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Survival to discharge after in-hospital cardiac arrest at emergency department and its associated factors: a prospective observational study

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ABSTRACT

Objectives: To study the rate of survival to discharge after in-hospital cardiac arrest and its associated factors in an emergency department of a tertiary care hospital, South India.

Methods: This prospective observational study was conducted between December 2016 and May 2017 among all patients above 12 years old, who suffered witnessed cardiac arrest, after arrival in the emergency department. A semi-structured questionnaire was used to collect data (socio demographic details, chief complaints, comorbidities). Initial documented rhythm, duration of CPR, use of defibrillator, and presumed cause of cardiac arrest and others were collected from the case records.

Results: The study cohort contained 252 participants. The age was (50.0+17.2) years and male patients accounted for 54.4%. The most common complaint was breathlessness (29%), followed by chest pain (20.2%) and trauma (17.5%). The proportion of non-shockable rhythm (77.4 %) was higher than shockable rhythm (22.6%). Pulseless electrical activity (53.9%) was the most common initially documented rhythm. The predominant presumed cause of arrest was cardiac origin (29.7%). The overall rate of survival to discharge was 17.5%. Logistic regression analysis showed age >60 years [odds ratio (*OR*): 3.4, 95% confidence interval (*CI*): 1.03-11.22, *P*=0.04], males (*OR*: 3.45, 95% *CI*: 1.00-11.44; *P*=0.04), presumed respiratory cause (*OR*: 11.8, 95% *CI*: 1.0-160.0, *P*=0.05), initial rhythm ventricular fibrillation (*OR*: 9.1, 95% *CI*: 1.0-92.0, *P*=0.05) as individual predictors of survival rate to discharge after in-hospital cardiac arrest.

Conclusions: Our study shows that less than one-fifth of patients survive to discharge after in-hospital cardiac arrest. This signifies the need to identify and to make the necessary changes at all levels of organization, service delivery and patient care, so as to improve the overall survival rate following cardiac arrest.

1. Introduction

Cardiopulmonary resuscitation has been used to revive the patients from cardiac arrest for several decades[1]. However, the rate of survival to discharge after such resuscitation still remains low[2]. Sudden cardiac arrest is the commonest cause of death in the emergency department (ED) globally. Cardiac arrest are usually categorized as in-hospital cardiac arrest (IHCA) or out of hospital cardiac arrest. The IHCA accounts for about 25% of deaths whereas 75% deaths occurs in out of hospital cardiac arrest[3]. The overall rate of survival to discharge after IHCA ranges from 7% to 26%[2]. The quality of IHCA has kept on check by several methods like mock codes, debriefing following resuscitation, simulation classes,

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audio-visual feedback systems[4]. But whether the actual outcome is improved following such efforts still remains unknown.

The focus of management has to be changed according to the underlying cause rather depending on the initial rhythm of arrest. This is because coronary artery disease has found to be the major cause of sudden cardiac arrest and death[5], and advances in management of acute myocardial infraction and heart failure have led to decline in proportion of IHCA due to ventricular fibrillation (VF) and ventricular tachycardia (VT). Though patients with these rhythms are found to have better survival rates[6], the overall survival rate has not been improved even the specific rate of the rhythm is found to be improved. The objective of the present study is to find the rate of survival to discharge after witnessed IHCA and its associated factors among individuals elder than 12 years in the ED of a tertiary care hospital.

2. Materials and methods

This study was approved by the Institute Ethics Committee-Human Studies, JIPMER, Pondicherry (Approval no JIP/IEC/2015/23/801 and approval date 03-03-2016).

This prospective observational study was conducted in the ED of tertiary care hospital in South India. It is a 2 100-bedded tertiary care referral hospital, located in Pondicherry, India, with an average of 350 emergency cases per day. The inclusion criteria for the study participants were, patients elder than 12 years, who have sustained cardiac arrest after reaching the ED but before being admitted into the speciality wards. The average duration of stay in ED varied from less than one day to eight days based on the underlying cause and clinical condition of the patient. The study was conducted for a period of 6 months from December 2016 to May 2017. The exclusion criteria for this study was the patients who had unwitnessed arrest, no proper case records, no bystanders to provide history, and those who were discharged against medical advice.

