoft (MS) Teams. These will take no longer than 1 hour. MS teams has been chosen as it is approved for use in research by the University of Hertfordshire and mitigates for any potential changes to guidelines with respect to face-to-face meetings. It also allows for recording of audio and visual data, as well as safe storage on the University of Hertfordshire's OneDrive.

All research will be conducted by a solo paramedic researcher.

Consent: Eligible participants will be issued a patient information leaflet (PIL) (see appendix 1) with consent declaration (see appendix 2) prior to data collection, to be signed at least 48 prior to commencement of interviews and stored on coded files on the University of Hertfordshire OneDrive as per current Research Data management recommendations.

Interview format: A flexible script to guide the flow of the discussion has been created following review of current literature consisting of open questions divided into themes. Themes include –

i) general experiences of PPE

ii) PPE's impact on patient care

iii) The physical & mental health implications of PPE

iv) Non-adherence with PPE guidelines

v) Service improvement

vi) PPE fatigue

Questions have been structured in such a way as to allow for development of any emerging perspectives or themes. It is probable that not every question will be asked to every participant however it has been created to act as an aide memoir to the interviewer should it be necessary.

Interviews will be run via Microsoft teams allowing for recording of audio-visual data, or just audio, should an objection be raised by the participants. The use of MS teams ensures COVID-19 guideline compliance as future restrictions cannot be ruled out at time of writing.

Follow up: No specific follow up of participants is planned. Contact details of the researcher will be issued to the participants should they wish to remain updated as to the progress of the research or decide at a later date to withdraw.

Data storage and analysis: Recordings shall be recorded directly to coded files on the Universities OneDrive. They will then be encrypted using the inbuilt encryption feature in WinZip, as recommended the Research and Scholarly Communications team at the University of

Hertfordshire. Video footage will be transcribed and anonymised within 3 days then video files deleted. The transcribed data shall then be coded to identify themes using NVIVO software. All files from NVIVO, notes made on Microsoft Word, or analysis via Excel, shall be saved on the University OneDrive and never to a PC or lap top desktop.

3.3. Sampling Strategy & Recruitment

A purposive sample aiming for a minimum of 10 participants shall be recruited through the use of online campaign through the College of Paramedics' website initially. Should response from this be insufficient recruitment over social media platforms such as twitter shall be considered. The study is supervised by Prof. J. Williams, who is also Head of Research for the College of Paramedics where they have a process of governance before agreeing to advertise any study..

Participant screening and enrolment. This shall occur prior to the interview process with a select set of inclusion and exclusion criteria.

Participant Withdrawal. Participants will be allowed to withdraw from the project up until 1 week after the interview has taken place, following this data will have to be captured. The PIL will include contact email addresses of the research team should they request to be omitted from the trial.

4. PARTICIPANT POPULATION

4.1. PARTICPANT INCLUSION CRITERIA

- NHS HCPC registered paramedics based in the UK.

- Must have worked from at least 11th of March 2020 then for at least 6 months thereafter. (Note the 11th of March 2020 was the date the World Health organisation declared COVID-19 a pandemic).

- Patient facing role.

- Required to wear PPE in the care of patients as part of their role.

4.2. PARTICIPANT EXCLUSION CRITERIA

- Not NHS paramedics
- Worked for less than 6 months following 11st of March 2020.
- Not in a patient facing role
- Not required to wear PPE in the care of patients.

5. EVALUATION OF SAFETY

5.1. ADVERSE EVENT DEFINITIONS

Confidentiality risk: Defined as potential Breach of confidentiality through cyberattack. Although every effort shall be made to maintain patient confidentiality and minimise risks, it is prudent to consider every eventuality including such things cyberattack. Data shall be recorded in anonymised, encrypted files on the University of Hertfordshire's OneDrive, in line with current data management policies. It is anticipated that within 3 days video files shall be transcribed into anonymous format and then deleted. As the university has recently been subject to a cyberattack, security now involves an additional layer of protection, using a two factor authentication when accessing any university system remotely via the Duo software system.

Emotional distress: Defined as participants required to recall events causing them emotional distress. The researcher is an experienced advanced clinical practitioner with extensive experience working with patients in highly stressful situations or experiencing mental health crises. As such they are adequately qualified to identify when participants should have the interview process paused, re-arranged, or terminated.

Disclosure of safeguarding issue / improper conduct: This is defined as a research participant disclosing, during interviews, matters of illegality or intension to cause themselves or others harm, either directly or indirectly, or disclosing previous behaviours that could have caused serious harm to others, either professionally or personally. Prior to the interview, participants shall be informed in writing, at the consent stage, that although the interview content is confidential and will be anonymised, the researcher is an HCP that is ethically bound to report any issues through the appropriate channels. Risk assessments considering safeguarding practices shall be conducted continually throughout the interview process with the need for any future actions reviewed at the closure of the interview. There is an awareness that this disclosure might inhibit the richness of data obtained at interview, a limitation of the researcher being a HCP.

5.2. ADVERSE EVENT ASSESSMENTS

As mentioned, assessment of adverse events shall be conducted by the researcher throughout the interview process. The researcher is an experienced, advanced clinical practitioner and paramedic, required to keep up to date with current information governance and safeguarding policies through statutory mandatory training, and who is well versed in the management of patients in highly stressful situations. They are fully compliant with data protection, Caldicott principles and information governance principles. Adverse event assessment shall be a dynamic process conducted throughout the interview process, meaning if the researcher feels there is undue stress on the participant the interview will be terminated, and the participant signposted

to appropriate agencies of support. The researcher shall be supervised in their activities by their academic lead at the university.

5.3. ADVERSE EVENTS REPORTING

Adverse events shall be reported in writing and escalated to academic supervisors.

5.4. SERIOUS ADVERSE EVENT REPORTING

This shall be reported in writing and escalated to academic supervisors, with research ceased pending review.

6. RISK EVALUATION

6.1. POTENTIAL RISKS

Researcher preconceptions: It is important that researcher remains impartial to the interview process. Questions will help to structure the interview process however it is important to not allow the format or tone of questions to restrict the broadness of the data collected.

Researcher being HCP: There is an understanding that the researcher disclosing their role might influence the data collected and an appreciation of the power balance of a potentially senior HCP interviewing junior staff must be acknowledged. It is important to be open and honest with participants at all times and every attempt should be made to ensure participants do not feel pressured to behave in a certain way or feel there will be judgement on their answers. It is also important that the researcher's clinical role does not allow them to inappropriately probe sensitive issues that might cause the participant to disclose more information than they may have felt comfortable with at the time of consenting.

Participant distress: Probing questions into experiences during an extremely challenging time both socially and professionally may elicit emotional distress.

Breach of confidentiality: This might be through cyberattack, or, through the researcher describing scenarios in the written text of any publication that may lead to identification of the participant.

6.2. METHODS TO MINIMIZE RISKS

Researcher preconceptions: Researchers inevitably will have preconceptions through their own personal experiences of events described within the research process. Understanding and exploring the researcher's viewpoint through self-reflection following extensive literature review prior to compiling any questions or conducting interviews shall aid to mitigate the influence of these preconceptions. However, an acceptance that an inevitable limitation of this research will be due to it being performed by a solo researcher will be considered when making any potential conclusions.

Researcher being an HCP: The researcher's full role and title shall be disclosed at the consent stage. It is felt that having the researcher positioned as an HCP provides benefits to participants that outweigh the risks. They are able to provide clinical and professional support during the interview process, should it be required, allowing for efficient and early identification of issues that may require follow up, particularly regarding matters of mental health and safeguarding.

Participant distress: As mentioned above, having a clinically qualified researcher who has significant experience in dealing with people during mental health crises, and managing highly emotional scenarios, will help to mitigate this element of risk. Details of the researcher will be provided, allowing participants to opt out after the interview has finished, should they feel they disclosed information that, on reflection, they later wish not to be included in the study.

Breach of confidentiality: Cloud based storage, on coded files, plus the use of two factor authentication, password secure IT equipment should mitigate this risk, as per University of Hertfordshire research data management recommendations.

ANALYSIS

Thematic analysis of data shall be conducted using NVIVO and Excel software.

DATA AND QUALITY MANAGEMENT

Consent forms adapted from templates provided by the University of Hertfordshire's ethics committee shall be stored on University of Hertfordshire One Drive as per current Research Data Management recommendations. Original paper copies shall be avoided in favour of electronically signed consent as per COVID-19 research guidance.

PDF copies of the consent forms will be sent to University of Hertfordshire Ethics department.

9. ADHERENCE TO PROTOCOL

Deviation from the protocol is discouraged however might be acceptable subject to relaxation of COVID-19 measures. Similarly, with regards to software, i.e., NVIVO/ Microsoft Teams / Excel, should on review, a more suitable software package be identified, this may be subject to change, although it is felt this is unlikely. Any changes shall be documented along with the rationale behind the change. These shall then be discussed with the academic supervisor. Significant

deviations will require input and further review from The University of Hertfordshire Ethics committee.

10. PROTOCOL AMENDMENT

Amendments might be made following research supervisory approval and if required, Ethics committee review.

11. REPORTING

Supervisory research leads shall be informed through 6 weekly meetings or on the identification of adverse or serious adverse events.

12. PUBLICATION POLICY

Data shall be disseminated as part of a PhD thesis published within the British library, on completion. Further publications may be in the form of relevant recognised journal articles.

13. REFERENCES

- Atzrodt, C., Maknojia, I., McCarthy, R. D. P., Oldfield, T. M., Po, J., Ta, K. T. L., Stepp, H. E., Clements, T. P., (2020). A Guide to COVID-19: a global pandemic caused by the novel coronavirus SARS-CoV-2. The FEBS Journal. Volume 287. Issue 17. PP 3633-3650

- Chandrasekharan, P., Vento, M., Trevisanuto, D., Partridge, E., Underwood, M. A., Wiedeman, J., Anup, Katheria. (2020). Neonatal Resuscitation and Postresuscitation Care of Infants Born to Mothers. American Journal of Perinatology. Vol. 37. No. 8. Pp813-823.

- Chapman, H. J., Vera-Estevez, B., Pomeranz, J. L., Perez-Then, E. N., Marcelino, B., Lauzardo, M., (2017). Perceived Barriers to Adherence to Tuberculosis Infection Control Measures among Health Care Workers in the Dominican Republic. MEDICC Review. Volume 19. Number 1. PP 16 – 22.

- Chen, C., Yang, P., Kuo, F., Yeh, I., Su, C., (2021). Experience of 2003 SARS has a negative psychological impact on healthcare workers in the COVID-19 pandemic: a cross-sectional study. Sao Paulo Medical Journal. Volume 139. Issue 1. PP 65 – 67.

- Cheruku, S., Dave, S., Goff, K., Park, C., Ebeling, C., Cohen, L., (2020) Cardiopulmonary resuscitation in intensive Care unit patients with coronavirus disease 2019. Journal of Cardiothoracic and vascular anaesthesia. Volume 34. Pp2595-2603.

- DeJonckheere, M., Vaughn, L. M. (2019), Semistructured interviewing in primary care research: a balance of relationship and rigour. Family Medicine and Community Health. Volume 7, issue 2. Accessed [online] from https://fmch.bmj.com/content/7/2/e000057 on 22/3/22.

- Fink, J. B., Ehrmann, S., Li, J., Dailey, P., McKiernan, P., Darquenne, C., Martin, A. R., Rothen-Rutishausser, B., Kuehl, P. J., Haussermann, S., MacLoughlin, R., Smaldone, G. C., Muellinger, B., Corcoran, T. E., Dhand, R., (2020), Reducing Aerosol-Related Risk of Transmission in the Era of COVID-19: An Interim Guidance Endorsed by the International

Society of Aerosols in Medicine. Journal of Aerosol Medicine and Pulmonary drug delivery. Volume 33. Number 6. Pp 300 – 304.

- Haji, J. Y., Subramaniam, A., Kumar, P., Ramanathan, K., Rajamani, A., (2020) State of Personal Protective Equipment Practice in Indian Intensive Care Units amidst COVID-19 Pandemic: A Nationwide Survey. Indian journal of critical care medicine. Vol. 24, issue 9. Pp809 – 816.

- Hoernke, K., Djellouli, N., Andrews, L., Lewis-Jackson, S., Manby, L., Martin, S., Vanderslott, S., Vinfrola-Padros, C., (2021) Frontline healthcare workers'experience with personal protective equipment during the Covid-19 pandemic in the UK: a rapid qualitative appraisal. BMJ Open, volume 11, p1-13

- Houghton, C., Meskell, P., Delaney, H., Smalle, M., Glenton, C., Booth, A., Chan, X. H. S., Devane, D., Biesty, L. M., (2020). Barriers and faciltators to healthcare workers' adherence with infection prevention and control (IPC) guidelines for respiratory infectious diseases: a rapid qualitative evidence synthesis (review). Cochrane Database of systematic reviews. Accessed [online] from https://www.cochranelibrary.com/cdsr/doi/10.1002/14651858.CD013582/full on 19/8/2021.

- Hunter, D., McCallum, J. and Howes, D. (2019). Defining Exploratory-Descriptive Qualitative (EDQ) research and considering its application to healthcare. Journal of Nursing and Health Care. Volume 4, issue 1.

- Kalita, S., Gogoi, B., Khaund, G., Agarwal, V., Borah, P. P., Dutta, A., Gogoi, D., (2020). Optimizing Airway Surgery in COVID 19 Era. Indian Journal of Otolaryngol Head Neck

Surgery. Accessed [online] from https://doi.org/10.1007/s12070-020-02326-6 on 19/8/2021.

- Leong, Y. C., Cheskes, S., Drennan, I. R., Buick, J. E., Latchmansingh, R. G., Verbeek, P. R., (2020). Clinical considerations for out-of-hospital cardiac arrest management during COVID-19. Resuscitation Plus.

- Li, F., Jiang, T., Shi, T., Liu, Y., Liu. X., Xu, G., Liu, Y., Shi, Y., (2021). Factors that affect the duration of wearing disposable personal protective equipment by healthcare professionals in Wuhan during treatment of COVID-19 patients: An epidemiological study. Nursing and Health Sciences. Volume 23. PP 245 – 254.

- Neves, H., Souza, A., Medeiros, M., Munari, D., Ribeiro, L., Tipple, A., (2011). Safety of Nursing Staff and Determinants of Adherence to Personal Protective Equipment. Rev. Latino-Am. Enfermagem. Volume 19. Issue 2. PP 354 – 361.

- Rees, N., Smythe, L., Hogan, C., Williams, J., (2021) Paramedics experiences of providing care in Wales (UK) during the 2020 COVID-19 pandemic (PECC-19): a qualitative study using evolved grounded theory. BMJ open, volume 11, pp 1 – 14.

- Royal College of Emergency Medicine (2020). PPE Fatigue. Safety Flash Card. Accessed [online] from https://www.rcem.ac.uk/docs/Safety/RCEM%20Safety%20Flash%20-%20PPE%20importance.pdf on the 18/8/21.

- Silverberg, S. L., Ritchie, L. M., Gobat, N., Murthy, S., (2021). COVID-19 infection prevention and control procedures and institutional trust: Perceptions of Canadian intensive care and emergency department nurses. Springer publications. Accessed

[online] from https://link.springer.com/article/10.1007%2Fs12630-021-02028-9 on 19/8/2021.

- Tien, T. Q., Tuyet-Hanh, T. T., Linh, T. N. Q., Phuc, H. H., Nhu, H. V., (2021). COVID-19 prevention among Vietnamese Healthcare Workers in 2020. Health Services Insight. Safe. Volume 14. PP 1-7.

- Yildiz, C. C., Kaban, H. U., Tanriverdi, F. S., (2020). COVID-19 pandemic and personal protective equipment: Evaluation of equipment comfort and user attitude. Archives of Environmental & Occupational Health. Accessed [online] from https://doi.org/10.1080/19338244.2020.1828247 on 16/8/2021.

APPENDICES

APPENDIX 1: EC6 - Pre-Interview Patient information Leaflet

APPENDIX 2: EC3 - Consent form

APPENDIX 3: Certificate of participation in research

APPENDIX 1: EC6: Patient information leaflet (Pre-interview) SEE CHASNGES I MADE ON THE ORIGINAL

UNIVERSITY OF HERTFORDSHIRE

ETHICS COMMITTEE FOR STUDIES INVOLVING THE USE OF HUMAN PARTICIPANTS
FORM EC6: PARTICIPANT INFORMATION SHEET (Pre-interview)

1 **Title of study**

Insights into experiences of frontline healthcare professionals (HCPs) using personal protective equipment (PPE) during the Covid-19 pandemic

2 **Introduction**

You are being invited to take part in a study. Before you decide whether to do so, it is important that you understand the study that is being undertaken and what your involvement will include. Please take the time to read the following information carefully and discuss it with others if you wish. Do not hesitate to ask about anything that is not clear or should you require any further information to help you make your decision. Please do take your time to decide whether you wish to take part. The University's regulation, UPR RE01, 'Studies Involving the Use of Human Participants' can be accessed via this link:

https://www.herts.ac.uk/about-us/governance/university-policies-and-regulations-uprs/uprs

(After accessing this website, scroll down to Letter S where you will find the regulation)

3 **What is the purpose of this study?**

The purpose of this study is to explore the experiences of patient facing, UK based, National Health Service (NHS) paramedics using PPE during the COVID-19 pandemic.

4 **Do I have to take part?**

No. It is completely up to you whether you decide to take part in this study. If you do decide to take part, you will be given this information sheet to keep and be asked to

sign a consent form. Agreeing to join the study does not mean that you must complete it. You are free to withdraw up to 1 week following completion of the interview.

5 **Are there any age or other restrictions that may prevent me from participating?**

Participants must meet the relevant inclusion criteria…

- NHS Paramedic in the UK

- Must have worked from at least 11th March 2020 and at least 6 months thereafter.

- Must have been in a patient facing role.

- Must have been required to wear PPE in the care of patients as part of their role.

6 **How long will my part in the study take?**

If you decide to take part in this study, you will be required to be available for no longer than 1 hour. Every effort will be made to not exceed the 1-hour target.

7 **What will happen to me if I take part?**

You will be issued with consent forms, then, once completed, and returned to the researcher, you will be contacted via email to arrange a suitable date for interview. You will then be issued with an invite to an MS teams meeting. Following completion, if you have requested, you will be sent a certificate thanking you for involvement.

8 **What are the possible disadvantages, risks, or side effects of taking part?**

There is a possibility that you will have to recall traumatic events that might elicit an emotional response. Should this become too harrowing the interview can be paused, re-arranged, or cancelled.

9 **What are the possible benefits of taking part?**

It is the intention of the research findings be used to better enable healthcare organizations to support staff who are required to use PPE. Understanding experiences both positive and negative can help contribute to future policy and better improve conditions and safety for HCPs when using PPE.

10 **How will my taking part in this study be kept confidential?**

Data shall be stored on encrypted files uploaded to the University of Hertfordshire's secure cloud-based OneDrive, accessed via two factor authentication on password secure laptops.

11 **Audio-visual material**

Once participants have joined the MS teams meeting, they shall be informed of the recording of audio-visual material. Audio only recordings can be made on request however video is encouraged as it can provide additional richness to the data that is obtained. These files will be stored and deleted within 3 days after being converted to anonymized, text only files (a process called transcribing), ready for analysis.

12 **What will happen to the data collected within this study?**

Video shall be recorded directly onto the highly secure, cloud based, University OneDrive, directly from MS teams. Video or audio files shall be transcribed within 3 days, anonymized and the video format then permanently erased. No hard copies of the transcribed notes shall be made. Digitally signed consent documents shall be stored as .pdf files on encrypted files within the OneDrive, no hard copies will be required as per the universities adapted ethical COVID-19 guidance.

All data, including any notes and analysis made by researcher, will be stored within the cloud based OneDrive system, as recommended by the University of Hertfordshire's Data management guidelines.

13 **Will the data be required for use in further studies?**

It is not envisaged that the data will be used in any further studies.

14 **Who has reviewed this study?**

This study has been reviewed by the University of Hertfordshire Health, Science, Engineering and Technology Ethics Committee with Delegated Authority. The UH protocol number is *<enter>*

15 **Factors that might put others at risk**

Please note that if, during the study any health related or unlawful activity become apparent that might, or has previously, put others at risk the University may refer the matter to the appropriate authorities and, under such circumstances, you will be withdrawn from the study.

16 **Who can I contact if I have any questions?**

If you would like further information or would like to discuss any details, please get in touch with me, in writing, by phone or by email: *t.millington@herts.ac.uk*

Although we hope it is not the case, if you have any complaints or concerns about any aspect of the way you have been approached or treated during this study, please write to the University's Secretary and Registrar at the following address:

Secretary and Registrar

University of Hertfordshire

College Lane

Hatfield

Herts

AL10 9AB

Thank you very much for reading this information and considering taking part in this study.

Tim Millington

Paramedic Researcher

Appendix 2: EC3 - CONSENT FORMS

UNIVERSITY OF HERTFORDSHIRE

ETHICS COMMITTEE FOR STUDIES INVOLVING THE USE OF HUMAN PARTICIPANTS

('ETHICS COMMITTEE')

FORM EC3: CONSENT FORM FOR STUDIES INVOLVING HUMAN PARTICIPANTS

I, the undersigned *[please give your name here*, *in BLOCK CAPITALS]*

……
….

of *[please give contact details here, sufficient to enable the investigator to get in touch with you, such as a postal or email address]*

…..……

……

……

hereby freely agree to take part in the study entitled *'Insights into paramedic experiences using personal protective equipment (PPE) during the COVID-19 pandemic.'*

(UH Protocol number ……)

1 I confirm that I have been given a Participant Information Leaflet giving particulars of the study, including its aims, methods and design, the names and contact details of key people and, as appropriate, the risks and potential benefits, how the information collected will be stored and for how long, and any plans for follow-up studies that might involve further approaches to participants. I have also been informed of how my personal information on this

form will be stored and for how long. I have been given details of my involvement in the study. I have been told that in the event of any significant change to the aims or design of the study I will be informed and asked to renew my consent to participate in it.

2 I have been assured that I may withdraw from the study until 1 week after the interview has been conducted without disadvantage or having to give a reason. After this data will have to be captured for analysis.

3 In giving my consent to participate in this study, I understand that voice & video recording will take place and I have been informed of how this recording will be displayed.

4 I have been told how information relating to me (data obtained in the course of the study, and data provided by me about myself) will be handled: how it will be kept secure, who will have access to it, and how it will or may be used, including the possibility of anonymised data being deposited in a repository with open access (freely available).

5 I understand that my participation in this study may reveal findings that could indicate that I may require medical advice. In that event, I will be advised to consult my GP and may be asked to withdraw from the study.

6 I understand that if there is any revelation of unlawful activity or any indication of non-medical circumstances that would or has put others at risk, the University may refer the matter to the appropriate authorities.

Signature of participant:

Please print name here:

Date:

Signature of (principal) investigator:

Date:

Name of (principal) investigator: *TIMOTHY MILLINGTON*

Appendix 3: Certificate of participation for participants portfolio.

University of Hertfordshire UH

COLLEGE OF paramedics

This certificate was issued to

>insert name<

in acknowledgement of their contribution to paramedic research.

This was part of the 'Insights into paramedic experiences using personal protective equipment (PPE) during the COVID-19 pandemic' study.

Appendix 7: EC1A form

Submitted for review as part of the University of Hertfordshire's Ethics approval process).

UNIVERSITY OF HERTFORDSHIRE

FORM EC1A: APPLICATION FOR ETHICS APPROVAL OF A STUDY INVOLVING HUMAN PARTICIPANTS
(Individual or Group Applications)

Please complete this form if you wish to undertake a study involving human participants.

Applicants are advised to refer to the Ethics Approval StudyNet Site and read the Guidance Notes (GN) before completing this form:
http://www.studynet2.herts.ac.uk/ptl/common/ethics.nsf/Homepage?ReadForm

Applicants are also advised to read the FAQ General Data Protection Regulation (GDPR) before completing this form.
http://www.studynet2.herts.ac.uk/ptl/common/ethics.nsf/Frequently+Asked+Questions/4AD88CD88D0F3F2D8025829800300621

Use of this form is mandatory [see UPR RE01, 'Studies Involving Human Participants', Sections 7.1-7.3]

Approval must be sought **and granted** before any investigation involving human participants begins [UPR RE01, S 4.4 (iii)]

Note: Supervisors should submit this form on behalf of their students.

