Deaths of individuals aged 16-24 years in the UK after using mephedrone

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ABSTRACT

Objective: Mephedrone is a stimulant drug chemically related to amphetamine, with effects similar to those of amphetamine and cocaine. This study aims to analyse fatalities following ingestion of mephedrone in the UK amongst 16-24 year olds in 2009-13, providing an update on data presented at the 2nd International Conference on Novel Psychoactive Substances.

Methods: A literature **search** was undertaken to identify **published** information on pharmacology, toxicity, and fatalities associated with mephedrone. Fatalities involving mephedrone were extracted from **the** National Programme on Substance Abuse Deaths database, which receives information on drug-related deaths from Coroners in the UK and Islands and other data suppliers. Selection criteria: deceased aged 16-24 at time of death; mephedrone directly implicated in the cause of death and/or mentioned in the Coroner's verdict.

Results: Thirty cases met the study criteria and, when known, all were of White ethnicity, most (85%) had a history of drug use and 73% were male. Two-thirds (63%) were accidental

poisonings. Mephedrone was used with other substances in most cases (87%); other substances were implicated in 60% **of deaths.**

Conclusions: Mephedrone use can have potentially fatal consequences, especially in combination with other substances. Deaths in the 16-24 years age-group continue to occur from its use in the UK, despite it being a controlled drug. Health professionals and potential consumers should be alert to this risk.

KEY WORDS: mephedrone; novel psychoactive substances; NPS; legal high; deaths; young people.

ABBREVIATIONS:

4-MA	4-Methylamphetamine
BZP	Benzylpiperazine
GHB	Gammahydroxybutyrate
MDA	Methylenedioxyamphetamine
MDMA	Methylenedioxymethylamphetamine
MDPV	Methylenedioxypyrovalerone
TFMPP	3-Trifluoromethylphenylpiperazine monohydrochloride

INTRODUCTION

Mephedrone is a synthetic drug related to the naturally occurring stimulant cathinone found in the leaves of the khat plant (*Catha edulis*) which have been chewed and enjoyed socially for centuries in Africa for their stimulant properties (Kalix, 1990; Kalix, 1992**). Mephedrone is**

one of the several novel psychoactive substances (NPS; commonly known in the market by several terms such as: "designer drugs", "herbal highs", "legal highs", "laboratory reagents", and "research chemicals"), belonging to the class of synthetic cathinones (UNODC, 2013). To clarify and unify the terminology on this issue, the European Union legally defined the term 'novel psychoactive substance' as a new narcotic or psychotropic drug, either in a pure form or a preparation, that is not scheduled under the Single Convention on Narcotic Drugs of 1961 or the Convention on Psychotropic Substances of 1971, but which may pose a public health threat comparable to that posed by substances listed in those conventions (Council of the European Union, 2011). This class of substances has played an increasingly important role in terms of both NPS use and related fatalities, being implicated in 53.8% (92/171) NPS-related deaths in the UK recorded by the National Programme on Substance Abuse Deaths (NPSAD) in 2009-2012 (Corkery et al., 2014; Ghodse et al., 2013). The importance of synthetic cathinones in the European market is still evident (EMCDDA, 2014:14).

Mephedrone use became popular in the United Kingdom (UK) during 2009, and adverse health effects including poisonings and fatalities gave rise to serious concern amongst the relevant UK authorities. These led to its control as a Class B substance under the UK Misuse of Drugs Act 1971 in April 2010 (ACMD, 2010), and also across the European Union. While mephedrone has now been banned, legal high manufacturers are increasingly altering the chemical formulas of banned legal highs to avoid prohibitions on specific substances. In response, the UK Advisory Council on the Misuse of Drugs (ACMD) suggested that legislation should be used either to ban specific chemicals as they emerge, or to make it illegal to produce substances with similar effects to banned drugs. (ACMD, 2011).

The issue of NPS is not recent, but has become important because of several factors including: chemical technologies, market availability, internet supply, price and others. NPS are often marketed as "not for human consumption" and may be described as "plant food", "fish food", "room odouriser" or other terms. Some materials are sold as "legal high" products with a trade name but no indication of the active ingredients.