Cardiac arrest was defined as the cessation of cardiac mechanical activity confirmed by the absence of detectable pulse, unresponsiveness and/or apnoea (agonal respirations)[7]. In instances where the patient suffered multiple cardiac arrests, only the initial in-hospital arrest at ED was recorded. This was to avoid falsely elevated rate of successful cardiopulmonary resuscitation (CPR). Return of spontaneous circulation (ROSC) was defined as return of cardiac activity associated with significant respiratory effort after cardiac arrest which can be identified by resumption of breathing, coughing, or movement and a palpable pulse or a measurable blood pressure[8]. Sustained ROSC was defined as maintaining for more than 20 min. The resuscitation was performed by consultants and residents posted in ED. CPR was given based on American Heart Association Guidelines 2016. All the ED consults and residents were Advanced Cardiac Life Support certified.

Data were collected after the written informed consents were obtained from the relatives or the by-stander of the patient. In case that the participants were younger than 18 years, consent was obtained from the parents or legally acceptable representative. A pre-tested semi-structured questionnaire was used to collect data on socio demographic details, chief complaints, comorbidities. Information related to initial documented rhythm, duration of CPR, use of defibrillator, adrenaline usage and presumed cause of cardiac arrest were collected from case records. Those patients who have survived, were followed up till discharge and the neurological status of them were assessed using Glasgow Coma Scale.

The outcomes of CPR were categorized as ROSC, survival to admission (Sustained ROSC) and survival to discharge. The initial documented rhythms are classified as VF, pulseless VT [VT(p)], pulseless electrical activity (PEA), and asystole. The arrests were classified into presumed cardiac origin and non-cardiac origin,

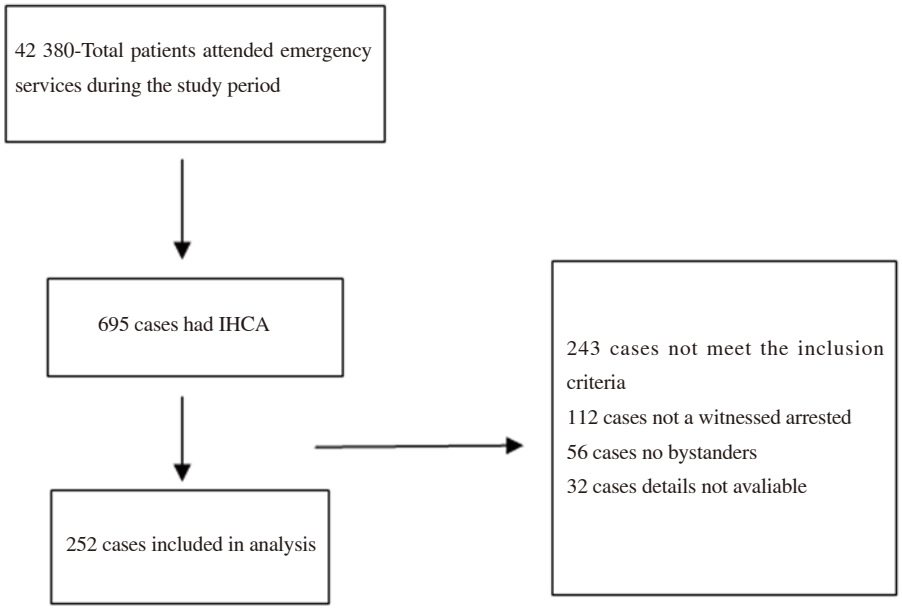

Figure 1. Flow chart of study cohort. IHCA: in-hospital cardiac arrest.