Please submit this form and any accompanying documentation to the appropriate Ethics Committee with Delegated Authority (ECDA):
Health, Science, Engineering and Technology ECDA: hsetecda@herts.ac.uk or
Social Sciences, Arts and Humanities ECDA: ssahecda@herts.ac.uk

(If you require any further guidance, please contact either hsetecda@herts.ac.uk or ssahecda@herts.ac.uk)

Abbreviations: GN = Guidance Notes UPR = University Policies and Regulations

THE STUDY

Q1 Please give the title of the proposed study

Insights into paramedic experiences using personal protective equipment (PPE) during the COVID-19 pandemic

THE APPLICANT

Q2 Name of applicant/(principal) investigator (person undertaking this study)

Timothy Ian Millington

Student registration number/Staff number

20034610

Email address

t.i.millington@herts.ac.uk

Status:

☐Undergraduate (Foundation)	☐Undergraduate (BSc, BA)
☐Postgraduate (taught)	☒Postgraduate (research)
☐Staff If other, please provide details here: Click here to enter text.	☐Other

School/Department:

School of Health & Social Work, Paramedic Science

If application is from a student NOT based at University of Hertfordshire, please give the name of the partner institution: n/a

Name of Programme (eg BSc (Hons) Computer Science): PHD Paramedic Science

Module name and module code: 8HSK0121-0000-2021

Name of Supervisor: Prof. Julia Williams Supervisor's email: j.williams@herts.ac.uk

Name of Module Leader if applicant is undertaking a taught programme/module:

n/a

Names and student/staff numbers for any additional investigators involved in this study (students should read GN Sections 1.5 and 2.2.1 concerning responsibilities of all members of the group)

Is this study being conducted in collaboration with another university or institution and/or does it involve working with colleagues from another institution?

☐Yes ☒No

If yes, provide details here:

DETAILS OF THE PROPOSED STUDY

Q3 Please give a short synopsis of your proposed study, stating its aims and highlighting where these aims relate to the use of human participants (See GN 2.2.3)

COVID-19 is a contagious respiratory disease associated with significant mortality in specific patient populations. Presentation can vary, with patients often asymptomatic, creating great challenges in infection control. PPE is vital to counter the threat of nosocomial transmission.

The use of PPE is not without consequence and themes emerging following review of the current literature suggesting PPE to have a negative impact on both physical and emotional well-being, as well as the delivery of patient care and clinical effectiveness.

Studies have explored health care professionals' (HCPs) perceptions of working in this new and challenging environment, however, to date, very limited data exist exploring the impact of PPE specifically investigating experiences of paramedics in the United Kingdom (UK). No studies were identified exploring paramedic non-adherence PPE protocols. PPE Fatigue is a phrase that has been used within safety campaigns to highlight the need to remain vigilant regarding HCPs PPE practices. The literature review showed this phrase, although widely used within literature, lacks clear definition.

It is anticipated a deeper understanding of how protective measures impact rescuers, particularly with regards to factors leading to non-adherence, will help to inform future healthcare strategies. Enabling better protection of HCPs who continue to remain at risk in the frontline fight against COVID-19.

This project will investigate UK based, paramedics' experiences of using PPE during the COVID-19 pandemic. The aim is to better understand paramedic perspectives of using PPE and the factors contributing to non-adherence to PPE policies. It is also a secondary aim that an evidence based definition of PPE fatigue will be constructed.

Q4 Please give a brief explanation of the design of the study and the methods and procedures used. You should clearly state the nature of the involvement the human participants will have in your proposed study and the extent of their commitment. Ensure you provide sufficient detail for the Committee to, particularly in relation to the human participants. Refer to any Standard Operating Procedures SOPs under which you are

operating here. (See GN 2.2.4).

An exploratory, qualitative study design, using semi-structured interviews will be used to capture experiences and perspectives of paramedics with focus on their reasons behind non-adherence to PPE guidelines. Interviews, lasting no longer than 1 hour will be conducted via Microsoft (MS) teams and recorded. Prior receipt of written consent from the participant will be required before conducting any interviews.

Data shall be stored on the University of Hertfordshire's OneDrive as recommended by the University's Research Data management guidance on appropriate data storage. Recorded video footage shall be transcribed and stored on coded files within this cloud based system.

A purposive sample aiming for 10 – 15 paramedics shall be recruited. This shall be done through the use of advertisement on the College of Paramedics' website. Should response via this method be inadequate, social media shall be used, e.g., Twitter.

Semi-structured interviews will consist of open questions. Interview questions have been prepared, aligned to several common themes that were identified following comprehensive literature review. These will act as prompts during the interview process to guide the conversation, should it be required. Not all questions will be asked. Flexibility will be given to enable any new, relevant, topics to be explored during the interview process. Ad hoc questions will be structured in such a way as to allow and encourage development of emerging perspectives outside of these pre-identified themes. The recorded video interview data will be transcribed, before being permanently deleted within 72 hours. The transcribed data will then be uploaded to NVIVO software to enable thematic analysis. No more then 1 interview shall be scheduled each day and preliminary analysis shall be conducted concurrently to the interviews with an approximate time from of 6 – 8 weeks.

Eligible participants who have made contact with the researcher via email, will be issued a Participant Information Leaflet (PIL) prior to the interviews. This has a description of how the information at interview will be obtained, stored, and destroyed, as well as a declaration of consent. The declaration of consent must be signed by the participant and returned to the researcher prior to conducting the interviews. Once received, the signed declaration of consent will be stored as above, namely on files within the University of Hertfordshire One-Drive.

Participants will be required to reflect upon events they have witnessed throughout the COVID-19 pandemic which could elicit an emotional response. The researcher is a paramedic registered with the Health and Care Professions Council (HCPC) and Advanced Clinical Practitioner in Emergency Medicine. This clinical expertise will enable identification and assistance of participants in undue stress.

The qualitative study design proposed by this research was borne following systematic searching of 5 key databases and the subsequent review of the current literature. It was identified that PPE use impacted HCPs in many ways. Physically and emotionally, users reported significant adverse events. PPE use showed links to increased feelings of anxiety, distress, and sleep disturbances by users. Physical symptoms attributed to PPE included ranged from mild skin irritation to, in extreme cases, collapse.

Patient care and clinical effectiveness were described as sub-optimal due to PPE use. Highlighted as a barrier to empathetic communication, inhibiting patient-carer interactions and provoking fear in patients who might be confused through conditions as infection or dementia. PPE also inhibited performance of physical examinations and procedures through circumstances such as fogging of eye wear or gloves impeding fine touch. It was also suggested its use obstructed communication and identification of team

members.

These themes were all postulated as possible issues leading to non-adherence in HCPs generally, however, the specific demographic of UK paramedics not directly targeted by any one particular study, nor were their reasons behind non-adherence explored.

It is proposed that this qualitative, exploratory approach can use the interview data as a 'pathfinder' of new themes that might emerge from exploring the views of this particular group of HCPs.

Q5 Does the study involve the administration of substances?

☐Yes ☒No

PLEASE NOTE: If you have answered yes to this question you must ensure that the study would not be considered a clinical trial of an investigational medical product. To help you, please refer to the link below from the Medicines and Healthcare Products Regulatory Agency:
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/317952/Algothrim.pdf

To help you determine whether NHS REC approval is required, you may wish to consult the Health Research Authority (HRA) decision tool: http://www.hra-decisiontools.org.uk/ethics/

If your study is considered a clinical trial and it is decided that ethical approval will be sought from the HRA, please stop completing this form and use Form EC1D, 'NHS Protocol Registration Request'; you should also seek guidance from Research Sponsorship.

I confirm that I have referred to the Medicines and Healthcare Products Regulatory Agency information and confirm that that my study is not considered a clinical trial of a medicinal product.

Please type your name here: Timothy Ian Millington

Date: 10/04/2022

Q6.1 Please give the starting date for your recruitment and data collection: 1/5/22 (estimated)

Q6.2 Please give the finishing date for your data collection: 31/1/23
(For meaning of 'starting date' and 'finishing date', see GN 2.2.6)

Q7.1 Where will the study take place?

Doncaster, South Yorkshire, England

Please refer to the Guidance Notes (GN 2.2.7) which set out clearly what permissions are required:

Please tick all the statements below which apply to this study

Q7.2 **Permissions**

This question is about two types of permission you may need to obtain. Depending on the study you may need more than one of each of these:

i Permission to access a particular group or groups of participants to respond to your study
ii Permission to use a particular premises or location in which you wish to conduct your study

If your study involves minors/vulnerable participants, please refer to Q18 to ensure you comply with the University's requirement regarding Disclosure and Barring Service clearance.

TICK THE APPROPRIATE BOXES IN EACH COLUMN

(i) Permission to access participants		(ii) Permission to use premises/location	
(tick)		(tick)	
	I confirm that I have obtained permission to access my intended group of participants and that the permission is attached to this application		Permission has been obtained to carry out the study on University premises in areas outside the Schools and the agreement is attached to this application.
	I have yet to obtain permission but I understand that this will be necessary before I commence my study. For student applicants only: I understand that the original copies of the permission letters must be verified by my supervisor before data collection commences		Permission has been obtained from an off-campus location to carry out the study on their premises and the agreement is attached to this application
	This study involves working with minors/vulnerable participants. I/we have obtained permission from the organisation (including UH/UH Partner Institutions when appropriate) in which the study is to take place and which is responsible for the minors/vulnerable participants. The permission states the DBS requirements of the organisation for this study and confirms I/we have satisfied their DBS requirements where necessary		I have yet to obtain permission but I understand that this will be necessary before I commence my study. For student applicants only: I understand that the original copies of the permission must be verified by my supervisor before data collection commences
X	Permission is not required for my study.	X	Permission is not required for my study.

	Please explain why: Participants are paramedics representing themselves, not speaking on behalf of their respective organisation. Each participant shall be briefed regarding the process prior to interview and be required to complete a consent form. Prof. J. Williams is supervising the project and is also Head of Research with the College of Paramedics and has agreed for recruitment via their website which is standard practice at the College of paramedics provided studies have gained REC approval.		**Please explain why:** Interviews will be conducted remotely. Access to specific premises is not required

HARMS, HAZARDS AND RISKS

Q8.1 It might be appropriate to conduct a risk assessment (in respect of the hazards/risks affecting both the participants and/or investigators). **Please use form EC5, Harms, Hazards and Risks, if the answer to any of the questions below is 'yes'.**

If you are required to complete and submit a School-specific risk assessment (in accordance with the requirements of the originating School) it is acceptable to make a cross-reference from this document to Form EC5 in order not to have to repeat the information twice.

Will this study involve any of the following?

Invasive Procedures/administration of any substance/s? ☐YES ☒NO

IF 'YES' TO THE ABOVE PLEASE COMPLETE EC1 APPENDIX 1 AS WELL AND INCLUDE IT WITH YOUR APPLICATION

Are there potential hazards to participant/investigator(s) from the proposed study? (Physical/Emotional or other non-physical harm) ☐YES ☒NO

Will or could aftercare and/or support be needed by participants ☐YES ☒NO

Q8.2 Is the study being conducted off-campus (i.e. not at UH/UH Partner?) ☒YES ☐NO

It might be appropriate to conduct a risk assessment of the proposed location for your study

(in respect of the hazards/risks affecting both the participants and/or investigators) (this might be relevant for on-campus locations as well). Please use Form EC5 and, if required, a School-specific risk assessment (See GN 2.2.8 of the Guidance Notes).

If you do not consider it necessary to submit a risk assessment, please give your reasons:

Interviews will be conducted remotely, via MS teams, to mitigate the risk of transmission of disease associated with face-to-face meetings during COVID-19.

The primary risk to participants will be emotional distress associated with the potential discussions of previous events. The researcher is a suitably qualified HCP and will terminate the interview should there be any undue stress noted. The researcher will direct the participant to appropriate supportive agencies should the unlikely event occur where they are required.

ABOUT YOUR PARTICIPANTS

Q9 Please give a brief description of the kind of people you hope/intend to have as participants, for instance, a sample of the general population, University students, people affected by a particular medical condition, children within a given age group, employees of a particular firm, people who support a particular political party, and state whether there are any upper or lower age restrictions.

- HCPC registered paramedics

- Must have worked from at least 11th March 2020 (the date the World Health Organisation declared a pandemic) then for at least 6 months thereafter.

- Patient facing role.

- Required to wear PPE in the care of patients as part of their role.

Q10 Please state here the maximum number of participants you hope will participate in your study. Please indicate the maximum numbers of participants for ***each*** method of data collection.

A purposive sample aiming for 10 – 15 participants shall be recruited through the use of an advert on the College of Paramedics' website for the interviews.

Q11 By completing this form, you are indicating that you are reasonably sure that you will be successful in obtaining the number of participants which you hope/intend to recruit. Please outline here your recruitment (sampling) method and how you will advertise your study. (See

GN 2.2.9).

Recruitment shall be via the College of Paramedic's website and if required, in the event of poor response rate, via social media.

CONFIDENTIALITY AND CONSENT

(For guidance on issues relating to consent, see GN 2.2.10, GN 3.1 and UPR RE01, SS 2.3 and 2.4 and the Ethics Approval StudyNet Site FAQs)

Q12 How will you obtain consent from the participants? Please explain the consent process for each method of data collection identified in Q4

☒ Express/explicit consent using an EC3 Consent Form and an EC6 Participant Information Sheet (or equivalent documentation)

☐ Implied consent (participant information will be provided, for example, at the start of the questionnaire/survey etc)

☐ Consent by proxy (for example, given by parent/guardian)

Use this space to describe how consent is to be obtained and recorded for each method of data collection. The information you give must be sufficient to enable the Committee to understand exactly what it is that prospective participants are being asked to agree to.

Consent will be gained in advance by asking the participant to read and sign EC3. Consent forms need to be returned via email at least 48 hours before the interview

If you do not intend to obtain consent from participants please explain why it is considered unnecessary or impossible or otherwise inappropriate to seek consent.

Q13 If the participant is a minor (under 18 years of age) or is unable for any reason to give full consent on their own, state here whose consent will be obtained and how? (See especially GN 3.6 and 3.7)

n/a

Q14.1 Will anyone other than yourself and the participants be present with you when conducting this study? (See GN 2.2.10)

☐YES ☒NO

If YES, please state the relationship between anyone else who is present other than the applicant and/or participants (eg health professional, parent/guardian of the participant).

Q14.2 Will the proposed study be conducted in private?

☒YES ☐NO

If 'No', what steps will be taken to ensure confidentiality of the participants' information. (See GN 2.2.10):

Q15.1 Are personal data of any sort (such as name, age, gender, occupation, contact details or images) to be obtained from or in respect of any participant? (See GN 2.2.11) (You will be required to adhere to the arrangements declared in this application concerning confidentiality of data and its storage. The Participant Information Sheet (Form EC6 or equivalent) must explain the arrangements clearly.)

☒YES ☐NO

If YES, give details of personal data to be gathered and indicate how it will be stored.

Data gathered as part of the interview process includes:
- Occupational information prior to interviews,
- Video recording of the interview
- Transcribed text of the interview
- Consent form

This will be stored on encrypted files, uploaded to the University OneDrive.

PLEASE NOTE: If you are processing personal information you MUST consider whether you need to complete a Data Protection Impact Assessment (DPIA). Please read the DPIA guidance available from the FAQ section of the UH Ethics Approval StudyNet site:

http://www.studynet2.herts.ac.uk/ptl/common/ethics.nsf/Frequently+Asked+Questions/935D97CDBC546E69802583A9005213A6

If you need to complete one, please find the DPIA template in the University's website here

The DPIA must be completed in consultation with the University's Data Protection Officer and submitted with your application for ethics approval.

Will you be making recordings?

☒YES ☐NO

If YES, give details of the types of recordings to be made and describe how and where they will be securely stored.

Interviews lasting no longer than 1 hour will be recorded and then transcribed into an anonymised text document. The video file shall be saved directly onto OneDrive, then encrypted. Encryption will be done by the inbuilt encryption feature in WinZip.

Q15.2 If you have made a YES response to any part of Q15.1, please state what steps will be taken to prevent or regulate access to personal data and/or recordings beyond the immediate investigative team, as indicated in the Participant Information Sheet.

Footage will be stored on encrypted files on the university's OneDrive. It will then be transcribed and anonymised to a text document within 72 hours. The original video footage will then be permanently deleted.

Indicate what assurances will be given to participants about the security of, and access to, personal data and/or recordings, as indicated in the Participant Information Sheet.

This process is clearly highlighted within the patient information leaflet.

State as far as you are able to do so how long personal data and/or recordings collected/made during the study will be retained and what arrangements have been made for its/their secure storage and destruction, as indicated in the Participant Information Sheet.

Identifiable data such as video recordings will be saved directly to the university OneDrive and stored in encrypted files. The video files will be stored for a maximum of 72 hours allowing adequate time for them to be transcribed into anonymised text files, the original video footage will then be destroyed by being permanently deleted. Text files (including transcribed video data and signed consent forms) shall be stored until the conclusion of the PhD program anticipated to be March 2024. These again will be in the form of encrypted files on the university OneDrive. Data uploaded to NVIVO will be stored in a similar fashion. No data shall be recorded in paper form or on computer hard drives. On completion of the PhD program, all files will be deleted form OneDrive permanently.

Q15.3 Will data be anonymised prior to storage? ☐YES ☒NO

Q16 Is it intended (or possible) that data might be used beyond the present study? (See GN 2.2.10) ☐YES ☒NO

If YES, please indicate the kind of further use that is intended (or which may be possible).

If NO, will the data be kept for a set period and then destroyed under secure conditions? ☒YES ☐NO

If NO, please explain why not:

Q17 Consent Forms: what arrangements have been made for the storage of Consent Forms and for how long?

Consent forms shall be stored on encrypted files on the university OneDrive until completion of the PhD program in March 2024. On completion of the PhD program all data pertaining to the study shall be permanently erased.

Q18 If the activity/activities involve work with children and/or vulnerable adults satisfactory Disclosure and Barring Service (DBS) clearance may be required by investigators. You are required to check with the organisation (including UH/UH Partners where appropriate) responsible for the minors/vulnerable participants whether or not they require DBS clearance.

Any permission from the organisation confirming their approval for you to undertake the activities with the children/vulnerable group for which they are responsible should make specific reference to any DBS requirements they impose and their permission letter/email must be included with your application.

More information is available via the DBS website - https://www.gov.uk/government/organisations/disclosure-and-barring-service

---

REWARDS

Q19.1 Are you receiving any financial or other reward connected with this study? (See GN 2.2.14 and UPR RE01, S 2.3)

☒YES ☐NO

If YES, give details here:

STIPEND from the university of Hertfordshire

Q19.2 Are participants going to receive any financial or other reward connected with the study? (Please note that the University does not allow participants to be given a financial inducement.) (See UPR RE01,

S 2.3)

☐YES ☒NO

If YES, provide details here:

No financial incentives are offered to participants.

A certificate thanking participants for their contribution to the research will be offered to all interview participants.

Q19.3 Will anybody else (including any other members of the investigative team) receive any financial or other reward connected with this study?

☐YES ☒NO

If YES, provide details here:

Click here to enter text.

OTHER RELEVANT MATTERS

Q20 Enter here anything else you want to say in support of your application, or which you believe may assist the Committee in reaching its decision.

Click here to enter text.

DOCUMENTS TO BE ATTACHED

Please indicate below which documents are attached to this application:

☐ Permission to access groups of participants
☐ Permission to use University premises beyond areas of School
☐ Permission from off-campus location(s) to be used to conduct this study
☐ Form EC5 (Harms, Hazards and Risks: assessment and mitigation)

☒ Consent Form (See Form EC3/EC4)
☒ Form EC6 (Participant Info Sheet)
☐ Data Protection Impact Assessment (DPIA)

☒ A copy of the proposed questionnaire and/or interview schedule (if appropriate for this study). For unstructured methods, please provide details of the subject areas that will be covered and any boundaries that have been agreed with your Supervisor

☐ Any other relevant documents, such as a debrief, meeting report. Please provide details here:

Click here to enter text.

DECLARATIONS

1 DECLARATION BY APPLICANT

1.1 I undertake, to the best of my ability, to abide by UPR RE01, 'Studies Involving the Use of Human Participants', in carrying out the study.

1.2 I undertake to explain the nature of the study and all possible risks to potential participants,

1.3 Data relating to participants will be handled with great care. No data relating to named or identifiable participants will be passed on to others without the written consent of the participants concerned, unless they have already consented to such sharing of data when they agreed to take part in the study.

1.4 All participants will be informed **(a)** that they are not obliged to take part in the study, and **(b)** that they may withdraw at any time without disadvantage or having to give a reason.

(**NOTE**: Where the participant is a minor or is otherwise unable, for any reason, to give full consent on their own, references here to participants being given an explanation or information, or being asked to give their consent, are to be understood as referring to the person giving consent on their behalf. (See Q 12; also GN Pt. 3, and especially 3.6 & 3.7))

Enter your name here: Timothy Ian Millington Date 10/04/2022

2 GROUP APPLICATION

(If you are making this application on behalf of a group of students/staff, please complete this section as well)

I confirm that I have agreement of the other members of the group to sign this declaration on their behalf

Enter your name here: Not applicable Date Click here to enter a date.

DECLARATION BY SUPERVISOR (see GN 2.1.6)

I confirm that the proposed study has been appropriately vetted within the School in respect of its aims and methods; that I have discussed this application for Ethics Committee approval with the applicant and approve its submission; that I accept responsibility for guiding the applicant so as to ensure compliance with the terms of the protocol and with any applicable ethical code(s); and that if there are conditions of the approval, they have been met.

Enter your name here: Julia Williams Date 12/04/2022

Appendix 8: EC3 'consent' form

University of Hertfordshire UH Ethics Committee

UNIVERSITY OF HERTFORDSHIRE
ETHICS COMMITTEE FOR STUDIES INVOLVING THE USE OF HUMAN PARTICIPANTS ('ETHICS COMMITTEE')

FORM EC3: CONSENT FORM FOR STUDIES INVOLVING HUMAN PARTICIPANTS

I, the undersigned *[please give your name here, in BLOCK CAPITALS]*

……

of *[please give contact details here, sufficient to enable the investigator to get in touch with you, such as a postal or email address]*

……

……

……

hereby freely agree to take part in the study entitled *'Insights into paramedic experiences using personal protective equipment (PPE) during the COVID-19 pandemic.'*

(UH Protocol number ……)

1 I confirm that I have been given a Participant Information Leaflet giving particulars of the study, including its aims, methods and design, the names and contact details of key people and, as appropriate, the risks and potential benefits, how the information collected will be stored and for how long, and any plans for follow-up studies that might involve further approaches to participants. I have also been informed of how my personal information on this form will be stored and for how long. I have been given details of my involvement in the study. I have been told that in the event of any significant change to the aims or design of the study I will be informed and asked to renew my consent to participate in it.

2 I have been assured that I may withdraw from the study until 1 week after the interview has been conducted without disadvantage or having to give a reason. After this data will have to be captured for analysis.

1

3 In giving my consent to participate in this study, I understand that voice & video recording will take place and I have been informed of how this recording will be displayed.

4 I have been told how information relating to me (data obtained in the course of the study, and data provided by me about myself) will be handled: how it will be kept secure, who will have access to it, and how it will or may be used, including the possibility of anonymised data being deposited in a repository with open access (freely available).

5 I understand that my participation in this study may reveal findings that could indicate that I may require medical advice. In that event, I will be advised to consult my GP and may be asked to withdraw from the study.

6 I understand that if there is any revelation of unlawful activity or any indication of non-medical circumstances that would or has put others at risk, the University may refer the matter to the appropriate authorities.

Signature of participant:

Please print name here:

Date:

Signature of (principal) investigator:

Date:

Name of (principal) investigator: *TIMOTHY MILLINGTON*

Appendix 9: EC6 form

University of Hertfordshire UH Ethics Committee

UNIVERSITY OF HERTFORDSHIRE
ETHICS COMMITTEE FOR STUDIES INVOLVING THE USE OF HUMAN PARTICIPANTS
FORM EC6: PARTICIPANT INFORMATION SHEET (Pre-interview)

1 **Title of study**

Insights into experiences of frontline health care professionals (HCPs) using personal protective equipment (PPE) during the Covid-19 pandemic

2 **Introduction**

You are being invited to take part in a study. Before you decide whether to do so, it is important that you understand the study that is being undertaken and what your involvement will include. Please take the time to read the following information carefully and discuss it with others if you wish. Do not hesitate to ask about anything that is not clear or should you require any further information to help you make your decision. Please do take your time to decide whether you wish to take part. The University's regulation, UPR RE01, 'Studies Involving the Use of Human Participants' can be accessed via this link:

https://www.herts.ac.uk/about-us/governance/university-policies-and-regulations-uprs/uprs

(After accessing this website, scroll down to Letter S where you will find the regulation)

3 **What is the purpose of this study?**

The purpose of this study is to explore the experiences of patient facing, UK based, National Health Service (NHS) paramedics using PPE during the COVID-19 pandemic.

4 **Do I have to take part?**

No. It is completely up to you whether you decide to take part in this study. If you do decide to take part, you will be given this information sheet to keep and be asked to sign a consent form. Agreeing to join the study does not mean that you must complete it. You are free to withdraw up to 1 week following completion of the interview.

5 **Are there any age or other restrictions that may prevent me from participating?**

You must meet the relevant inclusion criteria…

- NHS Paramedic in the UK
- Must have worked from at least 11th March 2020 and at least 6 months thereafter.
- Must have been in a patient facing role.
- Must have been required to wear PPE in the care of patients as part of their role.

6 **How long will my part in the study take?**

If you decide to take part in this study, you will be required to be available for no longer than 1 hour. Every effort will be made to not exceed the 1-hour target.

7 **What will happen to me if I take part?**

You will be issued with consent forms, then, once completed, and returned to the researcher, you will be contacted via email to arrange a suitable date for interview. You will then be issued with an invite to an MS teams meeting. Following completion, if you have requested, you will be sent a certificate thanking you for involvement.

