Clinical paper

Health care utilization prior to out-of-hospital cardiac arrest: A population-based study

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Abstract

Introduction: Although out-of-hospital cardiac arrest (OHCA) is thought of as a sudden event, recent studies suggest that many patients have symptoms or have sought medical attention prior to their arrest. Our objective was to evaluate patterns of healthcare utilization before OHCA.

Methods: We conducted a population-based cohort study in Ontario, Canada, which included all patients ≥20 years, who suffered out-of-hospital cardiac arrest and transferred to an emergency department (ED) from 2007 to 2018. Measurements included emergency room assessments, hospitalizations and physician visits prior to arrest.

Results: The cohort comprised 38,906 patients, their mean age was 66.5 years, and 32.7% were women. Rates of ED assessments and hospital admissions were relatively constant until 90 days prior to arrest where they markedly increased to the time before arrest. Within 90 days, rates of ED assessment, hospitalization, and primary care physician visit were 29.5%, 16.4%, and 70.1%, respectively. Cardiovascular conditions were diagnosed in 14.4% of ED visits, and 33.7% of hospitalizations in this time period. The largest age-difference was the mental and behavioural disorders within 90 days of OHCA in the ED, where rates were 12.2% among patients <65 years vs. 1.9% for patients ≥65 years.

Conclusions: In contrast to the conventional wisdom that OHCA occurs without prior contacts to the health care system, we found that more than 1 in 4 patients were assessed in the ED prior within 90 days of their arrest. Identification of warning signs of OHCA may allow future development of prevention strategies.

Keywords: Health care utilization, Out-of-hospital cardiac arrest

Introduction

Despite recent improvements in resuscitation care, out-of-hospital cardiac arrests (OHCA) remain a major public health burden because they occur frequently and only about one in 10 patients survive the event.[1–4] Although OHCA is typically considered to be a sudden event that is difficult to predict and without typical warning signs, recent studies suggest that many patients are symptomatic or have sought medical attention in the days to weeks prior to the event.[5,6] Studies on healthcare utilization prior to OHCA have been limited because of the difficulty in capturing reliable data on a large representative cohort. For example, Marijon et al. reported on data from the Oregon Sudden Unexpected Death Study found that about half of 839 patients had symptoms of dyspnea and chest pain occurring within 24 h preceding the arrest.[5] However, it is difficult to know the potential influence of recall biases because testimonies of family members and witnesses were included as data sources. Utilizing population data from Denmark, Weeke et al. evaluated an older OHCA cohort from 2001 to 2005 and found that 18% of patients were admitted to hospital in the month prior to cardiac arrest.[7]

Improved understanding of the signs and symptoms before OHCA has been advocated because this information may help to identify patients at risk, plan proper interventions and even potentially shed light on its pathogenesis.[8,9] Accordingly, the first objective of our study was to evaluate healthcare utilization prior to cardiac arrests by examining rates of emergency department (ED) assessments, hospitalizations, and visits to primary care physicians. Second, we sought to evaluate the diagnoses and reasons for these ED assessments and hospitalizations. To achieve these objectives, we made use of multiple large population-based databases in Ontario, Canada, which afforded a unique opportunity to track all healthcare utilization of OHCA patients in an unbiased fashion within a single payer system.

Methods

Design and data sources

We conducted a retrospective cohort study using multiple large longitudinal population-based databases in Ontario, Canada, as previously described.[3,10–12] Linkage of these databases was performed using unique encoded identifiers and analyzed at the Institute for Clinical Evaluative Sciences (ICES) to protect patient confidentiality. Demographic information of the Ontario population was identified using the Registered Persons Database, which is a registry of all residents who are eligible for the Ontario Health insurance Plan. Cause of death data was obtained by the Registrar General of Ontario Vital Statistics Database, which collects information on date and location of death, and uses death certificates or coroners' report when available to determine etiologies of death. The National Ambulatory Care Reporting System database, which contains information regarding emergency department visits, was used to identify patients transported to the emergency department after OHCA. The Canadian Institute for Health Information (CIHI) Discharge Abstract Database was used to identify comorbidities, and medical and surgical procedures. The Ontario Health Insurance Plan physician claims database, which captures information on services provided by physicians in Ontario, was used to identify outpatient physician visits.