The harms of NPS may be physical (intrinsic to the drug) or social in nature and unfortunately there is an upward trend in admissions, due to NPS drug toxicity, for both hospital and pre-hospital presentations (Wood et al, 2014). The ACMD (2011) recommends that the government implements strategies to decrease the request for NPS by including NPS in substance misuse education in schools and developing prevention initiatives. Mephedrone is often advertised as bath salts, plant food, insecticides, novelty items, chicken feed additives, or research chemicals, with products being sold with names like "Meow Meow", "Meph", "TopCat", "4-MMC", etc. (Winstock, *et al*., 2010). Warnings that the contents are not for human consumption are added to packaging in an attempt to escape legal and civil sanctions.

Pharmacology

The pharmacology of mephedrone is characterised by monoamine reuptake inhibition involving the dopamine, norepinephrine and serotonin transporters thus accounting for their cocaine- and amphetamine-like effects (Meltzer *et al*., 2006; Dargan *et al*., 2011). The dopamine (DAT) norepinephrine (NET) and serotonin transporters (SERT) strongly regulate the amount of neurotransmitters released into the synaptic cleft, influencing the extent and duration of neuronal signals. Mephedrone also increases presynaptic release of the same monoamines through changes in vesicular pH and inhibition of the vesicular monoamine transport receptor (VMAT2) which is located on the vesicular membrane and responsible for

monoamine uptake into the vesicles for storage (Cozzi *et al*., 1999). In addition, mephedrone exhibits relevant (<10 mM) 5-HT2A receptor binding (López-Arnau *et al*., 2012) and binds to α1-adrenergic receptors (Simmler *et al*., 2013).

Routes of administration and dosages

Mephedrone is most commonly used by nasal insufflation/snorting of powder; or oral ingestion of powder dissolved in liquid, or 'bombing' (wrapped in paper), or in capsule or tablet form (James *et al*., 2011; Carhart-Harris *et al.*, 2011). Rectal administration, inhalation, and intramuscular or intravenous injection have also been described (Psychonaut Web Mapping Research Group, 2009; Newcombe, 2009). Its physical characteristics (instability) make mephedrone unsuitable for smoking. Based on user reports, the onset of psychoactive effects after oral ingestion is approximately 15–45 min with duration of 2–4 h. Onset after insufflation is 10–20 min with duration of effect of about 1–2 h; intravenous users report symptoms peaking at 10–15 min with 30 min duration of desired effects (EMCDDA, 2010; Newcombe, 2009). Mephedrone dosages: snorting 25 - 75 mg (Sumnall & Wooding, 2009); oral 150- 250 mg (Psychonaut Web Mapping Research Group, 2009); intramuscularly 150-250 mg (Wood *et al*., 2010); intravenous doses are one half or two-thirds of the oral dose; rectal about 100 mg (Psychonaut Web Mapping Research Group, 2009).

Typical users and effects

Mephedrone use became popular in the UK during 2009 among a wide population of older adolescents and young adults due, in part, to its desired psychoactive effects, cheapness, legal status, and easy availability online (Psychonaut Web Mapping Research Project, 2010). Young people can easily search the Internet without parental control (Tsitsika *et al*., 2009) and find many sites that emphasise the positive effects of this drug and minimise its negative

effects. Young people's inexperience of drugs means exposure to different psychoactive drugs could increase vulnerability to accidents, fatal drug intoxications caused by consumption of multiple drugs, etc. (ACMD, 2011).

