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Original Research

Association between Teaching Status of Metropolitan Hospitals and Out-of-Hospital Cardiac Arrest Outcomes: A Retrospective Observational Study of Hospitals in the United States

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ABSTRACT

Introduction: The quality of care and patient outcome of out-of-hospital cardiac arrest (OHCA) are affected by different factors, one of which is the hospital teaching status. This study aims to assess the association between teaching status of hospitals and survival rates.

Methods: This retrospective observational study utilized the Nationwide Emergency Department Sample (NEDS) database of the year 2014 (released in 2016). The study sample included OHCA 122,776 patients. Descriptive analysis was performed. Patients' characteristics were compared according to the hospital teaching status. This was followed by a multivariate analysis to assess the impact of the hospital teaching status on the patients' survival at hospital discharge after controlling for confounding factors.

Results: A total of 122,776 patients with OHCA were included in this study. The average age was 65.91 years with male predominance (61.7%). Around 62.1% of patients were admitted to metropolitan teaching hospitals. Overall survival to hospital discharge was 6.4%. Survival was higher in patients who were treated in a metropolitan teaching hospital in comparison with those who presented to a metropolitan non-teaching hospital (7.2 % versus 4.9%, $p<0.001$). After adjusting for confounders, patients' survival to hospital discharge was similar in the two groups (teaching and non-teaching metropolitan hospitals) (OR=0.909, 95% CI 0.776 – 1.065).

Conclusion: In this study, there was no significant association between teaching status of US metropolitan hospitals and survival of OHCA patients. OHCA patients may be transferred to the nearest hospital regardless of teaching status in US metropolitan areas.

Key words: out-of-hospital cardiac arrests, outcomes, survival, teaching status

INTRODUCTION

Out of hospital cardiac arrest (OHCA) remains a major public health concern as it affects more than 350,000 patients in the United States (US) yearly.[1] OHCA has a poor outcome with high mortality rate and around 10% survival rate.[2] This outcome is affected by pre-hospital admission factors as well as by the patient's status at admission to the ED such as age, time to return of spontaneous circulation, initial rhythm, and pH among other factors.[3]

OHCA outcomes are also affected by characteristics of the receiving hospital. Treatment at specialized cardiac arrest centers that provide targeted temperature management, diagnostic angiography and percutaneous coronary interventions have been shown to be associated with increased survival.[4,5] In addition, volume-outcome relationship was previously reported in the literature where the volume status is usually related to experience with new technology and faster response. Lower mortality rates were observed in patients admitted post-resuscitation to intensive care units with high patient volumes in the US and in Taiwan.[6,7]

The teaching status of the hospital has also been linked to the quality of care and patient outcome. In Canada, OHCA patients had higher survival rates to day 30 in teaching hospitals compared to non-teaching hospitals.[8] Teaching hospitals in the US have lower mortality rates for common conditions such as pneumonia, heart failure, and acute myocardial

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infarction compared to non-teaching hospitals.[9,10] This is also true for surgical emergencies as in patients undergoing repair for ruptured abdominal aortic aneurysm at teaching hospitals.[11]

The geographical location of the hospital which is mainly considered a prehospital factor for OHCA survival was also previously examined. Literature reveals that surviving OHCA in urban areas is higher than rural areas. Rural areas have low prevalence of automated external defibrillators (AEDs) with slower Emergency Medical Services (EMS) response leading to a delay in initiating CPR and in defibrillation.[12-14]

In 2009, a national analysis was conducted in the US using data from the Nationwide Inpatient Sample (NIS) from 2000 to 2004 to determine hospital factors associated with lower mortality for victims of cardiac arrest. The analysis did not differentiate between in-hospital and out of hospital cardiac arrest. Lower mortality was reported at large teaching urban hospitals.[15]

Understanding factors associated with outcomes of cardiac arrest including hospital teaching status over time is vital for optimal healthcare delivery. The objective of this study is to examine the association between teaching status of hospitals and survival rates of OHCA patients using a national database from the United States. Results of our study will help international policy makers advance the global care of OHCA patients.

