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Epidemiology and outcomes of out-of-hospital cardiac arrest in Rochester, New York[☆]

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Summary
Objective: To characterize out-of-hospital cardiac arrest (OHCA) and factors that affect survival in a medium sized city that uses system status management for dispatch.
Methods: A retrospective cohort study of all adult OHCA patients treated by EMS between 1998 and 2001 was conducted using Utstein definitions. The primary end-point was 1-year survival.
Results: Of the 1177 patients who experienced OHCA during the study period, 539 (46%) met inclusion criteria. Age ranged from 18 to 98 years (median 67). The median call-response interval was 5 min (range 0—21), and 93% were 9 min or less. There was no significant difference in the median call-response intervals between call location zip (Post) codes ($p = 0.07$). Twenty percent of experienced ROSC (95% CI 17—23), 7% survived more than 30 days (95% CI 5—9%), and 5% survived to 1 year (95% CI 3—7%). In bivariate analysis, first rhythm and bystander CPR affected survival to 1 year. There was no significant difference in survival between male (4%) and female (7%), black (4%) and white (6%), or witnessed (7%) and unwitnessed arrest (4%). Logistic regression identified younger age, CPR initiated by bystander (19%) or first responder (41%), and presenting rhythm of VF/VT (32%) as factors associated with survival to 1 year.

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Conclusions: This study finds a 5% survival to 1 year among OHCA patients in Rochester, NY. A presenting rhythm of VF/VT and bystander CPR were associated with increased survival.

Introduction

Heart disease is the leading cause of mortality in the United States,[1] and death from heart disease most frequently presents as sudden death outside of the hospital, or out-of-hospital cardiac arrest (OHCA).[2] Many factors have been shown to influence OHCA survival, including demographic, clinical, and treatment factors, and attempts have been made to modify those factors that are modifiable. One factor shown to influence survival in multiple studies has been the call-response interval for emergency medical services (EMS).[3–6]

System status management (SSM) is a dynamic dispatch system commonly used in EMS.[7] SSM uses historical data to predict future requests for EMS responses. EMS dispatchers use this information to locate ambulances strategically throughout a service area. Theoretically, use of this system will result in approximately equal and more rapid call-response intervals throughout a service area.[8] To our knowledge, no study has described the epidemiology of OHCA in an EMS system that uses system status management exclusively.

This study describes the epidemiology and outcome of patients suffering from OHCA in Rochester, New York, a medium sized city with an EMS system that utilizes SSM. It also evaluates predictors of OHCA resuscitation and survival.

Materials and methods

Research design

A retrospective cohort study of all adult patients (18 and older) experiencing OHCA between 1 January 1998 and 31 December 2001 was conducted in Rochester, New York. The University of Rochester Research Subjects Review Board approved this study, and consent was waived. The Utstein recommendations and definitions were followed for data collection, analysis and reporting to allow comparison of our findings with other systems.[9–11]

Setting

The city of Rochester has a population of 220,000 and spans 36 square miles. The 2000 census described the city's residents as 52% female, 48% white, 38% black, and with a median age of 31. Twenty-seven percent have not completed high school, 45% have only a high school degree, and 28% have a college degree. Twenty-three percent of the population lives below the poverty level.[12]

The City of Rochester is served by a single, government-operated, public safety answering point. The City is also served by a single EMS agency that staffs each ambulance with two New York State certified emergency medical technicians, at least one of which is certified at the advanced EMT level (paramedic or critical care technician). EMS responds to approximately 50,000 calls per year in Rochester.

Residents of Rochester, NY access the public safety answering point by dialing 911. As soon as the call-taker identifies that the patient is requesting medical assistance, the call-taker uses the Medical Priority Dispatch System (Priority Dispatch Corporation,™ Salt Lake City, UT) to categorize the request for assistance and determine which resources to send to the patient.[13] City Fire Department units are sent to assist on all calls coded as potentially life-threatening by the dispatch system. Fire department units are located in traditional geographically fixed stations throughout the city and are staffed by personnel who are capable of performing cardiopulmonary resuscitation (CPR) and are equipped with automatic external defibrillators.

Patient information is transmitted electronically from the 911 center to the EMS agency dispatchers who initiate a response. The closest available crew is selected to respond from the ambulances which are staged dynamically depending on how many crews are available at the time the call is received. Time of call, defined as the time the call-taker receives the initial 911 call, is recorded electronically by the 911 center. The arrival time, defined as the time the crew reports to the dispatcher via radio that their vehicle has arrived at the call location, is recorded by the agency. 911 center and agency dispatch center times are synchronized for consistency. These times are applied consistently and recorded on the patient care report. The call-response interval was defined as the interval from time of call to arrival time.

Research methods

Cases were identified using a state-mandated, EMS agency-maintained list of all OHCA cases. The list includes the agency run number, patient name, age, gender, incident date, and incident location.

EMS medical records were obtained and data were abstracted by a research assistant (KI) using standardized abstraction forms. Standard chart review methods were followed to improve accuracy and reduce inconsistencies in abstraction.[14] The first 6 months of cases were also abstracted independently by a physician investigator (RJF), and inconsistencies were identified and discussed to resolution. From this, a codebook and abstraction rules were created to ensure consistency. During abstraction of the remaining cases, any ambiguous records were brought to biweekly research team meetings and coding rules and definitions were reviewed. Cases that were unclear were resolved by group consensus (RJF, MNS, KI).