Typical UK mephedrone consumers are young adults, mainly males, with a history of stimulant and polydrug use (Carhart-Harris *et al*., 2011). This profile is similar to that of consumers of typical amphetamine-type stimulants (including amphetamine, methylamphetamine, ecstasy, and ecstasy-type drugs) (De Letter *et al*. 2006). Over 40% of UK dance club drug users **have reported** the use of mephedrone (Winstock *et al*., 2011), and it is commonly used by patrons of UK and European nightclubs (Wood *et al*., 2012; Yamamoto *et al*., 2013). Mephedrone use has continued in the UK despite its prohibition. **T**he 2012/13 sweep of the Crime Survey for England and Wales (Home Office, 2013) found **that use** of mephedrone among young adults aged 16 to 24 years fell from 3.3% in 2011/12 to 1.6% in 2012/13. A self-selected sample of respondents reported a fall in **use** of the drug from 19.5% to 13.8%, in part due to its unwanted effects on mental health (Winstock, 2013).

Users report mephedrone's effects as somewhere between amphetamine, cocaine and ecstasy (Measham *et al*., 2010). The desired psychological and behavioural effects reported by users **include feelings of intense euphoria, increased energy, heightened concentration, moderate sexual arousal, intense stimulation and alertness, empathy/feelings of closeness, sociability and talkativeness, intensification of sensory experiences, and perceptual distortions (Winstock *et al.,* 2011). These are similar to a range of NPS, either with stimulant (Schifano et al, 2005) and/or hallucinogenic (Ricci et al, 2011) properties,** mephedrone may be associated with a number of both physical and psychopathological side effects especially reported in persons with psychiatric, cardiac or neurological issues, who

may have a higher risk of side-effects (Winstock *et al*., 2010). The most common adverse effects reported in mephedrone users who require medical care include: gastrointestinal symptoms (loss of appetite, dry mouth, nausea, vomiting) neurological signs (tremors, tense jaws, bruxism, headache, dizziness, seizures) and cardiovascular effects (tachycardia, elevated blood pressure, respiratory difficulties, chest pain, peripheral vasoconstriction; (Schifano *et al*., 2011), and psychiatric symptoms (anxiety, aggression, agitation, confusion, dysphoria, depression, irritability; time distortions, long-lasting hallucinations, paranoid delusions, short-term psychosis, short-term mania; insomnia and nightmares; impaired short-term and working memory). Several studies have also shown that cardiovascular and central nervous system (CNS) effects of mephedrone are related to its stimulation of the **catecholaminergic** system, which can lead to severe acute intoxication and high risk of fatal consequences (Meltzer *et al*., 2006; Durham, 2011). Withdrawal effects following mephedrone use most frequently include tiredness, insomnia, nasal congestion and impaired concentration (Winstock *et al*., 2011).

Emergency department admissions and fatalities

Although many individuals have presented at Emergency Departments (EDs) following exposure incidents and acute toxicity due to the ingestion of mephedrone, Wood *et al*. (2013) suggest that controlling mephedrone reduced the number of UK ED presentations with acute toxicity. Mephedrone is often used with other psychostimulants such as cocaine, amphetamine, benzylpiperazine, butylone, methylone or pentylone; such use is thought to enhance their stimulant and entactogen effects (Schifano *et al*., 2011). Mephedrone is sometimes used in association with alcohol or controlled substances including heroin (EMCDDA, 2010), cocaine, cannabis, ketamine (ACMD, 2010). Such drug combinations can result in fatal intoxication, as the co-occurrence of several stimulants might **enhance both**

dopaminergic and serotonergic stimulation, increasing the potential for serotonin syndrome and fatal intoxication to occur (Schifano *et al*., 2004). Most amphetamine, methylamphetamine and ecstasy victims die of polydrug ingestion (Schifano *et al*., 2010).

Mephedrone-fatalities among young people have been described in several studies. The earliest case report was **in** 2008 of an 18-year-old Swedish woman, where mephedrone was the only substance detected post mortem (Morris, 2010). A 22 year old US male died of accidental multiple drug toxicity; mephedrone along with morphine, codeine, and doxylamine, was detected in post-mortem samples (Dickson *et al*., 2010). Two UK cases of two teenagers aged 18 and 19 years old who died after taking mephedrone were noted by Dyer (2010). The death of a 19-year-old male who died of cardio-respiratory arrest after consuming an unknown quantity of mephedrone along with alcohol and "ecstasy" was reported together with a fatal intoxication of a 17 year old male where toxicological analysis disclosed mephedrone have been reported (Maskell *et al*., 2011). Cosbey *et al*. (2013) report**ed** 32 mephedrone-related poisonings, including fatalities, predominantly among young adult males, in Northern Ireland; only two were attributed directly to mephedrone toxicity.