8 **What are the possible disadvantages, risks, or side effects of taking part?**

There is a possibility that you will have to recall traumatic events that might elicit an emotional response. Should this cause you concern the interview can be paused, re-arranged, or cancelled.

9 **What are the possible benefits of taking part?**

It is the intention that the research findings be used to better enable healthcare organizations to support staff who are required to use PPE. Understanding experiences both positive and negative can help contribute to future policy and better improve conditions and safety for HCPs when using PPE.

10 **How will my taking part in this study be kept confidential?**

Data shall be stored on encrypted files uploaded to the University of Hertfordshire's secure cloud-based OneDrive, accessed via two factor authentication on password secure laptops.

11 **Audio-visual material**

Once you have joined the MS teams meeting, you will be reminded of the recording of audio-visual material. Audio only recordings can be made if you prefer however video is encouraged as it can provide additional richness to the data that is obtained. These files will be stored and deleted within 3 days after being converted to anonymized, text only files (a process called transcribing), ready for analysis.

12 **What will happen to the data collected within this study?**

Video shall be recorded directly onto the highly secure, cloud based, University OneDrive, directly from MS teams. Video or audio files shall be transcribed within 3 days, anonymized and the video format then permanently erased. No hard copies of the transcribed notes shall be made. Digitally signed consent documents shall be stored as .pdf files on encrypted files within the OneDrive, no hard copies will be required as per the university's adapted ethical COVID-19 guidance.

All data, including any notes and analysis made by researcher, will be stored within the cloud based OneDrive system, as recommended by the University of Hertfordshire's Data management guidelines.

13 **Will the data be required for use in further studies?**

It is not envisaged that the data will be used in any further studies.

14 **Who has reviewed this study?**

This study has been reviewed by the University of Hertfordshire Health, Science, Engineering and Technology Ethics Committee with Delegated Authority. The UH protocol number is HSK/PGT/UH/04962

15 **Factors that might put others at risk**

Please note that if, during the study any health related or unlawful activity become apparent that might, or has previously, put others at risk the University may refer the matter to the appropriate authorities and, under such circumstances, you will be withdrawn from the study.

16 **Who can I contact if I have any questions?**

If you would like further information or would like to discuss any details, please get in touch with me, in writing, by phone or by email: t.millington@herts.ac.uk

Although we hope it is not the case, if you have any complaints or concerns about any aspect of the way you have been approached or treated during this study, please write to the University's Secretary and Registrar at the following address:

Secretary and Registrar
University of Hertfordshire
College Lane
Hatfield
Herts
AL10 9AB

Thank you very much for reading this information and considering taking part in this study.

Tim Millington
Paramedic Researcher

Appendix 10: University of Hertfordshire Ethics Approval Notification

'Insights into paramedic experiences using personal protective (PPE) during the COVID-19 pandemic.

University of Hertfordshire UH

HEALTH, SCIENCE, ENGINEERING AND TECHNOLOGY ECDA

ETHICS APPROVAL NOTIFICATION

TO	Timothy Ian Millington
CC	Prof. Julia Williams
FROM	Dr Rosemary Godbold, Health, Science, Engineering & Technology ECDA Vice Chair
DATE	04/05/2022

Protocol number: **HSK/PGT/UH/04962**

Title of study: Insights into paramedic experiences using personal protective equipment (PPE) during the COVID-19 pandemic

Your application for ethics approval has been accepted and approved with the following conditions by the ECDA for your School and includes work undertaken for this study by the named additional workers below:

Any of no additional workers named

General conditions of approval:

Ethics approval has been granted subject to the standard conditions below:

Permissions: Any necessary permissions for the use of premises/location and accessing participants for your study must be obtained in writing prior to any data collection commencing. Failure to obtain adequate permissions may be considered a breach of this protocol.

External communications: Ensure you quote the UH protocol number and the name of the approving Committee on all paperwork, including recruitment advertisements/online requests, for this study.

Invasive procedures: If your research involves invasive procedures you are required to complete and submit an EC7 Protocol Monitoring Form, and copies of your completed consent paperwork to this ECDA once your study is complete.

Submission: Students must include this Approval Notification with their submission.

Validity:

This approval is valid:

From: 04/05/2022

To: 31/01/2023

PPE Experiences

Interview guide: Semi-structured

Duration 1 hour

Draft 1

<*Researcher Introduction. Consent recording*>

Thank you for agreeing to take part in this project exploring paramedic experiences of wearing PPE during the covid-19 pandemic.

Please speak as freely as you feel comfortable. If you require a break or wish the interview to be stopped, please say. Are you happy to begin the interview and for it to be recorded?

<*Ensure inclusion / exclusion criteria are met*>

Have you been a HCPC registered paramedic working in a patient facing role for at least 6 months since the start of the pandemic in March 2020.

What was your role?

How long have you been in that role?

How long have you been a HCPC registered paramedic?

What region do you work in?

<*General experiences*>

Can you tell me about your experiences of enhanced PPE?

What were your early experiences of PPE?

How did its introduction impact you personally?

How did your experiences change as time passed?

What if anything stands out in your mind?

Can you give 2 words that first come to mind when you think of enhanced PPE?

<*Patient care*>

How do you feel enhanced PPE impacts patient care?

Describe which aspects you feel are affected and in what way?

Thinking generally about patient care in PPE, what would you change? Why?

What would you keep? Why?

Do you feel you are able to deliver care to the standard you would like when using PPE – why do you think this is?

Have you felt safe in PPE? Has this changed with time?

Describe your experience of using PPE during cardiac arrests?

How has PPE impacted care during cardiac arrests?

<*Physical & mental health*>

How has using enhanced PPE impacted your physical health?

How has enhanced PPE impacted your mental health?

Has it made any pre-existing conditions you may have better or worse? In what way?

Have you been required to seek medical treatment as a result of using PPE?

How has your diet been affected since using enhanced PPE?

How has your fitness been affected since using enhanced PPE?

How has your sleep been affected since using enhanced PPE?

Do you feel PPE has had a direct impact on any of these aspects?

Have you developed strategies to help you since being required to work with PPE? If so what are they?

students

<*Non-adherence*>

At work, have you witnessed non-compliance to PPE guidelines by other HCP's?

Describe a time when PPE guidelines might not have been followed perfectly?

Why do you think this happened?

Have you ever been non-compliant of guidance regarding PPE either deliberately or accidentally?

What happened? Why do you think this happened?

<*Service improvement*>

How could your employer make working in enhanced PPE better?

What do you feel is working well?

How would you change your working environment to improve working conditions for staff in enhanced PPE?

Is there anything that you feel should be changed immediately?

What support do you need?

Do you feel more or less likely to leave your current role since covid-19 measures?

Does PPE impact your decision in any way?

Have you anything you'd like to suggest?

Finally, on reflecting on your experiences of using enhanced PPE, have you any further comments you wish to add?

<*PPE fatigue*>

What is your understanding of the term 'PPE fatigue'?

Have you experienced PPE fatigue?

<*Close*>

Thankyou for taking part in this interview. Your time and effort are very much appreciated.

Appendix 12: Copy of completed IRAS form

IRAS Form | Reference: 23/YH/0027 | IRAS Version 6.3.3

Welcome to the Integrated Research Application System

IRAS Project Filter

The integrated dataset required for your project will be created from the answers you give to the following questions. The system will generate only those questions and sections which (a) apply to your study type and (b) are required by the bodies reviewing your study. Please ensure you answer all the questions before proceeding with your applications.

Please complete the questions in order. If you change the response to a question, please select 'Save' and review all the questions as your change may have affected subsequent questions.

Please enter a short title for this project (maximum 70 characters)
STOPGAP

1. Is your project research?

◉ Yes ○ No

2. Select one category from the list below:

○ Clinical trial of an investigational medicinal product
○ Combined trial of an investigational medicinal product and an investigational medical device
○ Clinical investigation or other study of a medical device
○ Other clinical trial to study a novel intervention or randomised clinical trial to compare interventions in clinical practice
◉ Basic science study involving procedures with human participants
○ Study administering questionnaires/interviews for quantitative analysis, or using mixed quantitative/qualitative methodology
○ Study involving qualitative methods only
○ Study limited to working with human tissue samples (or other human biological samples) and data (specific project only)
○ Study limited to working with data (specific project only)
○ Research tissue bank
○ Research database

If your work does not fit any of these categories, select the option below:

○ Other study

2a. Will the study involve the use of any medical device without a UKCA/CE UKNI/CE Mark, or a UKCA/CE UKNI/CE marked device which has been modified or will be used outside its intended purposes?

○ Yes ◉ No

2b. Please answer the following question(s):

a) Does the study involve the use of any ionising radiation?	○ Yes	◉ No
b) Will you be taking new human tissue samples (or other human biological samples)?	○ Yes	◉ No
c) Will you be using existing human tissue samples (or other human biological samples)?	○ Yes	◉ No

Date: 28/12/2022 1

DRAFT

d) Will the study involve any other clinical procedures with participants (e.g. MRI, ultrasound, physical examination)? (●) Yes ( ) No

3. In which countries of the UK will the research sites be located? *(Tick all that apply)*

- [x] England
- [ ] Scotland
- [ ] Wales
- [ ] Northern Ireland

3a. In which country of the UK will the lead NHS R&D office be located:

- (●) England
- ( ) Scotland
- ( ) Wales
- ( ) Northern Ireland
- ( ) This study does not involve the NHS

4. Which applications do you require?

- [x] IRAS Form
- [ ] Confidentiality Advisory Group (CAG)
- [ ] Her Majesty's Prison and Probation Service (HMPPS)

Most research projects require review by a REC within the UK Health Departments' Research Ethics Service. Is your study exempt from REC review?

( ) Yes (●) No

5. Will any research sites in this study be NHS organisations?

(●) Yes ( ) No

5a. Are all the research costs and infrastructure costs (funding for the support and facilities needed to carry out the research e.g. NHS support costs) for this study provided by a NIHR Biomedical Research Centre (BRC), NIHR Applied Research Collaboration (ARC), NIHR Patient Safety Translational Research Centre (PSTRC), or an NIHR Medtech and In Vitro Diagnostic Co-operative (MIC) in all study sites?

Please see information button for further details.

( ) Yes (●) No

Please see information button for further details.

5b. Do you wish to make an application for the study to be considered for NIHR Clinical Research Network (CRN) Support and inclusion in the NIHR Clinical Research Network Portfolio?

Please see information button for further details.

(●) Yes ( ) No

DRAFT

The NIHR Clinical Research Network (CRN) provides researchers with the practical support they need to make clinical studies happen in the NHS in England e.g. by providing access to the people and facilities needed to carry out research "on the ground".

If you select yes to this question, information from your IRAS submission will automatically be shared with the NIHR CRN. ***Submission of a Portfolio Application Form (PAF) is no longer required.***

6. Do you plan to include any participants who are children?

○ Yes ◉ No

7. Do you plan at any stage of the project to undertake intrusive research involving adults lacking capacity to consent for themselves?

◉ Yes ○ No

Answer Yes if you plan to recruit living participants aged 16 or over who lack capacity, or to retain them in the study following loss of capacity. Intrusive research means any research with the living requiring consent in law. This includes use of identifiable tissue samples or personal information, except where application is being made to the Confidentiality Advisory Group to set aside the common law duty of confidentiality in England and Wales. Please consult the guidance notes for further information on the legal frameworks for research involving adults lacking capacity in the UK.

8. Do you plan to include any participants who are prisoners or young offenders in the custody of HM Prison Service or who are offenders supervised by the probation service in England or Wales?

○ Yes ◉ No

9. Is the study or any part of it being undertaken as an educational project?

◉ Yes ○ No

Please describe briefly the involvement of the student(s):
Students carrying out all practical research elements as part of PhD projects

9a. Is the project being undertaken in part fulfilment of a PhD or other doctorate?

◉ Yes ○ No

10. Will this research be financially supported by the United States Department of Health and Human Services or any of its divisions, agencies or programs?

○ Yes ◉ No

11. Will identifiable patient data be accessed outside the care team without prior consent at any stage of the project (including identification of potential participants)?

◉ Yes ○ No

Approval may be required from CAG to access patient data without consent. Please check your response in Question 4.

DRAFT

Integrated Research Application System
Application Form for Basic science study involving procedures with human participants

IRAS Form (project information)

Please refer to the E-Submission and Checklist tabs for instructions on submitting this application.

The Chief Investigator should complete this form. Guidance on the questions is available wherever you see this symbol displayed. We recommend reading the guidance first. The complete guidance and a glossary are available by selecting Help.

Please define any terms or acronyms that might not be familar to lay reviewers of the application.

Short title and version number: (maximum 70 characters - this will be inserted as header on all forms)
STOPGAP

Please complete these details after you have booked the REC application for review.

REC Name:
Yorkshire & The Humber - Leeds West Research Ethics Committee

REC Reference Number:
23/YH/0027

Submission date:
28/12/2022

PART A: Core study information

1. ADMINISTRATIVE DETAILS

A1. Full title of the research:

Study of cardiopulmonary resuscitation procedures thought to generate aerosol particles

A2-1. Educational projects

Name and contact details of student(s):

Student 1

Title	Forename/Initials	Surname
Miss	Ruth M	Fisher

Address	Yorkshire Ambulance Service NHS Trust
	Northside Road
	Bradford
Post Code	BD7 2AY
E-mail	rf21aac@herts.ac.uk
Telephone	07773156091
Fax	

Give details of the educational course or degree for which this research is being undertaken:

Name and level of course/ degree:
PhD Paramedic Science

Name of educational establishment:
University of Hertfordshire

Student 2

	Title	Forename/Initials	Surname
	Mr	Dale	Gedge
Address	University of Hertfordshire, School of Health & Social Work		
	College Lane, Hatfield		
	Hertfordshire		
Post Code	AL10 9AB		
E-mail	d.a.gedge@herts.ac.uk		
Telephone	07738113838		
Fax			

Give details of the educational course or degree for which this research is being undertaken:

Name and level of course/ degree:
PhD Paramedic Science

Name of educational establishment:
University of Hertfordshire

Student 3

	Title	Forename/Initials	Surname
	Mr	Timothy	Millington
Address	University of Hertfordshire, School of Health & Social Work		
	College Lane, Hatfield		
	Hertfordshire		
Post Code	AL10 9AB		
E-mail	t.i.millington@herts.ac.uk		
Telephone	07572462934		
Fax			

Give details of the educational course or degree for which this research is being undertaken:

Name and level of course/ degree:
PhD Paramedic Science

Name of educational establishment:
University of Hertfordshire

Name and contact details of academic supervisor(s):

Academic supervisor 1

	Title	Forename/Initials	Surname
	Prof	Julia	Williams
Address	University of Hertfordshire, School of Health & Social Work		
	Room 2F260 - Wright Building		
	College Lane, Hatfield		

DRAFT

Work Address	School of Health & Social Work Room 2F260 - Wright Building College Lane, Hatfield
Post Code	AL10 9AB
Work E-mail	j.williams@herts.ac.uk
* Personal E-mail	j.williams@herts.ac.uk
Work Telephone	07710281095
* Personal Telephone/Mobile	07710281095
Fax	

** This information is optional. It will not be placed in the public domain or disclosed to any other third party without prior consent.*
A copy of a current CV (maximum 2 pages of A4) for the Chief Investigator must be submitted with the application.

A4. Who is the contact on behalf of the sponsor for all correspondence relating to applications for this project?
This contact will receive copies of all correspondence from REC and HRA/R&D reviewers that is sent to the CI.

Title	Forename/Initials	Surname
Ms	Ellie	Hubbard

Address	Research Information and Governance Manager, University of Hertfordshire College Lane Hatfield
Post Code	AL10 9AB
E-mail	research-sponsorship@herts.ac.uk
Telephone	01707 285755
Fax	

A5-1. Research reference numbers. *Please give any relevant references for your study:*

Applicant's/organisation's own reference number, e.g. R & D (if available):	NA
Sponsor's/protocol number:	NA
Protocol Version:	6
Protocol Date:	06/06/2022
Funder's reference number (enter the reference number or state not applicable):	COP/TN/HL/06062022
Project website:	NA

Registry reference number(s):
The UK Policy Framework for Health and Social Care Research sets out the principle of making information about research publicly available. Furthermore: Article 19 of the World Medical Association Declaration of Helsinki adopted in 2008 states that "every clinical trial must be registered on a publicly accessible database before recruitment of the first subject"; and the International Committee of Medical Journal Editors (ICMJE) will consider a clinical trial for publication only if it has been registered in an appropriate registry. Please see guidance for more information.

International Standard Randomised Controlled Trial Number (ISRCTN):
ClinicalTrials.gov Identifier (NCT number):

Additional reference number(s):

Ref.Number Description	Reference Number

DRAFT

A5-2. Is this application linked to a previous study or another current application?

○ Yes ◉ No

Please give brief details and reference numbers.

2. OVERVIEW OF THE RESEARCH

To provide all the information required by review bodies and research information systems, we ask a number of specific questions. This section invites you to give an overview using language comprehensible to lay reviewers and members of the public. Please read the guidance notes for advice on this section.

A6-1. Summary of the study. *Please provide a brief summary of the research (maximum 300 words) using language easily understood by lay reviewers and members of the public. Where the research is reviewed by a REC within the UK Health Departments' Research Ethics Service, this summary will be published on the Health Research Authority (HRA) website following the ethical review. Please refer to the question specific guidance for this question.*

Throughout the COVID-19 pandemic, there has been concern for the safety of first responders performing life-saving treatments on patients who may be COVID-19 positive. It's thought that certain actions (such as cardiopulmonary resuscitation "CPR") may cause patients to exhale larger amounts of aerosols. This could increase the risk of contracting COVID-19 from the patient. For this reason, new advice was introduced to improve infection control including the greater use of personal protective equipment (PPE) and practical advice such as putting wet towels on a patient's face. These additional measures can cause delays before patients receive life-saving treatment. Evidence indicates new measures may have lowered the chance of surviving when a person's heart suddenly stops (cardiac arrest).

There is debate regarding which procedures pose a risk to first responders. It is generally agreed that current evidence is of low quality and so first responders find themselves with a dilemma. On the one hand, they could opt to use low performance PPE which can be put on quickly but increases risk of contracting COVID-19. In contrast, a higher level of PPE may reduce the risk of infection but could cause delays that might reduce the chance of their patient surviving. To put this delay into context, there is a 7 – 10 % decrease in survival for each minute that CPR is delayed.

We will study six procedures involved with standard CPR to determine if these cause an increase in aerosols exhaled by patients. We will collect this information when CPR is performed (1) out-of-hospital and (2) in an Emergency Department (ED) to determine if the risk level differs between the two environments. We aim to conduct each procedure on a maximum of 36 patients in ED and 36 patients in the out-of-hospital setting.

A6-2. Summary of main issues. *Please summarise the main ethical, legal, or management issues arising from your study and say how you have addressed them.*

Not all studies raise significant issues. Some studies may have straightforward ethical or other issues that can be identified and managed routinely. Others may present significant issues requiring further consideration by a REC, HRA, or other review body (as appropriate to the issue). Studies that present a minimal risk to participants may raise complex organisational or legal issues. You should try to consider all the types of issues that the different reviewers may need to consider.

The issues and resolutions summarised have been raised and addressed with a Patient and Public Involvement and Engagement (PPIE) panel consisting of lay-persons. The resolutions were also discussed with and deemed acceptable by the PPIE panel. The panel continues to support the project and are in favour of its continuation.

Gaining consent - One of the primary areas of concern for the research team is the difficulty of having a conversation with family members regarding consent to enrol their loved ones in the study during a highly emotive and distressing time. Through further engagement with community leaders and local critical care specialists, the team hopes to develop further insight and draw on expertise in initiating sensitive conversations, and to prepare the research team ahead of participant recruitment. However, as this is a time critical observational study it has been decided to apply for waiver of consent.

Information Governance - It is appreciated that access to confidential patient records shall be required by the research team and handling of such data must be approached with the utmost sensitivity and professionalism. The researchers involved in this study are experienced senior clinicians registered with the Health and Care Professions Council (HCPC) and extensively use data of this nature in their clinical roles. It is a legal requirement that the researchers stay up to date with information governance practices to meet expected professional standards. To

minimise risks, minimal demographic patient data shall be recorded in addition to aerosol data, namely; age, sex, body habitus and comorbidities. All data shall be stored on password secure laptops with no patient identifiable information. No retrospective access shall be required with regard to patient data.

Engagement with family members either on scene in WP 1 or in the ED WP 2 will be managed sensitively. Approaching family members to explain the research process has been deemed inappropriate by the research team, likely adding to the burden of distress, especially as this research will not cause any change in standard cardiac arrest care and management of the patient. To ensure family members remain informed, and to support them in their grieving process, a Patient Information Leaflet has been created and shall be issued on request. During data collection, should the family object to the presence of the research team, data collection shall be terminated, with the team removing themselves from the scene to avoid causing additional distress.

In WP 1 there has been consideration of impedance of resuscitation attempt/Research paramedic clinical involvement. A concern expressed by the research team members related to the possibility that collection of data may impede the resuscitation process. The research team are experienced paramedics with extensive Advanced Life Support (ALS) skills. The protocol states that the research paramedics shall attend all included cardiac arrest incidents as a clinician first and a researcher second, meaning they shall begin, lead, or assist the resuscitation efforts until such point that there is an appropriate team of rescuers on scene. At this point, the research paramedics will withdraw and begin research efforts in agreement with the resuscitation team. Researchers involved in STOPGAP are experienced in cardiac arrest management and shall draw upon this experience to reach decisions as to when it is appropriate to begin the research process. A dynamic risk assessment shall be conducted throughout the rescue attempt and at any point should it be felt the researcher's clinical expertise would best address the patient's need, the research process shall be halted, and the researcher will revert to their clinical role. In WP 2 the research paramedics will be observers who are collecting data and they will be physically situated on the periphery of the clinical care so as not to distract from time critical care delivery and interventions.

Family distress – The researchers are experienced senior clinicians with experience of terminating resuscitation efforts and delivering death notifications and appreciate the sensitivity of the situations they will be entering and the potential impact on those affected. As was further emphasised during consultation with the PPIE panel, witnessing resuscitative procedures in the out-of-hospital environment can be extremely distressing.

Waiver of consent – Thorough review of the options for consenting potential participants in the out-of-hospital setting has included assent and deferral of consent. Survivability of out-of-hospital cardiac arrest is 7-10%, so unfortunately the majority of participants are unlikely to survive. Due to the sensitive and distressing nature of the events being studied, it was deemed inappropriate and insensitive to make contact with the family at a later date for the purposes of obtaining consent as this may cause further undue distress. Also, obtaining consent at the time of data collection was deemed inappropriate due to the distressing nature of the event occurring. Therefore, a waiver of consent is requested for both WP 1 and WP2. A patient information leaflet that includes contact details of the research team shall be provided to family members to facilitate a line of communication should any concerns or queries arise at the scene.

Equipment weight and potential to obstruct environment - The research paramedics are highly conscious of the variable and dynamic environments that are likely to be present during a resuscitation attempt. The equipment to allow data collection consists of a particle analyser and battery pack with a combined weight of approximately 70kg. The equipment will be mounted in a custom-built, sound-proofed case for safe transport from the vehicle to the scene of the rescue attempt. A dynamic risk assessment of the scene will determine where equipment will be placed, with the ideal being in as close proximity to the patient as possible without causing any obstruction for the team involved in the rescue attempt. If the environment does not allow safe placement of the equipment at a distance that allows data collection, then the patient will not be enrolled in the study. The responsibility of carrying the equipment will lie solely with the research team who are well practiced in moving and handling techniques relating to the Elpi+ and its associated adjuncts.

Staff awareness and familiarisation - Through working closely with the Research and Development and Operational Teams at the host sites for both work packages, it was decided there would be benefit in the study being promoted to staff likely to encounter the research team during data collection. In addition, the researchers will be seeking to actively engage with operational staff to address any concerns or queries and support them throughout the data collection period. Staff engagement methods will include, but are not limited to, attendance at daily huddles, publication of study details in local newsletters and promotion of a video explaining the role of the researchers at the scene.

3. PURPOSE AND DESIGN OF THE RESEARCH

A7. Select the appropriate methodology description for this research. *Please tick all that apply:*

- ☐ Case series/ case note review
- ☐ Case control
- ☐ Cohort observation
- ☐ Controlled trial without randomisation
- ☐ Cross-sectional study
- ☐ Database analysis
- ☐ Epidemiology
- ☐ Feasibility/ pilot study
- ☐ Laboratory study
- ☐ Metanalysis
- ☐ Qualitative research
- ☐ Questionnaire, interview or observation study
- ☐ Randomised controlled trial
- ☑ Other (please specify)

Basic science study involving procedures with human participants
Non-interventional study where observational data will be recorded

A10. What is the principal research question/objective? *Please put this in language comprehensible to a lay person.*

Do procedures such as chest compressions, defibrillation, management of patients' airways and ventilation, (performed during standard cardiopulmonary resuscitation) result in the generation of excess aerosol from a patient's exhaled breath?

A11. What are the secondary research questions/objectives if applicable? *Please put this in language comprehensible to a lay person.*

What type of protective equipment is most appropriate for emergency responders who perform CPR?