Study sample

Our study sample included patients who had OHCA and were transported to an Ontario ED from April 1, 2007 to March 31, 2018. Patients who had an invalid health card number, or missing demographic information were excluded. We also excluded patients who had metastatic cancers, had been evaluated by palliative care physicians, or resided in long-term care facilities. These patients were excluded because they had competing reasons for healthcare utilization and our objective was to study patients who suffered unexpected cardiac arrests that could potentially be preventable. We used a previously validated algorithm to determine patients with OHCA using the International Classification of Disease, Tenth Revision, codes associated with cardiac arrest (I460, I461, I469, I4900, I4901, R960, R961, R98, and R99) and the Canadian Classification of Health Interventions codes for cardiopulmonary resuscitation (1HZ30JN and 1HZ30JY).[3]

Primary outcomes

Our primary outcomes were rates of ED assessments, hospitalizations, and visits to primary care physicians prior to cardiac arrest. Secondary outcomes included diagnoses for the ED assessments and hospitalizations.

Statistical analysis

Descriptive statistics were used to report on the baseline characteristics of the OHCA patients included in the study cohort. We evaluated healthcare utilization in the year prior to OHCA to get a longer term perspective and to identify potential changes in utilization patterns prior to the arrest. Rates of healthcare visits were categorized by time intervals (1–90 days, 91–180 days, 181–270 days, and 271–360 days) prior to arrest for display purposes. To evaluate trends in healthcare visits prior to cardiac arrest, we plotted the weekly rates of ED assessments and hospitalizations from 1 year to the time before cardiac arrest to qualitatively assess the pattern. We also compared baseline clinical characteristics between patients evaluated in the ED vs. no evaluation, hospitalized vs. no hospitalization in the 90 days before OHCA. Chi-squared tests were used to compare categorical variables and one-way ANOVA was used to compare continuous variables.

We determined the reasons of ED presentation and hospitalization for each OHCA patient by grouping them into (a) disease categories and (b) specific causes. We employed two methods for categorizations because the reasons for presentation and hospitalization were very heterogeneous. Disease categories were classified using the International Classification Disease, 10th revision chapters, and leading disease causes were identified by a method developed by Becker et al. to classify leading causes of death around the world.[13]

Our main analyses were performed using the entire cohort. In additional, we repeated these analyses in prespecified subgroups according to age groups (<65 years and ≥65 years) to potentially generate additional insights.

Statistical significance was established with a 2-sided p value of <0.05. All analyses were performed using SAS 9.1.3 software (SAS Institute Inc., Cary, NC). The use of data in this project was authorized under section 45 of Ontario's Personal Health Information Protection Act, which does not require review by a Research Ethics Board.

Results

Study sample

There were 43,792 patients who suffered OHCA and had valid health card information during the study period and presented to an Ontario ED from April 1 2007 to March 31 2018. After excluding 1553 patients who were younger than 20 years old, and 3353 patients who had cardiac arrest in long term care facilities, metastatic cancer or palliative care, our final study cohort included 38,906 patients (Supplementary Appendix Fig. 1).

Baseline characteristics of OHCA patients

Table 1 shows the baseline characteristics of OHCA patients. The mean age of the study cohort was 66 years old, 32.7% were women, 35.5% had diabetes, 26.9% had prior heart failure hospitalization and 11.5% had prior myocardial infarction.

ED assessments prior to OHCA

Table 2 and Fig. 1 show the overall pattern of ED assessment in the year prior to cardiac arrest, and stratified by patients older and younger

than 65 years old. The weekly rate of ED visits was relatively consistent at approximately 2% from one year until 90 days prior OHCA. Within 90 days, there was a substantial rise in ED visits peaking to almost 7% in the week prior to arrest. A similar increasing pattern was observed in patients in the two age groups.