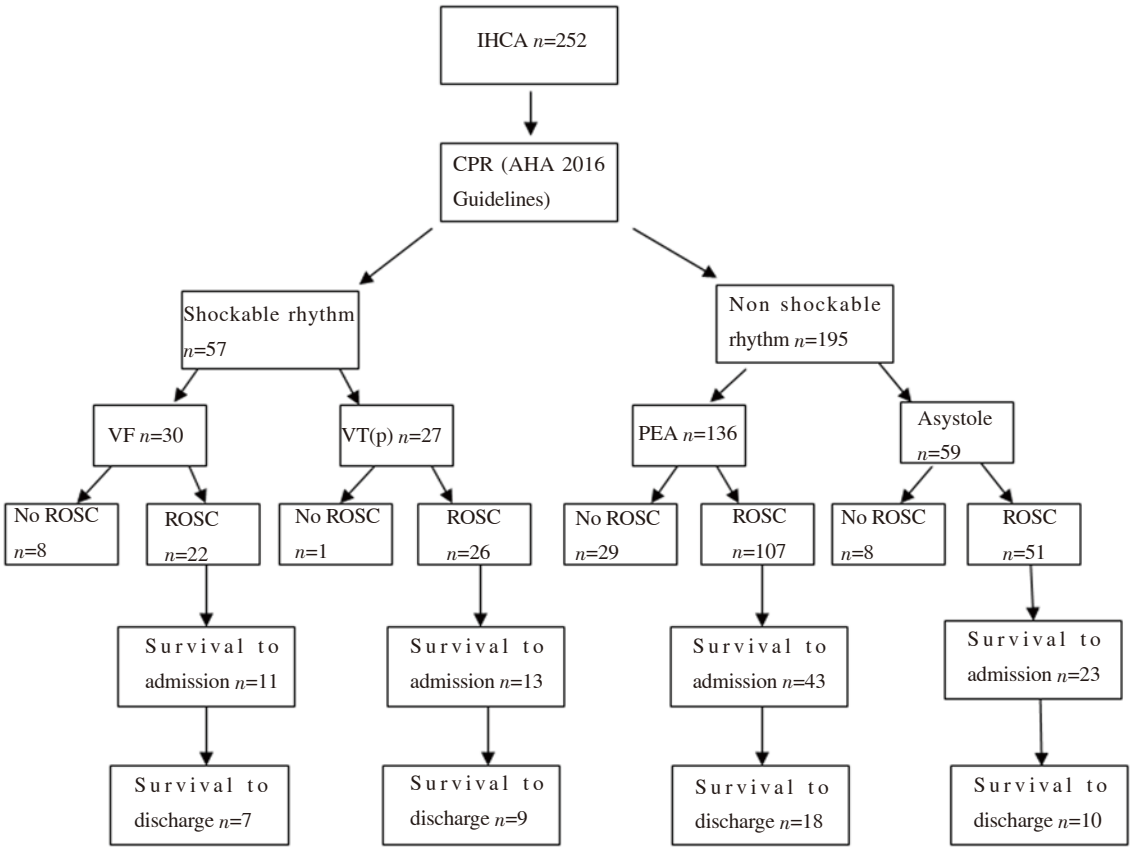

Figure 2. Flow chart of CPR outcome after in-hospital cardiac arrest. IHCA: in-hospital cardiac arrest; VF: ventricular fibrillation; VT (p): pulseless ventricular tachycardia; PEA: pulseless electrical activity; ROSC: return of spontaneous circulation.

with the latter resulting from external causes, respiratory diseases, malignant tumours, strokes, trauma, and any other non-cardiac causes based on history and review of medical records.

Sample size was calculated as 206 using OpenEpi version 3.01, and 15.9% was expected to be the rate of survival to discharge among patients with IHCA at the ED[9], with the alpha level at 0.05 and absolute precision as 5%. Final sample size was 227 after adding 10% non-response rate.

All the collected data was entered in Epidata Manager v2.0 and analysed using STATA 14.1 for Windows (StataCorp, College Station, Texas, USA) software. *Chi* square test/Fisher Exact was used to analyze the association among socio-demographic variables, co-morbidities, presumed cause of arrest, and CPR outcome. Univariate and multivariate analysis was perfomed to identify the individual predictors of CPR outcome.

3. Results

During the study period, out of 42 380 patients attended the ED, with 695 patients had IHCA, in which 243 cases did not meet the inclusion criteria (Figure 1). At the end, a total of 252 participants were selected.

3.1. Baseline characteristics of study population

The mean age was (50.0±17.2) years, and 112 (44.4%) were in age group of 41-60 years. The proportion of males was 137 (54.4%). Breathlessness [73 (29.0%)] was the most common symptom followed by chest pain [51 (20.2%)].

Table 1. Baseline characteristics of the study population (*n*=252).

