

# Incidence, Characteristics, and Survival Trend of Cardiopulmonary Resuscitation Following In-hospital Compared to Out-of-hospital Cardiac Arrest in Northern Jordan

Liqaa A. Raffee, Shaher M. Samrah<sup>1</sup>, Hani Najih Al Yousef<sup>2</sup>, Mahmoud Abu Abeeleh<sup>3</sup>, Khaled Z. Alawneh<sup>4</sup>

Departments of Accident and Emergency Medicine and <sup>1</sup>Internal Medicine, Faculty of Medicine, Jordan University of Science and Technology, <sup>4</sup>Department of Diagnostic and Interventional Radiology, Jordan University of Science and Technology, Irbid, <sup>2</sup>Paramedic at Ministry of Health, Jerash Governmental Hospital, Jordan, <sup>3</sup>Department of Surgery, Division of Cardio Thoracic Surgery, The University of Jordan, Amman, Jordan

## Abstract

**Background:** Cardiac arrest remains a leading cause of mortality worldwide. Early cardiopulmonary resuscitation (CPR) is the cornerstone intervention to optimize the survival rates. **Objectives:** The main aim of this study was to determine and compare the incidence, characteristics, risk factors, and outcomes of CPR in a referral university hospital following in-hospital cardiac arrests (IHCAs) and out-of-hospital cardiac arrest (OHCA) in Northern Jordan. **Patients and Methods:** Retrospective observational study of adults referred to King Abdulla University Hospital who received CPR between January 2014 and January 2015. Data were obtained from the medical recorded of included patients. The primary outcome was survival to hospital discharge. Chi-square and logistic regression analyses were performed to identify risk factors associated with survival to discharge. **Results:** A total of 79 OHCA and 257 IHCA were included in the study. The overall survival rate for OHCA was 2.97%. The survival rate increased to 4.3% if CPR performed before arriving the hospital. Only 22% of the OHCA cases had CPR performed mainly due to lack of knowledge and skills of bystanders. The survival rate for IHCA was 14.88%. In this study, patient survival was not associated with age, smoking habit, diabetes mellitus, cancer status, hypertension, or heart failure. **Conclusion:** This is the first study to describe the incidence and outcome of adult IHCA and OHCA in Jordan. The findings will serve as a benchmark to evaluate future impact of changes in service delivery, organization, and treatment for OHCA and IHCA. Furthermore, findings will urge the regulatory bodies to establish well-structured Emergency Medical Service system. Educational programs at the national level to improve public awareness of CPR intervention are crucial to improve survival rates.

**Keywords:** Arrests, cardiac, in-hospital, survival

## INTRODUCTION

In-hospital cardiac arrest (IHCA) or out-of-hospital cardiac arrest (OHCA) remains a significant and leading cause of mortality and morbidity worldwide despite advanced technology and diagnosis.<sup>[1,2]</sup> The incidence rate of cardiac arrest is widely debated and varies among hospitals, communities, and countries.<sup>[3]</sup> In one study, an approximately 200,000 IHCAs were reported each year in the United States with <20% of the patients survive to discharge.<sup>[4,5]</sup> An old retrospective that reviewed nearly 100 cardiac arrest peer-reviewed articles reported incidence rate that ranged from 35.7 to 128.3/100,000 and survival rates ranged significantly from 1.6% to 20.7%.<sup>[6]</sup> The incidence rate varies and depends on many factors. In one study, the most commonly reported

causes for OHCAs included age, cardiac arrhythmia, coronary artery disease, and cardiomyopathies,<sup>[4,5,7]</sup> whereas other study reported other causes including trauma, drug overdose, asphyxia, and drowning.<sup>[8]</sup>

Likewise, the survival rates vary and depend on many reported factors including age, parental education level, season, exercise status patient, location at the time of arrest, time to start

**Address for correspondence:** Dr. Liqaa A. Raffee,

Department of Accident and Emergency Medicine, Faculty of Medicine,  
Jordan University of Science and Technology, Irbid 22110, Jordan.  
E-mail: laraffee5@just.edu.jo

This is an open access article distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 3.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as the author is credited and the new creations are licensed under the identical terms.

**For reprints contact:** reprints@medknow.com

**How to cite this article:** Raffee LA, Samrah SM, Al Yousef HN, Abu Abeeleh M, Alawneh KZ. Incidence, characteristics, and survival trend of cardiopulmonary resuscitation following in-hospital compared to out-of-hospital cardiac arrest in Northern Jordan. *Indian J Crit Care Med* 2017;21:436-41.

