

BMJ Open Outcomes of out-of-hospital cardiac arrest in Beijing: a 5-year cross-sectional study

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ABSTRACT

Objective The purpose of this study was to assess the trends in outcomes of out-of-hospital cardiac arrest (OHCA) in Beijing over 5 years.

Design Cross-sectional study.

Methods Adult patients with OHCA of all aetiologies who were treated by the Beijing emergency medical service (EMS) between January 2013 and December 2017 were analysed. Data were collected using the Utstein Style. Cases were followed up for 1 year. Descriptive statistics were used to characterise the sample and logistic regression was performed.

Results Overall, 5016 patients with OHCA underwent attempted resuscitation by the EMS in urban areas of Beijing during the study period. Survival to hospital discharge was 1.2% in 2013 and 1.6% in 2017 (adjusted rate ratio=1.0, p for trend=0.60). Survival to admission and neurological outcome at discharge did not significantly improve from 2013 to 2017. Patient characteristics and the aetiology and location of cardiac arrest were consistent, but there was a decrease in the initial shockable rhythm (from 6.5% to 5.6%) over the 5 years. The rate of bystander cardiopulmonary resuscitation (CPR) increased steadily over the years (from 10.4% to 19.4%).

Conclusion Survival after OHCA in urban areas of Beijing did not improve significantly over 5 years, with long-term survival being unchanged, although the rate of bystander CPR increased steadily, which enhanced the outcomes of patients who underwent bystander CPR.

INTRODUCTION

Despite improvements in survival over recent years, out-of-hospital cardiac arrest (OHCA) is still a universal burden on public health. Nearly 400 000 cases of OHCA occur annually in the USA and 60 000 cases occur annually in England; the incidence of OHCA has not significantly changed in the past 5 years.^{1–3} Multiple studies have shown an improvement in the survival and neurological outcomes of patients after OHCA in several regions and cities resulting from efforts made over the past decade; however, outcomes vary greatly by region and city.^{1 4–10}

Strengths and limitations of this study

- This is the first cross-sectional study to report trends in out-of-hospital cardiac arrest outcomes over continuous years in Beijing.
- This study included a sample of over 5000 individuals who underwent attempted resuscitation by the emergency medical service in urban areas of Beijing in 5 years.
- A limitation of this study is that the results showed wide CIs due to the low number of survivors, which may add uncertainty to the results.
- It was difficult in some institutions to differentiate between ongoing resuscitation and postresuscitation care during data acquisition.

A study of the incidence and outcomes of OHCA in the urban areas of Beijing was launched in 2008, and the first report was published in 2014.¹¹ It was found that the proportion of survival to hospital discharge of OHCA cases with cardiac aetiology was 1.3%, and 1% had a favourable neurological outcome at discharge. However, little is known about the recent trends in the characteristics and outcomes of patients with OHCA in the urban areas of Beijing. As efforts have been made in recent years, such as public education about cardiopulmonary resuscitation (CPR), the reform of emergency medical services (EMS), and the spread of knowledge and employment of automated external defibrillators (AEDs), we aimed to explore trends in outcomes of patients with OHCA over these recent years and to provide valuable data that can be used to derive strategies to further improve the outcomes of OHCA in Beijing. In this observational study, we followed the Utstein recommendation for collecting and analysing data of patients with OHCA who underwent attempted resuscitation by emergency medical physicians in urban areas of Beijing. This is the first study to report trends in OHCA outcomes over continuous years in Beijing.

METHODS

Study design

This cross-sectional study involved prospective data collection of OHCA cases, conducted between January 2013 and December 2017 in Beijing, China. Data were collected from patients aged above 17 years old with OHCA as confirmed by EMS personnel. Data collection was performed according to the 2004 guidelines of the Utstein Style template.¹²

EMS system and study population

The population density of the urban areas of Beijing is 9817 inhabitants per square kilometre.¹³ The one-tiered Beijing EMS system, which consists of the Beijing Emergency Medical Center with dial number 120 and the Beijing Red Cross Emergency Rescue Center with dial number 999, covers the entire metropolitan area. The EMS in Beijing serves a population of 21 530 000, including 18 650 000 urban residents. Established in 1988, the Beijing Emergency Medical Center includes 254 network stations (115 in urban areas and 139 in rural areas) that can receive more than 5000 emergency calls and dispatch more than 1800 tasks per day. There are 130 first-aid stations with more than 300 ambulances at the Beijing Red Cross Emergency Rescue Center. Both emergency networks serve the urban and rural areas of the city and assign their stations based on the location of the emergency, the distance between substations, the population distribution and the call demands to shorten the radius of the first aid.