MATERIALS & METHODS

Study Design

This retrospective observational study used the Nationwide Emergency Department Sample (NEDS) database of the year 2014 (released in 2016). In the US, this database is the largest ED database which is developed for the Healthcare Cost and Utilization Project (HCUP).[16] Data elements of the NEDS database include demographic characteristics, chronic conditions, injury type, injury severity score, ED and hospital dispositions, total charges for ED and inpatient services, diagnoses, procedures and hospital characteristics. NEDS 2014 database included data on weighted 137,807,901 ED visits, of these 170,251 OHCA patients were identified by selecting those who had a CCS code 107 [the corresponding ICD9-CM codes are: 427.41, 427.42, 427.5] as their first listed diagnosis (i.e., "the diagnosis, condition, problem or other reason for encounter/visit shown in the medical record to be chiefly responsible for the services provided"). Patients excluded from the study were: those whose age ≤ 17 years (N=5,209); those who had one of the following categories of the ED disposition: routine (N=9,541); transfer to short-term hospital (N=6,961); other transfers including skilled nursing facility or intermediate care and another type of facility (N=1,160); home health care (N=55); against medical advice (N=307); not admitted, destination unknown (N=990); discharged alive/ destination unknown (N=1,236). Also, patients who presented to a hospital teaching status classified as "non- metropolitan" were excluded (N=22,998). After applying the exclusion criteria, the study sample included 122,776 patients. (Figure 1).

The study investigators completed the HCUP training course and signed the Nationwide Data Use Agreement. An exemption was obtained from the institutional review board of the American University of Beirut to use the de-identified NEDS database.

Statistical Analysis

SPSS (SPSS Inc., Armonk, NY, USA) was used to perform the data analysis. The mean with the corresponding 95% confidence interval (CI), the median and the interquartile range (IQR) were calculated to summarize patients' age. Frequencies, percentages, and 95% CI were presented to describe the hospital administrative data and patients' demographic and clinical characteristics. Comparison between the two groups of the hospital teaching status (metropolitan non-teaching, metropolitan teaching) and the proportion of the categorical variables was done using the Rao-Scott Chi-Square test, a modified version of the Pearson's Chi-Square test. A general linear model for complex samples was used to compare the mean difference in age between metropolitan non-teaching and metropolitan teaching hospitals. Complex samples logistic regression model was conducted to determine the effect of the hospital teaching status on patients' survival after controlling for all the clinically and statistically significant variables. A p-value of ≤0.05 was used to indicate statistical significance.

Ethical Approval

The study investigators completed the HCUP training course and signed the Nationwide Data Use Agreement. An exemption was obtained from

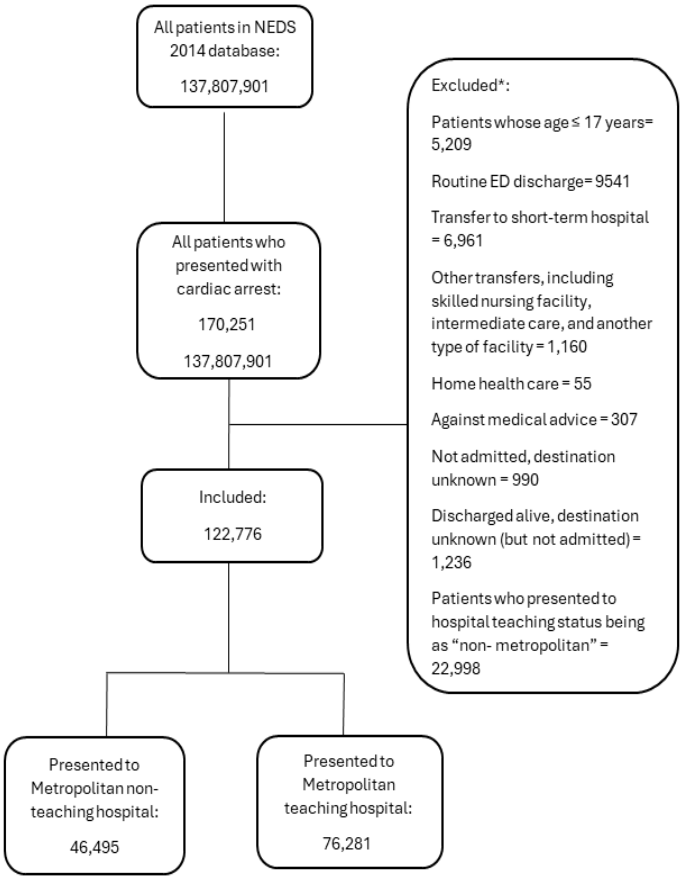

Figure 1 Flowchart of the study sample. Final number on which the data analysis was conducted could not be calculated by subtracting the number of excluded patients from the selected sample as some patients whose age was below 18 years died or were admitted to the hospital.

the institutional review board of the American University of Beirut to use the de-identified NEDS database.