### Access this article online

Quick Response Code:



Website:  
www.ijccm.org

DOI:  
10.4103/ijccm.IJCCM\_15\_17

cardiopulmonary resuscitation (CPR), underlying medical problems, initial electrocardiogram rhythm, knowledge and skills of CPR performed, presence of an Emergency Medical Service (EMS) system, early defibrillation, hemodynamic changes, blood loss, and other reasons.<sup>[9-16]</sup>

Cardiac arrest is a sudden and unexpected event which may happen anytime and at any location, and thus survival hinges on prompt and proper intervention by trained personnel. In a study, early CPR and defibrillation were associated with better survival outcome.<sup>[1]</sup> Despite the reported decline in the mortality associated with cardiovascular diseases over the past three decades due to improvement in diagnosis and treatment, the case fatality rate of sudden cardiac arrest remains unchanged.<sup>[17]</sup> Although IHCA and OHCA are relatively common, only a few studies have focused on this issue. To the authors' knowledge, there are no studies characterizing IHCA or OHCA in the third world and low-income countries. Therefore, the main aim of the study reported here was to characterize the incidence and characteristics of patients and evaluate the risk factors associated with survival trend between IHCA and OHCA patients at a single university hospital in Northern Jordan. Our hypothesis is that survival trend is different between IHCA and OHCA.

## PATIENTS AND METHODS

The study area was Northern Jordan with an estimated population of approximately fifth of the country's population where it includes urban, suburban, and rural areas. Well-structured EMS system does not exist in Jordan. The Jordanian Civil Defense (JCD) is a governmental agency that takes the responsibilities of transporting emergency cases to nearby hospitals.

This was a retrospective study that only included patients from Northern Jordan who had either IHCA or OHCA that received CPR. Data were extracted from the medical records of patients that met the inclusion and exclusion criteria who were admitted to various departments at the King Abdullah University Hospital including the emergency department (ED), the Intensive Care Unit, and the coronary care unit. Data were collected during the period January 2014 through January 2015. Patients were included in the study only if they had a cardiac arrest and were older than 18 years of age. Pregnant woman and patients with preliminary traumatic etiology as a cause of the arrest were excluded from the study.

Data collected included the following: age, sex, duration of the CPR, smoking status, diabetes mellitus status, hypertension status, asthma, chronic obstructive pulmonary disease (COPD), chronic heart failure, cancer, and coronary artery disease. Patients who experienced OHCA and presented to the ED had more data documented including time of arrest, time of starting CPR, method of transport to the hospital, and initial rhythm on arrival at the hospital. The outcome variable was surviving to discharge from the hospital. Etiology was reported when available. Patients that had cardiac arrests and CPR outside the

hospital were categorized as OHCA whereas patients who had cardiac arrests and CPR at hospital were categorized as IHCA.

## Statistical analysis

All statistical analyses were performed using the statistical software package SPSS (version 19.0, SPSS Inc., Chicago, IL, USA). Data were reported as mean  $\pm$  standard deviations for quantitative variables or as frequencies (%) for categorical variables. Associations between past medical history and type of arrest or outcome variable (survival) were initially screened in a univariable analysis using Pearson's Chi-square test. Only significant variables and variables with no collinearity ( $r < 0.50$ ) were considered for the final multivariable logistic regression. A univariate logistic regression was used to determine the odds ratio (OR) of survival by age, gender, location, past medical history, and response time. A multivariate logistic regression was used to model survival and potential predictors of outcome variable. Differences in patients' characteristics with regard to CPR interventions were analyzed using Student's independent *t*-test or Mann-Whitney U test for quantitative and categorical variables, respectively. Analysis was considered significant if  $P \leq 0.05$ .

## RESULTS

Table 1 summarizes patients' characteristics and past medical history. Overall, a total of 79 OHCA and 257 IHCA (76.2%) met the study criteria and were included in the study. Majority of the study population were males ( $n = 196$ ; 58.3%). Age-stratified incidence rate of cardiac arrests was 3.36% for patients younger than 20-year-old, 7.03% for ages 20–39, 26.6% for ages 40–60, 47.40% for ages 61–80, and 14.67% for patients older than 80 years. While most patients ( $n = 222$ , 66.8%) were nonsmokers, a significantly higher proportion of patients who experienced a cardiac arrest outside of hospital were smokers compared to those who experienced a cardiac arrest as an inpatient. The majority of patients had at least one reported comorbidity (68.5%,  $n = 230$ ). Of these, 76 (29.0%) had one comorbidity, 109 (47.4%) had two comorbidities, 42 (18.3%) had three comorbidities, and 3 (1.3%) had four comorbidities. Hypertension was the most common comorbidity reported in this study affecting 43.75% of all participants and was more significantly reported in IHCA than OHCA. Although there was no significant difference in the proportion of IHCA and OHCA with regard to the status of diabetes mellitus, the proportion of IHCA patients with diabetes mellitus (74.45%) were substantially higher when compared with OHCA patients.