As shown in Table 2, 29.5% of all patients had an ED assessment in the 90 days prior to OHCA; 32.0% for patients $\geq$65 years old, and 26.0% for patients <65 years. Patients who had ED assessment within 90 days were older (68.0 vs. 65.8 years old, p < 0.001), had significantly more cardiac risk factors, prior cardiac procedures, and medical comorbidities (Supplementary Appendix Table 1).

Table 3 shows the leading cause of disease categorization and specific causes of ED visits. Among the 11,459 patients who presented to the ED within 90 days of OHCA, their top 5 diagnostic categories were non-defined (23.6%), disease of the circulatory system (14.4%), disease of the respiratory system (12.0%), injury or poisoning (10.7%), and mental and behavioral disorders (6.1%) In terms of specific identifiable causes according to the Becker's algorithm, the majority were ill defined (23.6%), and the top causes were heart failure (6.0%), and lower respiratory disease (5.9%) (Table 3).

We observed a large age difference in the ED diagnostic category and specific cause in mental and behavioral disorders. In the 90 days of OHCA in the ED, rates of diagnosis of mental and behavioral disorders were 12.2% among patients <65 years vs. 1.9% for patients

Table 1 – Baseline characteristics of the study cohort.	
Patient characteristics	N = 38,906
Age (mean ± SD), years	66.49 ± 16.26
Female	12,733 (32.7%)
Cardiac risk factors and cardiac conditions	
Dyslipidemia	12,546 (32.2%)
Hypertension	25,376 (65.2%)
Diabetes	13,805 (35.5%)
Prior myocardial infarction	4475 (11.5%)
Prior heart failure hospitalization	10,480 (26.9%)
Atrial fibrillation	4601 (11.8%)
Ventricular arrhythmia	625 (1.6%)
Prior cardiac procedures or investigations within the past 5 years	
Cardiac catheterization	5256 (13.5%)
PCI	1823 (4.7%)
CABG	727 (1.9%)
Permanent pacemaker	888 (2.3%)
ICD	523 (1.3%)
Stress test	10,357 (26.6%)
Echocardiography or radionuclide angiography	19,403 (49.9%)
Medical comorbidities	
Peripheral vascular disease	1917 (4.9%)
Cerebrovascular disease	2004 (5.2%)
Renal disease	2782 (7.2%)
Dialysis	1282 (3.3%)
Respiratory disease	4311 (11.1%)
Peptic ulcer disease	825 (2.1%)
History of cancer	2221 (5.7%)
Anemia or blood disease	3919 (10.1%)
Charlson comorbidity index (mean ± SD)	1.23 ± 1.85

Abbreviations: SD standard deviation; PCI percutaneous coronary intervention; CABG coronary artery bypass artery grafting; ICD implantable cardioverter defibrillator.

Table 2 – Summary of health utilization prior to OHCA.

	N	Time frame prior to OHCA							
		1–90 days		91–180 days		181–270 days		271–360 days	
		N	%	N	%	N	%	N	%
All patients	38,906								
ED visits		11,459	29.5%	7805	20.1%	6869	17.7%	6413	16.5%
Hospitalization		6400	16.4%	3775	9.7%	3138	8.1%	2828	7.3%
Family physician visits		27,265	70.1%	25,873	66.5%	25,494	65.5%	25,285	65.0%
<65 years old	16,448								
ED visits		4275	26.0%	3163	19.2%	2921	17.8%	2698	16.4%
Hospitalization		1992	12.1%	1312	8.0%	1128	6.9%	958	5.8%
Family physician visits		9829	59.8%	9315	56.6%	9126	55.5%	8979	54.6%
≥65 years old	22,458								
ED visits		7184	32.0%	4642	20.7%	3948	17.6%	3715	16.5%
Hospitalization		4408	19.6%	2463	11.0%	2010	9.0%	1870	8.3%
Family physician visits		17,436	77.6%	16,558	73.7%	16,368	72.9%	16,306	72.6%