RESULTS

A total of 122,776 patients with out of hospital cardiac arrest were included in this study. The average age of patients was 65.91 (95% CI: 65.73 – 66.10) (Median: 67, IQR: 80 – 55), with males (61.7%; 95%; CI: 61.2 – 62.2) more than females (38.3%; 95% CI: 37.8 – 38.8). Most patients died in the ED (86.7%; 95% CI: 86.4 – 87.1) while few of them (13.3%; 95% CI: 12.9 – 13.6) were admitted to the hospital. Overall, only 6.4% (95% CI: 6.1 – 6.6) of OHCA patients survived to hospital discharge. Around 62.1% (95% CI: 62.1 – 62.1) of OHCA patients were admitted to metropolitan teaching hospitals and 37.9% (95% CI: 37.9 – 37.9) were admitted to metropolitan non-teaching hospitals (Table 1).

All OHCA patients (100.0%) had chronic conditions and all had diseases of the circulatory system (100.0%) across the two hospital groups. The frequency of diseases was significantly higher in OHCA patients treated at teaching hospitals compared to those at non-teaching hospitals including infectious and parasitic diseases; neoplasms; endocrine; nutritional; metabolic diseases; immunity disorders; diseases of blood and blood-forming organs; diseases of the nervous system; diseases of the respiratory system; diseases of the digestive system; diseases of the genitourinary system; diseases of the skin and subcutaneous tissue; diseases of the musculoskeletal system; symptoms, signs, and ill-defined conditions; and injury and poisoning. More patients with major trauma presented to teaching hospitals (0.5%; 95% CI: 0.4 – 0.7) compared to non-teaching (0.2%; 95% CI: 0.2 – 0.3). The survival of OHCA was higher in metropolitan teaching hospitals (7.2%;

Table 1 Baseline demographic characteristics of OHCA patients

	Frequency (N=122776)	Percentage (95%CI)
Sex		
Male	75633	61.7 (61.2 – 62.2)
Female	46990	38.3 (37.8 – 38.8)
Chronic condition indicator	122776	100 (100 – 100)
Infectious and parasitic disease	3641	3.0 (2.8 – 3.2)
Neoplasms	5230	4.3 (4.0 – 4.5)
Endocrine, nutritional, metabolic diseases and immunity disorders	40932	33.3 (32.8 – 33.8)
Diseases of blood and blood-forming organs	8630	7.0 (6.8 – 7.3)
Mental disorders	17768	14.5 (14.1 – 14.9)
Diseases of the nervous system and sense organs	15047	12.3 (11.9 – 12.6)
Diseases of the circulatory system	122776	100 (100 – 100)
Diseases of the respiratory system	26412	21.5 (21.1 – 22.0)
Diseases of the digestive system	10585	8.6 (8.3 – 8.9)
Diseases of the genitourinary system	17335	14.1 (13.8 – 14.5)
Complications of pregnancy, childbirth, and the puerperium	27	0 (0 – 0)
Diseases of the skin and subcutaneous tissue	1085	0.9 (0.8 – 1.0)
Diseases of the musculoskeletal system	6175	5.0 (4.8 – 5.3)
Congenital anomalies	507	0.4 (0.3 – 0.5)
Symptoms, signs, and ill-defined conditions	24215	19.7 (19.3 – 20.1)
Injury and poisoning	9510	7.7 (7.5 – 8.0)
Factors influencing health status and contact with health services	43234	35.2 (34.7 – 35.7)
Teaching status of hospital		
Metropolitan non-teaching	46495	37.9 (37.9 – 37.9)
Metropolitan teaching	76281	62.1 (62.1 – 62.1)
Injury severity score assigned by ICPIC Stata program		
Minor trauma (0 -15)	122150	99.6 (99.5 – 99.6)
Major trauma (16- 75)	521	0.4 (0.4 – 0.5)
Disposition of patient (uniform) from ED		
Admitted as an inpatient to this hospital	16300	13.3 (12.9 – 13.6)
Died in ED	106476	86.7 (86.4 – 87.1)
Disposition of patient (uniform) from hospital		
Routine	3951	24.2 (23.0 – 25.5)
Transfer to short-term hospital	993	6.1 (5.4 – 6.8)
Other transfers, including skilled nursing facility, intermediate care,	1861	11.4 (10.5 – 12.4)
and another type of facility	820	5.0 (4.4 – 5.7)
Home health care	91	0.6 (0.4 – 0.8)
Against medical advice	8482	52.0 (50.6 – 53.5)
Died in hospital	102	0.6 (0.4 – 0.9)
Discharge alive, destination unknown		
Survival Status		
Did not die	7818	6.4 (6.1 – 6.6)
Died in the ED/hospital	114958	93.6 (93.4 – 93.9)