Tables 2 and 3 summarize the relationship of resuscitation with the outcome for both IHCA and OHCA. Analysis revealed a significant difference in the survival rate if CPR was performed before arriving at hospital. The survival rate for OHCA patients was 2.97% whereas the survival rate for OHCA patients where CPR was performed by the Jordanian Civil Defense (JCD) before arriving to the hospital was 4.3%. In contrast, the survival rate for IHCA was 14.88%. In here,

**Table 1: Description of patients' demographics and the past medical history for out-of-hospital cardiac arrest and in-hospital cardiac arrest collectively**

Parameter	Description	OHCA	IHCA	Pearson $\chi^2$	P
<i>n</i>	Frequency	79	257		
Gender	Female	28	112	1.64	0.24
	Male	51	145		
	Missing	1	0		
Age (years)	Mean±SD	59.50±19.02	63.36±18.63	13.76	0.11
	<20	5	9		
	20-39	7	16		
	40-60	21	66		
	61-80	36	119		
	>80	8	40		
	Missing	3	7		
Past medical history					
Smoking status	No	36	186	18.30	0.000
	Yes	41	69		
Diabetes mellitus	No	45	165	0.79	0.43
	Yes	35	102		
Hypertension	No	29	144	7.69	0.007
	Yes	51	123		
CHF	No	57	236	13.76	0.001
	Yes	23	31		
Cancer	No	63	223	0.96	0.32
	Yes	17	44		
COPD	No	75	260	2.42	0.16
	Yes	5	7		

OHCA: Out-of-hospital cardiac arrest; IHCA: In-hospital cardiac arrest; CHF: Congestive heart failure; COPD: Chronic obstructive pulmonary disease; SD: Standard deviation

**Table 2: Information of patients presenting as out-of-hospital cardiac arrests**

Parameter	Description	Unsuccessful CPR	Successful CPR	Chi-square test	P
Location of arrest	Total	67	10	1.85	0.39
	Home	56 (84.8)	10 (15.2)		
	Public place	9 (100)	0		
	Others	2 (100)	0		
Time of arrest till CPR (min)		19.39±7.41	11.10±10.16		0.06
Transportation	Family	39 (90.7)	4 (9.3)	1.45	0.48
	First responders	27 (81.8)	6 (18.2)		
	Others	1 (100)	0		
Attempt to perform CPR	No	50 (92.6)	4 (7.4)	4.98	0.026
Before reaching ER	Yes	17 (73.9)	6 (26.1)		
Reasons not doing CPR	Not indicated	1		17.80	0.000
	Lack of knowledge	39		19.70	
	Lack of skills	3			
	Long transportation	7			
CPR duration (min)		15.14±7.38	9.50±5.21		0.023

CPR: Cardiopulmonary resuscitation; ER: Emergency room

most of the OHCA occurred at home (84.8%), and most of the patients were brought to ED by family members (90.7%) where only 5.1% were discharged to home whereas 7.8% of the patients brought by the JCD were discharged to home. In this study, only 22% of the OHCA patients had CPR performed. Reasons for not performing the CPR were mostly related to lack of knowledge and skills of the bystanders.

Overall, patients were most commonly given compression and ventilation and intubated (99.1%). None of the IHCA patients were given compression only or ventilation only, whereas two OHCA patients were given each of these treatments. Notably, while 30.4% of OHCA patients were given defibrillation, none of the IHCA patients received this intervention ( $P < 0.001$ ). The type of the rhythm in the IHCA group was nonshockable.