Abbreviations: ED, emergency department; OHCA, out of hospital cardiac arrest.
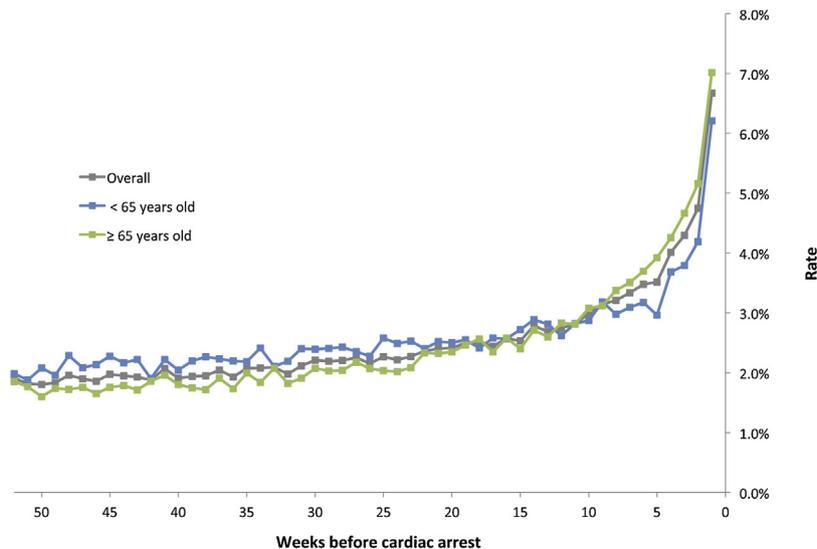
Fig. 1 – Rates of emergency department visits before OHCA. Pattern of emergency department assessment in the year prior to cardiac arrest. Y axis shows the rate of emergency department visits among OHCA patients and x axis shows the time (in weeks) from the day of the arrest and back to one year prior to the arrest.

older than 65 years of age. Similarly, 7.9% of patients <65 years were identified as having a specific cause of mental and behavioural disorders due to psychoactive substance use, as compared to only 0.4% in older patients.

Hospital admissions prior to OHCA

Similar to the pattern of ED assessments, rates of hospitalization were consistently low until about 90 days prior to cardiac arrest, increasing to over 3% in the week prior the arrest (Fig. 2). Overall, 16.4% of patients were admitted within 90 days prior OHCA; 19.6% for patients ≥65 years, and 12.1% for patients <65 years old (Table 2). Older patients with cardiac comorbidities and medical comorbidities were

significantly more likely to be hospitalized within 90 days (Supplementary Appendix Table 2).

The diagnoses for the 6400 OHCA patients who were hospitalized within 90 days of the event are shown in Table 4. We also observed a heterogeneous pattern of hospitalization in which the most common diagnosis for hospitalization was disease of the circulatory system (33.7%) followed by disease of the respiratory system (16.1%), digestive system (7.5%). Patients ≥65 years had substantially higher rates of admission for circulatory reasons as compared to patients <65 years (36.9% vs. 27.0%). In contrast, patients <65 years were more likely to be admitted for injury or poisoning (8.2% vs. 5.9%) compared with patients ≥65 years. The leading causes of admission were heart failure, ischemic heart disease, and chronic lower respiratory disease, as shown in Table 4.

Table 3 – Leading causes of ED visits up to 90 days prior to OHCA.