A12. What is the scientific justification for the research? *Please put this in language comprehensible to a lay person.*

A cardiac arrest describes the event where a person's heart stops and they are no longer breathing. Key to survival is prompt action by healthcare workers or members of the public. These prompt actions are collectively termed cardiopulmonary resuscitation (CPR). There are six elements to CPR: chest compressions, bag-valve-mask ventilation, defibrillation, oropharyngeal/nasopharyngeal suctioning, intubation and supraglottic airway insertion.

Until recently, standard clinical practice was to perform CPR straight away. The COVID-19 pandemic has changed this, as we now have to consider the risk of the responder catching COVID-19 from the patient. For the public, it is recommended to cover the patient's nose/mouth with a cloth before starting chest compressions only (so no breathing into the patient). For medical professionals, the advice is to put on medium-level (Level 2) PPE mask, place a disconnected oxygen mask on the patient as a barrier to any exhaled aerosol, and start compressions only until someone wearing a higher level of PPE (Level 3) can take over. Only then can full CPR begin.

There is considerable debate in the current literature and amongst various professional bodies regarding which of these procedures actually pose a risk to the responder. The consensus is that the current evidence is of low quality – so the responder finds themselves with a dilemma; an inadequate level of PPE may put them at higher risk of contracting COVID-19 but a higher level of PPE may delay their response and therefore reduce the chance of survival of the patient. For every minute without CPR, the patient's chances of survival will decrease by 7-10%, so seconds really do matter.

Risks arising from exposure to aerosols generated during CPR of patients infected with SARS-COV-2 (the virus which causes COVID-19) are largely unknown. Correspondingly, guidance for clinical professionals and lay responders has been based on a highly conservative approach involving revised clinical procedures (e.g., withdrawal of manual ventilation during initial stages of CPR), introduction of different levels of PPE and additional steps such as the use of towels/cloths placed over the face of patients.

DRAFT

Quantification of the quantity and particle size distribution of aerosols exhaled during individual elements of the six CPR stages would provide the critical evidence required to effectively address these public health issues during this current (and future) pandemics involving airborne pathogens, with the primary objective of developing evidence-based guidance for CPR to deliver optimal patient care while ensuring the safety of emergency responders and appropriate utilisation of limited resources e.g. Level 3 PPE.

The proposed multi-method design incorporates a clinical component (investigating CPR aerosol generation and distribution in the ED as well as in the out of hospital setting), which will inform subsequent laboratory-based work. Quantification and characterisation of aerosols will be performed using a high-resolution particle size analyser. The aim of the clinical studies will be to determine the contribution of each CPR procedure (chest compressions, bag-valve-mask ventilation, defibrillation, oropharyngeal/nasopharyngeal suctioning, intubation and supraglottic airway insertion) to the aerosol within expired air and the aerosol size distribution.

We will carry out these procedures in two different settings in order to determine whether there is a different level of risk in the out-of-hospital environment compared to a more controlled in-hospital environment.

Following comprehensive review of the literature no studies were identified that captured real time aerosol data measured during active resuscitation of patients in cardiac arrest.

The resulting data will facilitate the development of a laboratory model to reproduce the aerosol particle concentration and distribution characteristics using a non-infectious simulant (solvated salt particles) to assess effectiveness of fabrics (t-shirt, tea towel, bathroom towel; dry or humid conditions), a non-rebreather mask (without oxygen) and a standard fluid-repellent FFP2 face mask. The outcome of the laboratory studies will be to confirm the safety of level 2 and 3 respiratory protection and what, if anything, should be placed over the patient's face to limit aerosol being exhaled while they are being resuscitated.

A panel of lay people will work with the research team throughout the project to ensure that views of patients, families and the public are represented.

A13. Please summarise your design and methodology. *It should be clear exactly what will happen to the research participant, how many times and in what order. Please complete this section in language comprehensible to the lay person. Do not simply reproduce or refer to the protocol. Further guidance is available in the guidance notes.*

Work Package 1 (out-of-hospital)

As an observational study, the research team will have no control over what resuscitation procedures are being performed, how long for, and in what order during the data collection. The research paramedics will ensure their presence does not impact the resuscitation attempt. The research paramedics team will respond to 999 calls identified as a cardiac arrest by the call handler within the Emergency and Operations Centre. The distance to the location of the call will need to be deemed as within a suitable distance whereby the research paramedic arrives at a time which is either beneficial to provide clinical intervention or to begin data collection at an appropriate time during the resuscitation attempt. The research paramedics will attend these calls ready to be a responding clinician if necessary, or as a supernumerary researcher within a critical care team.

The Work Package 1 protocol flowchart details the scenarios that may occur with regards to resource allocation and at what times it is appropriate to begin data collection. Ultimately, the research paramedic will act in the best interests of the patient and only when sufficient numbers and grade of clinician are present at the scene, will they step away from a clinical role to begin data collection.

If appropriate to do so, the research paramedic will position a sampling tube (1.8 cm diameter) at a standardised location (20mm) immediately near the patient's mouth opening, connect it to the aerosol analyser, and record chronology and timings of the treatment provided with the use of a data collection form. The research paramedic will remain positioned away from the patient to eliminate the possibility of interference with patient treatment and management. The analysing equipment (ELPI+, pump, battery and control system; all encased in a noise-proof, portable case) will be set-up following a dynamic risk assessment of the environment so that it is within close proximity of the patient, whilst not obstructing the resuscitation attempt in anyway. There is potential that equipment may be in an adjacent room if the risk assessment of the environment allows. Data relating to relative humidity and temperature will also be recorded.

Work Package 2 (Emergency Department)

Just as in WP 1 as an observational study, the research team will have no control over what resuscitation procedures are being performed, how long for, and in what order during the data collection. The research paramedics will ensure their presence does not impact the resuscitation attempt.

The research paramedic will be present in the ED over a six week period (24/7) to manage the Dekati HR-ELPI®+ and collect data during the cardiac arrest so that the clinicians are not distracted from patient treatment.

The particle analyser (Dekati HR-ELPI®+) provides real-time measurement of particle size distribution and concentration. The instrument works in combination with an oil-free vacuum pump (encased in a noise-eliminating housing), battery and computer control system which have been integrated into one, portable, stand-alone unit. Data will be collected in a designated resuscitation bay in the participating hospital.

As this work package is based within a working ED and not a controlled laboratory environment it will be important to analyse the environmental aerosols regularly on a 24 hour basis if possible. This will provide the research team with 'baseline' data and enable comparisons to be made with aerosol data collected during each cardiac arrest.

We have chosen two work packages within different settings to gauge whether there is a difference between an uncontrolled environment and a more controlled in-hospital environment.

In summary both WP 1 and WP 2 will be observational and involve measuring particle size distribution and concentration during active resuscitation attempts in the out of hospital setting (uncontrolled environment) and an Emergency Department which is a more static, controlled environment. A maximum of 36 events in each setting will be included.

A14-1. In which aspects of the research process have you actively involved, or will you involve, patients, service users, and/or their carers, or members of the public?

- [x] Design of the research
- [x] Management of the research
- [x] Undertaking the research
- [ ] Analysis of results
- [x] Dissemination of findings
- [ ] None of the above

Give details of involvement, or if none please justify the absence of involvement.
PPIE meetings were conducted with lay persons who had experience of the ambulance service both as patients and/or service users. The PPIE group were consulted on the research design and consent considerations. The PPIE group involved lay people with research knowledge as well as those with personal experiences relating to unwell family members within an acute hospital setting.
We will continue to work with our PPIE members, actively engaging them in the progression of the study and looking to them to be involved in dissemination of the findings.

4. RISKS AND ETHICAL ISSUES

RESEARCH PARTICIPANTS

A15. What is the sample group or cohort to be studied in this research?

Select all that apply:

- [ ] Blood
- [ ] Cancer
- [x] Cardiovascular
- [ ] Congenital Disorders
- [ ] Dementias and Neurodegenerative Diseases
- [ ] Diabetes
- [ ] Ear

- [ ] Eye
- [x] Generic Health Relevance
- [x] Infection
- [ ] Inflammatory and Immune System
- [ ] Injuries and Accidents
- [ ] Mental Health
- [ ] Metabolic and Endocrine
- [ ] Musculoskeletal
- [ ] Neurological
- [ ] Oral and Gastrointestinal
- [ ] Paediatrics
- [ ] Renal and Urogenital
- [ ] Reproductive Health and Childbirth
- [x] Respiratory
- [ ] Skin
- [ ] Stroke

Gender:	Male and female participants
Lower age limit: 18	Years
Upper age limit:	No upper age limit

A17-1. Please list the principal inclusion criteria (list the most important, max 5000 characters).

Work Package 1 - Clinical – Out-of-hospital setting
• ≥18yo
• Out-of-hospital cardiac arrest (OHCA), including overdose, hypothermia, pulmonary embolism, atraumatic major haemorrhage.
• Scene deemed appropriate following dynamic risk assessment

Work Package 2 - Clinical – ED setting
• ≥18yo
• Cardiac arrest, including overdose, hypothermia, pulmonary embolism, atraumatic major haemorrhage

A17-2. Please list the principal exclusion criteria (list the most important, max 5000 characters).

Work Package 1 - Clinical - Out-of-hospital setting
• <18yo
• Tracheostomy in situ
• Circumstances surrounding cardiac arrest that require police investigation
• DNACPR / end of life directives in place
• OHCA in pregnancy
• OHCA due to drowning (dry or wet)
• OHCA secondary to smoke inhalation / house fires
• Multi-patient incidents
• Public places – following researcher led dynamic risk assessment
• Research impedes resuscitation attempt
• Resuscitation not commenced based on futility, e.g., decomposition / putrefaction / rigor mortis
• Family request
• Scene deemed unsafe
• Crew request
• Return of spontaneous circulation (ROSC)

DRAFT

• Institutionalised patients – prison, secure mental health facilities, nursing homes or care homes
• Patient with a surgical airway in situ.

Work Package 2 - Clinical – ED setting
• <18yo
• Tracheostomy in situ
• DNACPR / end of life directives in place
• Pregnant patients
• OHCA due to drowning (dry or wet)
• OHCA secondary to smoke inhalation / house fires
• Institutionalised patients – prison, secure mental health facilities
• Eligible for organ donation <18yo

RESEARCH PROCEDURES, RISKS AND BENEFITS

A18. Give details of all non-clinical intervention(s) or procedure(s) that will be received by participants as part of the research protocol. *These include seeking consent, interviews, non-clinical observations and use of questionnaires.*

Please complete the columns for each intervention/procedure as follows:

1. Total number of interventions/procedures to be received by each participant as part of the research protocol.
2. If this intervention/procedure would be routinely given to participants as part of their care outside the research, how many of the total would be routine?
3. Average time taken per intervention/procedure (minutes, hours or days)
4. Details of who will conduct the intervention/procedure, and where it will take place.

Intervention or procedure	1	2	3	4
Documentation of data during cardiac arrest. The time it takes will be determined by the length of the resuscitation attempt	1	0		Research Paramedic both in the ED and out of hospital setting

A19. Give details of any clinical intervention(s) or procedure(s) to be received by participants as part of the research protocol. *These include uses of medicinal products or devices, other medical treatments or assessments, mental health interventions, imaging investigations and taking samples of human biological material. Include procedures which might be received as routine clinical care outside of the research.*

Please complete the columns for each intervention/procedure as follows:

1. Total number of interventions/procedures to be received by each participant as part of the research protocol.
2. If this intervention/procedure would be routinely given to participants as part of their care outside the research, how many of the total would be routine?
3. Average time taken per intervention/procedure (minutes, hours or days).
4. Details of who will conduct the intervention/procedure, and where it will take place.

Intervention or procedure	1	2	3	4
This is difficult to answer. In both WP 1 and WP 2 cardiac arrest the patient will receive full cardiac arrest procedures as appropriate to individualised patient care basis.				CPR delivered by ambulance staff in WP 1 and hospital clinicians in WP 2. The researchers will merely be monitoring particles

A21. How long do you expect each participant to be in the study in total?

Less than 3 hours per participant in either Work Package, dependent on duration of resuscitation attempt in both Work Packages.

A22. What are the potential risks and burdens for research participants and how will you minimise them?

For all studies, describe any potential adverse effects, pain, discomfort, distress, intrusion, inconvenience or changes to lifestyle. Only describe risks or burdens that could occur as a result of participation in the research. Say what steps would be taken to minimise risks and burdens as far as possible.

In both WP1 and WP 2 the following are considered:
- Information governance
- Impedance of resuscitation attempt
- Family distress
- Research equipment causing trip hazard
- Staff wellbeing
- Consent of patients who do not have capacity

Information governance - It is appreciated that access to confidential patient records shall be required by the research team and handling of such data must be approached with the utmost sensitivity and professionalism.
The researchers involved in this study are experienced senior clinicians registered with the Health and Care Professions Council and extensively use data of this nature in their clinical roles. It is a legal requirement that they stay up to date with information governance practices to meet expected professional standards. Information accessed would not go beyond the research paramedics' normal scope/privileges as part of their clinical role. To minimise risks, minimal demographic patient data shall be recorded in addition to aerosol data, namely; age, sex, body habitus, co-morbidities and cardiac arrest characteristics (i.e., aetiology). This shall be stored on password secure laptops with no identifying patient information. Information governance procedures shall be discussed in greater depth further on in this application.

Impedance of the resuscitation attempt – When a patient suffers a cardiac arrest time is of the essence to restart their heart and potentially save their life. In a recent PPIE workshop, conducted by the research team, a concern was raised regarding collection of data impeding the resuscitation process particularly in WP1. This concern was addressed by referencing the out-of-hospital research protocol. The researchers involved in STOPGAP are experienced paramedics with extensive Advanced Life Support (ALS) skills. The protocol for the out-of-hospital study has been designed to utilise their skills as part of the rescue attempt. Research paramedics shall attend all included cardiac arrest incidents as a clinician first and a researcher second, meaning they shall begin, lead, or assist the resuscitation efforts until such point that there is an appropriate team of rescuers on scene. They then shall withdraw and begin research efforts in agreement with the resuscitation team. Researchers involved in STOPGAP are well versed in cardiac arrest management and shall draw upon this experience to reach decisions as to when it is appropriate to begin the research process. 'Dynamic risk assessment' is a tool engrained in paramedic training and involves the continued review of scene management to ensure optimal care and safety. Dynamic risk assessment shall be conducted throughout the rescue attempt and at any point should it be felt the researcher's clinical expertise would best address the patient's need, the research process shall be halted, and the researcher will revert to their clinical role. It is a fundamental aspect of this trial that any decisions regarding data collection are made with the patients' best interests at its heart.
In WP 2 the research paramedic will be physically positioned away from the clinicians' immediate working area and will be in a wholly observational role, unless directed otherwise by the lead clinician.

Family distress – This was another consideration raised within the PPIE workshop and has been discussed in depth by the research team from the early stages of protocol design. Cardiac arrest is often a highly stressful event for family members to witness either in or out of hospital. The resuscitation procedures are often upsetting to observe, and this can be a time of great uncertainty and confusion for the family. Approaching family members at this time to explain the research process has been deemed inappropriate by the research team. To ensure family members remain informed, and to support them in their grieving process, a patient information leaflet has been created. This contains a plain English overview of the study as well as contact details of the research team should they wish to discuss further or withdraw from the research. It also has useful links to supportive services.

Research equipment causing trip hazard – As with any resuscitation attempt, scene safety is of paramount importance. The researchers shall draw upon their experience in cardiac arrest scene management to ensure the position of the equipment maintains a safe and practical working environment and does not obstruct any rescue attempt. Dynamic risk assessments shall be conducted throughout, and should it be felt the equipment poses a risk, at any point, it shall be removed, and the research halted. It then shall be escalated via appropriate reporting channels, i.e., Datix, as described in the protocol. Research shall be stopped pending this review. In the ED setting risks are minimised as the equipment will be in one place for the whole six weeks as opposed to be being moved to different cardiac arrest events as in WP 1.

Staff wellbeing – Attending cardiac arrests can be traumatic emotional events for responders and other staff both in hospital and in ambulance services and has been linked to post traumatic stress disorder, depression, and anxiety (Hasselqvist-Ax et al., 2019; Petrie et al., 2018). To help mitigate this, the research team (of which one member is a mental health advocate within an ambulance service trust) has compiled a health care professional's information leaflet which signposts staff to appropriate supportive organisations, via contact details i.e., websites and phone numbers. It also contains information regarding the study.

Consent of patients who do not have capacity – Thorough review of the principles of consent has concluded that deferral of consent would be potentially insensitive to the patient and their family. As a result, a waiver of consent is being requested to avoid undue distress to those affected. To allow families to withdraw from the study, should they wish, the patient information leaflet highlighted earlier in this section includes contact details of the research team. This channel of communication shall remain open until publication of the data allowing for families to follow up on any points of concern through the study.

Infection control - The research team are aware of the risk COVID-19 having all worked in front-line, patient facing, roles throughout the pandemic. As a result, they are well versed in infection control practices that minimise the risk of transmission. Their presence in both arms of the study minimally increases this risk. However, adhering to trust policies (including lateral flow testing prior to entering any health care facility), vigilance for symptoms of illness, the use of enhanced PPE and their experiences as front line clinicians will mitigate this. Regular cleaning of equipment in between patient use will be conducted with disposable, single use items being used where possible.

A24. What is the potential for benefit to research participants?

No benefit to the research participant as care delivered will not be altered, but data obtained may benefit the wider community by helping to inform PPE protocols which may result in a faster commencement of a resuscitation attempt (and hence an enhanced survival probability) in future cardiac arrest patients.

RECRUITMENT AND INFORMED CONSENT

In this section we ask you to describe the recruitment procedures for the study. Please give separate details for different study groups where appropriate.

A27-1. How will potential participants, records or samples be identified? Who will carry this out and what resources will be used?*For example, identification may involve a disease register, computerised search of GP records, or review of medical records. Indicate whether this will be done by the direct healthcare team or by researchers acting under arrangements with the responsible care organisation(s).*

We recommend that all participating Trusts have a statement on their public facing webpages that describe the trial process and how patients or their families can opt out.

Work Package 1 - Clinical - Out-of-hospital setting

All cardiac arrest calls will be screened in real-time by the research team, whilst on duty in the host Trust via the computer aided dispatch (CAD) system.

When an appropriate call is identified, the research paramedic/team on duty will self-deploy in liaison with the Emergency Operations Centre (EOC) and respond in a blue light vehicle to the address of the call. Whilst on duty, the research team will be identified to the EOC as acting in a research capacity at the start of their shift to avoid confusion.

Work Package 2 - Clinical - Emergency Department

All patients in cardiac arrest (meeting the eligibility criteria) being received into the nominated resuscitation bay during a 6 week period will be entered into the study. Research paramedics will be available in the ED on 24/7 rota for this duration.

A27-2. Will the identification of potential participants involve reviewing or screening the identifiable personal information of patients, service users or any other person?

(●) Yes ( ) No

Please give details below:
Participants will be screened for clinical eligibility as defined earlier

A27-3. Describe what measures will be taken to ensure there is no breach of any duty of confidentiality owed to

patients, service users or any other person in the process of identifying potential participants. *Indicate what steps have been or will be taken to inform patients and service users of the potential use of their records for this purpose. Describe the arrangements to ensure that the wishes of patients and service users regarding access to their records are respected. Please consult the guidance notes on this topic.*

The researchers involved in this study are experienced senior clinicians registered with the Health and Care Professions Council and extensively use data of this nature in their clinical roles. It is a legal requirement that they stay up to date with information governance practices to meet expected professional standards. To minimise risks, minimal demographic patient data shall be recorded in addition to aerosol data, namely; age, sex, body habitus, co-morbidities, and cardiac arrest characteristics (i.e., aetiology). This shall be inputted on password secured laptops and immediately stored securely on the University of Hertfordshire's OneDrive cloud system in accordance with the University's data storage policies.

At no time will researchers have access to any confidential patient files or information beyond that consented to at the time that informed consent is obtained. No confidential or identifiable data will be recorded on any research documentation to ensure confidentiality is maintained.

A27-4. Will researchers or individuals other than the direct care team have access to identifiable personal information of any potential participants?

○ Yes ◉ No

A28. Will any participants be recruited by publicity through posters, leaflets, adverts or websites?

○ Yes ◉ No

A29. How and by whom will potential participants first be approached?

No consent is being sought as we are seeking permission to waive consent. We will make provision where appropriate (via Patient Information Leaflet) for the relatives or legal guardians (e.g. Power of Attorney) of the patient to withdraw consent at any time up until anonymisation of data.

A30-1. Will you obtain informed consent from or on behalf of research participants?

○ Yes ◉ No

If you will be obtaining consent from adult participants, please give details of who will take consent and how it will be done, with details of any steps to provide information (a written information sheet, videos, or interactive material). Arrangements for adults unable to consent for themselves should be described separately in Part B Section 6, and for children in Part B Section 7.

If you plan to seek informed consent from vulnerable groups, say how you will ensure that consent is voluntary and fully informed.

If you are not obtaining consent, please explain why not.

As mentioned earlier, gaining consent at the time of data collection is not possible as the patient does not have capacity and it is inappropriate in a time critical situation to gain consent from others therefore a waiver is requested. There will be no direct involvement of the patient and no interference with care delivery to patient. Samples of the air in the location of resuscitative efforts will be taken without the need to involve the patient directly. Engaging with family members on scene regarding the purpose of the research paramedics' presence is viewed to add additional burden during an extremely stressful time. However, we will provide a Patient Information Sheet (PIS) to relatives and/or legal guardians (e.g. Power of Attorney) of the deceased if they express a wish to engage with the research paramedic. The PIS will clearly state that they may withdraw the data from the study at any time up until anonymisation of the data.

Please enclose a copy of the information sheet(s) and consent form(s).

A30-2. Will you record informed consent (or advice from consultees) in writing?

DRAFT

◯ Yes ◉ No

If No, how will it be recorded?

No consent is being sought. We are asking for waiver of consent as this is a purely observational study which does not change care at any level.

A31. How long will you allow potential participants to decide whether or not to take part?

NA

In compliance with the national data opt-out policy, any potential participant identified as having chosen to opt-out of having their data shared for research purposes will be removed from the study.

A32. Will you recruit any participants who are involved in current research or have recently been involved in any research prior to recruitment?

◯ Yes
◯ No
◉ Not Known

If Yes, please give details and justify their inclusion. If Not Known, what steps will you take to find out?

There is no plan to actively or intentionally recruit participants that have specifically been involved in ongoing or previous research studies but neither would this be a reason for exclusion. It is anticipated that a participant's involvement in other research will not be known due to the nature of the events occurring and the fact that resuscitation attempts are time critical there is no action to be taken to establish this..

A33-1. What arrangements have been made for persons who might not adequately understand verbal explanations or written information given in English, or who have special communication needs?*(e.g. translation, use of interpreters)*

The research team will be on hand to support the direct-care teams. Where translators are already in use by the direct-care team, they will be included within conversations between next of kin/consultees and direct-care teams if it is deemed necessary.

CONFIDENTIALITY

In this section, personal data means any data relating to a participant who could potentially be identified. It includes pseudonymised data capable of being linked to a participant through a unique code number.

Storage and use of personal data during the study

A36. Will you be undertaking any of the following activities at any stage (including in the identification of potential participants)?*(Tick as appropriate)*

☑ Access to medical records by those outside the direct healthcare team
☐ Access to social care records by those outside the direct social care team
☐ Electronic transfer by magnetic or optical media, email or computer networks
☐ Sharing of personal data with other organisations
☐ Export of personal data outside the EEA
☐ Use of personal addresses, postcodes, faxes, emails or telephone numbers
☐ Publication of direct quotations from respondents
☐ Publication of data that might allow identification of individuals
☑ Use of audio/visual recording devices

☑ Storage of personal data on any of the following:

- ☐ Manual files (includes paper or film)
- ☐ NHS computers
- ☐ Social Care Service computers
- ☐ Home or other personal computers
- ☑ University computers
- ☐ Private company computers
- ☐ Laptop computers

Further details:
Audio log of times at which procedures carried out will be used

All anonymised participant details and collected data will be stored on secure university-maintained OneDrive systems in line with the University of Hertfordshire's procedures and guidance. Any paper copies or notes made during data collection will be scanned and saved to the OneDrive system, at which time all paper copies will be destroyed in line with local Trust procedures for destruction of confidential waste.

Data stored will not contain patient-identifiable information.

A37. Please describe the physical security arrangements for storage of personal data during the study?

A data collection form, with a designated anonymised incident identifier, will be used to record the required data for each participating incident. The data collection forms will be completed as soon as practicable, depending on the circumstances. The data collected on the form will be corroborated by an audio log and additional notes taken by the research paramedic(s) during the resuscitation efforts.

The data collection forms and additional notes, where possible will be electronic and saved in PDF format once completed. Any handwritten notes will be scanned to PDF files and stored on secure, University maintained OneDrive systems. Audio files will also be stored in this manner. Original paper copies of forms and notes will be destroyed securely once they have been uploaded.

Live data from the particle analyser will also be stored securely on the University OneDrive system. The raw data the form of a DAT file will be transferred from a USB flash drive at the end of each data collection. The file will then be deleted from the USB flash drive.

A38. How will you ensure the confidentiality of personal data? *Please provide a general statement of the policy and procedures for ensuring confidentiality, e.g. anonymisation or pseudonymisation of data.*

No specific identifiable personal data will be recorded on any forms, or stored electronically to ensure confidentiality. Participants and incidents will be allocated identifiers and minimal personal information, such as gender, age, co-morbidities, body habitus and cardiac arrest details will be recorded.