**Table 3: Method of resuscitation and associated outcome for out-of-hospital cardiac arrest and in-hospital cardiac arrest**

Method of resuscitation	OHCA (%)	IHCA (%)	P
Chest compression only			
No	78 (97.5)	-	0.002
Yes	2 (2.5)	0	
Ventilation only			
No	78 (97.5)	-	0.01
Yes	2 (2.5)	0	
Compression and ventilation			
No	4 (5)	-	0.000
Yes	76 (95)	257 (100)	
Defibrillation			
No	56 (70)	-	0.000
Yes	24 (30)	0	
Intubation			
No	4 (5)	-	0.000
Yes	76 (95)	257 (100)	
CPR medications			
No	5 (6.3)	-	0.000
Yes	75 (93.7)	257 (100)	
Outcome			
Patient discharged	5 (6.3)	50 (14.8)	0.000
Successful for short time	5 (6.3)	47 (13.9)	
Unsuccessful	70 (87.5)	160 (47.61)	

The data are presented as frequencies (%). CPR: Cardiopulmonary resuscitation; OHCA: Out-of-hospital cardiac arrest; IHCA: In-hospital cardiac arrest

Table 4 summarizes the relationship between patient demographics and CPR outcome. The analysis revealed that there was no significant relationship between patient age, gender, status of smoking, presence of hypertension, cancer status, COPD status, diabetes mellitus ( $P = 0.08$ ), and congestive heart failure (CHF) ( $P = 0.06$ ) with the outcome of CPR. However, diabetes mellitus was significantly associated with the outcome for IHCA (OR = 1.9; confidence interval: 1.16, 3.24). In contrast, hypertension was significantly associated with the outcome of OHCA patients.

In the study reported here, diagnostic information on the etiology of cardiac arrest was available for only five of the OHCA patients and fifty of the IHCA patients. Of the OHCA patients that survived, three were diagnosed with ischemic heart disease (IHD), one patient was diagnosed with arrhythmia, and one patient was diagnosed with myocardial infarction (MI). One of the IHD patients was treated with a cardiac catheter whereas the remaining four received conservative medical intervention. All three IHD patients had stable neurological status postintervention. No information was available for the MI or the arrhythmia patient. Regarding the IHCA patients, a range of diagnoses was identified for the IHCA patients including ten patients with IHD, seven patients with CHF, four patients with a cerebral vascular accident, and 12 patients with various types of cancer (including lung and pancreatic). The majority of patients ( $n = 32$ , 64.0%) received

conservative medical treatment. Four IHD patients received cardiac catheters, whereas two received coronary artery bypass grafts. One patient with valvular heart disease received open heart surgery. The majority of patients had stable neurological status postintervention ( $n = 31$ , 62.0%), three were confused, and one was not conscious. No information was available for the remaining patients.

## DISCUSSION

This study is considered the first study to characterize the incidence and survival trend following CPR for IHCA and OHCA in Northern Jordan. As expected, it was found that the survival was significantly higher for patients experiencing IHCA when compared to those who experienced a cardiac arrest out-of-hospital. The majority of the OHCA patients did not receive CPR before hospital arrival. Cardiac arrest occurring outside of hospital was significantly associated with lower survival rates which suggest the urgent need for public education to improve knowledge and skills of bystander for prompt response to manage cardiac arrest cases. National educational programs to improve public awareness of CPR intervention are crucial to improve survival rates. Such public educational programs may have a huge impact in improving survival rates of OHCA patients. In addition, access to automated external defibrillators (AEDs) may further improve OHCA survival rates. In a study, survival after OHCA has increased in communities where public access defibrillation utilized.<sup>[18]</sup> In a study, the absolute survival associated with bystander CPR declined rapidly with time. Yet, bystander CPR while waiting for an ambulance was associated with a more than doubling of 30-day survival even in case of long ambulance response time.<sup>[19]</sup>

In Jordan, EMS system does not exist as in many other low-income third world countries. Prehospital care for cardiac arrest patients is largely relied on paramedics affiliated with department of the Jordanian Civil Defense (JCD). As our study revealed, majority of the OHCA did not receive the appropriate prehospital health care due mainly to lack of knowledge and skills of bystanders. Furthermore, prehospital care provided by the JCD is still underdeveloped and below acceptable standards. The prehospital care provided by the JCD is mainly and purely for transportation and not as well-structured emergency care vehicle. Furthermore, one major issue that even more restricts the optimal role of the JCD is the underdeveloped nature of the country's infrastructure in many parts of the country. For instance, most of the populated cities, with the exception of the capital city, still lack formal residential address and the JCD personnel mainly rely on description of bystanders of how to reach to the location of the arrested patient, usually, using governmental buildings or schools as landmarks, thus prolongs the time to provide prompt care for the arrested patients. Furthermore, many hospitals are only capable of providing essential diagnostic tests, and only a very few are able to do so at the point or time of presentation. This may explain the relatively higher survival rate for the IHCA. In the study reported here, the



