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Incidence, characteristics, and prehospital outcomes of out-of-hospital cardiac arrest in Qatar: a nationwide gender-based investigation

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Abstract

Background Research on incidence and characteristics of Out-of-Hospital Cardiac Arrest (OHCA) in the Middle East is limited. We assessed the incidence, prehospital characteristics, and outcomes of OHCA in Qatar, a Middle Eastern country. Subsequently, we performed gender-specific analysis.

Methods This was a retrospective examination of data obtained from the OHCA registry at Hamad Medical Corporation (HMC) in Qatar from 2017 to 2022. We included adults, non-traumatic, EMS-treatment OHCA. We calculated the incidence of adult OHCA and conducted descriptive analyses for prehospital characteristics, and prehospital outcomes presented by return of spontaneous circulation (ROSC). We evaluated gender differences in prehospital characteristics and ROSC using Student's t-test and the Chi-Square test as appropriate. Furthermore, we conducted a multivariable logistic regression analysis to investigate the correlation between gender and achieving ROSC.

Results We included 4,306 adult OHCA patients, with 869 (20.2%) being females. The mean annual incidence of adult OHCA was 27.4 per 100,000 population-year. Males had a higher annual incidence of OHCA than females. Among all cases, 36.3% occurred in a public location, 25.8% had an initial shockable rhythm, and 28.8% achieved ROSC. Males had a higher proportion of bystander CPR, arrests in public locations, and initial shockable rhythms. While unadjusted analysis showed no significant gender differences in achieving ROSC, adjusted analysis revealed that male gender was associated with higher odds of achieving ROSC (adjusted OR male vs. female 1.38, 95% CI 1.15–1.66, $p < 0.001$).

Conclusions Approximately 720 adults undergo non-traumatic OHCA in Qatar every year, with a higher incidence observed in males. Male gender was associated with higher odds of achieving ROSC. Further gender-specific research in OHCA intervention and outcome in the Middle East is required.

Keywords OHCA, Incidence, Gender, ROSC, Qatar, Middle East

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Introduction

Out-of-hospital cardiac arrest (OHCA) constitutes a crucial public health concern leading to millions of deaths worldwide [1]. Existing data reveal noteworthy variations in both OHCA incidence and survival rate [2–5] across populations and regions. Recently reported OHCA incidence rates were approximately 93 per 100,000 person-years in the USA [6], 89 per 100,000 person-years in Europe [5], and 95.7 per 100,000 person-years in China [7]. Survival rates also vary across regions, ranging from 15,8% in the USA [6], 8% in England [8], and 12.0% in Australia and New Zealand [9]. OHCA incidence and outcomes not only differ across regions but also exhibit variations based on gender [10–12]. Previous data from western societies consistently reported lower incidence in females and inconsistent survival rate results [13–16]. Gender-related differences in the OHCA interventions [17] may contribute to the reported disparities in OHCA survival outcomes.

While OHCA incidence and gender differences in interventions and outcomes have been well investigated in Western countries, research on these topics is deficient in developing countries, particularly in the Middle East. This study's objective was to quantify the incidence of non-traumatic OHCA in Qatar and investigate gender differences in OHCA incidence, prehospital characteristics, and short-term outcomes.

Design and setting

We conducted a population-based investigation using data from the Hamad Medical Corporation (HMC) OHCA registry in Qatar. Qatar, a Middle Eastern country, with a total population of approximately three million people, with around 2,614,000 adults aged 18 years and older [18]. HMC serves as the primary public healthcare provider in Qatar [19]. Prehospital emergency care for OHCA across the entire country is provided by HMC Ambulance Service (HMCAS), which has a modern fleet of fully equipped vehicles distributed nationally based on a hub and spoke model to ensure a rapid response to all emergency calls [20, 21]. Ambulances and rapid response cars are respectively crewed by two ambulance paramedics or a critical care paramedic and critical care assistant, all of whom are trained in advanced cardiopulmonary life support (ACLS). Clinicians undertake a rigorous training program upon joining HMCAS, irrespective of their previous qualification as they come for a variety of countries. [22]. In order to better meet the population's needs and prevent communication issues, crews in each vehicle are always mixed so they can speak a minimum of three languages in total [23, 24]. Further, HMCASs ensure the medical management of emergency cases for those who call 999 based on the clinical practice guidelines (CPGs), which recapitulate the operational response flowcharts for all potential emergencies that can occur in the prehospital environment. In addition, unless there exists a definitive objection from the patient regarding transportation, HMCAS advocates for hospital transport for all encountered patients [25]. This helps minimize patients' call-back and enhances patients' outcomes. The average EMS response time to OHCA ranges from 5 to 10 min [26]. The HMC OHCA registry contains data collected on all Emergency Medical Services (EMS)-attended OHCA victims.