Table 2 Characteristics of OHCA patients by hospital teaching status

	Metropolitan non-teaching		Metropolitan teaching		
	Frequency (N=46495)	**Percentage (95%CI)**	**Frequency (N=76281)**	**Percentage (95%CI)**	**p-value**
Indicator of sex					
Male	28799	61.9 (61.1 – 62.8)	46833	61.5 (60.8 – 62.2)	0.428
Female	17689	38.1 (37.2 – 38.9)	29301	38.5 (37.8 – 39.2)	
Chronic condition indicator	46495	100 (100 – 100)	76281	100 (100 – 100)	-
Infectious and parasitic disease	1126	2.4 (2.2 – 2.7)	2514	3.3 (3.1 – 3.6)	<0.001
Neoplasms	1832	3.9 (3.6 – 4.3)	3398	4.5 (4.2 – 4.7)	0.023
Endocrine, nutritional, and metabolic diseases and immunity disorders	15107	32.5 (31.7 – 33.3)	25825	33.9 (33.2 – 34.5)	0.010
Diseases of blood and blood-forming organs	2777	6.0 (5.6 – 6.4)	5853	7.7 (7.3 – 8.0)	<0.001
Mental disorders	6690	14.4 (13.8 – 15.0)	11077	14.5 (14.0 – 15.0)	0.740
Diseases of the nervous system and sense organs	4794	10.3 (9.8 – 10.8)	10253	13.4 (13.0 – 13.9)	<0.001
Diseases of the circulatory system	46495	100 (100 – 100)	76281	100 (100 – 100)	-
Diseases of the respiratory system	9491	20.4 (19.7 – 21.1)	16920	22.2 (21.6 – 22.8)	<0.001
Diseases of the digestive system	3622	7.8 (7.4 – 8.3)	6962	9.1 (8.7 – 9.5)	<0.001
Diseases of the genitourinary system	5796	12.5 (11.9 – 13.0)	11540	15.1 (14.6 – 15.6)	<0.001
Diseases of the skin and subcutaneous tissue	322	0.7 (0.6 - 0.8)	762	1.0 (0.9 – 1.1)	0.003
Diseases of the musculoskeletal system	2125	4.6 (4.2 – 4.9)	4050	5.3 (5.0 – 5.6)	0.003
Congenital anomalies	152	0.3 (0.2 – 0.5)	356	0.5 (0.4 – 0.6)	0.063
Symptoms, signs, and ill-defined conditions	8473	18.2 (17.6 – 18.9)	15742	20.6 (20.1 – 21.2)	<0.001
Injury and poisoning	2800	6.0 (5.6 – 6.4)	6710	8.8 (8.4 – 9.2)	<0.001
Factors influencing health status and contact with health services	16259	35.0 (34.2 – 35.8)	26975	35.4 (34.7 – 36.0)	0.459
Injury severity score assigned by ICPIC Stata program					
Minor trauma (0 -15)	46363	99.8 (99.7 – 99.8)	75787	99.5 (99.3 – 99.6)	<0.001
Major trauma (16- 75)	108	0.2 (0.2 – 0.3)	413	0.5 (0.4 – 0.7)	
Disposition of patient (uniform) from ED					
Admitted as an inpatient to this hospital	4658	10.0 (9.5 – 10.5)	11642	15.3 (14.8 – 15.8)	<0.001
Died in ED	41837	90.0 (89.5 – 90.5)	64639	84.7 (84.2 – 85.2)	