The University of Hertfordshire has strict guidance regarding data collection and storage, in which, it stipulates data be stored on the university's encrypted and password protected cloud storage system. Therefore demographic and medical data shall be stored as per this recommendation alongside humidity, temperature and aerosol data collected via the particle analyser.

A40. Who will have access to participants' personal data during the study? *Where access is by individuals outside the direct care team, please justify and say whether consent will be sought.*

In both Work Packages, the direct-care teams will have access to participants' personal data during the study as they would normally as part of their role as care providers. The research team will require access to patient details as part of the identification and recruitment of eligible patients. The research team will store demographic information including eligible participants' sex, age, co-morbidities, body habitus and details of their cardiac arrest. This is in addition to the aerosol data that will be collected. Similarly, in both work packages, non-identifiable descriptive environmental details shall be noted such as ventilation, humidity and temperature.

Storage and use of data after the end of the study

A41. Where will the data generated by the study be analysed and by whom?

The data generated by the study will be analysed by R Fisher, D Gedge, T Millington as a part of their PhD studies, and by Prof J Williams and Prof R Chilcott as their supervisors. The data will be analysed on password-protected university-issued personal laptops, and stored on the University OneDrive system, with access exclusively restricted to the aforementioned individuals. The University OneDrive system is maintained by the University of Hertfordshire. Any file transfers will be conducted through Exchange File to ensure data security, and any references to participants will be solely by their unique participant identifier.

A42. Who will have control of and act as the custodian for the data generated by the study?

	Title	Forename/Initials	Surname
	Professor	J	Williams
Post	Associate Dean Research		
Qualifications	PhD		
Work Address	School of Health and Social Work University of Hertfordshire College Lane, Hatfield		
Post Code	AL10 9AB		
Work Email	j.williams@herts.ac.uk		
Work Telephone	01707285260		
Fax			

A43. How long will personal data be stored or accessed after the study has ended?

- (•) Less than 3 months
- ( ) 3 – 6 months
- ( ) 6 – 12 months
- ( ) 12 months – 3 years
- ( ) Over 3 years

A44. For how long will you store research data generated by the study?

Years: 5
Months: 0

A45. Please give details of the long term arrangements for storage of research data after the study has ended. *Say where data will be stored, who will have access and the arrangements to ensure security.*

Following completion of the STOPGAP project, data in XLSX format and associated metadata will be uploaded to the University of Hertfordshire Research Archive (UHRA) for preservation. The data will be preserved for 5 years.

INCENTIVES AND PAYMENTS

A46. Will research participants receive any payments, reimbursement of expenses or any other benefits or incentives

DRAFT

for taking part in this research?

◯ Yes ◉ No

A47. Will individual researchers receive any personal payment over and above normal salary, or any other benefits or incentives, for taking part in this research?

◯ Yes ◉ No

A48. Does the Chief Investigator or any other investigator/collaborator have any direct personal involvement (e.g. financial, share holding, personal relationship etc.) in the organisations sponsoring or funding the research that may give rise to a possible conflict of interest?

◯ Yes ◉ No

NOTIFICATION OF OTHER PROFESSIONALS

A49-1. Will you inform the participants' General Practitioners (and/or any other health or care professional responsible for their care) that they are taking part in the study?

◯ Yes ◉ No

If Yes, please enclose a copy of the information sheet/letter for the GP/health professional with a version number and date.

PUBLICATION AND DISSEMINATION

A50. Will the research be registered on a public database?

The UK Policy Framework for Health and Social Care Research sets out the principle of making information about research publicly available. Furthermore: Article 19 of the World Medical Association Declaration of Helsinki adopted in 2008 states that "every clinical trial must be registered on a publicly accessible database before recruitment of the first subject"; and the International Committee of Medical Journal Editors (ICMJE) will consider a clinical trial for publication only if it has been registered in an appropriate registry. Please see guidance for more information.

◉ Yes ◯ No

Please give details, or justify if not registering the research.
College of Paramedics Research Studies database (CReD)

Please ensure that you have entered registry reference number(s) in question A5-1.

A51. How do you intend to report and disseminate the results of the study? *Tick as appropriate:*

- ☑ Peer reviewed scientific journals
- ☐ Internal report
- ☑ Conference presentation
- ☑ Publication on website
- ☑ Other publication
- ☑ Submission to regulatory authorities
- ☐ Access to raw data and right to publish freely by all investigators in study or by Independent Steering Committee on behalf of all investigators

☐ No plans to report or disseminate the results

☐ Other (please specify)

A52. If you will be using identifiable personal data, how will you ensure that anonymity will be maintained when publishing the results?

The research team has no intention to collect identifiable personal data. All participants will be assigned a randomly designated identifier to further ensure anonymity in publishing. The randomly designated identifier will align with data collected during the procedures along with age, sex, body habitus and co-morbidities. In addition, WP1 (out-of-hospital) will also include data relating to assumed cardiac arrest aetiology, initial cardiac arrest rhythm and whether bystander CPR had been commenced.

A53. How and when will you inform participants of the study results?

If there will be no arrangements in place to inform participants please justify this.
No identifiable personal details are expected to be collected, further preventing follow-up from taking place.

5. Scientific and Statistical Review

A54. How has the scientific quality of the research been assessed? *Tick as appropriate:*

☐ Independent external review

☐ Review within a company

☐ Review within a multi-centre research group

☑ Review within the Chief Investigator's institution or host organisation

☑ Review within the research team

☐ Review by educational supervisor

☐ Other

Justify and describe the review process and outcome. If the review has been undertaken but not seen by the researcher, give details of the body which has undertaken the review:
This application has been fully reviewed and approved through the University of Hertfordshire's Sponsorship processes. Details of the UH ECDA can be provided on request.

For all studies except non-doctoral student research, please enclose a copy of any available scientific critique reports, together with any related correspondence.

For non-doctoral student research, please enclose a copy of the assessment from your educational supervisor/ institution.

A56. How have the statistical aspects of the research been reviewed? *Tick as appropriate:*

☐ Review by independent statistician commissioned by funder or sponsor

☐ Other review by independent statistician

☐ Review by company statistician

☐ Review by a statistician within the Chief Investigator's institution

☐ Review by a statistician within the research team or multi-centre group

☑ Review by educational supervisor

☐ Other review by individual with relevant statistical expertise

☐ No review necessary as only frequencies and associations will be assessed – details of statistical input not required

In all cases please give details below of the individual responsible for reviewing the statistical aspects. If advice has

DRAFT

been provided in confidence, give details of the department and institution concerned.

	Title	Forename/Initials	Surname
	Professor	Robert P	Chilcott
Department	Life and Medical Sciences		
Institution	University of Hertfordshire		
Work Address	College Lane		
	Hatfield		
	Hertfordshire		
Post Code	AL10 9AB		
Telephone	07718696629		
Fax			
Mobile	07718696629		
E-mail	r.chilcott@herts.ac.uk		

Please enclose a copy of any available comments or reports from a statistician.

A57. What is the primary outcome measure for the study?

The primary outcome measure for the study will be the average particle number concentration and particle mass concentration measured during each of the six CPR procedures and from corresponding baseline conditions where included in the study design.

A58. What are the secondary outcome measures?*(if any)*

The secondary outcomes will be determined from subsequent laboratory studies to identify which level of PPE is appropriate. This work is not directly related to this ethics application, but will utilise the aerosol particle data acquired during the course of this present study to establish an accurate, laboratory aerosol model for subsequent testing of different types of respiratory protection e.g. FFP2 (Filtering Face Piece Level 2), FFP3 (Filtering Face Piece Level 3) during simulated CPR.

A59. What is the sample size for the research? *How many participants/samples/data records do you plan to study in total? If there is more than one group, please give further details below.*

Total UK sample size:	72
Total international sample size (including UK):	0
Total in European Economic Area:	0

Further details:

Work Package 1 - Out-of-hospital setting - sample size of 36 incidents/participants.
Work Package 2 - ED setting: - 36 participants

A60. How was the sample size decided upon? *If a formal sample size calculation was used, indicate how this was done, giving sufficient information to justify and reproduce the calculation.*

The sample size was calculated using peer-reviewed, open-access software (G*Power, v3.1.9.6) and was based on previous studies performed in our laboratory which quantified exhaled aerosols from a healthy cohort (n=7) of subjects using the same instrumentation which will be used in this present study. The data fed into the power calculation represented the total number of aerosol particles summated over a one minute sampling period, averaged for the 7 volunteers. (Please note that this pilot study was performed on UH members of staff and had been authorised by the UH ECDA; reference acHSK/SF/UH/04449). It has been assumed for this power calculation that a two-fold increase in aerosol will be representative of an aerosol generating procedure. That is, we need to be able to demonstrate a statistical significance for a doubling of total aerosol particles. A one-sided test has been used, as the total aerosol particles will be expected to increase if the CPR procedures are aerosol generating. If the procedures are not aerosol generating, the total number of aerosol particles will remain the same (i.e. not decrease below baseline). Therefore, a

one-sided test is most appropriate.

The a priori calculation is reproduced below and is based on a t-test of the difference between two independent means.

Input: Tail(s) = One
Effect size d = 0.7835518
α err prob = 0.05
Power (1-β err prob) = 0.95
Allocation ratio N2/N1 = 1
Output: Noncentrality parameter δ = 3.3243287
Critical t = 1.6669145
Df = 70
Sample size group 1 = 36
Sample size group 2 = 36
Total sample size = 72
Actual power = 0.9502296

A61. Will participants be allocated to groups at random?

○ Yes ◉ No

A62. Please describe the methods of analysis (statistical or other appropriate methods, e.g. for qualitative research) by which the data will be evaluated to meet the study objectives.

The data will be analysed to determine distribution ("parametric" or "non-parametric") using a standard test such as the Anderson-Darling or D'agostino-Pearson omnibus normality test. Appropriate descriptive statistics, dependant on normality, will be applied to the data collected to ascertain changes in aerosol generation alongside the timings of the recorded procedures. Standard statistical tests will not be used, owing to the clinical settings not being conducive with establishment of a control group

6. MANAGEMENT OF THE RESEARCH

A63. Other key investigators/collaborators. *Please include all grant co-applicants, protocol co-authors and other key members of the Chief Investigator's team, including non-doctoral student researchers.*

Title Forename/Initials Surname

Post
Qualifications
Employer
Work Address

Post Code
Telephone
Fax
Mobile
Work Email

DRAFT

A64. Details of research sponsor(s)

A64-1. Sponsor

Lead Sponsor

Status:
- ○ NHS or HSC care organisation
- ◉ Academic
- ○ Pharmaceutical industry
- ○ Medical device industry
- ○ Local Authority
- ○ Other social care provider (including voluntary sector or private organisation)
- ○ Other

Commercial status: Non-Commercial

If Other, please specify:

Contact person

Name of organisation	University of Hertfordshire
Given name	John
Family name	Senior
Address	College Lane
Town/city	Hatfield, Hertfordshire
Post code	AL10 9AB
Country	United Kingdom
Telephone	01707284000
Fax	01707284000
E-mail	j.m.senior@herts.ac.uk

Legal representative for clinical investigation of medical device (studies involving Northern Ireland only)
Clinical Investigations of Medical Devices that take place in Northern Ireland must have a legal representative of the sponsor that is based in Northern Ireland or the EU

Contact person

Name of organisation	
Given name	
Family name	
Address	
Town/city	
Post code	
Country	
Telephone	
Fax	
E-mail	

DRAFT

A65. Has external funding for the research been secured?

Please tick at least one check box.

- [x] Funding secured from one or more funders
- [ ] External funding application to one or more funders in progress
- [ ] No application for external funding will be made

What type of research project is this?

- ( ) Standalone project
- ( ) Project that is part of a programme grant
- ( ) Project that is part of a Centre grant
- (•) Project that is part of a fellowship/ personal award/ research training award
- ( ) Other

Other – please state:

Please give details of funding applications.

Organisation	College of Paramedics
Address	The Exchange, Express Park Bristol Road Bridgwater
Post Code	TA6 4RR
Telephone	01278 420014
Fax	
Mobile	
Email	enquiries@collegeofparamedics.co.uk

Funding Application Status: (•) Secured ( ) In progress

Amount: 10000

Duration

Years: 3

Months: 0

If applicable, please specify the programme/ funding stream:

What is the funding stream/ programme for this research project?

This is the joint award between the College of paramedics and the University of Hertfordshire PhD Stipend award. This project successfully acquired three of these awards.
The College of Paramedics is a recognised non commercial partner but this was not part of the main, annual awards. This was via national competitive application and selection. Three awards were awarded.

Organisation	University of Hertfordshire
Address	College Lane

DRAFT

Post Code AL10 9AB
Telephone
Fax
Mobile
Email

Funding Application Status: (•) Secured ( ) In progress

Amount: 15650 pa

Duration
Years: 3
Months: 0

If applicable, please specify the programme/ funding stream:

What is the funding stream/ programme for this research project?

This is the joint award between the College of paramedics and the University of Hertfordshire PhD Stipend award. This project successfully acquired three of these awards PLUS £5000 research costs via open competition.

A66. Has responsibility for any specific research activities or procedures been delegated to a subcontractor (other than a co-sponsor listed in A64-1) ? *Please give details of subcontractors if applicable.*

( ) Yes (•) No

A67. Has this or a similar application been previously rejected by a Research Ethics Committee in the UK or another country?

( ) Yes (•) No

Please provide a copy of the unfavourable opinion letter(s). You should explain in your answer to question A6-2 how the reasons for the unfavourable opinion have been addressed in this application.

A68-1. Give details of the lead NHS R&D contact for this research:

	Title	Forename/Initials	Surname
	Dr	Fiona	Bell

Organisation Yorkshire Ambulance Service NHS Trust
Address Brindley Way
Wakefield

Post Code WF2 0X2
Work Email fiona.bell7@nhs.net
Telephone 0333 130 0524
Fax 0333 130 0524
Mobile 07748070643

Details can be obtained from the NHS R&D Forum website: http://www.rdforum.nhs.uk

A68-2. Select Local Clinical Research Network for NHS Organisation identified in A68-1:

Yorkshire and Humber

For more information, please refer to the question specific guidance.

A69-1. How long do you expect the study to last in the UK?

Planned start date: 27/02/2023
Planned end date: 04/09/2023
Total duration:
Years: 0 Months: 6 Days: 6

A71-1. Is this study?

- ○ Single centre
- ◉ Multicentre

A71-2. Where will the research take place? *(Tick as appropriate)*

- ☑ England
- ☐ Scotland
- ☐ Wales
- ☐ Northern Ireland
- ☐ Other countries in European Economic Area

Total UK sites in study 2

Does this trial involve countries outside the EU?

○ Yes ◉ No

A72. Which organisations in the UK will host the research? *Please indicate the type of organisation by ticking the box and give approximate numbers if known:*

- ☑ NHS organisations in England 2
- ☐ NHS organisations in Wales
- ☐ NHS organisations in Scotland
- ☐ HSC organisations in Northern Ireland
- ☐ GP practices in England
- ☐ GP practices in Wales
- ☐ GP practices in Scotland
- ☐ GP practices in Northern Ireland
- ☐ Joint health and social care agencies (eg community mental health teams)
- ☐ Local authorities
- ☐ Phase 1 trial units
- ☐ Prison establishments
- ☐ Probation areas

DRAFT

☐ Independent (private or voluntary sector) organisations
☐ Educational establishments
☐ Independent research units
☐ Other (give details)

Total UK sites in study: 2

A73-1. Will potential participants be identified through any organisations other than the research sites listed above?

○ Yes ◉ No

A76. Insurance/ indemnity to meet potential legal liabilities

***Note:** in this question to NHS indemnity schemes include equivalent schemes provided by Health and Social Care (HSC) in Northern Ireland*

A76-1. What arrangements will be made for insurance and/or indemnity to meet the potential legal liability of the sponsor(s) for harm to participants arising from the management of the research? *Please tick box(es) as applicable.*

Note: Where a NHS organisation has agreed to act as sponsor or co-sponsor, indemnity is provided through NHS schemes. Indicate if this applies (there is no need to provide documentary evidence). For all other sponsors, please describe the arrangements and provide evidence.

☐ NHS indemnity scheme will apply (NHS sponsors only)
☑ Other insurance or indemnity arrangements will apply (give details below)

Insurance and indemnity are provided by the University of Hertfordshire:
Professor J M Senior, Pro Vice-Chancellor (Research and International), University of Hertfordshire
email: j.m.senior@herts.ac.uk

Please enclose a copy of relevant documents.

A76-2. What arrangements will be made for insurance and/ or indemnity to meet the potential legal liability of the sponsor(s) or employer(s) for harm to participants arising from the design of the research? *Please tick box(es) as applicable.*

Note: Where researchers with substantive NHS employment contracts have designed the research, indemnity is provided through NHS schemes. Indicate if this applies (there is no need to provide documentary evidence). For other protocol authors (e.g. company employees, university members), please describe the arrangements and provide evidence.

☐ NHS indemnity scheme will apply (protocol authors with NHS contracts only)
☑ Other insurance or indemnity arrangements will apply (give details below)

Insurance and indemnity are provided by the University of Hertfordshire:
Professor J M Senior, Pro Vice-Chancellor (Research and International), University of Hertfordshire
email: j.m.senior@herts.ac.uk

Please enclose a copy of relevant documents.

A76-3. What arrangements will be made for insurance and/ or indemnity to meet the potential legal liability of investigators/collaborators arising from harm to participants in the conduct of the research?

Note: Where the participants are NHS patients, indemnity is provided through the NHS schemes or through professional

DRAFT

indemnity. Indicate if this applies to the whole study (there is no need to provide documentary evidence). Where non-NHS sites are to be included in the research, including private practices, please describe the arrangements which will be made at these sites and provide evidence.

☑ NHS indemnity scheme or professional indemnity will apply (participants recruited at NHS sites only)

☐ Research includes non-NHS sites (give details of insurance/ indemnity arrangements for these sites below)

Please enclose a copy of relevant documents.

A78. Could the research lead to the development of a new product/process or the generation of intellectual property?

○ Yes ○ No ◉ Not sure

DRAFT

B. All research other than CTIMPs

In this sub-section, an adult means a person aged 16 or over.

B1. What impairing condition(s) will the participants have?

The study must be connected to this condition or its treatment.

Participants will be in cardiac arrest, and therefore will have impaired capacity at the time of the research.

B2. Justify the inclusion of adults unable to consent for themselves. It should be clear why the research could not be carried out as effectively if confined to adults capable of giving consent.

The purpose of the research is to determine the aerosol generating potential of cardiopulmonary resuscitation (CPR) procedures. Previous cadaveric and simulation studies were found to be limited by the lack of relevance to the realities of providing resuscitation in practice, requiring further investigation of real-time incidents.

B3. Who in the research team will decide whether or not the participants have the capacity to give consent? What training/experience will they have to enable them to reach this decision?

Decisions regarding capacity will be made by direct-care teams, consisting of appropriately trained and registered healthcare professionals, including doctors, nurses, and paramedics.

B4. Does the research have the potential to benefit participants who are unable to consent for themselves?

○ Yes ◉ No

B5. Will the research contribute to knowledge of the causes or the treatment or care of persons with the same impairing condition (or a similar condition)?

◉ Yes ○ No

If Yes, please explain how the research will achieve this:

The outcomes of this research have the potential to influence future guidance related to the response of emergency services to those in cardiac arrest, particularly with high consequence infectious diseases (HCIDs). The findings may result in improved response times and approaches to care that improve resuscitation outcomes in the future.

B6. Will the research involve any foreseeable risk or burden for these participants, or interfere in any way with their freedom of action or privacy?

◉ Yes ○ No

If Yes, please give an assessment below. Highlight any risk, burden or discomfort specific to these participants and say what will be done to minimise it. You may refer back to your answers to Questions A22 and A23.

We are seeking waiver of consent as the participants will be technically dead but active resuscitation will be in progress. We do not anticipate any foreseeable risk or burden for these participants.

Questions B7 and B8 apply to any participants recruited in England and Wales.

B7. What arrangements will be made to identify and consult persons able to advise on the presumed wishes and feelings of participants unable to consent for themselves and on their inclusion in the research?

A waiver of consent is being sought due to the time-criticality of the emergency setting and nature of the events taking place.

Please enclose a copy of the written information to be provided to consultees. This should describe their role under section

32 of the Mental Capacity Act and provide information about the research similar to that which might be given to participants able to consent for themselves.

B8. Is it possible that a participant requiring urgent treatment might need to be recruited into research before it is possible to identify and consult a person under B7?

○ Yes ◉ No

If Yes, say whether arrangements will be made instead to seek agreement from a registered medical practitioner and outline these arrangements. Or, if this is also not feasible, outline how decisions will be made on the inclusion of participants and what arrangements will be made to seek consent from the participant (if capacity has been recovered) or advice from a consultee as soon as practicable thereafter.

A waiver of consent is being sought due to the envisaged and unnecessary distress this might cause family members, as well as the time-criticality of the emergency setting.

B9. What arrangements will be made to continue to consult such persons during the course of the research where necessary?

The research team will be able to provide family members and/or significant others with a patient information leaflet if requested, and to provide verbal information regarding the research. Primary communication will be between direct-care teams and family on scene as to patient wishes and continuation of resuscitative efforts as per normal clinical practice seen in a resuscitation attempt.

B10. What steps will you take, if appropriate, to provide participants who are unable to consent for themselves with information about the research, and to consider their wishes and feelings?

We are seeking approval for a waiver of capacity approach due to the distressing and time-critical nature of the events taking place. Leaflets are available if we are asked for further details of the study.

B11. Is it possible that the capacity of participants could fluctuate during the research? How would this be handled?

In the event of a return of spontaneous circulation (ROSC) and return of capacity, data collection will cease immediately.

B12-1. What will be the criteria for withdrawal of participants?

With no consent being gained due to the time criticality of this medical condition, if the research team were asked by relatives/significant others on the nature of the research, an Information Leaflet would be left with the relatives with information detailing how to withdraw (via a dedicated email address) on behalf of the participant. In WP 1 if asked to leave the property, the research team would cease data collection, leave the property, and withdraw participant from the study if they had been enrolled at this stage.

B13. Describe what steps will be taken to ensure that nothing is done to which participants appear to object (unless it is to protect them from harm or minimise pain or discomfort).

There will be no direct interaction with patient or interference with delivery of care.

B14. Describe what steps will be taken to ensure that nothing is done which is contrary to any advance decision or statement by the participant?

No data collection will take place if cardiopulmonary resuscitation is in contravention of an advanced directive, do not attempt cardiopulmonary resuscitation (DNACPR) or Recommended Summary Plan for Emergency Care and Treatment (ReSPECT).

PART C: Overview of research sites

Please enter details of the host organisations (Local Authority, NHS or other) in the UK that will be responsible for the research sites. *For further information please refer to guidance.*

Investigator identifier	Research site		Investigator Name	
IN1	◉ NHS/HSC Site ○ Non-NHS/HSC Site		Forename Middle name Family name Email Qualification (MD...) Country	Fiona Bell fiona.bell7@nhs.net PhD United Kingdom
	Organisation name	YORKSHIRE AMBULANCE SERVICE NHS TRUST		
	Address	SPRINGHILL 2 BRINDLEY WAY WAKEFIELD 41 INDUSTRIAL ESTATE WAKEFIELD		
	Post Code	WF2 0XQ		
	Country	ENGLAND		
IN2	◉ NHS/HSC Site ○ Non-NHS/HSC Site		Forename Middle name Family name Email Qualification (MD...) Country	Lindy-Lee Folscher Lindy-Lee.Folscher@nnuh.nhs.uk MD Consultant in Emergency Medicine United Kingdom
	Organisation name	NORFOLK AND NORWICH UNIVERSITY HOSPITALS NHS FOUNDATION TRUST		
	Address	COLNEY LANE COLNEY NORWICH		
	Post Code	NR4 7UY		
	Country	ENGLAND		

DRAFT

PART D: Declarations

D1. Declaration by Chief Investigator

1. The information in this form is accurate to the best of my knowledge and belief and I take full responsibility for it.
2. I undertake to fulfil the responsibilities of the chief investigator for this study as set out in the UK Policy Framework for Health and Social Care Research.
3. I undertake to abide by the ethical principles underlying the Declaration of Helsinki and good practice guidelines on the proper conduct of research.
4. If the research is approved I undertake to adhere to the study protocol, the terms of the full application as approved and any conditions set out by review bodies in giving approval.
5. I undertake to notify review bodies of substantial amendments to the protocol or the terms of the approved application, and to seek a favourable opinion from the main REC before implementing the amendment.
6. I undertake to submit annual progress reports setting out the progress of the research, as required by review bodies.
7. I am aware of my responsibility to be up to date and comply with the requirements of the law and relevant guidelines relating to security and confidentiality of patient or other personal data, including the need to register when necessary with the appropriate Data Protection Officer. I understand that I am not permitted to disclose identifiable data to third parties unless the disclosure has the consent of the data subject or, in the case of patient data in England and Wales, the disclosure is covered by the terms of an approval under Section 251 of the NHS Act 2006.
8. I understand that research records/data may be subject to inspection by review bodies for audit purposes if required.
9. I understand that any personal data in this application will be held by review bodies and their operational managers and that this will be managed according to the principles established in the Data Protection Act 2018.
10. I understand that the information contained in this application, any supporting documentation and all correspondence with review bodies or their operational managers relating to the application:
    - Will be held by the REC (where applicable) until at least 3 years after the end of the study; and by NHS R&D offices (where the research requires NHS management permission) in accordance with the NHS Code of Practice on Records Management.
    - May be disclosed to the operational managers of review bodies, or the appointing authority for the REC (where applicable), in order to check that the application has been processed correctly or to investigate any complaint.
    - May be seen by auditors appointed to undertake accreditation of RECs (where applicable).
    - Will be subject to the provisions of the Freedom of Information Acts and may be disclosed in response to requests made under the Acts except where statutory exemptions apply.
    - May be sent by email to REC members.
11. I understand that information relating to this research, including the contact details on this application, may be held on national research information systems, and that this will be managed according to the principles established in the Data Protection Act 2018.
12. Where the research is reviewed by a REC within the UK Health Departments Research Ethics Service, I understand that the summary of this study will be published on the website of the Health Research Authority (HRA) together with the contact point for enquiries named below. Publication will take place no earlier than 3 months after the issue of the ethics committee's final opinion or the withdrawal of the application.