Age (year)	*n*	Percent
<20	12	4.8
21-40	65	25.8
41-60	112	44.4
>60	63	25.0
Gender		
Male	137	54.4
Female	115	45.6
Chief complaints		
Breathlessness	73	29.0
Chest pain	51	20.2
Trauma	44	17.5
Fever	37	14.7
Poisoning	24	9.5
Others*	23	9.1
Location of collapse		
Triage	14	5.5
Observation area	23	9.1
Resuscitation area	215	85.3

*Abdominal pain, hematemesis, giddiness, vomiting, palpitations, sweating.

Table 2. Co-morbidities of the study participants (*n*=205).

Co-morbidity	*n*	Percent
Diabetes	39	19.0
Hypertension	31	15.1
Both diabetes and hypertension	31	15.1
Ischemic heart disease	35	17.1
Chronic obstructive pulmonary disease	18	8.7
Chronic renal failure	19	9.3
Malignancy	20	9.8
Others†	12	5.8

†Asthma, Decompensated chronic liver disease, congenital heart disease.

The proportion of trauma cases due to road traffic injuries, self-fall and accidental injuries was 44 (17.5%). Majority of patients [215 (85.3%)] collapsed in resuscitation area in the ED (Table 1). Among 205 (81.3%) participants who had comorbidities, diabetes [39 (19.0%)], hypertension 31 (15.1%) and ischemic heart disease 35 (17.1%) were the most common (Table 2).

3.2. CPR outcome

Of the 252 IHCA participants, 206 (81.7%) patients had ROSC, however, only 44 (44/252, 17.5%) patients survived to discharge. The average duration of CPR was (13.2±1.64) min. Most participants had non-shockable rhythm (195/252, 77.4%) as initial documented rhythm after CPR, of which majority was PEA (136/195, 69.7%). Among 57 (22.6%) patients with shockable rhythm, the incidence of VF (30/57, 52.6%) and VT(p) (27/57, 47.4%) were almost similar (Figure 2).

Majority of patients with IHCA were presumedly caused by cardiac reasons [75 (29.7%)], followed by respiratory reasons [69 (27.4%)], trauma [44 (17.5%)], poisoning [25 (9.9%)], electrolyte imbalance [18 (7.1%)], sepsis [12 (4.8%)] and other causes like perforation peritonitis, burns, stroke, diabetic ketoacidosis, malignancy were [9 (3.7%)]. Of the 44 patients who survived till admission, the average duration of stay in hospital was (12.4±4.3) d. Among these 44 patients, 16 (36.4%) had complete neurological recovery, 5 (11.4%) mild deficit, 5 (11.5%) were in vegetative state and 18 (41.0%) were discharged at request.

The univariate analysis showed that age, gender, initial documented rhythm, and adrenaline usage had significant association with the outcome, whereas other factors such as co-morbidities, duration of CPR, trauma cases had no significant association (Table 3). Logistic regression analysis showed that age >60 years [odds ratio (*OR*): 3.4, 95% confidence interval (*CI*): 1.03-11.22, *P*=0.04), males (*OR*: 3.45, 95% *CI*: 1.00-11.44, *P*=0.04), presumed respiratory cause (*OR*: 11.8, 95% *CI*: 1.0-160.0, *P*=0.05), initial rhythm VF (*OR*: 9.1, 95% *CI*: 1.0-92.0, *P*=0.05) were individual predictors of survival rate to discharge after IHCA.

Table 3. Univariate analysis of factors associated with survival to discharge rate following IHCA (*n*=252).

Variables	Survival to discharge		*P* value
	Yes [*n* (%)]	No [*n* (%)]	
Age (years)			
12 - 20	3 (25)	9 (75)	0.04
20 - 40	14 (21.5)	51 (78.5)	
41 - 60	12 (10.7)	100 (89.3)	
>60	15 (23.8)	48 (76.2)	
Gender			
Male	33 (24.1)	104 (75.9)	0.03
Female	11 (9.6)	104 (90.4)	
Co-morbidities			
Yes	12 (25.5)	35 (74.4)	0.10
No	32 (15.6)	173 (84.3)	
Presumed cause			
Cardiac	11 (14.9)	64 (85.3)	0.44
Non-cardiac	33 (18.6)	144 (81.3)	
Initial documented rhythm			
VF	7 (23.3)	23 (76.7)	0.05
VT(p)	9 (33.3)	18 (66.4)	
PEA	18 (13.2)	118 (86.7)	
Asystole	10 (16.9)	49 (83.1)	
CPR duration in minutes			
<10	26 (20.4)	101 (79.5)	0.13
>10	18 (14.4)	107 (85.6)	
Trauma			
Trauma	6 (13.6)	38 (86.3)	0.46
Non- trauma	38 (18.2)	170 (81.7)	
Adrenaline ampoules			
<4	40 (22.1)	141 (77.9)	0.02
>4	4 (5.6)	67 (94.3)	

4. Discussion

IHCA is the major cause of mortality especially in ED. Our study shows that only 17.5% patients survived to discharge after IHCA in ED.