The National Programme on Substance Abuse Deaths (NPSAD) has previously reported on 60 UK mephedrone-fatalities in the UK, ages ranged from 14 to 64 years. Overall (n = 36 where quantified) post mortem blood levels were mean = 1.59 mg/L, range = <0.01 – 22.0 mg/L, excluding one outlier with a level of >2000 mg/L (Schifano *et al*., 2012; Corkery *et al*., 2012a). Cosbey *et al*. (2013) noted that in fatal cases in which death was attributed directly to mephedrone toxicity alone, blood mephedrone concentrations were approximately 2.0 mg/L. This concentration is similar to the single case reported by Maskell *et al*. (2011), in which mephedrone was considered to be the primary cause of death (blood mephedrone

concentration of 2.24 mg/L) (Maskell *et al*. 2011). Moreover, Torrance *et al*. (2010) found that post-mortem blood concentrations detected in confirmed mephedrone-related deaths were between 0.13 and 22 mg/L.

METHODS

A literature review using the PubMed, PsycINFO, Embase and Medline databases was undertaken, focusing on mephedrone's effects, pharmacology, toxicity, fatalities and public health harms related to its use in people aged 16-24 years. This age group was chosen because of its use in UK prevalence surveys and other indicators.

Fatalities involving mephedrone were then extracted from the NPSAD database. The Programme has been collecting and analysing drug-related deaths in the UK since 1997 with Coroners and relevant regional authorities submitting information voluntarily on drug-related deaths (Corkery *et al*., 2014). To date, details of some 30,000 deaths have been received.

For a case to qualify as a 'mephedrone-related death' for the purposes of this paper, it had to fulfil one or more of the following criteria: 'mephedrone' or '4-methylmethcathinone' either implicated in the cause of death and/or mentioned in the Coroner's verdict. **The deceased** had to be aged between 16 and 24 at time of death. This paper includes cases notified up to September 2013.

Analyses were performed using IBM® SPSS® Statistics, version 19 for Windows™. Demographics, risk factors, and other categorical data were expressed as frequencies and percentages within groups.

RESULTS

Up to September 2013, 30 cases meeting the study criteria had been notified, equating to 43% of notified mephedrone-related fatalities. The first death in this sample occurred in September 2009 and the last in April 2013. Just over half (57%) occurred in England. The age in this group ranged from 17 to just under 25 years; mean age was about 20 years. Most cases were male (73%), lived with others (73%), **and where their ethnicity was known (27/30), all were White.** Of those with known employment status, 50% were employed. **Amongst the 13 whose drug use or addiction status was known, 11 were known drug users** (Table 1). Where known, only one out of 17 cases had been prescribed drugs (citalopram and diazepam); in 13 cases this status was unknown.

< Table 1 about here >

Just under half (47%) died in a defined residential address (typically their own home or that of a friend) and one-quarter (27%) in hospital (Table 2). Where known (n = 24), the majority had used mephedrone recreationally: eight with a friend, three at a party, two during a night out, and one alone at home. In at least three cases, death followed 'bombing'. Three individuals died in road traffic accidents; for two the drug **could** have affected their ability to drive. A drowning occurred as a result of impaired judgement following its consumption. Three deaths followed an argument or the ending of a relationship. In two cases suicide followed after changes in mood following consumption, and one as a result of depression. Two-thirds (63%) of cases were considered to be accidental or as the result of misadventure, with abuse of drugs in one case and drug dependence in another. There were three intentional and four possible suicides.