Contact point for publication*(Not applicable for R&D Forms)*

HRA would like to include a contact point with the published summary of the study for those wishing to seek further

information. We would be grateful if you would indicate one of the contact points below.

- (•) Chief Investigator
- ( ) Sponsor
- ( ) Study co-ordinator
- ( ) Student
- ( ) Other – please give details
- ( ) None

Access to application for training purposes *(Not applicable for R&D Forms)*

Optional – please tick as appropriate:

☑ I would be content for members of other RECs to have access to the information in the application in confidence for training purposes. All personal identifiers and references to sponsors, funders and research units would be removed.

This section was signed electronically by Dr Julia Williams on 23/12/2022 11:22.

Job Title/Post:	Professor
Organisation:	University of Hertfordshire
Email:	J.Williams@herts.ac.uk

DRAFT

D2. Declaration by the sponsor's representative

If there is more than one sponsor, this declaration should be signed on behalf of the co−sponsors by a representative of the lead sponsor named at A64-1.

I confirm that:

1. This research proposal has been discussed with the Chief Investigator and agreement in principle to sponsor the research is in place.
2. An appropriate process of scientific critique has demonstrated that this research proposal is worthwhile and of high scientific quality.
3. Any necessary indemnity or insurance arrangements, as described in question A76, will be in place before this research starts. Insurance or indemnity policies will be renewed for the duration of the study where necessary.
4. Arrangements will be in place before the study starts for the research team to access resources and support to deliver the research as proposed.
5. Arrangements to allocate responsibilities for the management, monitoring and reporting of the research will be in place before the research starts.
6. The responsibilities of sponsors set out in the UK Policy Framework for Health and Social Care Research will be fulfilled in relation to this research.

   Please note: *The declarations below do not form part of the application for approval above. They will not be considered by the Research Ethics Committee.*
7. Where the research is reviewed by a REC within the UK Health Departments Research Ethics Service, I understand that the summary of this study will be published on the website of the National Research Ethics Service (NRES), together with the contact point for enquiries named in this application. Publication will take place no earlier than 3 months after issue of the ethics committee's final opinion or the withdrawal of the application.
8. Specifically, for submissions to the Research Ethics Committees (RECs) I declare that any and all clinical trials approved by the HRA since 30th September 2013 (as defined on IRAS categories as clinical trials of medicines, devices, combination of medicines and devices or other clinical trials) have been registered on a publically accessible register in compliance with the HRA registration requirements for the UK, or that any deferral granted by the HRA still applies.

This section was signed electronically by Professor John Senior on 23/12/2022 11:34.

Job Title/Post:	Pro Vice-Chancellor (Research and Enterprise)
Organisation:	University of Hertfordshire
Email:	j.m.senior@herts.ac.uk

DRAFT

D3. Declaration for student projects by academic supervisor(s)

1. I have read and approved both the research proposal and this application. I am satisfied that the scientific content of the research is satisfactory for an educational qualification at this level.

2. I undertake to fulfil the responsibilities of the supervisor for this study as set out in the UK Policy Framework for Health and Social Care Research.

3. I take responsibility for ensuring that this study is conducted in accordance with the ethical principles underlying the Declaration of Helsinki and good practice guidelines on the proper conduct of research, in conjunction with clinical supervisors as appropriate.

4. I take responsibility for ensuring that the applicant is up to date and complies with the requirements of the law and relevant guidelines relating to security and confidentiality of patient and other personal data, in conjunction with clinical supervisors as appropriate.

Academic supervisor 1

This section was signed electronically by Professor Robert Chilcott on 23/12/2022 11:25.

Job Title/Post:	Head of Toxicology
Organisation:	University of Hertfordshire
Email:	r.chilcott@herts.ac.uk

Academic supervisor 2

This section was signed electronically by Dr Julia Williams on 23/12/2022 11:23.

Job Title/Post:	Professor
Organisation:	University of Hertfordshire
Email:	J.Williams@herts.ac.uk

DRAFT

Appendix 13: Abstract unpublished study 'Anthropogenic bioaerosol kinetics within a simulated ambulance environment: estimating potential exposure to SARS-CoV-2'.

Anthropogenic bioaerosol kinetics within a simulated ambulance environment: estimating potential exposure to SARS-CoV-2

Chilcott RP[1], Thomas ET[1], Fisher RM[1,2], Gedge DA[1,3], Millington TI[1,4] and Williams J[1]

[1]University of Hertfordshire, UK; [2]Yorkshire Ambulance Service NHS Trust, UK; [3]Norfolk and Norwich University Hospital NHS Foundation Trust, UK; [4]Rotherham NHS Foundation Trust, UK.

The COVID-19 pandemic has seen an unprecedented demand on primary care facilities and ambulance services in the UK, with substantial delays between the arrival of patients at hospital and subsequent admission. Following transport by ambulance, it has been necessary at times for the patient and crew to remain within the vehicle for prolonged hand-over intervals [1]. This has raised concerns that ambulance staff may be at increased risk of exposure to SARS-CoV-2. The aim of this study was to determine the kinetics of exhaled aerosol particles from healthy human volunteers within a simulated ambulance environment to enable an estimation of viral exposure in terms of infectious dose.

This study was approved by the University of Hertfordshire's Health, Science, Engineering and Technology Ethics Committee (reference acHSK/SF/UH/04449(1)). Aerosol measurements were acquired using a Dekati high resolution ELPI+ particle sizer which reported the number of particles detected as a function of particle size (range 6 nm – 10 µm) at a sampling frequency of 1 Hz. Each volunteer was asked to sit in an unventilated chamber (2.5 x 4 x 2.5 m) for one hour. The particle counter was placed adjacent to the volunteer at a distance of 1.5 m to model the approximate distance between a patient and the attendant's seat within an ambulance. Averaged (n=6) particle counts were converted to aerosol volume from which the theoretical maximum number of viroid particles could be present (assuming an upper SARS-CoV-2 particle concentration of 2.35×10^9 mL^{-1} in respiratory fluid [2]). A threshold of 100 viroid particles was assumed to be consistent with an infectious dose [3].

A potentially infectious dose was predicted to occur within two to five minutes and was primarily associated with two particle size ranges; 1.3 – 1.4 µm and 3.4 – 5.3 µm. To our knowledge, this is the first time specific particle sizes have been tentatively associated with the transmission of SARS-CoV-2 from exhaled aerosols. Interestingly, the predicted concentration of viroid particles increased exponentially when each volunteer left the chamber, indicating that movement of air within such a confined environment may further enhance the risk of infection.

Further work is on-going to reproduce this study under more realistic conditions.

This work was funded by the College of Paramedics.

1. *Care Quality Commission (2021) Covid 19 Insight Issue 9 available at: https://www.cqc.org.uk/publications/major-reports/covid-19-insight-9-impact-pandemic-urgent-emergency-services [Accessed: 23rd September 2021.]*.
2. Wang, Y., G. Xu, and Y.W. Huang, *Modeling the load of SARS-CoV-2 virus in human expelled particles during coughing and speaking.* PLoS One, 2020. **15**(10): p. e0241539.
3. Karimzadeh, S., R. Bhopal, and H. Nguyen Tien, *Review of infective dose, routes of transmission and outcome of COVID-19 caused by the SARS-COV-2: comparison with other respiratory viruses.* Epidemiol Infect, 2021. **149**: p. e96.

Appendix 14: Yorkshire & The Humber – Leeds West Research Ethics Committee confirmation letter.

NHS
Health Research Authority

Yorkshire & The Humber - Leeds West Research Ethics Committee
NHSBT Newcastle Blood Donor Centre
Holland Drive
Newcastle upon Tyne
NE2 4NQ

15 May 2023

Professor Julia Williams
Professor
University of Hertfordshire
School of Health & Social Work
Room 2F260 - Wright Building
College Lane, Hatfield
AL10 9AB

Dear Professor Williams

Study title:	**Study of cardiopulmonary resuscitation procedures thought to generate aerosol particles**
REC reference:	**23/YH/0027**
Protocol number:	**NA**
IRAS project ID:	**304724**

Thank you for your letter responding to the Research Ethics Committee's (REC) request for further information on the above research and submitting revised documentation.

The further information has been considered on behalf of the Committee by the Vice-Chair.

Confirmation of ethical opinion

On behalf of the Committee, I am pleased to confirm a favourable ethical opinion for the above research on the basis described in the application form, protocol and supporting documentation as revised, subject to the conditions specified below.

Mental Capacity Act 2005 (England and Wales)

I confirm that the committee has approved this research project for the purposes of the Mental Capacity Act 2005 (England and Wales). The committee is satisfied that the requirements of section 31 of the Act will be met in relation to research carried out as part of this project on, or in relation to, a person who lacks capacity to consent to taking part in the project.

Mental Capacity Act (Northern Ireland) 2016

The Committee approved this research project for the purposes of the Mental Capacity Act (Northern Ireland) 2016. The Committee is satisfied that the requirements of Part 8 of the Act will be met in relation to research carried out as part of this project on, or in relation to, a person who lacks capacity to consent to taking part in the project.

Relevance of the research to the impairing condition

The Committee agreed the research was connected with an impairing condition affecting persons lacking capacity or with the treatment of the condition.

The Committee agreed the research could not be carried out as effectively if it was confined to participants able to give consent due to the observation and aerosol particles samples being undertaken during emergency resuscitation of the participant at which point the participant would be deceased.

Arrangements for appointing consultees

The Committee considered the arrangements set out in the application for appointing consultees under Section 32 of the Mental Capacity Act 2005 (England and Wales) and the equivalent Section 135 of the Mental Capacity Act (Northern Ireland) 2016) to advise on whether participants lacking capacity should take part and on what their wishes and feelings would have likely to have been if they had capacity.

The arrangements for recruitment in an emergency setting

The Committee noted that the research would take place in circumstances involving the provision of urgent treatment to participants lacking capacity.

The Committee agreed that, in the circumstances, it was justified to recruit participants prior to obtaining advice from a consultee under the provisions in Section 32(8) and (9) of the Mental Capacity Act 2005 (England and Wales) and the equivalent Section 136 of the Mental Capacity Act (Northern Ireland) 2016). The Committee agreed that consent should be sought those that were successfully resuscitated and were able to consent for themselves.

Balance between benefit and risk, burden, and intrusion

The Committee noted that while the research would not benefit participants lacking capacity it is intended to provide knowledge of the causes, treatment or care of their impairing condition or a condition similar to their impairing condition. The Committee agreed that the risk to participants was likely to be negligible and the research would not significantly interfere with their freedom of action or privacy and would not be unduly invasive or restrictive.

Additional safeguards

The Committee was satisfied that reasonable arrangements would be in place to comply with the additional safeguards set out in Section 33 of the Mental Capacity Act 2005 (England and Wales) and the equivalent Section 137 of the Mental Capacity Act (Northern Ireland) 2016).

Information for consultees

The Committee agreed that Consultees should not be sought for those participants that did not survive emergency resuscitation or those that did not regain capacity following emergency resuscitation. The Committee accepted the applicants' justification that this was a non-interventional study, that no information would be collected following emergency treatment and that seeking consultees in these circumstances would not be appropriate.

Good practice principles and responsibilities

The UK Policy Framework for Health and Social Care Research sets out principles of good practice in the management and conduct of health and social care research. It also outlines the responsibilities of individuals and organisations, including those related to the four elements of research transparency:

1. registering research studies
2. reporting results
3. informing participants
4. sharing study data and tissue

Conditions of the favourable opinion

The REC favourable opinion is subject to the following conditions being met prior to the start of the study.

Confirmation of Capacity and Capability (in England, Northern Ireland and Wales) or NHS management permission (in Scotland) should be sought from all NHS organisations involved in the study in accordance with NHS research governance arrangements. Each NHS organisation must confirm through the signing of agreements and/or other documents that it has given permission for the research to proceed (except where explicitly specified otherwise).

Guidance on applying for HRA and HCRW Approval (England and Wales)/ NHS permission for research is available in the Integrated Research Application System.

For non-NHS sites, site management permission should be obtained in accordance with the procedures of the relevant host organisation.

Sponsors are not required to notify the Committee of management permissions from host organisations

Registration of Clinical Trials

All research should be registered in a publicly accessible database and we expect all researchers, research sponsors and others to meet this fundamental best practice standard.

It is a condition of the REC favourable opinion that **all clinical trials are registered** on a publicly accessible database within six weeks of recruiting the first research participant. For this purpose, 'clinical trials' are defined as:

- clinical trial of an investigational medicinal product
- clinical investigation or other study of a medical device
- combined trial of an investigational medicinal product and an investigational medical device
- other clinical trial to study a novel intervention or randomised clinical trial to compare interventions in clinical practice.

Failure to register a clinical trial is a breach of these approval conditions, unless a deferral has been agreed by the HRA (for more information on registration and requesting a deferral see: Research registration and research project identifiers).

If you have not already included registration details in your IRAS application form you should notify the REC of the registration details as soon as possible.

Publication of Your Research Summary

We will publish your research summary for the above study on the research summaries section of our website, together with your contact details, no earlier than three months from the date of this favourable opinion letter.

Should you wish to provide a substitute contact point, make a request to defer, or require further information, please visit:
https://www.hra.nhs.uk/planning-and-improving-research/application-summaries/research-summaries/

N.B. If your study is related to COVID-19 we will aim to publish your research summary within 3 days rather than three months.

During this public health emergency, it is vital that everyone can promptly identify all relevant research related to COVID-19 that is taking place globally. If you haven't already done so, please register your study on a public registry as soon as possible and provide the REC with the registration detail, which will be posted alongside other information relating to your project. We are also asking sponsors not to request deferral of publication of research summary for any projects relating to COVID-19. In addition, to facilitate finding and extracting studies related to COVID-19 from public databases, please enter the WHO official acronym for the coronavirus disease (COVID-19) in the full title of your study. Approved COVID-19 studies can be found at:
https://www.hra.nhs.uk/covid-19-research/approved-covid-19-research/

It is the responsibility of the sponsor to ensure that all the conditions are complied with before the start of the study or its initiation at a particular site (as applicable).

After ethical review: Reporting requirements

The attached document "After ethical review – guidance for researchers" gives detailed guidance on reporting requirements for studies with a favourable opinion, including:

- Notifying substantial amendments
- Adding new sites and investigators
- Notification of serious breaches of the protocol
- Progress and safety reports
- Notifying the end of the study, including early termination of the study
- Final report
- Reporting results

The latest guidance on these topics can be found at https://www.hra.nhs.uk/approvals-amendments/managing-your-approval/.

Ethical review of research sites

NHS/HSC sites

The favourable opinion applies to all NHS/HSC sites taking part in the study, subject to confirmation of Capacity and Capability (in England, Northern Ireland and Wales) or management permission (in Scotland) being obtained from the NHS/HSC R&D office prior to the start of the study (see "Conditions of the favourable opinion" below).

Non-NHS/HSC sites

I am pleased to confirm that the favourable opinion applies to any non-NHS/HSC sites listed in the application, subject to site management permission being obtained prior to the start of the study at the site.

Approved documents

The final list of documents reviewed and approved by the Committee is as follows:

Document	*Version*	*Date*
Copies of materials calling attention of potential participants to the research [STOPGAP NNUH cover poster v1.0 17th April 2023]	1	17 April 2023
Copies of materials calling attention of potential participants to the research [STOPGAP YAS cover poster v1.1 17th April 2023]	1.1	17 April 2023
Copies of materials calling attention of potential participants to the research [STOPGAP NNUH Poster v2.1 17th April 2023]	2.1	17 April 2023
Copies of materials calling attention of potential participants to the research [STOPGAP YAS Poster v1.1 17th April 2023]	1.1	17 April 2023
Covering letter on headed paper [Covering letter STOPGAP 6th June 2022]	1	06 June 2022
Covering letter on headed paper [IRAS 304724. HRA & HCRW Approval Status Update Response to comments 17th April 2023]	1.0	17 April 2023
IRAS Application Form [IRAS_Form_28122022]		28 December 2022
Letter from funder [Letter from Funder for STOP GAP 6th June 2022]	1	06 June 2022
Letter from sponsor [Version 1 27-05-22 Research Sponsorship in principle WIlliams Fisher Millington Gedge]	1	27 May 2022
Letters of invitation to participant [Survivors invitation letter v1.1 17th April 2023]	1.1	17 April 2023
Organisation Information Document [Organisation_Information_Document_NonCommercial_v1-6+STOP	1.6	23 December 2022

GAP 23rd December 2022 Norfolk & Norwich University Hospitals NHS Foundation Trust]		
Organisation Information Document [Organisation_Information_Document_NonCommercial_v1-6+STOP GAP 23rd December 2022 Yorkshire Ambulance service]	1.6	23 December 2022
Participant consent form [Work Package 2 – Clinical – Emergency Department Participant Information Leaflet v 3.1]		
Participant consent form [Survivors' consent form vs 1 17th April 2023]	1	17 April 2023
Participant information sheet (PIS) [Work Package 1 – Clinical – Out-of-hospital Setting Participant Information Leaflet Version 2]	2	22 October 2022
Participant information sheet (PIS) [Health Care Professional Information Leaflet v3.1]		
Participant information sheet (PIS) [Work Package 1 – Clinical – Out-of-hospital Setting Participant Information Leaflet Version 3.1]		
Participant information sheet (PIS) [STOPGAP PIL survivors v1.2 17th April 2023]	1.2	17 April 2023
Participant information sheet (PIS) [STOPGAP PIL HCW v3.3 17th April 2023]	3.3	17 April 2023
Participant information sheet (PIS) [STOPGAP PIL WP1 v3.3 17th April 2023]	3.3	17 April 2023
Participant information sheet (PIS) [STOPGAP PIL WP2 v3.3 17th April 2023]	3.3	17 April 2023
Protocol [Protocol]	7	04 May 2023
Referee's report or other scientific critique report [STOPGAP Scientific Review]	1	27 May 2022
Research protocol or project proposal [Project STOPGAP Protocol v6.6 17th April 2023]	6.6	17 April 2023
Schedule of Events or SoECAT [IRAS_schedule-events-STOPGAP vs 1]	1	06 June 2022
Summary CV for Chief Investigator (CI) [Prof Julia Williams CV 31st May 2022 Chief Investigator]	1	31 May 2022
Summary CV for student [Tim Millington CV 1st June 2022]	1	01 June 2022
Summary CV for student [RM Fisher CV 31st May 2022]	1	31 May 2022
Summary CV for student [Dale Gedge CV 31st May 2022]	1.1	31 May 2022
Summary CV for supervisor (student research) [Professor R Chilcott CV]	1	31 May 2022
Summary, synopsis or diagram (flowchart) of protocol in non technical language [STOPGAP STUDY FLOWCHART vs 6.2 22nd October 2022]	6.2	22 October 2022

Statement of compliance

The Committee is constituted in accordance with the Governance Arrangements for Research Ethics Committees and complies fully with the Standard Operating Procedures for Research Ethics Committees in the UK.

User Feedback

The Health Research Authority is continually striving to provide a high quality service to all applicants and sponsors. You are invited to give your view of the service you have received and the application procedure. If you wish to make your views known please use the feedback form available on the HRA website:
http://www.hra.nhs.uk/about-the-hra/governance/quality-assurance/

HRA Learning

We are pleased to welcome researchers and research staff to our HRA Learning Events and online learning opportunities– see details at:
https://www.hra.nhs.uk/planning-and-improving-research/learning/

IRAS project ID: 304724 Please quote this number on all correspondence

With the Committee's best wishes for the success of this project.

Yours sincerely

Mr Anthony Warnock-Smith
Chair

Email:leedswest.rec@hra.nhs.uk

Enclosures: "After ethical review – guidance for researchers"

Copy to: Ms Ellie Hubbard

Lead Nation

England: approvals@hra.nhs.uk

Appendix 15: Peer reviewed poster presentation

Presented at the Centre for Applied Clinical, Health and Care Research (CACHE) conference 2023.

'It's just what we do'

A qualitative study exploring personal protective equipment (PPE) experiences of paramedics.



T. I. Millington, R. P Chilcot, J. Williams.

In recent years, respiratory disease, specifically COVID-19, has significantly impacted healthcare in the United Kingdom (UK) (Cheruku et al 2020). Paramedics have been required to wear various PPE when caring for patients. A paucity of evidence capturing paramedic experiences exists, with no identified literature investigating their reasons behind non-adherence to PPE guidelines (Millington et al 2022).

AIMS

To explore paramedic experiences of using PPE during the COVID-19 pandemic, with focus on non-adherence to PPE guidelines.

METHODS

Exploratory study design, purposive sampling, virtually held semi-structured interviews, transcribed and coded with NVIVO, analysed using 6 stage reflexive thematic analysis in line with Braun & Clarke's (2022) recommendations.

RESULTS & THEMES

The sample included 16 paramedics / extended paramedic roles across 6 services and 2 countries of the UK.

1. Communication: PPE caused issues with certain patient demographics, when leading cardiac arrests or breaking bad news.

> '...it's a barrier to basic humanity. (Interview 12)

> 'elderly patients who can't hear very well... you end up pulling your mask down so they can lip read.' (Interview 1).

> '... You can't run a scene like that if no one can hear you – it is impossible.' (Interview 11.)

2. Non-adherence: Triggered by a sense of duty to the patient, whereby the patient's needs were prioritised over their own.

> 'I had a palliative patient on the floor... I ended up taking it all off... I even took my mask off... he was COVID+. I picked him up, carried him back to bed... I understood completely that I hadn't followed the guidance and... put myself at risk.' (Interview 3)

> '...the nature... of what paramedics are. They will put themselves at risk to try and help others... It's just what we do... if something happened to me... I was prepared to accept that.' (Interview 7).

3. Patient care: Clinical effectiveness was felt to be detrimentally impacted and led to an associated moral injury

> '...clinical examination, there's so much tactile sensation that you lose...' (Interview 5).

> '...cannulas were harder, drawing up drugs were harder.' (Interview 12)

> 'I take a lot of pride in what I do... leaving a patient's side... to... change into a different level of PPE... I found that really, really tough...' (Interview 10)

4. Physical & Mental well-being: Both were negatively impacted either directly or indirectly by PPE.

> '...my mental health has been a problem... I'm currently having counselling... I got COVID... was on intensive care... I thought I would never see my daughter again... I saw colleagues not wearing masks... that annoyed me. My mental health suffered because of my situation... my worry increased... because of the quality of the PPE.' (Interview 13).

> 'Did PPE contribute to burnout?... Yes! Do I want to go back to it? No! My colleague is off with PTSD... I went into my old station... at least half... are leaving or wanting to leave.' (Interview 3).

5. Motivators behind adherence: Personal experiences and a desire to protect ones family motivated paramedics to wear PPE.

> '...we had 3 members of staff who died... it became real... people who we actually knew, friends and family... our station became quite nervous, we would use the PPE religiously.' (Interview 8).

> 'my own family was shielding...You sort of felt responsible for looking after yourself and making sure you didn't come down with this virus.' (Interview 16).

DISCUSSION

The willingness of paramedics to put patients' needs ahead of their own was repeatedly observed and saw them remove PPE for the betterment of patient care. To explain this phenomena one might consider a health care workers (HCWs) 'duty to treat' alongside a psychological concept 'identity fusion'. Duty to treat refers to general societal expectations that HCWs take more risk than members of the public when aiding those in need (McConnel 2020). Identity fusion refers to the blurring of boundaries between oneself and others a state thought to be heightened during shared, intense, physical or emotional experiences such as was seen during the pandemic (Chinchilla et al 2022). It is proposed that these circumstances in combination, could lead to a rescuer state of overpowering urge to save, , where patients' needs take precedence over all else. The author proposes this heightened rescuer state be termed 'the blue mist'. This phrase was first used anecdotally, referring to emergency drivers using of excessive speed during driver training. This practice put themselves and others at risk so it could be said 'the blue mist had sent in', clouding their judgement. However, this exploratory study was designed to gather rich data, adding to a limited evidence base. As such, more generalisable findings will require further research.