	Overall cohort		<65 years old		≥65 years old	
	Visits	%	Visits	%	Visits	%
Diagnostic categories of ED visits[a]						
Symptoms, signs and abnormal clinical and laboratory findings or not elsewhere classified	4902	23.6%	1815	21.4%	3087	25.1%
Diseases of the circulatory system	2998	14.4%	771	9.1%	2227	18.1%
Diseases of the respiratory system	2487	12.0%	848	10.0%	1639	13.3%
Injury, poisoning and certain other consequences of external causes	2220	10.7%	1043	12.3%	1177	9.6%
Mental and behavioural disorders	1262	6.1%	1032	12.2%	230	1.9%
Diseases of the digestive system	1179	5.7%	485	5.7%	694	5.6%
Factors influencing health status and contact with health services	1110	5.3%	543	6.4%	567	4.6%
Diseases of the musculoskeletal system and connective tissue	860	4.1%	409	4.8%	451	3.7%
Diseases of the genitourinary system	845	4.1%	244	2.9%	601	4.9%
Endocrine nutritional and metabolic diseases	791	3.8%	356	4.2%	435	3.5%
Specific cause of ED visits[a]						
Remainder	6954	33.5%	3226	38.1%	3728	30.3%
Symptoms signs and ill-defined conditions	4902	23.6%	1815	21.4%	3087	25.1%
Heart failure & complications and ill-defined heart disease	1237	6.0%	223	2.6%	1014	8.3%
Chronic lower respiratory diseases	1229	5.9%	407	4.8%	822	6.7%
Diseases of musculoskeletal and connective tissue	860	4.1%	409	4.8%	451	3.7%
Diseases of urinary system	755	3.6%	205	2.4%	550	4.5%
Mental and behavioural disorders due to psychoactive substance use	720	3.5%	669	7.9%	51	0.4%
Ischemic heart disease	671	3.2%	201	2.4%	470	3.8%
Influenza and pneumonia	629	3.0%	205	2.4%	424	3.5%
Diabetes	450	2.2%	206	2.4%	244	2.0%
Cardiac arrhythmias	412	2.0%	109	1.3%	303	2.5%

[a] Diagnostic categories of ED visits were grouped using the International Classification Disease, 10th revision chapters. Specific causes of ED visits were grouped by a method developed by Becker to group diagnoses into specific cause of death.
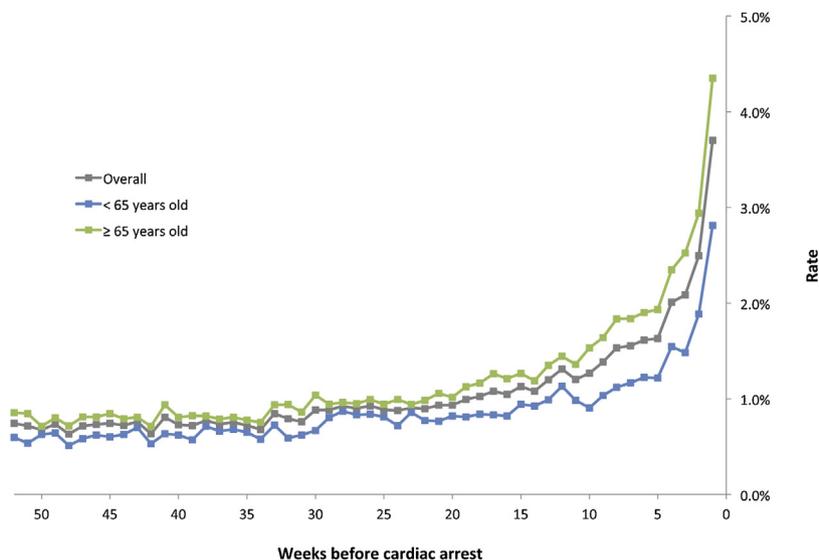
Fig. 2 – Rates of hospitalization before OHCA. Pattern of hospitalizations in the year prior to cardiac arrest. Y axis shows the rate of hospitalizations among OHCA patients and x axis shows the time (in weeks) from the day of the arrest and back to one year prior to the arrest.

Physician visits prior to OHCA

Almost all patients (93.2%) in our study cohort had at least one physician visit in the year prior to OHCA. Much smaller increases in primary care physician visits were observed within 90 days. In the 90 days prior to OHCA, 70.1% had visited a primary care physician, as compared to 66.5% from 91 to 180 days, 65.5% from 181 to 270 days, and 65% from 271 to 360 days (Table 2).

Table 4 – Leading causes of hospitalization prior to OHCA in overall cohort.