< Table 2 about here >

In most cases (63%) accidental poisoning was the underlying cause of death, with 10% accounted for by intentional hanging. Other traumatic deaths involved unintentional hanging, drowning, and firearm and road traffic injuries. Accidental poisoning accounted for half (53%) of proximal (immediate) causes of death. This lower rate is due to more deaths from natural causes (10%). Here too, intentional hanging accounted for 10% of deaths (Table 3).

< Table 3 about here >

In only 4 cases was mephedrone the sole substance found at post mortem, whilst alcohol and mephedrone only were consumed in a further 4 cases (Table 4). Polydrug use with or without alcohol consumption occurred in all remaining cases (n = 22). The most common substances consumed were, in descending frequency: alcohol, benzodiazepines, piperazines, cocaine, opiates/opioids, amphetamine and ecstasy.

< Table 4 about here >

Post mortem mephedrone blood levels were available in 17/30 cases (Table 5). Where mephedrone was the only substance taken the levels were 0.190 and 3.300mg/L (mean 1.745 mg/L). For cases (n = 6) where only mephedrone was implicated but multiple substances were consumed the mean level was 1.372 (range 0.070-2.240) mg/L. The mean level for cases where mephedrone was implicated with other substances (n = 9) was 0.518 (range 0.002 – 2.000>) mg/L. The overall mean was 0.938 (range 0.002-3.300) mg/L. There was one outlier of 22.000 mg/L. Summary details for individual cases are given in Table 6.

< Table 5 about here >

DISCUSSION

This study highlights the dangers for young people aged 16-24 years of consuming mephedrone in association with alcohol, stimulants and/or CNS depressants. Typical victims in this study were male, White, with a history of previous drug use or dependence, and living with others. These demographics are similar to those found in our previous research on mephedrone (Corkery *et al*., 2012a; Schifano *et al*., 2012), as well as for deaths from stimulants more generally.

Death occurred in a private home in just under half (47%) of cases, one quarter (27%) in hospital, and also in a variety of other locations, such as a street, river or park. The majority of cases followed recreational use of mephedrone leading to accidental overdoses/poisonings.

Serious concern about the potential toxicity of this drug itself is confirmed by the occurrence of four deaths (13%) where mephedrone was implicated on its own. In a further 8 cases (27%) mephedrone was considered the sole drug implicated although other substances were present post mortem. Mephedrone was found to be implicated with other substances in 18 cases. On average, at least two other substances had been used (Table 5). Our findings here reinforce the continuing pattern of polysubstance use by young people. Many of these substances are stimulants (ecstasy, amphetamine, cocaine), piperazines (BZP, TFMPP) and other synthetic cathinones (methylone, MDPV).

According to the literature, other stimulants, such as amphetamine-like drugs, are frequently detected in toxicology reports of mephedrone-associated fatalities, suggesting that simultaneous use of synthetic cathinones with stimulants may amplify, in a synergic way, both dopaminergic and serotoninergic stimulation, and enhance the risk of death (Schifano *et al*., 2012). Indeed, one death (case 11) was attributed to Serotonin Toxicity Syndrome (with 4-MA). The co-ingestion of CNS depressants appears to be another common feature of these deaths, specifically alcohol, benzodiazepines (mainly diazepam), and opiates/opioids. This aspect is a well-known risk factor for elevated risk of death (Ghodse *et al*., 2010).

Where post mortem blood levels were available and excluding an outlier of 22.0 mg/L, the mean mephedrone concentration was 0.938 (range 0.0016-3.300) mg/L. This is in line with our previous findings (Corkery *et al*., 2012**a**) and those of Torrance *et al*. (2010), some of which cases are included on the NPSAD database. Lower concentrations were found in cases where other substances were implicated and/or consumed compared to cases of solely mephedrone consumption. This **suggests that** lower dosages of mephedrone **can potentially** cause/trigger serious adverse consequences when taken in combination with other substances.