Patients with no resuscitation attempt (either dead on arrival or do not attempt resuscitation), less than 18 years old, arrest witnessed by EMS, and arrest from non-cardiac etiology were excluded from the analysis. Non-cardiac etiology cases were defined as those which, in the reviewer's judgment, had a clearly documented traumatic, toxicological, or respiratory cause (except CHF). Ambiguous causes were assumed to be cardiac.

Survival data were obtained using the county medical examiner records and the Social Security Death Index database (SSDI).[15,16] Medical examiner and SSDI records were searched at least 1 year after enrollment of the last patient, and the SSDI was searched for a second time in 2004, 3—7 years after the OHCA event date. In addition, hospital medical records were accessed if missing demographic data prevented identification of the subject using the SSDI. Survival was assumed if a patient with complete identifying data, including name, date of birth, and social security number, was absent from the medical examiner database and the SSDI. The SSDI was searched manually and independently for all of these cases by four of the investigators (RJF, MNS, KI, ECP) using different permutations and the soundex function in order to reduce the chance that a patient was missed due to errors in the spelling of names, social security number, or date of birth.

Additional demographic data were obtained from the 2000 Census by using the patient's home address to determine their census block group. The information obtained for the patients block group included: (1) median household income, (2) educational attainment for individuals 25 years of age and older and (3) percent unemployment within the civilian workforce. Abstraction, census, and outcome data were entered into a Microsoft Access database (Redmond, WA).

Three outcome measures were used: (1) return of spontaneous circulation (ROSC), defined as transient or sustained return of pulses and organized rhythm before reaching the emergency department, (2) 30-day survival, and (3) 1 year survival. Survival to 1 year was the primary end point.

Data analysis

The population of patients experiencing OHCA was characterized using standard descriptive statistics. Call-response intervals were analyzed and characterized by median, range, and percent over preestablished thresholds. This analyses were performed using Microsoft Excel (Redmond, WA) and Stata 7.0 (College Station, TX).

Survival rate at 1 year was compared by presenting rhythm, call-response interval, and patient demographics (race, age, and gender). Bivariate analysis was conducted to investigate which variables were independent predictors of OHCA survival. During each individual analysis, cases were excluded if the variable was unknown.

Multivariate analysis was conducted using logistic regression to identify predictors associated with survival to 1 year. Variables were entered into the regression model if they demonstrated moderately significant bivariate associations (defined as $p < 0.20$) or there was previous literature or clinical relevance to support its inclusion. Variables identified a priori for entrance into the regression model included age, sex, race, witnessed arrest, presence of bystander CPR, initial rhythm, and call-response interval of 9 min or less. Cases were excluded from the regression analysis if any of these variables was unknown.

Results

A total of 1177 patients experienced OHCA during the study period. Five hundred and thirty-nine (46%) patients met inclusion criteria. Patient age ranged from 18 to 98 years (median 67). Figure 1 shows the distribution of OHCA inclusions and exclusions according to the Utstein template. The demographic characteristics are reported in Table 1. Social security number was not available for seven patients (1%) and there was no known date of death from other sources (medical examiner or hospital medical record data) so these seven patients were excluded prior to all analyses involving outcomes since there was insufficient information to assume