Table 2 continued

Disposition of patient (uniform) from hospital					
Routine & Home health care	1296	27.8 (25.4 – 30.4)	3474	29.8 (28.2 – 31.5)	
Transfer to short-term hospital & Other transfers, including skilled nursing facility, intermediate care, and another type of facility	933	20.0 (18.0 – 22.2)	1921	16.5 (15.2 – 17.8)	0.037
Against medical advice & Discharge alive, destination unknown	59	1.3 (0.8 – 2.0)	134	1.2 (0.8 – 1.6)	
Died in hospital	2370	50.9 (48.2 – 53.6)	6112	52.5 (50.7 – 54.3)	
Patient underwent a procedure					
No	32471	69.8 (69.1 – 70.6)	50219	65.8 (65.2 – 66.5)	
1	7739	16.6 (16.0 – 17.3)	12264	16.1 (15.6 – 16.6)	<0.001
≥ 2	6285	13.5 (13.0 – 14.1)	13797	18.1 (17.6 – 18.6)	
Diagnosis					
Ventricular fibrillation & ventricular flutter	2920	6.3 (5.9 – 6.7)	7360	9.6 (9.3 -10.1)	<0.001
Cardiac arrest	43575	93.7 (93.3 – 94.1)	68920	90.4 (89.9 – 90.7)	
Died visit					
Did not die	2288	4.9 (4.6 – 5.3)	5529	7.2 (6.9 – 7.6)	<0.001
Died in the ED/hospital	44207	95.1 (94.7 – 95.4)	70751	92.8 (92.4 – 93.1)	

95% CI: 6.9 – 7.6) compared to metropolitan non-teaching (4.9%; 95% CI: 4.6 – 5.3). More hospital admission was observed in metropolitan teaching hospitals (15.3%; 95% CI: 14.8 – 15.8) compared to metropolitan non-teaching hospitals (10.0%, 95% CI: 9.5 – 10.5). OHCA patients presenting to metropolitan teaching hospitals had significantly higher number of procedures done where 18.1% (95% CI: 17.6 – 18.6) of patients underwent two or more procedures compared to metropolitan non-teaching (13.5%; 95% CI: 13.0 – 14.1). Around 29.8% (95% CI: 28.2 – 31.5) of patients who survived in metropolitan teaching hospitals had routine and home health care as hospital disposition compared to 27.8% (95% CI: 25.4 – 30.4) in metropolitan non-teaching (Table 2).

Prior to adjusting for confounders, patients who presented to metropolitan teaching hospitals were more likely to survive compared to those who presented to metropolitan non-teaching hospital (OR= 1.510, 95% CI: 1.373 – 1.660). After adjusting for confounders, survival to hospital discharge was similar between the two hospital groups (OR= 0.909, 95% CI: 0.776 – 1.065) (Table 3).

Understanding the difference of OHCA outcome between hospitals is crucial to understand the value of health care delivery at large teaching institutions. In this retrospective observational study utilizing the NEDS database of the year 2014, more patients were admitted to metropolitan teaching hospitals compared to metropolitan non-teaching hospitals. It was observed that OHCA patients admitted to metropolitan teaching hospitals had more major trauma, and more comorbidities, compared to metropolitan non-teaching hospitals. However, the OHCA patients' survival to hospital discharge was similar between the two hospital groups (metropolitan teaching and metropolitan non-teaching).

The teaching status of the hospital has been studied in different clinical settings.[9,17] Teaching hospitals usually have greater experience and practice evidence-based medicine. They serve as referral centers and hence play critical role in healthcare delivery. Academic EDs where early resuscitative measures take place were shown to be associated with higher survival to admission during the year 2007 in the US.[18] In Japan, patients admitted to a tertiary emergency department (ED) had better neurological outcome at 1 and 3 months.[19] This would have led the EMS to transfer higher risk patients to metropolitan teaching hospitals compared to metropolitan non-teaching hospitals.