The city formally established the Beijing Public Health Incident Command Center in 2011 to share information, coordinate dispatch, synchronise commands and unify prehospital emergency rescue resources. The command centre can bring together police emergency, traffic emergency and fire emergency services of the Beijing 120/999 Joint Emergency Rescue Command and Dispatch Platform.

The prehospital medical crew of the EMS in Beijing typically consists of one physician, one nurse, one stretcher-bearer and one driver. The specialty of all physicians is emergency medicine. A senior physician is dispatched for critical cases. All treatments in the resuscitation field are in accordance with the international guidelines recommended by the American Heart Association and the International Liaison Committee on Resuscitation for advanced cardiac life support and postresuscitation care.^{14–16} In Beijing, EMS providers are allowed to stop administering CPR at the scene.

Data collection

All data were collected prospectively from patients with OHCA who underwent attempted resuscitation by staff of the Beijing Emergency Medical Center or the Beijing Red Cross Emergency Rescue Center. Data in this study were collected from 145 stations of two EMS in the urban area of Beijing. All EMS physicians were familiar with the Utstein case report form for documenting events, and

the data were entered into a web-based database after the completion of each event. In addition, they continued to track whether the patients survived to the hospital. There are two staff who are in charge of quality control, such as monitoring the inputting process and reviewing the medical record. We collected information about the sex and age of patients; aetiology and location of the OHCA; first ECG type, such as a shockable rhythm including ventricular fibrillation and pulseless ventricular tachycardia, or a non-shockable rhythm including pulseless electrical activity (PEA), bradycardia and asystole; presence of witnesses; bystander CPR; response interval (time from the call to the ambulance's arrival at the scene); and prehospital medications.

Outcome analysis

The collected outcomes were any return of spontaneous circulation (ROSC), survival to hospital admission, survival to hospital discharge, survival to 1 year, neurological outcome at hospital discharge and neurological outcome at 1 year after discharge. Any ROSC was defined as a brief (>30s) restoration of spontaneous circulation that involved more than an occasional gasp or an occasional fleeting palpable pulse. Survival to hospital admission was defined as patients with ROSC who were admitted to the inpatient ward or intensive care unit. Good neurological outcome was defined as a surviving patient who achieved a cerebral performance category (CPC) score of 1 or 2.¹⁷

Statistical methods

We used the χ^2 test for categorical variables and analysis of variance or the Kruskal-Wallis *H* test for continuous variables to compare differences in baseline characteristics by calendar year. Multivariable regression models using modified Poisson regression with a robust error variance were constructed for the overall cohort to assess whether survival to discharge improved over time. Adjusted rate ratios with 95% CIs were calculated. Our independent variable, the calendar year, was included as a categorical variable and 2013 was included as the reference year. We multiplied the adjusted rate ratio for each year (2014–2017) by the observed survival rate for the reference year to obtain the yearly risk-adjusted survival rates for the study period. These rates represent the estimated survival for each year if the patient case mix was identical to that in the reference year. We also evaluated the calendar year as a continuous variable to obtain the adjusted rate ratios for the year-to-year survival trends. All statistical analyses were conducted using Stata/SE V.15.1 software. All hypothesis tests were two-sided, with a significance level of 0.05.

Patient and public involvement

Patients were not involved in the development of the research question and outcome measures, study design or conduct of this study.