	Overall cohort		<65 years old		≥65 years old	
	Visits	%	Visits	%	Visits	%
Diagnostic categories of hospitalizations[a]						
Diseases of the circulatory system	3064	33.7%	797	27.0%	2267	36.9%
Diseases of the respiratory system	1465	16.1%	431	14.6%	1034	16.8%
Diseases of the digestive system	685	7.5%	276	9.4%	409	6.7%
Symptoms signs and abnormal clinical and laboratory findings or not elsewhere classified	671	7.4%	200	6.8%	471	7.7%
Injury poisoning and certain other consequences of external causes	603	6.6%	243	8.2%	360	5.9%
Endocrine nutritional and metabolic diseases	457	5.0%	221	7.5%	236	3.8%
Diseases of the genitourinary system	448	4.9%	113	3.8%	335	5.4%
Neoplasms	358	3.9%	112	3.8%	246	4.0%
Certain infectious and parasitic diseases	272	3.0%	113	3.8%	159	2.6%
Mental and behavioural disorders	182	2.0%	94	3.2%	88	1.4%
Specific cause of hospitalizations[a]						
Remainder	2226	24.5%	824	28.0%	1402	22.8%
Ischemic heart disease	1103	12.1%	320	10.9%	783	12.7%
Heart failure and complications and ill-defined heart disease	1098	12.1%	223	7.6%	875	14.2%
Chronic lower respiratory diseases	722	7.9%	185	6.3%	537	8.7%
Symptoms signs and ill-defined conditions	671	7.4%	200	6.8%	471	7.7%
Diseases of urinary system	410	4.5%	105	3.6%	305	5.0%
Influenza and pneumonia	304	3.3%	88	3.0%	216	3.5%
Diabetes	289	3.2%	153	5.2%	136	2.2%
Cardiac arrhythmias	280	3.1%	69	2.3%	211	3.4%
Diseases of musculoskeletal and connective tissue	225	2.5%	84	2.9%	141	2.3%
Cerebrovascular diseases	134	1.5%	27	0.9%	107	1.7%

[a] Diagnostic categories of hospitalizations were grouped using the International Classification Disease, 10th revision chapters. Specific causes of hospitalizations were grouped by a method developed by Becker to group diagnoses into specific cause of death.

Cardiac interventions and outcomes

Among the 12,234 patients that were evaluated at the ED or hospitalized during 90 days prior the arrest, 3391 (27.7%) had a cardiac catheterization, 1556 (12.7%) had coronary revascularization by PCI and 202 (1.7%) by CABG. A pacemaker or an AICD implanted in 469 (3.8%) and 689 (5.6%) patients respectively. Only 84 patients (0.7%) had undergone a stress test, and 6161 (50.4%) had an echocardiography.

Mortality rates of the cohort were high: 26,456 patients (68.0%) died at the day of the arrest, and 30-day mortality rate reached 87.2%. Mortality rates at 30-days were slightly higher among patients who were evaluated in the ED within 90 days compared with patients that were not evaluated at the ED (89.7% vs. 86.1%, $p < 0.01$). Similar pattern was observed in patients that were hospitalized within 90 days prior the arrest compared with patients that were not (89.9% vs. 86.6% for 30 days mortality, $p < 0.01$). These patterns might be explained by the different baseline characteristics of patients who utilized health care prior the arrest. These patients were older and had more medical comorbidities (Supplementary Appendix Tables 1 and 2).

Conclusions

In this population-based study, we were able to evaluate healthcare utilization for all OHCA patients in a comprehensive and unbiased fashion because of the availability of longitudinal data within a single healthcare system. In contrast to the conventional wisdom that cardiac arrests most often occur in patients without contacts to the health care system, we found that a substantial proportion of patients were evaluated by physicians, or were assessed at the EDs or hospitals prior to their arrest, presumably because these patients had new or ongoing symptoms which prompted seeking care. We also found that the reasons for presentations varied widely, and non-cardiac diagnoses were responsible for the majority of the visits to EDs or hospitals prior to cardiac arrest. Furthermore, we found substantial difference in rate of mental/behavioral illness/substance abuse according to age prior to arrest, suggesting reasons causing OHCA vary significantly by age.