The average age of participants in our study were (50.0±17.2) years. Pandian *et al.*[10] and Mallikethi-Reddy *et al.*[11] reported similar average age which was 55 (interquartile range: 42-64) years and (50.9±10.9) years, respectively. Majority of our participants were male (54.4%), higher than female which is similar to studies of Pandian *et al.* (64.6%)[10], Herlitz *et al.* (69%)[12], and Cooper *et al.*(59%)[2]. It indicates that men are at higher risk of cardiac arrest. In our study, most participants (81.3%) had co-morbidities, which is similar to the findings of Miranzadeh *et al.*[13] (83%). The proportion of coronary artery disease cases was 17.1% from our study, while findings of Bansal *et al.*[14] and Khan *et al.*[15] reported 17.1% and 37.0%, respectively. The proportion of chronic obstructive pulmonary disease and chronic renal insufficiency from our study was 8.7% and 9.6%, respectively, which was comparable

to the findings of Bansal *et al.* with chronic obstructive pulmonary disease as 9.5% and chronic renal failure as 8.6%[14], and the study of Miranzadeh *et al.* with COPD as 14.3% and CRF as 13%[13].

Our study reported 17.5% patients complained of trauma cases. Similar findings were reported by Johnson *et al.* (16.9%)[16] However, very few trauma cases were reported by Miranzadeh *et al.* (8.5%)[13], and Mallikethi-Reddy *et al.* (3.1%)[11]. The fewer cases from other studies may be due to the difference in the study setting. Since our study was conducted in the ED, the proportion of trauma cases may be relatively higher.

The incidence of shockable rhythm (22.6%) of our study was comparable to the findings of Cooper *et al.* (23.6%)[2], but was higher than the findings of Cui *et al.* (5.8%)[17]. and Bansal *et al.* [14]. PEA (53.9%) was the most common initial documented rhythm from our study which is similar to the results of Pandian *et al.* (76%)[10], Khan *et al.* (50%)[15], and Cooper *et al.* (42%) [2]. Based on these researches, PEA is the predominant initial documented rhythm following CPR across different regions even if the study settings are dissimilar. In our study 29.7% of patients had cardiac causes and 27.8% had respiratory causes as presumed cause of cardiac arrest. Studies of Khan *et al.* (33.1%), Pandian *et al.* (21%)[10] also had similar findings. Results of Krittayaphong *et al.*[18] had respiratory cause (30.8%) as predominant cause for arrest. However, 17.5% of our participants had arrest due to trauma which was higher than the results of Pandian *et al.* (10%)[10] and Khan *et al.* (3%)[15]. The incidence of sepsis was 4.8% in our study, similar to the findings of Sawanyawisuth *et al.* (5.5%)[19]. From our findings, 9.9% of participants had poisoning as presumed cause of arrest, whereas Pandian *et al.*[10] reported only 2%. The average duration of CPR in our study was (13.2±1.64) min, which is shorter than (35.11±11.42) min reported by Miranzadeh *et al.*[13] and 30 (Median interquartile range 3 125) min by Sawanyawisuth *et al.*[19]. This difference in CPR duration maybe due to several factors such as quality of CPR provided, availability of defibrillators, location of the arrest and availability of the by-standers or CPR providers.