A study conducted by C.W. Callaway et al. evaluated OHCA survival according to the receiving hospital characteristic in the US during the period between December 1, 2005 to July 1, 2007.[20] The study found no association between the teaching status of the hospital and the survival to discharge similar to our findings that even included newer database from the year 2014. This indicates that the effect of the teaching status of the hospital on OHCA cases in US didn't improve with time.

Many system level initiatives were however launched in the US to improve the survival of OHCA.[21] The American heart association (AHA) recommends transport of OHCA patients to specialized cardiac arrest centers (CACs) defined as centers that provide evidence-based resuscitation and post-cardiac arrest care as part

Table 3 Crude and adjusted odds ratio of outcome of OHCA patients (survival)

	Crude			Adjusted*		
	OR	**95% CI**	**p-value**	**OR**	**95% CI**	**p-value**
Teaching status of hospital						
(Metropolitan non-teaching) Metropolitan teaching	1.510	1.373 – 1.660	<0.001	0.909	0.776 – 1.065	0.237

Adjusted for: Teaching status of hospital - age – sex - admission day - infectious and parasitic disease – neoplasms - endocrine, nutritional, and metabolic diseases and immunity disorders - diseases of blood and blood-forming organs - mental disorders - diseases of the nervous system and sense organs - diseases of the respiratory system - diseases of the digestive system - diseases of the genitourinary system - diseases of the skin and subcutaneous tissue - diseases of the musculoskeletal system - congenital anomalies - symptoms, signs, and ill-defined conditions - injury and poisoning - factors influencing health status and contact with health services - injury diagnosis reported on records - primary expected payer - patient location: nchs urban-rural code - median household income national quartile for patient zip code -region of hospital - diagnosis (cardiac arrest vs. ventricular fibrillation & ventricular flutter) - procedures (0, 1, ≥2)

of regional systems of care.[4,22] Teaching hospitals also apply novel therapeutic interventions and are hypothesized to be the ideal cardiac arrest centers.[8,23] Thus, the lack of difference in survival between the two hospital types observed in this study may be attributed to other factors. One study reported that residents in teaching institutions do not feel prepared to be cardiac arrest team leaders despite finishing the advanced cardiac life support (ACLS) course.[24] Other unmeasured factors related to training level of involved team members, time of arrest presentation, ED overcrowding at teaching hospitals among others may also be affecting results.

The results of this study however suggest that OHCA patients may be transferred to the nearest metropolitan hospital in the US regardless of teaching status as there was no difference in survival between teaching and non-teaching metropolitan hospitals. More educational interventions such as simulation can be implemented for the residents to improve the survival of the OHCA cases.

LIMITATIONS

Limitations of the study are linked to its retrospective nature. Moreover, patients were identified based on the code of the first diagnosis thus not all eligible patients may have been included in the study due to the possibility of coding difference between hospitals, but the large sample size of our study would overcome this limitation. Patients who were declared dead on the scene were not transported to the ED which may have led to an overestimation in the survival of the OHCA patients. It is also difficult to determine the reason why EMS transferred more OHCA patients the metropolitan teaching hospitals due to the lack of pre-hospital data and difference in EMS protocols across different US regions. Other clinically important variables related to prehospital care aren't included in the NEDS database such as the transport time from scene to the hospital, duration of the arrest, and duration of the cardiopulmonary resuscitation. Finally, we didn't have access to neurologic status of the OHCA survivors, which is an important marker in OHCA survivors. Despite these limitations, NEDS is a large national database with high quality control measures for published data and the study findings are representative of a large proportion of metropolitan US hospitals.

CONCLUSION

OHCA patients admitted to metropolitan teaching hospitals had more major trauma, and more comorbidities compared to metropolitan non-teaching hospitals. However, no difference in the survival to hospital discharge was found between the OHCA patients treated in metropolitan teaching hospitals and those treated in metropolitan non-teaching hospitals. These findings suggest that OHCA patients may be transferred to the nearest hospital regardless of teaching status in US metropolitan areas.

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