RESULTS

After evaluating the integrity and validity of the data, we removed the stations that provided incomplete data, and 92 of 145 stations in the urban area of the city were enrolled in the study. During the 5-year study period, OHCA was confirmed in 11 295 patients and 5016 of them underwent attempted resuscitation by EMS personnel. The data recorded in the Utstein template for each calendar year showed that there were 1028 patients with OHCA in 2013, 983 in 2014, 1096 in 2015, 969 in 2016, and 940 in 2017 (table 1).

The 5016 patients who received CPR included 1402 women (28.0%) and 3614 men (72.0%), and they had an average age of 65.4 years, with ages ranging from 18 to 106 years. Nearly two-thirds (62.5%) were over 60 years old.

Of the 5016 patients who were resuscitated, the majority (3850 cases, 76.8%) had a cardiac aetiology, whereas the remaining were due to trauma (81 cases), respiratory causes (403 cases), unknown cause (361 cases) or other causes (321 cases). Among patients who were resuscitated, the majority (74.9%) were at home at the time of OHCA, while 15.8% of patients collapsed in a public place. There were no obvious trends in the aetiology or location of cardiac arrest (table 1).

For those who received CPR, the median interval from call receipt to ambulance arrival at the collapse location was 15 min (IQR 11–20) in 2013 and 15 min (IQR 11–19) in 2017. The time interval was unchanged over the 5 years ($p=0.19$) (table 1).

Furthermore, 68.8% of the OHCA cases were witnessed either by bystanders (3077 cases) or an EMS physician (373 cases), while 1566 patients collapsed without witnesses. The average rate of bystander CPR performed before the arrival of EMS personnel was 15.3%, with the rate steadily improving over the 5 years (from 10.4% to 19.4%; table 1), and bystander CPR was associated with improved survival (tables 2 and 3).

We recorded 3198 patients (63.8%) whose first rhythm was asystole on arrival and 308 patients (6.1%) with a shockable rhythm, while PEA and bradycardia were observed in 1510 patients (30.1%). The data showed a small decline in the rates of patients in a shockable rhythm over the 5 years (from 6.5% to 5.6%), a greater decline in other rhythms, and a marked increase in asystole (from 59.1% to 74.3%) (table 1).

Of the 5016 patients with OHCA, ROSC was achieved in 287 patients (5.7%), and 221 patients (4.4%) were alive at admission. Altogether, 80 patients (1.6%) were discharged alive and 66 patients (1.3%) survived with good neurological outcome (a CPC score of 1 or 2). One year after discharge from hospital, 44 patients were documented alive and 37 survived with good neurological outcome.

After risk adjustment, ROSC showed an improvement from 4.2% in 2013 to 6.3% in 2017 ($p=0.01$); no significant improvement was observed in survival to admission (from 3.6% to 5.0%, $p=0.15$), survival to hospital

discharge (from 1.2% to 1.6%, $p=0.60$), neurological outcome at discharge (from 0.87% to 0.97%, $p=0.85$), survival to 1 year (from 0.88% to 0.82%, $p=0.92$) and neurological outcome at 1-year survival (from 0.79% to 0.53%, $p=0.89$) (figure 1 and table 4).

In the multivariate logistic regression analysis, witnessed OHCA, shockable rhythm and bystander CPR were associated with a higher incidence of survival to discharge, survival to 1 year, favourable neurological outcome at hospital discharge and favourable neurological outcome at 1-year survival (tables 2 and 3).

DISCUSSION

This study was a continuation of a study of the outcomes of OHCA in urban areas of Beijing in 2012¹¹ and is the first study to report trends in OHCA outcomes over continuous years in urban areas of Beijing. The results showed that the adjusted outcomes, including survival to discharge, survival to 1 year, neurological outcome at discharge and CPC at survival to 1 year, were not substantially different from 2013 to 2017. The rate of survival to hospital discharge among all Beijing EMS-treated OHCA cases was continuously less than 2%, and it remains poor when compared with that of other countries in recent years, including the USA (9.6%), Korea (8.5%) and England (7.9%).^{5–10}

Improving the early links in the cardiac arrest chain of survival, including early recognition and calling the EMS, bystander CPR and the use of public access defibrillation (PAD) can improve outcomes.¹⁸ We found that the distributions of the sex and age of patients with OHCA enrolled in the current study and the ratio of witnessed cardiac arrest were stable during the study years. The most common place for the occurrence of OHCA in recent years remained the home (table 1). We consider that the sustained poor survival outcome of OHCA in Beijing may be due to the unsatisfactory improvement in the chain of survival, particularly in these early links.