**Table 4: Relationship of patients' characteristics, medical history, and outcome of cardiopulmonary resuscitation among out-of-hospital cardiac arrest and in-hospital cardiac arrest**

	OHCA		P	IHCA		P
	Unsuccessful	Successful		Unsuccessful	Successful	
Age (years)	58.82±20.00	64.80±12.06	0.36	62.62±20.06	64.58±16.00	0.41
Gender						
Female	21	6	0.08	66	46	0.20
Male	46	4		94	51	
Smoking						
No	28	6	0.25	115	71	0.36
Yes	37	4		45	24	
Diabetes						
No	36	6	0.49	107	49	0.08
Yes	31	4		54	48	
Hypertension						
No	26	1	0.07	88	47	0.20
Yes	41	9		73	50	
CHF						
No	45	9	0.13	146	81	0.06
Yes	22	1		15	16	
Cancer						
No	51	9	0.29	133	81	0.49
Yes	16	1		28	16	
COPD						
No	62	10	0.49	157	94	0.52
Yes	5	0		4	3	
CPR duration (min)	15.14±7.738	9.50±5.21	0.00	14.36±4.79	8.20±9.50	0.00

Before reaching. CHF: Congestive heart failure; COPD: Chronic obstructive pulmonary disease; OHCA: Out-of-hospital cardiac arrest; IHCA: In-hospital cardiac arrest; CPR: Cardiopulmonary resuscitation

survival rate for IHCA patients was comparable with reported survival rates of many other international studies which may suggest that our university hospital performs in line with the international standards with respect to IHCA survival.

Previous studies have demonstrated that time to postarrest CPR is critical for survival. Studies have suggested that prompt initiation of CPR is associated with better survival rates.<sup>[20]</sup> A study has suggested that decreasing response time by even a few minutes could potentially lead significantly better survival rate.<sup>[19]</sup> In our study, we have found that longer time to starting CPR in OHCA patients was associated with lower survival rates. This finding again emphasizes on the urgent national need for training the public of how to recognize and initiate appropriate CPR for OHCA.

In our study, patient characteristics did not appear to affect survival outcomes for OHCA and IHCA patients, with no clear differences in survival in terms of age, gender, or underlying disease for either set of patients.

Limitation of the study reported here is few. This is a retrospective study where obtained data depend on many factors including comprehensive and accurate medical record keeping.

For the OHCA group, the number of survive-to-discharge patients was small, and therefore statistical comparisons should

be interpreted with some caution. Furthermore, the findings only represent a single site study, and thus results may not be fully generalizable across the country, and therefore further multicenter study would examine whether there are variations across Jordan in both IHCA and OHCA survival rates.

## CONCLUSION

Our study suggests a number of key strategies that should be employed to improve cardiac arrest outcomes. Public educational programs are crucial, both to improve the public's awareness of how to identify cardiac arrest and initiate successful CPR. In addition, the distribution of AED in public places, and training of both the general public and JCD personnel located in the vicinity should be considered. Further training of the JCD and regular training updates should also be developed, to ensure that the optimum intervention such as the use of defibrillation is applied, for all OHCA patients. Finally, methods to ensure timely initiation of CPR when a patient arrives in the ER following an OHCA should be incorporated into routine hospital practice. Together, these initiatives have the potential for a significant impact on the survival rate following cardiac arrest.

## Financial support and sponsorship

This study was financially supported by Deanship of Research.

## Conflicts of interest

There are no conflicts of interest.