References:

- Braun, V., Clarke, V., (2022). Thematic Analysis: A Practical Guide. SAGE publishing.
- Cheruku, S., Dave, S., Goff, K., Park, C., Ebeling, C., Cohen, I., (2020) Cardiopulmonary resuscitation in Intensive Care unit patients with coronavirus disease 2019. Journal of Cardiothoracic and vascular anaesthesia. Volume 34. PP2595-2603.
- Chinchilla, J., Vázquez, A., & Gómez, A. (2021). Identity fusion predicts violent behaviour when it is morally justifiable. The Journal of Social Psychology. Volume 162. Issue 6. PP 701 – 715. https://doi.org/10.1080/00224545.2021.1948813
- Chinchilla, J., Vazquez, A., Gomez, A., (2022). Strongly fused individuals feel viscerally responsible to self-sacrifice. British Journal of Social Psychology. Vol. 61. Issue 4. 1067 – 1085. https://doi.org/10.1111/bjso.12526
- McConnell, D., (2020). Balancing the duty to treat with the duty to family in the context of the COVID-19 pandemic. Journal of Medical Ethics. Vol. 47.360 – 363. doi:10.1136/medethics-2020-106250
- Millington, T. I., Chilcott, R. P., Williams, J., Experiences of personal protective equipment and reasons for non-compliance. Journal of Paramedic Practice. Vol. 14. No. 10. https://doi.org/10.12968/jpar.2022.14.10.411

Appendix 16: Interview 2 transcription word document.

Key: I = interviewer, P = participant

I: Can you confirm you've been a HCP registered paramedic working since March 2020 for 6 months.

P: Yes. I have been qualified for almost 2 years.

I: Can you tell me your full role please?

P: Ambulance paramedic

I: So to clarify… you've been a paramedic for almost 2 years and registered for almost 2 years?

P: errr yeah registered for 23 months.

I: and the region where you work?

P: Yorkshire

I: Ok we'll start with exploring your general experiences. Can you tell me your experiences of using and wearing PPE when you've been in your role seeing patients, please?

P: So, at first, I wasn't a big fan of PPE although I understood the reasons as to why… to limit the chances of catching and passing on COVID-19. I just saw it as a bit of a hindrance because of things such as communicating with patients… how it's not always the words we use, it's facial expressions, our body language. If we go to patients who might have communication difficulties such as hard of hearing, they might rely on lip reading and such…. And so, I did find it quite difficult in that respect. In some cases, I did find it quite bliss… for example if I was at a job where I was thinking 'why on earth am I here?' it would hide my facial expressions so in that case it was a bit of a good thing. But I do think as well… that level 3 is a bit over the top – like the level 3 PPE for AGPs because surely just speaking is an aerosol generating procedure? So, I do not understand why we waste time with putting on that PPE when we need to performing CPR and ALS on that person. So, kind of ups and downs with PPE really.

I: Thinking of when PPE first came in… do you feel you views towards PPE have changed with time and experience?

P: Yeah – I think… I don't see it as a chore anymore. At first it was trying to remember as it was something new and different. Whereas now it's been indoctrinated into us – it's part of everyday practice – put on your gloves, put on your mask. I don't put on an apron if I'm being entirely honest. Basically, because in my view aprons are completely pointless. They don't protect my sleeves, they don't protect my arms or my back, so I don't really get the point of them. But I do see the benefit from PPE. I just see it as part of my routine now… on the way to a job… getting the gloves and the mask for me and my mate. Gloves we would've worn anyway before COVID so it's really just grabbing a mask for me. I do see the benefit of it, to protect us from other things not just OVID-19. Obviously working in the ambulance service, we are privy to picking up things that people have because we are always working around illness so I think it is helping prevent us catching those more minor illnesses as well.

I: I agree I think PPE discussions tend to be very COVID orientated but there are other diseases that PPE can protect against. Do you find that you've been in better or worse health since the introduction of PPE measures. Or has your health been reasonably constant?

P: I think it's been good to be fair, I suffer with hayfever and I usually get bunged up with that in the summer months anyways. I think over the last 2 years I haven not suffered form a cold very much whereas I can usually have them a couple of times a year. In fact I cannot recall the last time I had one! Yeah so it does help with general protection against other things. It acts as a barrier to protect against catching things we might potentially get from patients.

I: Have you 2 words that spring to mind when we talk about PPE?

P: Mask and protection.

I: Is there any one specific scenario or example where you can think PPE has worked well or hindered your work?

P: I do think it hinders cardiac arrest where we have to put on level 3. What I got into the habit of doing was if we weren't already driving and we got an arrest call. I'd tell me crew mate to hang on a sec, then jump in the back to put on my level 3 when on the way to the job. That was to reduce the hindrance it was going to be when we arrived at the scene. Obviously, I know that puts my self in a risky position because I'll be in the back of the ambulance putting on this PPE usually when driving the most… how do I describe it… ermm the most aggressive driving that we do – which is towards a job. It puts me at risk, being in the back, doing that, but it's because I want to make sure I'm not detrimenting patient care when I get there, by wasting time putting it on.

I: So you put the patient ahead of yourself safety wise?

P: Yeah

I: Have you ever been injured as a result of doing that?

P: I wouldn't say I've been inured as such. I've had a few tumbles and that where I've had to stop myself from falling. Like banging my side on the back table or something but not severely hurt myself or anything like that.

I: Have you ever had any issues with the quality of PPE when you've arrived on scene? Has it met your expectations?

P: The service did get these masks in where I remember the first time I put one on… I was like "where on earth are the straps?"… The straps were kind of like built into the mask at the side you had to like pull them away from the mask and stretch them out and they were really uncomfortable. They were just so tight because the bands were so thick – they were just pulling your ears forward and they were really uncomfortable causing a bit of pain around our ears as well. A few people at work other then just myself agreed with that. If they're not too tight they are ok but I know we need them tight enough to work. Those specific ones they got in were not great.

I: Regarding patient care specifically… Do you feel PPE has impacted patient care? Either positively or negatively?

P: I'd say it's probably been positive overall. It's protecting us and the patient. From us catching things from our patients and the patients potentially catching things from us. So I don't think its detrimental to patient care. Also say if I do go to someone who struggles with communication,

say they're a bit deaf or whatever, I'll keep my distance a bit and lower my mask and speak in a bit mor of an accentuated way, over pronouncing my words, to help them with their lip reading for example. So I don't think it's detrimental to patient care at all.

I: Do you think PPE has made you feel more safe at work?

P: To a degree. I's like to say I'm a young healthy male. Yeah of got asthma but other than that I don't have any medical problems. For my more elderly colleagues who might have more problems I can understand how they might feel more safe but for me personally I don't think it made too much of a difference.

I: You've touched on how you adjusted your practices by donning PPE enroute to a patient in cardiac arrest, when you've been attending and treating a patient in cardiac arrest has your performance been hindered or unaffected?

P: I think my performance hasn't been hindered but I have found it difficult to communicate with other people. The respirator hoods that we wear are quite loud and I do struggle with my hearing so I did find that quite difficult trying to hear what people were saying. What I have been trying to now is moving towards the FFP3 masks to try to avoid the respiratory.

I: Was there a reason why you went for a respirator hood over FFP3 originally?

P: In all honesty I failed the fit test, but that was because I hadn't had a shave when it was testing. But I think I would rather just wear the FFP3 and take the risk if it gets me to the patient quicker, not need to don it in the back of a moving ambulance and potentially save the patient, and also if it means I can hear my colleagues more clearer during the cardiac arrest situation. Personally, I don't think there's much difference in the AGP risk of putting an airway into somebody and talking to somebody. At the end of the day, I'm breathing in and out, talking and if I do a cough or anything like that – I personally don't see how that is any less of a risk then putting an airway into somebody.

I: What is interesting speaking to you is that you were qualified into PPE and covid so you offer a really interesting take on things. Have you been satisfied with the standard of patient care you have delivered in PPE?

P: yeah – I think that is more something personal to myself rather than the PPE that I wear. I like to treat people well and make sure they are treated the best way possible. And like I say if I feel I am not able to do this, if needs be I will just lower my mask briefly to make sure there is that understanding but no I don't think it is affecting my patient care.

I: It's interesting how you say "if needs be", what sort of factors might lead you to consider lowering your mask?

P: If someone is hard of hearing or struggling to hear me I might do that to help them with lip reading and help them see my mouth. If someone is maybe a bit anxious such as dementia patient I will maybe pull my mask down so that they can see my whole face which means I can smile at them so they can see that I am not a threat and that I'm there to help them. Try to give that more warming presence. It's the same with children – if they can only see half a face then it can be quite scary for them. So it can be a way to build rapport by lowering my mask briefly just so they can see me smiling then I can pull my mask back up and continue as normal then.

I: If a patient was immune-compromised and hard of hearing, would that that thought process?

P: With that I would, if I was going to lower my mask I would try and do it at a bit of a distance. There have been some cases where I've instead used my phone if the patients hard of hearing. I'd speak into my phone for it to bring up text then allow the patient to read what is on my screen. If there things such as immunocompromised factors to take into account I wont then just pull down my mask as I obviously don't want to put them at risk.

I: It sounds like you do a rapid risk assessment in your mind?

P: yeah.

I: Has your own personal health been impacted either positive or negative? You mentioned reduced frequency of cold and it also lying heavy on your ears so have there been any associated improvements or symptoms with that?

P: Yeah so because I'm asthmatic, and particularly after I had covid myself, I found the masks were making me quite short of breath, so there were points where I'd find myself having to pull the mask away from my face just for a few seconds just to catch my breath. Such as if I'd had to carry a lot of equipment or walk up a few flights of stairs. Sometimes even just being stood talking I might notice I became short of breath in a mask. I feel that was mostly after I caught covid and was recovering from it.

I: So you feel although PPE didn't make it easier you don't feel it directly contributed to it?

P: It's hard to say, it happened occasionally before I got covid, but became more regular afterwards. I think there was a potential input of the PPE that led to me feeling breathless but it was more notable after I had had covid. Maybe a slight influence but nothing major.

I: Do you feel you got covid outside of work or at work? I appreciate it is difficult to answer.

P: I'd say outside of work. I was out a lot when restrictions were lifted, playing catch up and trying to wide down after the stressful time of covid. I'm amazed I didn't get it sooner to be honest. I went to Manchester pride and that was heaving, like sardines in a tin and I thought surely I'm going to get it here but I didn't. It wasn't til much after I think I got it from a friend who I'd gone out with who's kids have had it the week before.

I: Do you feel your pre-existing medical conditions were made worse by PPE? I know you said you had asthma…

P: yeah definitely. I rarely used to use my salbutamol inhaler and I never used my beclomethasone inhaler which I know is naughty of me. But since getting covid I have been having to take my salbutamol inhaler much more regularly and I now take my beclomethasone inhaler every day. I've had to see my GP and now had to double the dose of my beclomethasone but I find now that I'm not needing to use my blue inhaler after increasing the brown one.

I: dd this happen before you had covid at all?

P: A little. I was having it use my inhaler a little bit more often before I had covid compared to like a year before PPE was introduced. But not too much more often. I'd say once every week which was an increased from hardly ever using it. After I had covid it became a daily thing.

I: After the covid infection you saw your GP?

P: yeah because before even though I was having to use my inhaler more then before I wasn't concerned too much thinking… I know i'm asthmatic anyways and I don't manage it very well

lets just start using my inhaler a bit more. But it was after I got the covid that I need to use it a lot more and see the GP about making changes. It could potentially have had some input from the PPE.

I: When you were working after you had recovered from covid, and you were in PPE did you notice breathing issues more?

P: yeah that definitely! I struggled with my breathing at work. I found myself having to pull my mask down quite frequently to catch my breath.

I: Do you feel PPE had a direct impact on this?

P: Yeah there were differences before and after having caught covid but my breathing has definitely been affected by wearing PPE. More so having had covid then before certainly.

I: With regards to mental health, you've touched on how you wanted to get out there and live your life. Was that as a result of having had your mental health impacted prior to that?

P: It was hard because I had finished my paramedic degree and had plans to go relax and go on holiday. Chill out basically before my paramedic registration came through but because of covid I became what YAS call a 'COVID paramedic'. So I was effectively a technician that could do paramedic interventions if I got permission for it. And so because of that I was thrown straight in at the deep end. I didn't have any time to rest or recuperate after finishing my degree even though I was still waiting on my registration I was thrown straight into this role due to the demand due to covid. It was hard. I felt like I had not stopped. I'm going on holiday in a few weeks and I have started realising just how much I need that. I've gone straight from university, into this covid paramedic role then the NQP role with no respite. We've not had the support and I feel a lot of this has been blamed on covid. Or things have been omitted because of covid. We've not had any of our team leader days or support from our clinical managers or anything. We've basically just been left to it with only the support of contacts at the clinical hub which anyone can do so it has been very stressful. Like with other facets of life I think a lot of people are using covid as an excuse to not deliver or to help. Especially when you're an NQP. Things are so different to years ago when there wasn't an NQP program perhaps because it used to be a bit more straight forward then what it is now, what with pathways and everything else. So it has been stressful.

I: It sounds like a stressful time. Do you feel your life was made more stressful by the fact that you had to go to work in PPE everyday?

P: Oh sorry if I went off topic.

I: No its not wrong what you're saying. It's fascinating and there are no right or wrong answers. It's all relevant.

P: That's good. OK I think with the masks. I think the only stress I had was with the plastic aprons and the level 3 PPE in arrest situations. The actual mask itself is absolutely fine and didn't cause me any stress. The fact that the level 3 prevents me from giving the best patient care for those patients that are in cardiac or respiratory arrest, or are potentially conscious but are breathing ineffectively and might need bagging, which I have had to do a couple of times… in fact I had a patient recently to be honest who was really struggling to breath and I ended up bagging him when he was conscious and I did not put level 3 on despite knowing I should have. Because to me that would have made me stressed, thinking I'm having to waste time putting this PPE on

when my patient needs help breathing. I don't think the masks have been stressful bit I do think the level 3 have added to my stresses.

I: If you felt there was delay to a time critical intervention if you were required to increase your level of PPE you would avoid using that higher level PPE?

P: Yeah, the guy I'm thinking of, he'd had the full shebang of all the medications I can give for exacerbation of COPD, and his chest just became silent, he was really struggling to get any air in. So I had to help him through bagging him. Obviously bagging is an AGP and so I should put level 3 on but I couldn't justify it to myself, saying to a patient who is struggling and conscious – just bear with me whilst I put on this PPE and then I'll help you with your breathing.

I: Did this happen after you had recovered from COVID?

P: Yeah

I: Did you feel you had a better understanding of your own personal risk?

P: Yeah but also I think a lot of it comes from the history taking. From the patient. I didn't feel like he was at risk of having covid and therefore I wasn't at risk of getting covid. If he had had a high temperature, or a loss of smell or taste or any of the other symptoms of covid, or if he had been here or there or everywhere and seeing his friends and family or anything like that then I might think hmmm maybe I should put on level 3 but there was nothing there to make me think he was a risk to me so I would rather just get on with treating him.

I: how frequently do you think the pulling o the mask down occurred?

P: Not too frequently. Maybe a couple of times a week depending on the sort of patients I would get sent to. But again, if I thought they were at risk of covid, I would still do it, but I would try to maintain more of a distance and maintain at least my 2 metres. I do think it is important to build rapport and make sure patients understand what is happening especially during covid times when they are so frightened and not sure of what was going to happen to them. People were so scared and not wanting to go to hospital. So I think trying to build that rapport with your patients was just as important and sometimes I felt like I needed to do that.

I: You said frequency depends on the sort of patients so what sort of patients would lead to the dipping of the mask down?

P: Paediatric patients who might be scared, the elderly who might be hard of hearing, those with dementia, you know just someone who might need that bit of extra reassurance and just need to see my face. Or even those who don't understand very well and might need those extra visual cues and to know that I'm there to help.

I: I'm guessing there might've been a thought process at the first time you did this? What kind of feelings would you experience when you felt your communication was not effective due to PPE?

P: It was frustrating at first because there was this barrier. There was a thought process initially which later became a bit more automatic the more I did it. Obviously I did it once and found I was fine so I did it again. I think because I was newly qualified as well, I wanted to stick to the rules. Obviously being in a new role and everything. I was thinking I shouldn't really be doing this, but the patient wasn't understanding, or they seemed quite worried, but I could put myself at risk, or my crewmate or other people. So, at first, I did start to do it but at some distance to try and mitigate that risk but then, I dunno, the more I got comfortable doing it I then would, maybe,

do it a bit closer to the patient, then more regularly and with more ease, not thinking too much about it.

I: Have you seen other people be non-compliant?

P: Yeah. They don't wear aprons. People will have the masks only covering their mouth. Or they'll pull them down a bit particularly in the A and E department, or if they are not within 2 metres of the patient. Maybe they are sat at the opposite side of the room from a patient when at work, then the mask will come down a bit. I think because it can be a bit overbearing if you've had it on for too long. It does affect me if it's on for too long as I've mentioned with covid and being short of breath. Yeah I see quite a lot of non-compliance.

I: Overbearing for you is the breathing issue?

P: yeah.

I: How about other people, do you think they had different reasons for pulling the mask down?

P: I'd probably say maybe comfort and also again that better communication with patients and it enables more visual cues as well. Cos what is it, something like 7% what we say, 38% how we say and 55% body language. I do think body language is a big part of how we communicate. So, I think as long as we are maintaining that distance and we are obviously testing ourselves regularly knowing that we haven't got coronavirus from LFTs and such and we're mitigating risks to the patients by testing ourselves and maintaining the distance, then by doing that we can enable somewhat of a better communication with them.

I: Do you feel that the guidance was clear? Did you feel you always understood what you were meant to do and why?

P: Yeah. Yeah. Gloves, mask, apron to protect yourselves and others from the risk of catching covid, yeah I was aware of it. We had it drilled into us quite regularly at work.

I: DO you feel like there was any support you didn't get or you could have done with?

P: Ermm no? No. No it was always quite good. There was always PPE available.

I: Do you feel like there is anything that needs changing immediately?

P: Just for my service to stop buying those awful masks with the straps that you have to pull that dig in your ears. Just because they are quire painful to wear. But otherwise no I think it's alright.

I: Did you ever have any physical damage to your ears or was it more the discomfort?

P: Those sort of masks did hurt the back of peoples ears and sometimes people would get marks on the back from the straps of these specific masks. It got to the point that people would, if these masks were on the ambulance at the start of the shift, would go and replace them with another box, for the more straight back ones rather then these ones cos they were uncomfortable to the point where they were starting to cause friction marks.

I: Would people not wear them?

P: No. No.

I: Would they take them before they should?

P: yeah I think they would. From the discomfort from them, I'd say that people definitely were a lot more, what's the word… they'd try and get them off sooner then they should because of the discomfort.

I: Are you still an ambulance paramedic?

P: I am

I: Do you feel more or less likely since covid 19 measure have been introduced?

P: Do you mean in terms of PPE?

I: Well yeah, I guess I'm asking if you're happy in your work still despite the PPE measures?

P: Yeah, in terms of PPE it hasn't affected how I feel about my job. It has now become the norm really – to wear masks and like I say through identifying risks and adapting how I wear it, like if I need to drip it for a second just to smile at a patient I will. But no it hasn't affected me too much. There are other things that make me think about looking for alternate employment in the future but PPE hasn't.

I: PPE fatigue used by the royal college of emergency medicine as part of a safety bulletin. Have you ever come across it?

P: No mate what does it mean?

I: well, that was my next question, what does it mean to you, can you think of what comes to mind?

P: I guess it could be something like shallow and deep processing, like how when you first do something like learning to drive you think about it quite a lot don't you. So you stick to the rules and stick to the highway code, you have your hands at 10 and 2. But then the more practise that you get you might not keep your hands at 10 and 2 and take short cuts when driving. I'm guessing PPE fatigue might be a similar thing where it becomes this automatic thing in our daily work life and so we might start to cut corners and maybe got a bit more lackadaisical with it. Maybe like dropping the mask a bit. Or even completely losing it in some instances.

I: Do you feel every time you have been non-compliant it has been a deliberate thought to have you been non-compliant by accident?

P: Yeah, I've had one occasion where I've gone into a patient's house, I've fully assessed them, we're about to leave and I've realised… I've gone gosh I'm so sorry I have completely forgot to wear a mask for the whole time I've been here, and I just completely forgot about wearing a mask. The people that we had been to see were completely fine with it and had gone don't worry that kinda thing. I was like 'no I really am genuinely sorry'. I just didn't even realise. But there has been one occasion as well where we have gone to see a gentleman, his grand daughter was on scene. She met us when we arrived. And said would you please not wear PPE because he was extremely hard of hearing and does rely on lip reading. That felt really strange how we walked in without our masks on. Obviously, we then had to get quite close to him to do our assessments and everything, but he didn't have any risk of covid. But yeah, that was the only time I had someone request for us not to wear PPE so we could communicate better with the patient.

I: Have you had patients refuse to wear PPE when you've asked them to?

P: No every time I've asked them to put a mask on they've always been quite compliant. Family however have been a bit, what's the word I'm after, they don't want to do it. For example I've had to tell family that they all were not allowed in the hospital and they've replied saying "you don't still believe in all that bollocks" or "you still believe in that shit?" referring to how they don't think it is real. We do still come across people who think covid is not real but we just have to ignore that and just have to respect that as we're in their domain at the end of the day.

I: Has anyone aggressively refused PPE?

P: I've never had any aggression regarding PPE. Theyre usually quite compliant like if they have covid. To be fair a lot of people will say "ooh I've not got a mask" but if it's not because of covid why we're there or they don't have symptoms then I will say no don't bother. Because I will have mine on so its ok.

I: What do you think would make not adhering to policy less likely to occur?

P: I don't know I've never really thought of that. Ermmm I dunno to be honest. We have them in the cab with us so they are easy to get hold of and that one time I forgot I just genuinely forgot. Couldn't tell you why. Maybe it was just the conversation with my crew mate.

I: Is there anything else you'd like to add?

P: No that's it to be fair. I just don't see the point in level 3 PPE. And the importance of communication and getting to the patient quickly to deliver timely care.

I: So you feel there's as much aerosols in speaking then there is in some other AGPs?

P: I'm sure there is more science and data out there that I maybe haven't seen that shows that there is more AGPs in inserting an airway as such, but I think if I'm stood with someone talking to them, and we're breathing in and out whilst talking… I get it that the person we're assessing might not have a mask on so that could be why but at the end of the day I assess people that are conscious who might not have a mask on so, just because this persons is unconscious and I'm putting an airway in, is the contents of their lungs suddenly going to come out, the contents of their lungs is going to come out anyway when I'm speaking to them when they're conscious surely? So that just doesn't make any sense to me regarding level 3 PPE. I don't know the data, haven't seen any visual aids to demonstrate the point of level 3 in that instance if that makes sense.

I: So if a service provider shared the evidence behind their decisions or made it more readily available that would help you?

P: yeah, cos it's very easy to just say you must have this, you must wear this, you must do this. I've heard instances where a crew has been taking a patient from their home to the ambulance. It was a bit distance to the ambulance and they've arrested on the way and they obviously started CPR and then they've got in trouble and I think maybe suspended for not wearing PPE but if someone's just arrested on you when you're taking them from A to B you're not gonna be like oh just hang on a minute whilst I go get my level 3 PPE on. And your not going to think 'I'm not going to do compressions' when you have all your equipment there ready to go. It's not in our nature to delay treatment. We want to help them and as ambulance people we forget about our well-being because we are there for the patient.