The formal conclusions by Coroners and their counterparts reflect the largely recreational circumstances of mephedrone use described here, i.e. accidental/misadventure (63%) and abuse of drugs (7%). We have previously noted growing concern about the addiction potential of synthetic cathinones (Schifano *et al*., 2012) **and other worrying** adverse effects on the mental state of individuals consuming mephedrone are worrying (Corkery *et al*., 2012**a**), including in this 16-24 years age-group. Here, we would highlight: (a) impaired judgement leading to fatal road traffic accidents and drowning; and (b) depression, paranoia and psychoses resulting in intentional self-harm leading to death, e.g. hanging (see Table 2 for

examples); (c) withdrawal from mephedrone was regarded as a contributory factor in one case.

Study limitations

Blood levels were only available to NPSAD in 17/30 cases; this limits the interpretation of post mortem mephedrone blood concentrations, but can be set beside results from our previous research. Due to the voluntary nature of reporting to NPSAD and the inquest procedures associated with most drug-related deaths, other mephedrone-related deaths may have occurred prior to the publication of this study but which have not yet been reported to the Programme as the inquests into such cases may have not yet been concluded. In most cases, mephedrone was identified in combination with other drugs; hence, it is difficult to describe here the exact role that mephedrone played in the reported fatalities in this age-group. However, our previous research suggests that mephedrone **can be** fatally toxic on its own (Corkery *et al*., 2012**a**; Schifano *et al*., 2012).

CONCLUSIONS

This study describes the largest case-series of mephedrone-related fatalities in young people aged 16-24 years. It confirms that individuals in this age-group are at potential risk of **fatal** mephedrone toxicity, whether on its own or more likely in combination with other substances, or from adverse mental health issues/depression following its use. Despite being controlled in the UK since April 2010, mephedrone has caused/contributed to fatalities and continues to do so (at least 9 in this age-group in 2011-3); there may be more waiting to be notified. This fact underlines the need for health and other professionals, as well as potential consumers to be alert to the potentially fatal consequences of using mephedrone.

Declaration of interest

No conflicts of interest.

Ethics approval

Not required.

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Table 1: Summary socio-demographic characteristics of UK mephedrone-related deaths in young people aged 16-24 years, reported to NPSAD by September 2013 (N = 30)

Characteristic	Attribute	Number	%
Country of death	England	17	56.7
	Wales	1	3.3
	Scotland	7	23.3
	Northern Ireland	5	16.7
Gender	Male	22	73.3
	Female	8	26.7
Ethnicity	White	27	90.0
	Not known	3	10.0
Employment status	Employed	12	40.0
	Unemployed	8	26.7
	Student	4	13.3
	Not known	6	20.0
Living arrangements	With others	22	73.3
	Alone	1	3.3
	Not known	7	23.3
History of drug use/dependence	Yes	11	36.7
	No	2	6.7
	Not known	17	56.7
Prescribed psychoactive drugs	Yes	1	3.3
	No	16	53.3
	Not known	13	43.3

Table 2: Summary characteristics of UK mephedrone-related deaths in young people aged 16-24 years, reported to NPSAD by September 2013 (N = 30)

Characteristic	Attribute	Number	%
Place of death	Defined residential address (own home or home of friend/relative)	14	46.7
	Hospital	8	26.7
	Street/road	3	10.0
	Open place	1	3.3
	Woodland	1	3.3
	River	1	3.3
	Not known	2	6.7
Coroner's verdict/legal finding	Accident/Misadventure	19	63.3
	Abuse of drugs	2	6.7
	Dependence on drugs	1	3.3
	Open/undetermined intent	4	13.3
	Suicide	3	10.0
	Other finding	1	3.3
Manner of death	Accidental	23	76.7
	Undetermined intent	3	10.0
	Suicide	4	13.3
Circumstances leading to death	Recreational – taken with friend (one case was on prescribed anti-depressants)	8	26.7
	Recreational – taken at party	3	10.0
	Recreational – taken during evening out	2	6.7
	Recreational – taken at home with other substances	1	3.3
	Driving a car – fatal collision (inc. 2 where mephedrone could have affected ability to drive)	3	10.0
	Drowning in river – impaired judgement following consumption	1	3.3
	Suicide by poisoning following end of relationship with boyfriend (no history of mental health issues/depression)	1	3.3
	Self-harm by poisoning following argument with boyfriend (no history of mental health issues/depression)	1	3.3
	Hanging following argument with girlfriend (contributed to by withdrawal from mephedrone)	1	3.3
	Hanging after becoming 'moody' following consumption	1	3.3
	Hanging following depression (history of depression)	1	3.3
	Suicide by shotgun after taking drugs at a party (no history of mental health issues/depression)	1	3.3
	Not known	6	20.0