## REFERENCES

1. Aaboe ML, Qvortrup M, Sondergaard HM, Moller DS. Characteristics and outcome after in-hospital cardiac arrest: 2 years systematic registration in the Danish Cardiac Arrest Registry at one single hospital. *Resuscitation* 2015;96:45.
2. Harmon KG, Asif IM, Maleszewski JJ, Owens DS, Prutkin JM, Salerno JC, *et al.* Incidence, cause, and comparative frequency of sudden cardiac death in National Collegiate Athletic Association Athletes: A decade in review. *Circulation* 2016;133:e447.
3. Kolte D, Khera S, Aronow WS, Palaniswamy C, Mujib M, Ahn C, *et al.* Regional variation in the incidence and outcomes of in-hospital cardiac arrest in the United States. *Circulation* 2015;131:1415-25.
4. Merchant RM, Yang L, Becker LB, Berg RA, Nadkarni V, Nichol G, *et al.* Incidence of treated cardiac arrest in hospitalized patients in the United States. *Crit Care Med* 2011;39:2401-6.
5. Ehlenbach WJ, Barnato AE, Curtis JR, Kreuter W, Koepsell TD, Deyo RA, *et al.* Epidemiologic study of in-hospital cardiopulmonary resuscitation in the elderly. *N Engl J Med* 2009;361:22-31.
6. Becker LB, Smith DW, Rhodes KV. Incidence of cardiac arrest: A neglected factor in evaluating survival rates. *Ann Emerg Med* 1993;22:86-91.
7. Meyer L, Stubbs B, Fahrenbruch C, Maeda C, Harmon K, Eisenberg M, *et al.* Incidence, causes, and survival trends from cardiovascular-related sudden cardiac arrest in children and young adults 0 to 35 years of age: A 30-year review. *Circulation* 2012;126:1363-72.
8. Kitamura T, Kiyohara K, Sakai T, Iwami T, Nishiyama C, Kajino K, *et al.* Epidemiology and outcome of adult out-of-hospital cardiac arrest of non-cardiac origin in Osaka: A population-based study. *BMJ Open* 2014;4:e006462.
9. Nolan JP, Soar J, Smith GB, Gwinnutt C, Parrott F, Power S, *et al.* Incidence and outcome of in-hospital cardiac arrest in the United Kingdom National Cardiac Arrest Audit. *Resuscitation* 2014;85:987-92.
10. Rajan S, Wissenberg M, Folke F, Hansen CM, Lippert FK, Weeke P, *et al.* Out-of-hospital cardiac arrests in children and adolescents: Incidences, outcomes, and household socioeconomic status. *Resuscitation* 2015;88:12-9.
11. Nehme Z, Andrew E, Bernard S, Patsamanis H, Cameron P, Bray JE, *et al.* Impact of a public awareness campaign on out-of-hospital cardiac arrest incidence and mortality rates. *Eur Heart J* 2017;38:1666-73.
12. Berdowski J, de Beus MF, Blom M, Bardai A, Bots ML, Doevendans PA, *et al.* Exercise-related out-of-hospital cardiac arrest in the general population: Incidence and prognosis. *Eur Heart J* 2013;34:3616-23.
13. Haque A, Rizvi A, Bano S. Outcome of in-hospital pediatric cardiopulmonary arrest from a single center in Pakistan. *Indian J Pediatr* 2011;78:1356-60.
14. Krittayaphong R, Saengsung P, Chawaruechai T, Yindeengam A, Udompunturak S. Factors predicting outcome of cardiopulmonary resuscitation in a developing country: The Siriraj cardiopulmonary resuscitation registry. *J Med Assoc Thai* 2009;92:618-23.
15. Lundy DJ, Ross SE, Schorr C, Jones AE, Trzeciak S. Outcomes of trauma victims with cardiac arrest who survive to Intensive Care Unit admission. *J Trauma* 2011;71:E12-6.
16. Pembeci K, Yildirim A, Turan E, Buget M, Camci E, Senturk M, *et al.* Assessment of the success of cardiopulmonary resuscitation attempts performed in a Turkish university hospital. *Resuscitation* 2006;68:221-9.
17. Rosamond WD, Chambless LE, Folsom AR, Cooper LS, Conwill DE, Clegg L, *et al.* Trends in the incidence of myocardial infarction and in mortality due to coronary heart disease, 1987 to 1994. *N Engl J Med* 1998;339:861-7.
18. Hallstrom AP, Ornato JP, Weisfeldt M, Travers A, Christenson J, McBurnie MA, *et al.* Public-access defibrillation and survival after out-of-hospital cardiac arrest. *N Engl J Med* 2004;351:637-46.
19. Rajan S, Wissenberg M, Folke F, Hansen SM, Gerds TA, Kragholm K, *et al.* Association of bystander cardiopulmonary resuscitation and survival according to ambulance response times after out-of-hospital cardiac arrest. *Circulation* 2016;134:2095-104.
20. Marijon E, Bougouin W, Celermajer DS, Perier MC, Benameur N, Lamhaut L, *et al.* Major regional disparities in outcomes after sudden cardiac arrest during sports. *Eur Heart J* 2013;34:3632-40.