The percentage of resuscitation efforts remains low, similar to our previous study, in which resuscitation was attempted in less than half of patients with OHCA. This may be attributed to factors such as patients who were already in a very poor condition, or the relatives calling too late, or the presence of rigor mortis or decomposition before resuscitation began. Moreover, there were a large number of cases where relatives terminated resuscitation attempts for patients with OHCA. Some cardiac arrests occur at the end stage of a severe, chronic disease, and kin may fear that resuscitation would harm the patients, and/or they do not want the patients to suffer from unfavourable outcomes. In contrast, in some cases, resuscitation efforts were undertaken at the request of family members, even though physicians considered resuscitation to be futile. Both situations are common in mainland China. Third, bystanders may not have recognised cardiac arrest, which has been shown to be the case 50% of the time in a European context.¹⁹ There is no Do not

Table 1 Trends in baseline characteristics of patients with out-of-hospital cardiac arrest in urban areas of Beijing

Characteristics	Year group				P value	
	2013 (n=1028)	2014 (n=983)	2015 (n=1096)	2016 (n=969)		2017 (n=940)
Age, years, mean (SD)	64 (17.17)	65 (16.44)	66 (15.46)	65 (15.81)	66 (16.33)	0.06
Sex, %						0.64
Female	29.28	26.75	27.28	27.45	29.04	
Male	70.72	73.25	72.72	72.55	70.96	
Location, %						0.02
Home	74.51	74.77	75.73	73.99	75.53	
Public place	15.56	14.65	16.79	18.37	13.83	
Others	9.92	10.58	7.48	7.64	10.64	
Witnessed, %						0.40
By bystander	59.44	62.56	60.95	62.95	60.96	
Not witnessed	33.56	28.79	32.03	29.82	31.70	
By EMS	7.00	8.65	7.03	7.22	7.34	
Aetiology, %						<0.001
Cardiac	68.97	75.69	81.57	79.36	78.09	
Trauma	3.40	1.73	0.55	1.34	1.06	
Respiratory	11.96	8.95	3.28	7.43	8.94	
Unknown	7.20	7.12	9.31	5.78	6.28	
Others	8.46	6.51	5.29	6.09	5.64	
Bystander CPR						<0.001
Yes	10.41	13.02	16.24	17.54	19.36	
No	89.59	86.98	83.76	82.46	80.64	
Initial rhythm						<0.001
VF/VT	6.52	6.82	6.30	5.37	5.64	
Others*	34.44	33.67	28.10	33.85	20.11	
Asystole	59.05	59.51	65.60	60.78	74.26	
Call to EMS arrival, min, median (IQR)	15.00 (11.00–20.00)	15.00 (12.00–17.00)	15.00 (11.00–18.00)	15.00 (11.00–20.00)	15.00 (11.00–19.00)	0.19

*Others: pulseless electrical activity and atrioventricular block. CPR, cardiopulmonary resuscitation; EMS, emergency medical services; VF, ventricular fibrillation; VT, ventricular tachycardia.

Table 2 Risk factors for survival of patients with out-of-hospital cardiac arrest in Beijing