Table 3: Cause of death in UK mephedrone-related deaths in young people aged 16-24 years, reported to NPSAD by September 2013 (N = 30)

Cause of death	Proximal (immediate)		Underlying	
	Number	%	Number	%
Accidental poisoning by drugs/alcohol	16	53.3	19	63.3
Poisoning of undetermined intent	0	0.0	1	3.3
Drug overdose	1	3.3	0	0.0
Stimulant abuse	0	0.0	1	3.3
Intentional hanging	3	10.0	3	10.0
Hanging of undetermined intent	1	3.3	1	3.3
Hanging	1	3.3	1	3.3
Intentional self-harm by shotgun	1	3.3	1	3.3
Drowning in river	1	3.3	1	3.3
Bronchopneumonia	1	3.3	0	3.3
Sudden cardiac death	1	3.3	0	3.3
Disseminated intravascular coagulation	1	3.3	0	3.3
Driver injured in collision with fixed or stationary object	1	3.3	1	3.3
Multiple injuries	2	6.7	1	3.3

Table 4: Post mortem drug combinations found in UK mephedrone-related deaths in young people aged 16-24 years, reported to NPSAD by September 2013 (N = 30)

Combination	Number
Mephedrone only	4
Mephedrone + alcohol	4
Mephedrone + amphetamine	1
Mephedrone + diazepam	1
Mephedrone + GHB	1
Mephedrone + 4-MA	1
Mephedrone + alcohol + cocaine	1
Mephedrone + alcohol + diazepam	1
Mephedrone + alcohol + morphine	1
Mephedrone + alcohol + TFMPP	1
Mephedrone + cocaine + methylone	1
Mephedrone + diazepam + cannabis	1
Mephedrone + diazepam + citalopram	1
Mephedrone + MDMA + BZP	1
Mephedrone + morphine + cannabis	1
Mephedrone + alcohol + amphetamine + cocaine	1
Mephedrone + alcohol + amphetamine + diazepam	1
Mephedrone + BZP + TFMPP + diazepam	1
Mephedrone + alcohol + cannabis + mirtazapine + propranolol	1
Mephedrone + amphetamine + BZP + TFMPP + chlorpheniramine	1
Mephedrone + BZP + TFMPP + cannabis + dextromethorphan + temazepam	1
Mephedrone + cocaine + diazepam + MDMA + MDA + MDPV	1
Mephedrone + cocaine + diazepam + methadone + morphine + alprazolam	1
Mephedrone + diazepam + MDMA + MDA + dihydrocodeine + codeine	1
Frequencies of common substances: alcohol (11); benzodiazepines (9); piperazines (6); cocaine (4); opiate/opioid (4); amphetamine (3); ecstasy-type (3)	

Table 5: Post mortem levels of mephedrone found in UK mephedrone-related deaths in young people aged 16-24 years, reported to NPSAD by September 2013 (N = 30)

	No of mentions	No with levels	Mephedrone blood levels (mg/L)		
			Mean	Minimum	Maximum
Mephedrone only implicated – sole substance in PM	4	2	1.745	0.190	3.300
Mephedrone only implicated – multiple substances in PM	8*	6	1.372	0.070	2.240
Mephedrone with other drugs and/or alcohol implicated (exc. previous categories)	18	9	0.518	0.002	>2.000
Mephedrone implicated – any mention	30*	17	0.938	0.002	3.300
* excludes an outlier of 22 mg/L					
Number of post mortem drugs: Minimum: 1; Maximum 9; Mean 3.37; Standard Deviation 2.09.					