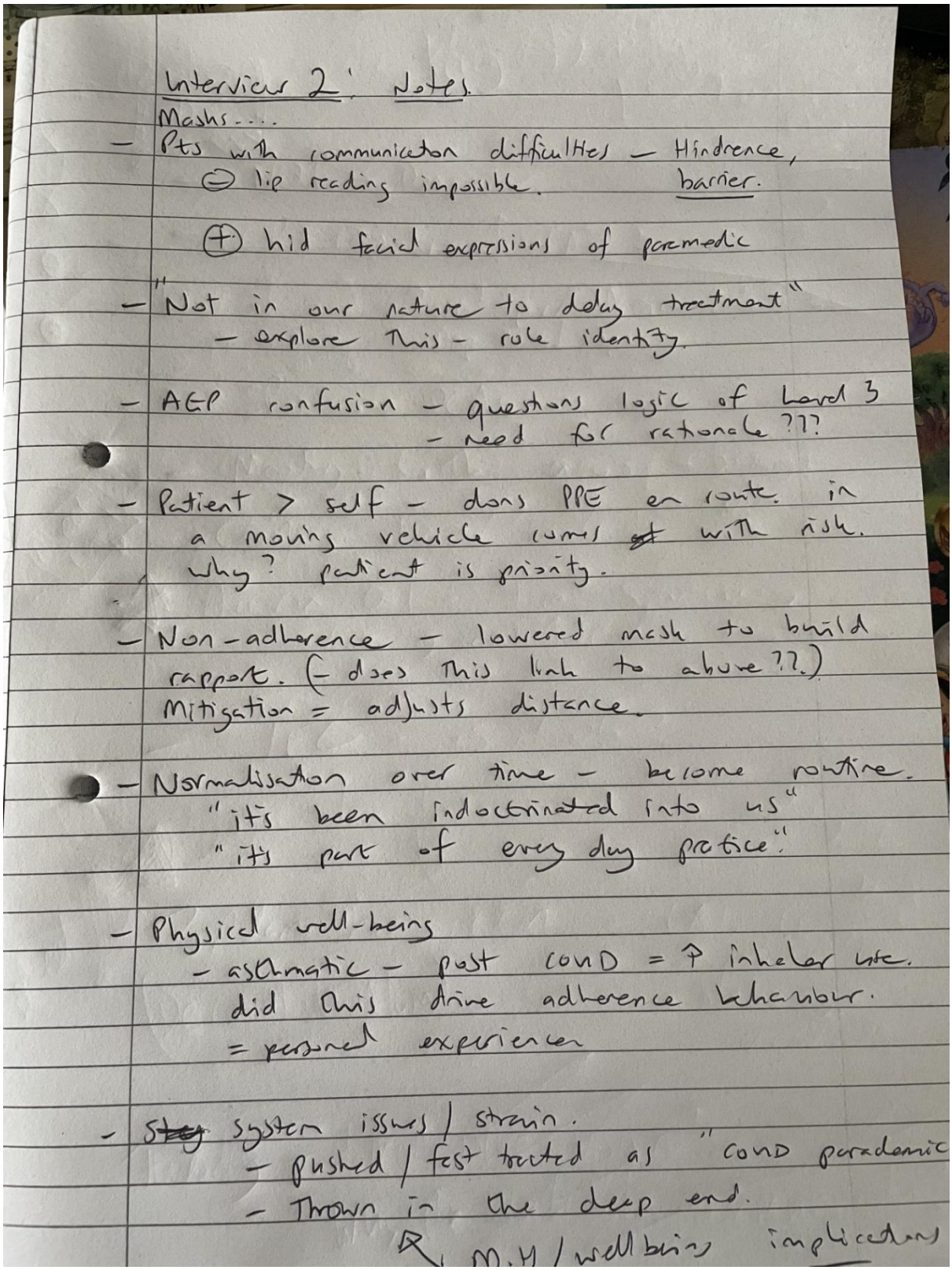
I: So you feel as protected in the lower levels of PPE as you do in the higher levels?

P: yeah

I: That’s brilliant thanks. I’ll stop recording.

Appendix 17: Photograph of handwritten notes made during manual transcription of interview 2.

In the case of Interview 2, this was audio only at the request of the participant.



Interview 2: Notes.

Masks....

- Pts with communication difficulties — Hindrence, barrier.
  - ⊖ lip reading impossible.
  - ⊕ hid facial expressions of paramedic
- "Not in our nature to delay treatment"
  - explore This - role identity.
- AGP confusion - questions logic of Level 3
  - need for rationale ???
- Patient > self - dons PPE en route. in a moving vehicle comes with risk. why? patient is priority.
- Non-adherence - lowered mask to build rapport. (- does This link to above ??)
  Mitigation = adjusts distance.
- Normalisation over time - become routine.
  "it's been indoctrinated into us"
  "it's part of every day patice."
- Physical well-being
  - asthmatic - post COVID = ↑ inhaler use.
    did This drive adherence behaviour.
    = personal experience
- ~~Stay~~ system issues / strain.
  - pushed / fast tracted as "COVID paramedic
  - Thrown in the deep end.

↳ M.H / well being implications

Appendix 18: Example of coding and node analysis taken from NVIVO[12™]

This shows how the PRECEDE theoretical framework enabled more rich analyses. The sections highlighted in grey were not captured when using the information-motivation-behaviour (IMB) model alone. Therefore by using the PRECEDE model the data analysis became enhanced. This was influenced in part due to the emic researcher perspective but also a limitation of the singular lens approach.

Enabling factors can refer to the environmental factors that block or promote self-protective behavior, including skills, knowledge, and availability and accessibility of PPE and other resources.

Limited supply

I found that communication was better in the FFP3 masks because they're sort of sealed at the top and around the nose they didn't make my glasses steam up either. The issue was supply of them. There were never enough so I couldn't wear them at every single job. So, it became reserved for cardiac arrests. If I did a shift in ops I'd have a pocket full of FFP3s and use them for any level 3 work. Which wasn't not supported by the trust, because all the student paramedics were wearing the FFP3s as well, so it wasn't just HART wearing them. I can't remember any time where I had to break bad news wearing one though. For me they came in to their own during long distance transfers.

Oh, there was this thing, where I was having to go to this company to have this fit testing for the FFP3, before I did that there was a period of time where I didn't have an FFP3 mask as I had to wait to go this company to have the fit test. And that made being at work that little bit more stressful, but only in the sense that if we got a job like a cardiac arrest, I didn't have an FFP3 mask, so then what I was supposed to do? The guidelines were that you can do chest compressions, and you can do defibrillation, but anything to do with airway management would have to wait. Touch wood, it never happened, but I remember going to work on those days and think to myself, what would I do if I went to one of those jobs, I wouldn't want to not treat the patient, but then I haven't got the right kit, and the right PPE to wear for that. Like I say, thankfully it didn't happen, but that was quite stressful, being on those shifts and worrying about going to cardiac arrests where I didn't have the right kit.

We struggled to get the masks to start with. All we had initially was the surgical masks, and then we managed to get the FFP3 masks, and then we went on to the rubber version with the filers on the front.

we realised very quickly that we didn't have any in stock.

Vs Good supply

There was always PPE available.

But I never had an issue with not having access to PPE. That was never an issue locally for us.

the fact they managed to acquire all the RP units, train everyone up, and deploy them must have been really difficult, in such a short period of time,

I had all the appropriate PPE at my disposal, every single shift. I cannot recall of one time where I thought I have not got this and would prefer not to be going out there today. It was always there and

again I have heard that has not always been the case but all I can tell you is what my personal experience was, and it was very positive in terms of access to PPE and it made me feel comfortable and safe.

When we were watching TV and news reports about ambulances and hospitals running out, I can say that we never ran out. I don't know how they managed it, but we did not run out of PPE.

Sometimes it wasn't the best, but we always had something.

PPE requiring maintenance led to non-adherence

The surgical mask I had on over the top then slid around all over the place on this sort of satin thing and the instructions I was given that came with them was that you had to separate them to everything else, I think, when washing them and I thought I haven't got enough to get me through a run of shifts to then be coming home and washing these things every night. So, I just gave up with it in the end and just put up with the sore throats.

Confusing guidelines

Do you feel the guidance was always clear regarding PPE?

P: No. Not at all. It was as clear as mud. There were times where you didn't know what you were wearing or why. Especially when it first came in and you had to adapt quite quickly but there was never a rationale for staff behind it as in "we are doing this because…".

Did you feel at the start the guidance was clear?

P: No, not at all. It's been the same throughout. To be honest I still think it's really vague. Well, it's not vague, so, we'll get sent these very lengthy memos on PPE that are about a dozen pages long and it takes a lot of time to sieve through them and really get to understand them. I feel like they still have quite contradictory information in them. Now, I can't remember which job exactly, but one of the first jobs, when the criteria changed from where we'd have to wear it for people that had been in contact with somebody who had covid or had been to one of the countries that had had an outbreak, to when it changed to being required to wear it for just anybody with respiratory symptoms as they might potentially be COVID… I would… just because I was interested in it and been keeping an eye on news as it was developing, and the department of health guidelines were changing, and all that kind of thing, I knew that, over one weekend, the guidance had changed to anybody having any respiratory symptoms should be thought of as potentially having COVID, and I remember going into work on that Monday and they'd been nothing said at work. They hadn't acknowledged it, they hadn't said "we're aware this has changed" or give any advice on what we might need to do differently. There was no mention of it whatsoever. By this point we had set up a dedicated covid hot desk in our EOC where you could ring for advice and that kind of thing. I remember going into work on the Monday and trying to get through to them at the desk to ask what do we do when we go to one of our first patients and they've got respiratory symptoms, do we need PPE? Do we not? Do we treat them as COVID? What do we do? And I could not get through to that desk. So, I rang one of the managers and again they didn't know what to advise or what to do. And I remember being despatched to the first job and the details that we were sent was that it wasn't going to be anything respiratory related, but then when we got there, the patient had, u know, you could tick them off the list… all these symptoms that meant they

were potentially covid. And I remember just thinking, I do not know what to do. Because we had had nothing formally to say that we needed to get kitted up in PPE, but I knew that it had changed nationally, but locally as a trust, it hadn't been acknowledged. So, I remember having a conversation where I rang up to speak to one of the clinicians in the control room and again, they were none the wiser, but I pointed out the online guidance to tell them this is what I think has changed and they very much left it to me to make a decision and decide what to do. So, I thought, surely, it's better to wear the PPE then not, I mean you cannot undo it if you walk in without it in the first place, so we took the decision to get kitted out in all this PPE, which as it turned out was what we ended up doing regularly for those kinds of patients with those kind of symptoms, but I felt very much like…. I felt a bit daft I suppose, in one way, I thought am I taking this decision on myself. But at the end of the day, it was probably the right thing to do, because by the time I got home that night the ambulance trust guidance had changed to say that we should be wearing PPE for these types of patients.

Volume of information meant details were missed

Do you feel like the guidance was always clear?

P: They sent out a lot of information, I'll give them that. The higher echelons did send out a lot of guidance on what we needed to do. They were quite adamant that the PPE was utilised, and used often, during every patient interaction. They'd send out general reminders, for example when we went through this change with eye wear, there was lots of information to say, "make sure you wear your goggles" and so on.

I: Was too much information given out? Could it be more succinct?

P: Yes certainly. That is very standard for the ambulance service as well. They expect you to read all your bulletins and all these updates whilst also operating and running a home life, you don't get a great deal of time to do that kind of thing. When they are sending lots and lots of bulletins and updates, especially with important information like that on, it probably isn't the best way of communicating changes.

Frequency of changes led to confusion

And that of course was not helped in a way by my trust, like most trusts, not knowing how to respond but doing the best it could, as it was being drip fed extra bits of information then it would kind of change its plans. Constantly the way that we were approaching this was evolving, policy was changing on a weekly, even daily basis, and so the problem with that is this is where human factors come in. If you change it too much, without any time for change management to under pin it, all you get is "what's todays bulletin about? What are we supposed to be doing?". By the time the chips are down, you basically resort to either primacy or recency or usually a bastardised mix of the two and you're not really following any policy instead creating a mish mash of whatever you could remember at the time. Then I think by summer, actually probably late March early summer, they actually had a generally solid policy of how we should approach it, what are PPE policy should be, and that didn't change in anything other than minor detail after that. But yeah, it was a bit chaotic, and it felt chaotic

Once we got past the first month or two, we probably had a new set of guidance daily at one point, or at least that's what it felt like. But say for the last 2 years, that would take us to what, June 2020? It's been pretty stable.

Lack of rationale led to mistrust of guidance

Did you feel you feeling of the inadequacy of the explanation led to you not trusting the policy?

P: Essentially, yes. I think so.

Also, I think the bombardment of emails and videos and everything else, and when I tend to look back, I found I then missed out on the most important emails because it was stuck in between something that was less relevant. You were getting emails from all different sorts of people that you had never heard of before saying 'You must read this and acknowledge it and then return it'. And it was a bit of a tick box exercise at times, I felt so anyways. And I think we were kind of treated like schoolchildren at times to be honest, like naughty school kids, and I think, you know, we're adults, we're clinicians, we're registered professionals and if there are individuals out there who are not adhering to PPE for whatever reasons then address those people individually and see what anxieties or issues they have. But every day it was just bombardment. It was everywhere, emails, social media.

Good practice involved highlighting changes to make them easier to understand

There were certainly periods where we would receive what felt like daily updates. It becomes available now on Para pass – that's what they use. You would get a notification of it quite quickly, usually weekly, or daily when they were sending it out, so I think the guidance has always been quite good. Perhaps over the top – too much maybe. That is what it felt like. It was good how they highlighted the bit that had changed in the process. So, you didn't have to read the whole document from the beginning, you could just look for the bit in bold or coloured highlight to see what had changed, so that was good. Certainly, my operations managers, they had the understanding that there would be times where we wouldn't be able to follow the procedures properly. At the beginning they were pretty strict on it. Like I said to you early, the example where I was suctioning the patient and I just put my hood on, I got a bit of a talking too about that but after that, the time when I took that fire truck off the road, so, that would've been probably September, the ops manager said to me, yeah, we understand you don't wear it all the time.

Observed practice encouraged adherence

at cardiac arrests we went through a stage of having a team leader, or clinical supervisor that would often attend. At the end of the cardiac arrets I was taking off the PPE in the wrong order and the pointed this out to me. It wasn't a significant critique, but it made me realise where I was going wrong. I had been doing it the way I understood it should be done but it wasn't necessarily right. It just goes to show I hadn't understood the guidance or there hadn't been adequate training for me perhaps.

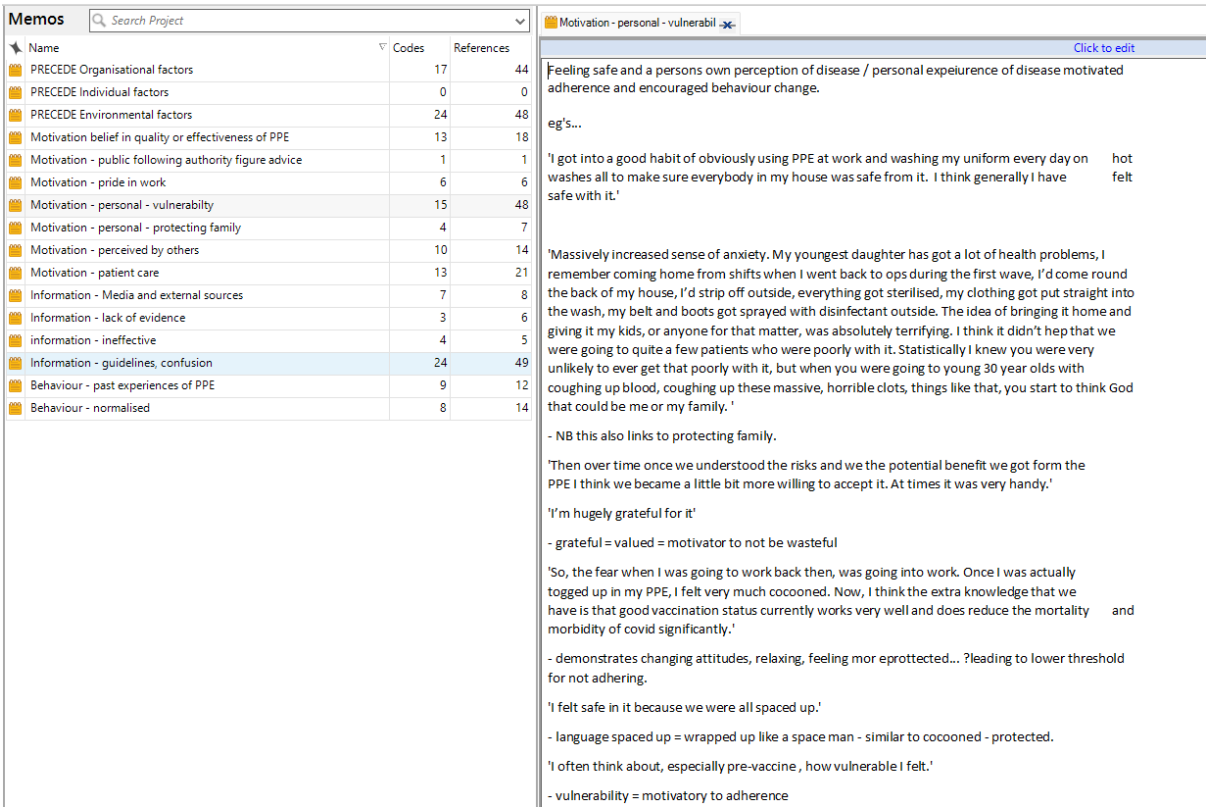
Suggested improvements for dissemination

All the ambulances, certainly where I am, have tablets in them, it might have been possible to have updates via them and the service intranet. But the reality being, and it's still the case, is that you rarely get back on to station and if you do it's to dine for 10 minutes or 15 minutes before you get another red call and that's you heading out. You'll get your dining disturbed, they'll try and get you back but

that's usually it. The communication that they used, they used as many modes as they could, so they tried intranet, emails, it was on the JRCALC app as well. Of course, when you have the JRCALC app and you check it you will see there's an update there but its getting the time to read it. That was difficult in its self because they were quite lengthy documents too for PPE and often it was only a very small change to it, so perhaps at the very beginning of the document they could have highlighted what the update is, and then shared the rest of the document with you for you to read when you had the time. That could've been a better way of doing things. They probably under utilised the tablets on the vehicles, that could have been an additional way of getting the information out there. The problem is as well though is that the government was changing guidance all the time as well though so they were just acting on what the government was telling them what to do, and because everything was rapidly evolving, particularly in the first phase of the pandemic, it was really difficult, really difficult, keeping up to speed with things and keeping a service that has 4 and half thousand members of staff all up to date with these minor changes in PPE requirements… I'm sympathetic towards them. It was a really, really, tough challenge for them to try and do and they had never experienced anything like this before. So, I kind of understood the difficulties there but I suppose there are going to be things we could have done differently.

Better guidance, but again, I don't think was just down to our employer. Nobody knew what we had to do. We have received some substandard PPE, you know, the masks where you tie them round the back. I'll be honest they have all gone, they've gone to PDSA because we wanted rid of them. I'm just trying to think… Better guidance like I say. Better equipment. A better standard of equipment. But on the whole though I don't think there was much else they could have done given the circumstances. We got what we could get at the time.

Appendix 19: Example of Theory-informed Code Grouping, using the Information – Motivation – Behaviour (IMB) theoretical lens (NVIVO[12] memo).



Memos

Search Project

Name	Codes	References
PRECEDE Organisational factors	17	44
PRECEDE Individual factors	0	0
PRECEDE Environmental factors	24	48
Motivation belief in quality or effectiveness of PPE	13	18
Motivation - public following authority figure advice	1	1
Motivation - pride in work	6	6
Motivation - personal - vulnerabilty	15	48
Motivation - personal - protecting family	4	7
Motivation - perceived by others	10	14
Motivation - patient care	13	21
Information - Media and external sources	7	8
Information - lack of evidence	3	6
information - ineffective	4	5
Information - guidelines, confusion	24	49
Behaviour - past experiences of PPE	9	12
Behaviour - normalised	8	14

Motivation - personal - vulnerabil

Click to edit

Feeling safe and a persons own perception of disease / personal expeiurence of disease motivated adherence and encouraged behaviour change.

eg's...

'I got into a good habit of obviously using PPE at work and washing my uniform every day on hot washes all to make sure everybody in my house was safe from it. I think generally I have felt safe with it.'

'Massively increased sense of anxiety. My youngest daughter has got a lot of health problems, I remember coming home from shifts when I went back to ops during the first wave, I'd come round the back of my house, I'd strip off outside, everything got sterilised, my clothing got put straight into the wash, my belt and boots got sprayed with disinfectant outside. The idea of bringing it home and giving it my kids, or anyone for that matter, was absolutely terrifying. I think it didn't hep that we were going to quite a few patients who were poorly with it. Statistically I knew you were very unlikely to ever get that poorly with it, but when you were going to young 30 year olds with coughing up blood, coughing up these massive, horrible clots, things like that, you start to think God that could be me or my family. '

- NB this also links to protecting family.

'Then over time once we understood the risks and we the potential benefit we got form the PPE I think we became a little bit more willing to accept it. At times it was very handy.'

'I'm hugely grateful for it'

- grateful = valued = motivator to not be wasteful

'So, the fear when I was going to work back then, was going into work. Once I was actually togged up in my PPE, I felt very much cocooned. Now, I think the extra knowledge that we have is that good vaccination status currently works very well and does reduce the mortality and morbidity of covid significantly.'

- demonstrates changing attitudes, relaxing, feeling mor eprottected... ?leading to lower threshold for not adhering.

'I felt safe in it because we were all spaced up.'

- language spaced up = wrapped up like a space man - similar to cocooned - protected.

'I often think about, especially pre-vaccine , how vulnerable I felt.'

- vulnerability = motivatory to adherence

Appendix 20: Example of Node structure taken from NVIVO[12]

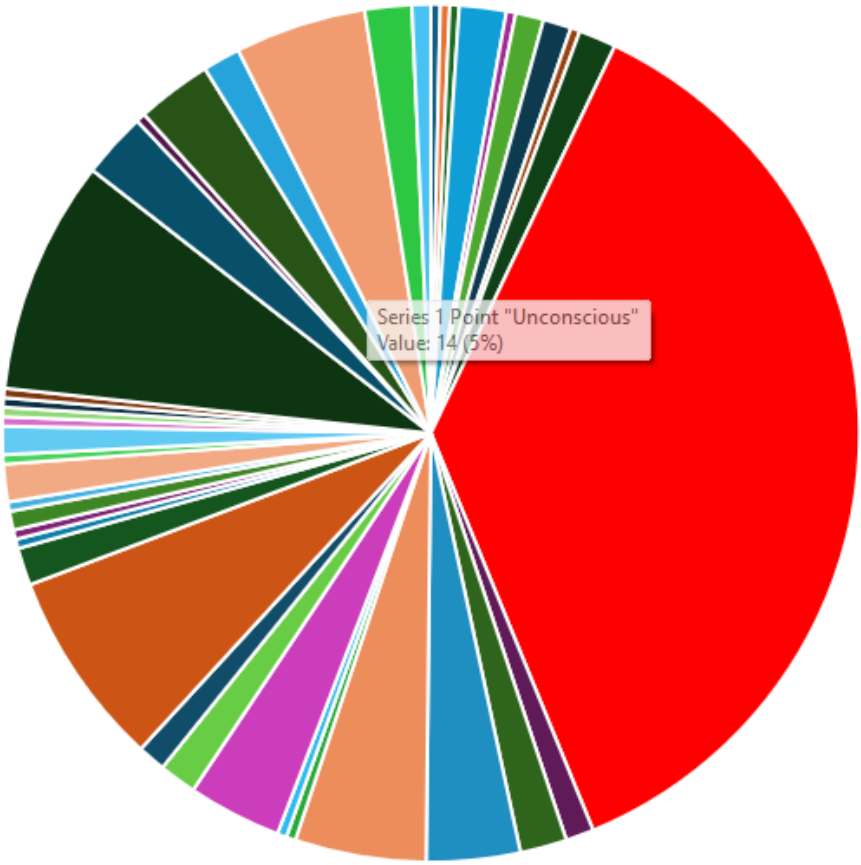
Nodes

Name	Files	References
demographic info	0	0
Impact	0	0
on the wearer	1	1
on patient care	4	12
Cardiac arrest	16	30
delays	15	30
detrimental impact	18	43
body language	8	15
on communication	14	41
sensory	0	0
positive impact	10	12
initial impressions	5	6
cognitive burden	1	2
Feelings and emotions	0	0
types of PPE	3	3
Organisational	0	0
Promoting policy	15	51
conflict	4	5
savings over safety	1	2
external influences	4	4
guidance	19	62
Attrition	6	9
Cultural behaviour	7	12
suggested improvements	17	36
support	8	12
supply	7	12
Non-adherence	1	2
Behaviour	1	1
Word cloud	14	14
Procurement	8	25
Compliance of the public	3	4
paramedics in hospital	1	1
Personal COVID experience	4	12

Appendix 21: Types of incidents attended by the research team, as per AMPDS descriptor.

Chief complaint	Number of calls
Acute Behavioural Disturbance	1
Abdominal pain	1
Agonal breathing	1
Allergic reaction	5
Animal bite	1
Assault	3
Bleeding	3
Blocked catheter	1
Burns	4
Cardiac arrest	105
Chest pain	3
Choking	5
Collapse	10
Difficulty breathing	14
Epistaxis (nose bleed)	1
Facial swelling	1
Fall	10
Fall from height	4
Fire	3
Fitting	21
Hanging	4
Head injury	1
Hypoglycaemic episode	1
Ineffective breathing	2
Jumped onto train tracks	1
Maternity	4
Middle East Respiratory Syndrome	1
Mental health crises	3
Overdose	1
Passing out	1
Peri-arrest	1
Person down	1
Road Traffic Collision	25
Stabbing / gun shot	6
Stroke	1
Trauma	8
Traumatic cardiac arrest	4
Unconscious	14
Unresponsive	5
Unwell	2
Unknown	1
Total	**284**

Appendix 22: Pie Chart showing incidents as per AMPDS classification



- ABD
- Abdominal pain
- Agonal breathing
- Allergic reaction
- Animal bite
- Assault
- Bleeding
- Blocked catheter
- Burns
- Cardiac arrest
- Chest pain
- Choking
- Collapse
- Diff breathing
- Epistaxis
- Facial swelling
- Fall
- Fall from height
- Fire
- Fitting
- Hanging
- Head injury
- Hypoglycaemic episode
- Ineffective breathing
- Jumped onto train tracks
- Maternity
- MERS
- MH crisis
- OD
- Passing out
- Peri-arrest
- Person down
- RTC
- Stabbing/gun shot
- Stroke
- Trauma
- Traumatic cardiac arrest
- Unconscious
- Unresponsive
- Unwell

Appendix 23: Chart showing reasons behind exclusion of calls coded as ‘Cardiac Arrest’.