To achieve the goal of this study, we analyzed data collected between December 2017 and December 2022 from all regions of Qatar [19]. The data included valuable information on patient demographics, arrest location, bystander cardiopulmonary resuscitation (CPR), initial cardiac rhythm, EMS-provided treatments, and return of spontaneous circulation (ROSC). This study obtained ethical approval from the Institutional Review Board (IRB) of HMC Medical Research Center (MRC-01-22-501).

Study population

Using the HMC OHCA registry, we generated an analytical dataset comprising adult patients who experienced OHCA and received treatment from EMS. We excluded patients under 18 years of age, those with traumatic cardiac arrest, and cases with missing data.

Variable of interest

The primary outcomes of interest were OHCA characteristics, including age per year, arrest location (public vs. private), witnessed status (witnessed by bystanders vs. witnessed by EMS personnel), initiation of immediate CPR: classified into three categories: no CPR initiated, bystander-initiated CPR, or CPR performed by EMS personal), initial heart rhythm (shockable vs. non-shockable), arrest period: OHCA cases were categorized based on whether they occurred during the COVID-19 pandemic or outside of the pandemic period. The secondary outcome was achieving ROSC, defined as "the restoration of a spontaneous perfusing rhythm, resulting in a palpable pulse" [27], prior to arrival at the hospital's ED and sustained until the patient's admission to the ED.

Data analysis

We calculated the annual incidence of adult OHCA for each year between 2017 and 2022 for the full cohort and separately for each gender using the formula: Incidence rate = (number of new cases in a specific year/ population at risk in that year) *100,000. Subsequently, we extrapolated the mean annual incidence rate overall and for each gender.

We conducted descriptive statistics for OHCA pre-hospital characteristics in the entire cohort. We employed

Student's t-test for continuous variables and the Chi-Square test for categorical variables to analyze the bivariate associations between gender and ROSC. To further examine association between gender and ROSC while accounting for variables known to influence ROSC [27], we used multivariable logistic regression analysis. We built multiple regression models using forward variable selection technique and used −2 loglikelihood (deviance) values to assess the goodness of fit of the competing models. We repeated the multivariable analysis within two subgroups (patients with shockable rhythms and those with non-shockable rhythms). Before conducting the multivariable analyses, we checked for logistic regression assumptions including absence of multicollinearity. All analyses were performed using IBM SPSS version 29, Armonk, NY.

Results

Incidence

We initially had a total population of 5.084 individuals. Among these, 57 individuals under the age of 18 and 693 cases with traumatic OHCA were excluded. Additionally, 28 cases were omitted due to missing data on key variables. The remaining 4,306 individuals were included in the analytic dataset (Fig. 1). Their mean age was 54.0±17.9 years. Of the total, 3,434 (79.8%) were males, and 869 (20.2%) were females. The mean annual incidence of adult OHCA was 27.4 per 100,000 population, corresponding to 717 cases a year. The gender-specific annual incidence was higher in males (30.1 per 100,000 male population) than in females (20.4 per 100,000 female population).

Baseline characteristics

Among the 4,306 OHCA cases, 1,582 (36.3%) occurred in public locations, 1,110 (25.8%) had an initial shockable rhythm, and 1,241 (28.8%) achieved ROSC (Table 1). The male-female unadjusted comparison revealed several significant differences. Males were younger than females, with a mean age of 50.7 compared to 64.2 years. Males had significantly higher proportions of OHCA in public locations (42.4% vs. 14.5%), bystander CPR (35.4% vs., 31.0%), and shockable initial rhythm (28.8% vs. 13.8%), compared to females. No statistically significant difference was observed in ROSC (28.5% vs. 30.3%, $p=0.29$). Table 1 summarizes the pre-hospital characteristics for the entire cohort and differences by gender.

Multivariable analysis: full cohort

Overall, 1,241 (28.8%) patients in the cohort achieved ROSC. The proportion of males who achieved ROSC compared to females was 28.5% vs. 30.3% ($p=0.29$). The crude odds of ROSC was not significant (crude OR males vs. females 1.09, 95% Confidence Interval (CI) 0.93–1.28, $p=0.31$). However, after adjusting for variables known to influence ROSC, males had significantly higher odds of ROSC than females (adjusted OR 1.38, 95% CI 1.15–1.66, $p<0.001$) (Table 2). The final model (Table 2) had a lower deviance value compared to all other models and had. No VIF value was >2.5, suggesting absence of multicollinearity among the explanatory variables.