The incidence rate of ROSC was 81.7% in our study following CPR. Khan *et al.* (72%)[15], Pandian *et al.* (71%)[10] and Kaki *et al.* (64%)[20] had similar immediate survival following CPR, whereas Bansal *et al.*[14] reported immediate survival as 38.1% following CPR. Rate of survival to admission was 35.7% in our study, similar to findings of Khan *et al.* (42%)[15] Kaki *et al.* (43%)[20]. The survival to discharge rate in our study was 17.5%. Cooper *et al.* (15.9%)[2], Pechtel *et al.* (14%)[21], Khan *et al.* (19%)[15], Johnson *et al.* (15.7%)[16] reported similar rate of survival to discharge; whereas Miranzadeh *et al.*[13] and Pandian *et al.*[10] reported only 4.8% and 9.9%. In our study, though the immediate ROSC rates after the CPR are higher, there is drastic fall in the rate of survival to discharge. These are also consistent with results of various studies from different regions and in different settings. Thus, there is substantial lacuna in post ROSC care that needs to be improved. Though there are various advances, changes and improvements in techniques and skills of CPR, the likelihood of improving the rate of survival to discharge after IHCA still remains a great challenge.

The rate of survival to discharge was over 25% among age group of 12-20 years in our study, which is similar to the study of Hajbaghery *et al.*[22], with 16.7% patients surviving to discharge among age group of less than 20 years. Survival rates of male patients was higher in our study, which is similar to the results of Rakic *et al.*[23], but contradictory to the findings of Pandian *et al.*[10] and Ehlenbach *et al.*[2], where female patients had better survival rates although these differences were not statistically significant.

Similar to the findings of Meaney *et al.*[24], Rakic *et al.*[23], and Ozcan *et al.*[25], the participants from our study with shockable rhythm as initial documented rhythm had better rate of survival to discharge than those with non-shockable rhythms. Also, there was not significant difference in survival rates between individuals with VF or VT(p) as initial rhythm. In our study, logistic regression showed that patients with presumed respiratory cause had higher odds of survival to discharge. Comparable findings was reported by Cooper *et al.*[2], Kaki *et al.*[20] Krittayaphong *et al.*[18]. It is also reported that patients with non-cardiac cause had better outcome than those with cardiac cause[13,15,18]. In the present study there is no significant relationship between duration of cardio pulmonary resuscitation and survival outcome. However, Miranzadeh *et al.*[13], Adib-Hajbaghery *et al.*[22] reported a significant relation between duration of CPR and survival rates, and they reported that no patients survived to discharge with CPR lasting more than 60 min. Our study found that, over 60 years old, male, patients with VF as initial documented rhythm, presumed respiratory mode of arrest are independent predictors of survival to discharge after IHCA. Pandian *et al.*[10] reported age >65 years and total duration of CPR >10 min as independent predictors. Krittayaphong *et al.*[18] reported non-cardiac causes, non-sepsis causes as independent predictors. Study of Sawanyawisuth *et al.*[19] reported CPC score <2 before arrest, CPR duration <30 min, cardiopulmonary cause of arrest as individual predictors of the rate of survival to discharge. Miranzadeh *et al.*[13] reported CPR duration, response time, history of previous CPR, other co-morbidities as individual predictors.

In this study, only patients with witnessed cardiac arrest after arrival to ED are included. It excludes the unwitnessed arrests which in some cases may not be a real arrest and may falsely increase the rates. Also, the patients were followed up till discharge from the hospital, which makes sure the actual rate of survival to discharge. Besides, most of the variables were assessed and included in regression analysis.

The limitation is the selection bias in this study since only patients with bystanders and proper case record are included. In addition, the actual definite clinical diagnosis for cardiac arrest is not confirmed due to short stay in the ED.

In conclusion, our study shows that the survival rate after IHCA is very low. Majority of the patients with sustained cardiac arrest have ROSC, but only less than one-fifth of the participants survive to discharge. Patients are more likely to survival to hospital discharge when the first documented rhythm is shockable rather than non-shockable rhythm. One third of the participants have cardiac

reasons as presumed cause of arrest. All these findings indicate that the rate of survival to discharge after IHCA hasn't changed in decades. Though there are several advances in the CPR techniques, the quality of CPR is still doubtful, since it is dependent on several factors like setting of arrest, duration of CPR, skill of the provider *etc*. Inadequate post cardiac arrest cares in in-hospital due to logistic issues and delay in intervention has drastically impacted our study outcome. Hence, to improve survival outcome, integrated multidisciplinary approaches to post-cardiac arrest care are needed. Thus, there is a need to identify and to make necessary changes at all levels of administration, service delivery, survival outcomes following cardiac arrest and also the post resuscitation care for the patients.

Conflict of interest statement

The authors report no conflict of interest.

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