	Survival to discharge		Survival to 1 year	
	Adjusted rate ratio* (95% CI)	P value	Adjusted rate ratio* (95% CI)	P value
Year				
2013	1.00		1.00	
2014	1.37 (0.68 to 2.76)	0.38	1.23 (0.51 to 2.95)	0.65
2015	1.49 (0.76 to 2.92)	0.24	1.29 (0.58 to 2.88)	0.53
2016	1.34 (0.65 to 2.79)	0.43	1.31 (0.53 to 3.28)	0.56
2017	1.29 (0.60 to 2.80)	0.52	0.93 (0.33 to 2.61)	0.90
Witnessed				
Not witnessed	1.00		1.00	
By bystander	1.59 (0.79 to 3.19)	0.19	7.72 (1.16 to 51.20)	0.03
By EMS	5.51 (2.53 to 11.97)	<0.001	35.82 (5.01 to 256.13)	<0.001
Bystander CPR				
No	1.00		1.00	
Yes	2.23 (1.38 to 3.61)	0.001	3.47 (1.86 to 6.46)	<0.001
Location				
Home	1.00		1.00	
Public place	0.56 (0.3 to 1.05)	0.07	0.44 (0.20 to 0.97)	0.04
Others	0.43 (0.16 to 1.14)	0.09	0.16 (0.03 to 0.78)	0.02
Initial rhythm				
Others†	1.00		1.00	
VF/VT	17.32 (8.56 to 35.03)	<0.001	33.47 (10.44 to 107.25)	<0.001
Asystole	1.96 (0.93 to 4.11)	0.08	3.18 (1.00 to 10.13)	0.05

*Adjusted for age, sex and aetiology.

†Others: pulseless electrical activity and atrioventricular block.

CPR, cardiopulmonary resuscitation; EMS, emergency medical services; VF, ventricular fibrillation; VT, ventricular tachycardia.

attempt resuscitation (DNAR) protocol in Beijing, while the EMS physicians on the scene have the right to declare death and terminate resuscitation efforts.

It is commonly accepted that the outcome of ventricular fibrillation is much more favourable than that of asystole, but the ratio of the shockable rhythm as the initial rhythm found by the Beijing EMS personnel showed a decrease in recent years and it is very low when compared with other nations (table 1).²⁰ This may be due to the relatively long time interval from the initial call to the EMS arrival in Beijing; the longer the average interval from the call to the ambulance arrival at the collapse location, the less likely it is for the first monitored rhythm to be shockable. In recent years, this interval has remained the same (15 min), and despite several regulations being implemented to reform the Beijing EMS (table 1) the efficiency is still unsatisfactory. In addition to the unsolved problem of traffic jams, the limited dispatch resources have great room for improvement. There is still a great burden on non-urgent services to deal with urgent needs during daily EMS tasks, and besides the shortage of EMS staff the unequal quality of EMS staff and the inefficiency of dispatch also lead to the unsatisfactory efficiency of Beijing EMS. Regulations to solve these related problems

have been discussed for quite a long time, and some efforts have been made, but no improvement in the response interval was found in the study period. As of the time this article is written, no formal prearrival telephone instructions for CPR have been provided to bystanders or first responders by the dispatcher or the EMS unit as a routine practice. There have been reports that dispatch often offers casual instructions to bystanders to resuscitate patients with OHCA with a good public response, and some experts in the field have proposed to the administration department to start an experimental project of dispatch CPR in near future.

Moreover, poor patient conditions at the time of calling EMS could be the reason for the increase in the ratio of asystole as the first rhythm. The deterioration of starting conditions could also explain why overall survival measures did not improve despite an increase in bystander CPR. Finally, wide clinical application of β -adrenergic receptor blockade, calcium channel blockers and ACE inhibitor drugs may also contribute to the majority of the first monitored rhythms being asystole.

Bystander-initiated CPR is a crucial factor associated with significantly higher survival outcomes after OHCA.^{21–23} Our study showed that the rate of bystander CPR improved

Table 3 Risk factors for neurological outcomes of patients with out-of-hospital cardiac arrest in Beijing