Subgroup 1 analysis (patients with shockable rhythm)

Of the total cohort ($N=4,306$), 1,110 (25.8%) had initial shockable rhythms (including 28.8% [990/3,437] of the males in the cohort and 13.8% [120/869] of the females). Results of this subgroup analysis were similar to the full cohort. The crude odds of ROSC was not significant (crude OR males vs. females 1.33, 95% CI 0.91–1.96, $p=0.15$), and the adjusted odds was in favour of males (adjusted OR 1.59, 95% CI 1.05–2.41, $p<0.001$) (Table 3).

Subgroup 2 analysis (patients with non-shockable rhythm)

Of the total cohort ($N=4,306$), 3,196 (74.2%) had initial non-shockable rhythms (including 71.2% [2,447/3,437] of the males in the cohort and 86.2% [749/869] of the females). Results of this subgroup analysis showed that the crude odds of ROSC was significantly greater in males (crude OR males vs. females 1.52, 95% CI 1.25–1.84, $p=0.15$). After adjustment, the odds of ROSC remained significantly higher in males (adjusted OR 1.33, 95% CI 1.08–2.56, $p<0.001$) (Table 3).

Discussion

We analyzed data from 4,306 adults with non-traumatic OHCA in the State of Qatar and calculated the annual incidence of non-traumatic OHCA for the population and for each gender. We also assessed gender differences in OHCA characteristics and ROSC.

Our study found that the annual incidence of non-traumatic OHCA in Qatar is 27.4 per 100,000 population. This is higher than that reported of 23.5 per 100,000 population in Qatar for the year 2013–2014 when the country's population was around 1.9 million inhabitants [28]. It was lower than the annual global incidence (55 per 100,000) [29], lower than that reported in the USA (93 per100,000) [6], Australia (72.39 per 100,000) [30], and England (53 per 100,000) [8]. The lower incidence in Qatar compared to other societies can perhaps be explained by differences in the population's characteristics. Compared to Western societies, Qatar has a relatively younger population with a median age of approximately 34 years, largely due to the substantial number of expatriate male workers [31]. This distinction may have contributed to the lower occurrence of OHCA in Qatar. Our findings also indicated that the annual incidence of OHCA was higher among males than females, which aligns with previous studies [30, 32].