A small but emerging literature suggests that many OHCA patients may be symptomatic prior to the event.[5–7] The Oregon Sudden Unexpected Death Study assembled a cohort of 839 OHCA patients aged 35–65 years found that about half of all patients had clinical symptoms (mostly chest pain and dyspnea) within four weeks of arrest.[5] In addition, more than 90% of patients who were initially symptomatic had recurrence of symptoms within one day of the arrest.[5] Using the Denmark nationwide data, Weeke et al. examined 12,089 patients who had OHCA from 2001 to 2005 and found that approximately one in five patients were hospitalized in the month prior to arrest.[7] Interestingly, they found that cardiac-related admissions were responsible for two thirds of all admissions prior to cardiac arrests. We were able to assemble one of the largest cohorts to date to extend prior findings in this area. We found that only 28.1% of hospitalizations were cardiac in origin. These differences may be related to the changes in cardiac arrest epidemiology with the majority of patients now suffering from non-shockable cardiac arrest. In addition, significant reductions in acute coronary syndrome admissions and improvement in mortality rates due to improvement in cardiac treatment have been observed in recent decades.[14–16]

Understanding how to stratify patients at risk for cardiac arrest and implement prevention strategies before they occur may lead to a reduction in the burden of cardiac arrest. For example, in patients with

left ventricular dysfunction, assessing risk of ventricular arrhythmia and implementing implantable cardioverter defibrillator for appropriate candidates has been shown to significantly improve survival.[17] In our cohort of OHCA, however, we found that only 11.5% of patients had a prior myocardial infarction and 26.9% had a history of heart failure. In addition, patients assessed in EDs and hospitals had heterogeneous diagnoses that were mostly non-cardiac in nature. These findings suggest that traditional evaluation and treatment for detection of ventricular arrhythmia would likely have a small impact on cardiac arrest prevention. Additional research is needed to identify predictive factors associated with cardiac arrests.

We performed a subgroup analysis by the median age of our cohort to evaluate whether reasons for ED visits and hospitalizations differ by age groups. Interestingly, we found that visits related to cardiac reasons were uncommon among younger patients, while one-quarter of patients who were treated in the ED had mental related conditions or substance abuse prior to arrest. Data from nationwide survey in Denmark suggest that the cause of death is unexplained in 31% of patients younger than 50 years old.[18] Notably, in 37% of the unexplained death of patients age 35 or less, positive toxicology was detected.[19] Findings from Australian forensic medicine facility suggest that non-cardiac reasons are the cause of 40% of sudden deaths in patients <35 years old.[20] Our group used medical and coroner records found that only 30% of patients younger than 45 years who suffered OHCA had a confirmed cardiac etiology.[21] Our findings may imply that strategies for prevention of sudden death in the younger populations should include multidisciplinary strategies with a specific attention for patients with mental disorder and substance abuse. Further insights for predictors of OHCA could be obtained by comparing health utilization patterns in patients who have not experienced OHCA.

Several potential limitations of this study merit consideration. First, we assessed healthcare utilization by estimating rates of physician and hospital visits. However, these observed rates were likely an underestimation of the actual number of patients suffering from symptoms and requiring care prior to OHCA because many patients may not have come to the attention of the healthcare system. Second, although we were able to capture the diagnoses of why patients were evaluated in the EDs or hospitalized, we did not have data on their symptoms or physiological measures in this large cohort. Third, we conducted this study in Ontario, Canada, where all patients had access to medical services at no direct cost. Healthcare utilizations prior to cardiac arrest will also be highly dependent on the proportion of patients with access to health care in other countries. Fourth, we did not have data on utstein variables like initial rhythm at presentation. To address this issue, we presented our analyses in pre-specified subgroups according to the median age of our cohort (<65 years and ≥65 years) because it has been previously shown the most remarkable difference between patients with non-shockable and shockable rhythms was their age. Patients who presented with shockable rhythm are significantly younger compared with patients with non-shockable rhythm.[22] Finally, our cohort did not include patients who were not transferred to the ED because of the lack of data. The majority of these patients who satisfied termination of resuscitation were patients who had "do not resuscitation" orders, terminal illness, or futile resuscitations.[23]

In summary, we found that a substantial proportion of patients had health services utilization within 90 days of the event. Identification of factors associated with cardiac arrest in this time period may allow future development of prevention strategies.

Conflicts of interest

None.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.resuscitation.2019.04.033.

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