	CPC at hospital discharge		CPC at survival to 1 year	
	Adjusted rate ratio* (95% CI)	P value	Adjusted rate ratio* (95% CI)	P value
Year				
2013	1.00		1.00	
2014	1.71 (0.78 to 3.77)	0.18	0.53 (0.17 to 1.72)	0.29
2015	1.99 (0.95 to 4.16)	0.07	1.45 (0.61 to 3.46)	0.40
2016	1.85 (0.85 to 4.03)	0.12	1.38 (0.55 to 3.43)	0.50
2017	1.11 (0.48 to 2.56)	0.81	0.67 (0.25 to 1.79)	0.42
Witnessed				
Not witnessed	1.00		1.00	
By bystander	1.68 (0.72 to 3.95)	0.23	6.49 (1.2 to 35.17)	0.03
By EMS	6.94 (2.64 to 18.25)	<0.001	20.66 (3.86 to 110.56)	<0.001
Bystander CPR				
No	1.00		1.00	
Yes	2.63 (1.53 to 4.51)	<0.001	3.36 (1.70 to 6.65)	<0.001
Location				
Home	1.00		1.00	
Public place	0.39 (0.19 to 0.79)	0.009	0.25 (0.09 to 0.67)	0.006
Others	0.37 (0.11 to 1.22)	0.10	0.08 (0.01 to 0.75)	0.03
Initial rhythm				
Others†	1.00		1.00	
VF/VT	23.92 (9.81 to 58.30)	<0.001	225.74 (29.28 to 1740.10)	<0.001
Asystole	2.02 (0.81 to 5.04)	0.13	10.60 (1.17 to 95.77)	0.04

*Adjusted for age, sex and aetiology.

†Others: pulseless electrical activity and atrioventricular block.

CPC, cerebral performance category; CPR, cardiopulmonary resuscitation; EMS, emergency medical services; VF, ventricular fibrillation; VT, ventricular tachycardia.

gradually year to year (from 10.41% in 2013 to 19.36% in 2017) and that there was a statistically significant difference in the survival rate between patients who did and did not undergo bystander CPR. Although the bystander CPR rates are poor compared with some regions, such as 45% reported in Denmark, 44% in North America, 55% in England, 66% in the Netherlands, 68.8% in Australia and 73% in Norway,^{4 6 24-26} the outcomes do contrast with the result we observed in 2012 in Beijing, when there was no difference in the survival between patients with OHCA who had and had not undergone bystander CPR.¹¹ This finding implies that bystanders' perception of and willingness to perform resuscitation have improved over the years. This may be due to the great attention given by the government, the public education programme about CPR implemented in communities and schools, and the public gradually becoming aware of the importance of CPR technique. Public knowledge and attitudes towards CPR have been improving gradually over the years. CPR training programmes are provided by hospitals, academic and scientific societies, non-governmental organisations, and branches of the Red Cross. Currently, there are several ways to educate the public about CPR, including

offering teaching video clips at mobile facilities, teaching the technique via mobile phone applications (apps) that have been specially designed for CPR, and offering classes organised by communities or academic societies where members of the public can practise CPR technique using a simulation and with an instructor present.

However, despite progress in the construction of necessary equipment, environments and training systems, the PAD programme in Beijing currently does not have a satisfactory reach. Although AEDs have been made available in some public areas, such as airports, shopping centres, schools and stadiums, in recent years, citizens still lack the knowledge to operate AEDs properly. In our study, all prehospital defibrillations were performed by ambulance crews. The AED maps in mobile phone apps, from which the public can find the nearest available AED, have been online during the study years in some cities in China, but the Beijing map is still under construction. The first AED activated by non-medical personnel in public for OHCA in Beijing was in 2018 at the Beijing Baiyun Temple. In the past 2 years, there have been four reports of AED activated by non-medical personnel in the resuscitation of OHCA, with three of these patients with OHCA surviving