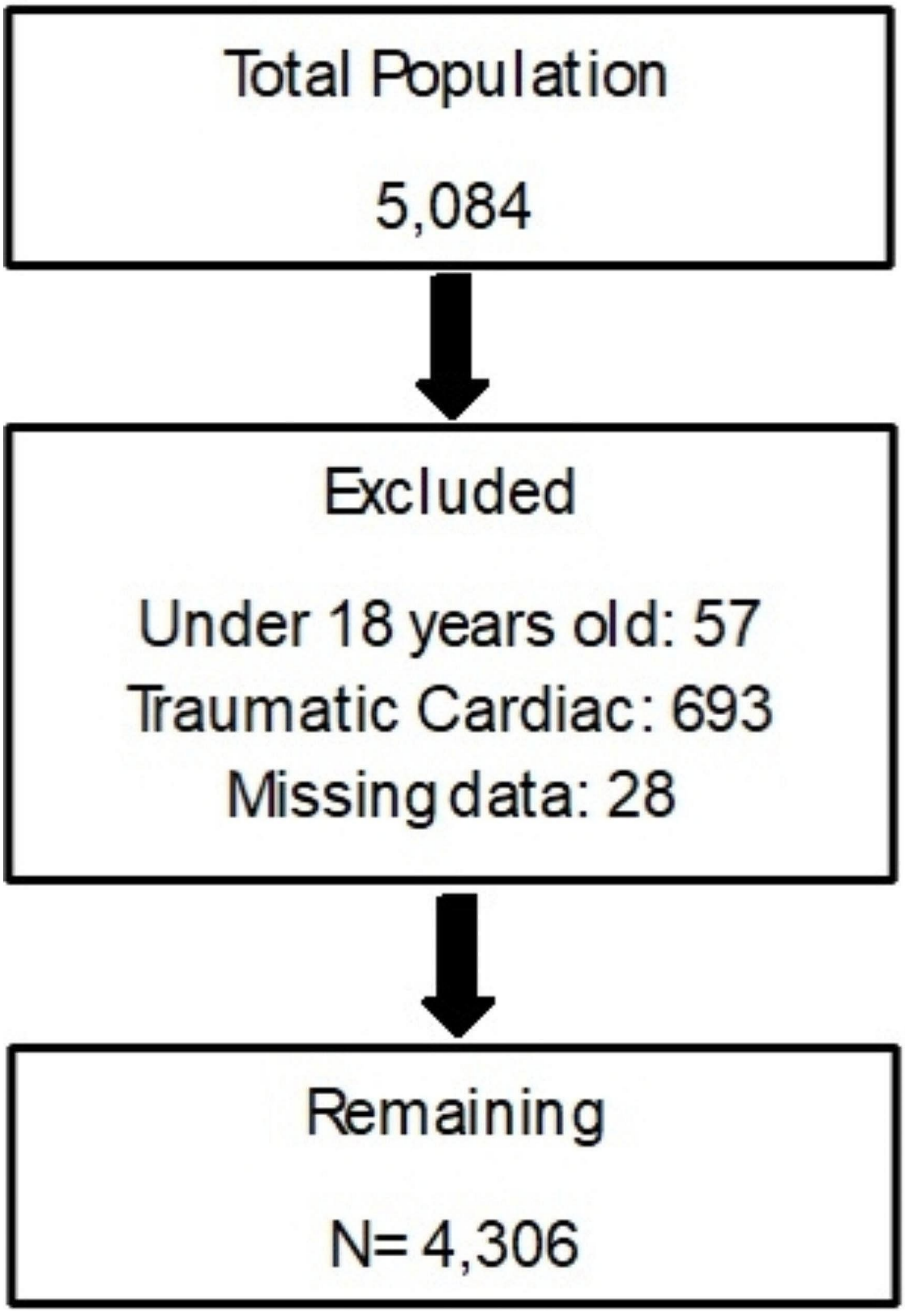

Fig. 1 Study flow chart

Table 1 OHCA baseline characteristics for the full cohort and stratified by gender

Variable	Total *N* = 4306	Male 3437 (79.8%)	Female 869 (20.2%)	*P* value
Age (years)	54.0 ± 17.8	50.7 ± 16.4	64.2 ± 19.1	< 0.001
Arrest location				
Private	2,724 (63.3%)	1,981 (57.6%)	743 (85.5%)	< 0.001
Public	1,582 (36.7%)	1,456 (42.4%)	126 (14.5%)	
Witness status				
Bystander-witnessed	3,598 (83.6%)	2,900 (84.4%)	698 (80.3%)	0.004
EMS-witnessed	708 (16.4%)	537 (15.6%)	171 (19.3%)	
Bystander CPR				
Not provided	2,235 (51.9.%)	1,685 (49.0%)	429 (49.4%)	0.02
Bystander CPR	1,363 (31.7%)	1,215 (35.4%)	269 (31.0%)	
EMS CPR	708 (16.4%)	537 (15.6%)	171 (19.6%)	
Initial rhythm				
Non-shockable	3,196 (74.2%)	2,447 (71.2%)	749 (86.2%)	< 0.001
Shockable	1,110 (25.8%)	990 (28.8%)	120 (13.8%)	
Arrest period				
Non-pandemic	2,954 (68.6%)	1,071 (31.2%)	281 (32.3%)	0.60
Pandemic	1,352 (31.4%)	2,366 (68.8%)	588 (67.7%)	
ROSC	3,065 (71.2%)	2,459 (71.5%)	606 (69.7%)	0.29
Not achieved				
Achieved	1,241 (28.8%)	978 (28.5%)	263 (30.3%)	

Table 2 Association between gender and ROSC: logistic regression analysis (*N* = 4306)

Variable	OR	(95% C I)	*P* value
Male gender (crud)	1.09	0.93–1.28	0.31
Male gender (adjusted)	1.38	1.15–1.66	< 0.001
Age	1.01	0.99–1.01	0.13
Public location	1.30	1.11–1.52	0.002
Bystander CPR	1.38	1.18–1.62	< 0.001
EMS CPR	4.74	3.96–5.68	< 0.001
EMS-witnessed	3.58	2.99–4.29	< 0.001
Initial Rhythm	4.75	4.05–5.54	< 0.001
Non-pandemic period	1.35	1.17–1.57	< 0.001

Table 3 Association between gender and ROSC: subgroup analyses

	Subgroup 1: Patients with shockable Rhythm (*N* = 1110)			Subgroup 2: Patients with non-shockable rhythm (*N* = 3196)		
Variable	OR	(95% C I)	*P* value	OR	(95% C I)	*P* value
Male gender (crude)	1.33	0.91–1.96	0.15	1.52	1.25–1.84	< 0.001
Male gender (adjusted)	1.59	1.05–2.41	0.03	1.33	1.08–1.65	0.01
Age	0.99	0.98–1.01	0.36	1.01	1.01–1.01	0.001
Public location	1.16	0.90–1.51	0.03	1.44	1.18–1.76	0.02
Bystander CPR	0.90	0.69–1.15	0.20	1.31	1.06–1.61	0.01
EMS CPR	0.93	0.70–1.20	0.26	0.82	0.63– 1.14	0.30
EMS-witnessed	4.42	3.65–8.04	< 0.001	3.80	2.96–4.90	< 0.001
Non-pandemic period	1.04	0.80–1.35	0.79	1.53	1.28–1.84	< 0.001