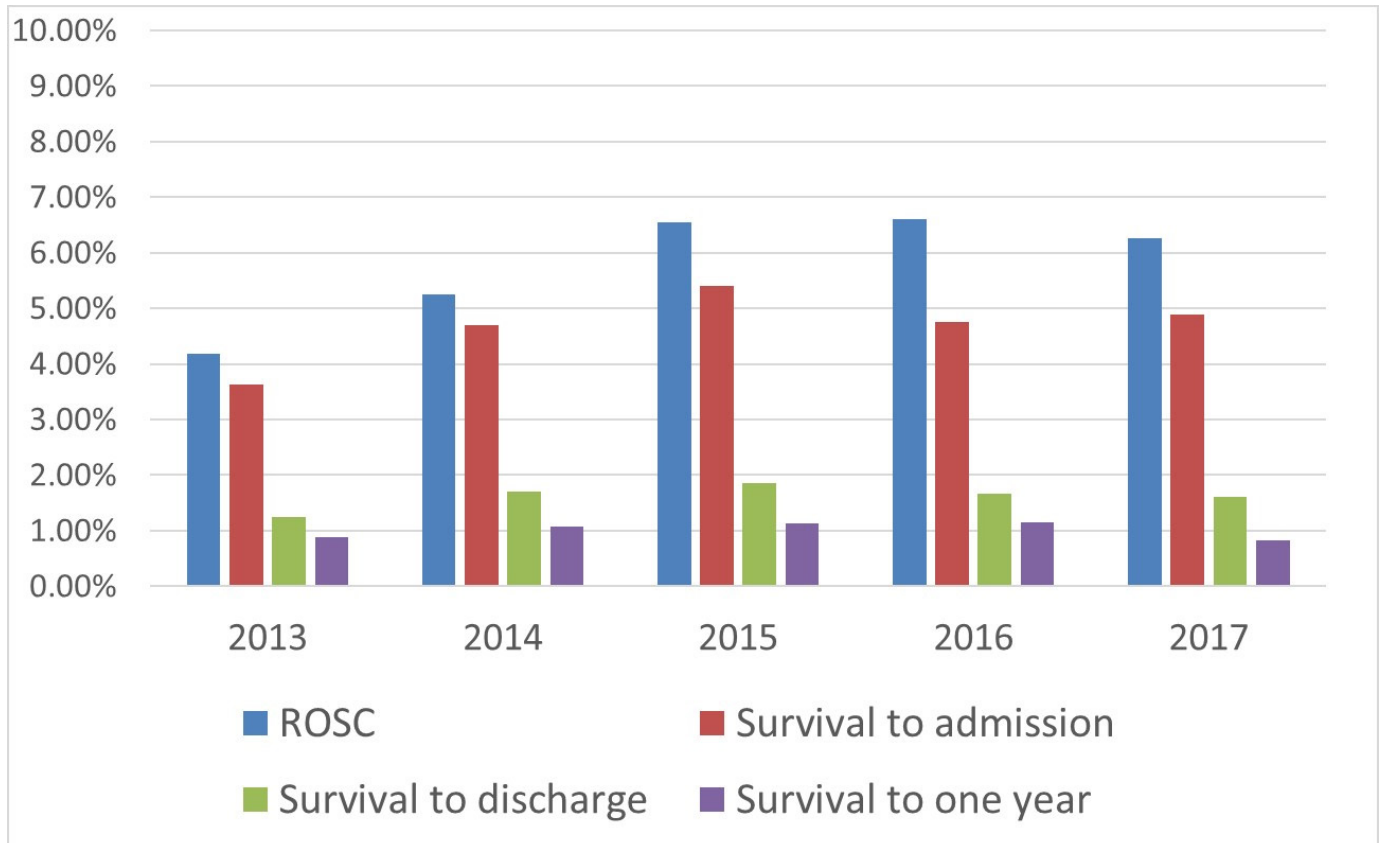


Figure 1 Trend in the adjusted outcomes of patients with out-of-hospital cardiac arrest in urban areas of Beijing from 2013 to 2017. ROSC, return of spontaneous circulation.

to hospital discharge; the use of PAD is far lower than in the USA and England.^{6 24} Only with public education about resuscitation being reinforced and more AEDs being employed in public will the outcomes of OHCA cases in Beijing likely improve in the future.

High-quality CPR has been recommended in international guidelines for resuscitation for years.^{15 16 27} Training sessions for EMS personnel regarding updates to the international CPR guidelines have been implemented

occasionally in two emergency medical centres in Beijing. The quality of practice and service should be continuously improved to maintain a resuscitation team that is highly responsive and efficient.

There have been a series of projects initialised by the Beijing Municipal Health Commission to improve the survival rate of OHCA in Beijing in the past years, including reforming the dispatching patterns, merging the alarming platform, educating the public with CPR

Table 4 Trends in survival and neurological outcomes of patients with out-of-hospital cardiac arrest in urban areas of Beijing

Outcome	Risk-adjusted rates* (%)					Adjusted rate ratio per year (95% CI)†	P value for trend†
	2013	2014	2015	2016	2017		
ROSC	4.18	5.25	6.55	6.60	6.26	1.10 (1.02 to 1.19)	0.01
Survival to admission	3.58	4.49	5.48	4.69	4.96	1.07 (0.98 to 1.17)	0.15
Survival to discharge	1.24	1.70	1.86	1.67	1.60	1.04 (0.89 to 1.23)	0.60
CPC at discharge	0.87	1.49	1.73	1.61	0.97	1.02 (0.87 to 1.19)	0.85
Survived to 1 year	0.88	1.07	1.13	1.15	0.82	0.99 (0.80 to 1.23)	0.92
CPC at survival to 1 year	0.79	0.42	1.15	1.09	0.53	0.99 (0.81 to 1.20)	0.89

*The risk-adjusted rates of ROSC, survival to admission, survival to discharge, CPC at discharge, survival to 1 year and CPC at survival to 1 year for each calendar year are reported for the overall cohort. The rates were adjusted for temporal changes in the patient and hospital characteristics. The risk-adjusted rates for each calendar year were obtained by multiplying the observed rate for the reference year (2013) by the corresponding rate ratios for 2014–2017 from a model that evaluated each calendar year as a categorical variable.

†The adjusted risk ratios and p values for the trends were determined with a model that evaluated each calendar year as a continuous variable.

CPC, cerebral performance category; ROSC, return of spontaneous circulation.



knowledge and legislating to protect the bystander CPR from 2013. The overall efficiency of EMS, however, does not seem to be improved substantially, compared with that of 2012. Even though the rate of bystander CPR has shown a steady trend of increasing year by year, the encouraging progress was offset by the stagnant EMS efficiency over the years. It is apparent that, given the current outcome of OHCA in Beijing, the actions taken by the government in the past were not quite effective.

While learning from the progress and lessons over the past years on the outcome of OHCA in Beijing municipal area, we consider that broader audience outside of Beijing might also face similar challenge in the field of public health, with a need to improve the effectiveness and productivity in the field of OHCA. This article is an attempt to share experience and knowledge for the potential common interests. We will continue to monitor the change of every aspect of resuscitating OHCA in Beijing in the following years and keep sharing our benchmark on the effectiveness of the effort to improve the outcome of OHCA in Beijing.

Certain limitations of this study should be taken into account. First, there is no government-developed OHCA registry in China, and the data collected in this study did not include all patients with OHCA treated by the Beijing EMS. The results also had very wide CIs because of the low number of survivors, which may have resulted in uncertainty in the findings. Second, the time data were not as complete as they should be according to the Utstein guidelines because some core time data were missing, such as time from collapse to intubation and first defibrillation. Third, it was difficult to identify the difference between institutions that received patients with OHCA for ongoing resuscitation and postresuscitation care. These variations in postresuscitation care could also affect the survival rates and consequently our results.

CONCLUSIONS

The overall 5-year survival rate post-OHCA in the urban areas of Beijing is still unsatisfactory, and long-term survival remains unchanged over the 5 years. Outcomes are still worse than those in developed countries over the past few years. However, we found that the rate of bystander CPR in Beijing was increasing significantly each year and that the outcome of patients with OHCA who received bystander CPR was steadily improving. In the future, efforts to improve the efficiency of the EMS system, bystander CPR, the PAD programme, and public education and knowledge about the international CPR guidelines have the potential to enhance OHCA outcomes in Beijing.

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Contributors CL and FS contributed to conception and design of the study. DL and SM collected the medical information of the patients. FS and HL contributed to

the process of data cleaning and analysis. HL performed the statistical analysis. FS wrote the draft of the manuscript. All authors contributed to manuscript revision and read and approved the submitted version.

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