Our results additionally revealed significant differences in the OHCA pre-hospital characteristics predictive of ROSC, in favour of males. Specifically, males showed a higher incidence of OHCA in public locations and a higher proportion of shockable rhythm. Previous studies consistently reported similar advantages in males [13, 16, 33–39]. Despite these favorable characteristics, our initial analysis did not detect a significant difference in crude ROSC rates between males and females. This finding contradicted our initial expectation of females having lower crude odds of ROSC based on their unfavorable pre-hospital characteristics. One possible explanation

for this unexpected result is the potential positive effect of female estrogen hormones on achieving ROSC [40]. However, after accounting for variables known to be associated with ROSC, our analysis revealed that males had higher odds of achieving ROSC. Our findings align with those reported in recently published studies [16, 41]. This favorable ROSC in males could partially be due to the males' advantages in OHCA prehospital characteristics [38]. Recent studies have reported that females are less likely to receive prehospital interventions including bystander CPR, perhaps due to a fear of being accused of inappropriate touch [42, 43]. This issue may be even more pronounced in a Middle Eastern cultural context.

The results of our subgroup 1 analyses (patients with shockable rhythm) were very similar to the findings observed in the full cohort. In subgroup 2 (those with non-shockable rhythm), the crude and adjusted odds of ROSC were in favour of males, suggesting shorter time to providing CPR to males or differences in the intensity of treatment provided to males. Other possible explanations for this gender differences in achieving ROSC could be due to variations in underlying causes of arrest or physiological variances between males and females that influence the response to CPR efforts. Nevertheless, subgroup adjusted analyses revealed greater odds of ROSC and OHCA occurring at a younger age in male. These findings strengthen the evidence that male gender is associated with higher odds of ROSC.

This study has some limitations. First, the analyses were limited to OHCA data from Qatar and the results may not be generalizable to other regions worldwide. Second, the underlying causes of OHCA among females may differ systematically from those among males, potentially having substantial impacts on outcomes. Third, data on some variables, such as EMS response time, prehospital interventions, ethnicity, and comorbidities were incomplete in the dataset, and subsequently were not included in the analyses. Finally, no data was available for survival to hospital discharge. Quantifying gender differences in survival to hospital discharge would provide more comprehensive information. Further studies specifically investigating gender differences in survival to hospital discharge in Qatar are required.

Conclusion

The incidence of adult, non-traumatic OHCA in Qatar is 27.4 per 100,000 population, corresponding to approximately 720 cases every year, with a lower occurrence in females than males. OHCA baseline characteristics were advantageous for males. Male gender was associated with higher odds of achieving ROSC. This advantage for males was observed in the full cohort and within both shockable and non-shockable rhythm subgroups. This study highlights the need for additional gender-specific research in pre-OHCA care and survival outcome in the Middle East.

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Author contributions
All authors contributed to the study's conception and design. Material preparation and data collection were completed by Hassan Farhat, Bothina Mortada, Adnaan Azizurrahman, and Abdul Rahman Arabi. Data analyses were performed by Emad Awad, Guillaume Alinier, Bothina Mortada, Adnaan and Nooreh Gholami. The first draft of the manuscript was written by Emad Awad and revised by Niki Rumbolt and Rakan Shami. All authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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Data availability
The data that support the results of this study are available from the OHCA registry at Hamad Medical Corporation (HMC), but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. However, data are available from the authors upon reasonable request and with permission of HMC.

Declarations

Ethics approval and consent to participate
Ethics approval for this study was obtained from the Research Ethics Board of Hamad Medical Corporation Medical Research Center (MRC-01-22-501). We certify that the study was performed in accordance with the Declaration of Helsinki ethical standards. No written informed consent was obtained from patients as this was a secondary analysis of deidentified data. The study meets all requirements for exemption from informed consent.

Consent for publication
Not applicable.

Conflict of interest
This research was supported by Qatar National Research Fund (QNRF) provided by Qatar Foundation under UREP project (UREP29-195-3-061). The funding agency had no role in the study design, data analysis and interpretation, or in writing the manuscript. The authors affirm that the research was conducted in an unbiased manner, and the results and interpretations presented in this manuscript are not influenced by any conflicting interests. The authors declare no other conflicts of interest.

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