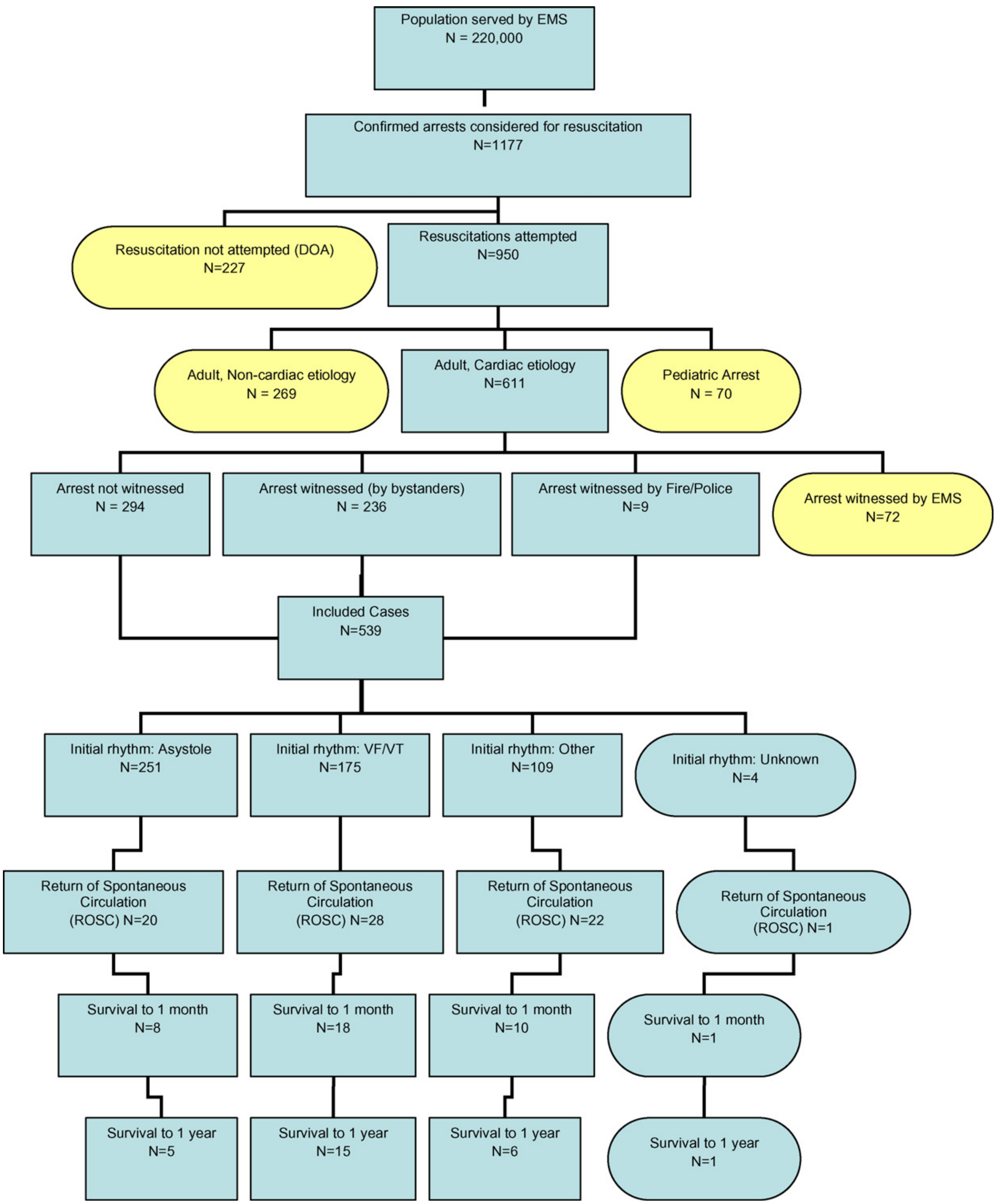

Figure 1 Distribution of OHCA types.

survival. However, a sensitivity analysis was performed and showed that there would be no effect on the results if all these individuals were assumed to have survived.

Definitive death data were available from the medical record, medical examiner, or SSDI in all but 10 patients (2%), and since complete identification data were available for these 10 patients, their absence from these databases was considered sufficient evidence to assume survival. Overall survival data are shown in Table 2, and survival by characteristic for this group is reported in Table 3. For each of these individual analyses, the small amount of cases in which the characteristics were

Table 1 Demographic characteristics of included cases

		95% confidence interval
Age (median, range)	67 (18—98)	
Gender (female)	219 (41%)	36—45%
Race		
White	274 (51%)	47—55%
Black	190 (35%)	31—39%
Other	28 (5%)	3—7%
Unknown race	47 (9%)	6—11%
Witnessed arrest		
Not witnessed	286 (53%)	49—57%
Fire	9 (2%)	1—3%
Bystander	236 (44%)	40—48%
Unknown	8 (1%)	1—3%
CPR started by		
EMS	212 (39%)	25—44%
Fire/police	219 (41%)	36—45%
Bystander	105 (19%)	16—23%
Unknown	3 (1%)	0—2%
First defibrillation performed by		
EMS	202 (37%)	33—42%
Fire	43 (8%)	6—11%
Bystander	1 (0%)	0—1%
Unknown	3 (1%)	0—2%
Not defibrillated	290 (54%)	49—58%
First rhythm		
Asystole	251 (47%)	42—51%
VF/VT	175 (32%)	29—37%
Other	109 (20%)	17—34%
Unknown	4 (1%)	0—2%
Call-response interval		
7 min or less	451 (84%)	80—87%
8 min or less	478 (89%)	86—91%
9 min or less	501 (93%)	90—95%

unavailable in the chart were excluded. Whites had a higher ROSC rate than blacks (23% versus 15%, $p = 0.028$), but a lower rate of VF/VT as presenting rhythm (29% versus 35%, $p = 0.038$). However, there was no difference in survival to 1 year between whites and blacks (6% versus 4%, $p = 0.67$).

The median call-response interval was 5 min (range 0—21), and 93% of calls had a call-response interval of 9 min or less. There was no significant difference in the median call-response intervals between call location zip codes ($p = 0.07$). There was no difference in median response times between blacks and whites (both 5 min).

The 2000 census describes the city's residents as 52% female, but only 41% of OHCA cases were female. Thirty-eight of city residents are black, and 35% of OHCA cases were black, and 48% of residents are white, while 51% of cases were white.

Table 2 Survival data

Survival	*N*	Percent	CI
ROSC	107	20	95% CI 17—23%
Died within 30 days	495	92	95% CI 89—94%
Alive at 30 days	37	7	95% CI 5—9%
Alive at 1 year	27	5	95% CI 3—7%
Incomplete survival data	7	1	95% CI 1—3%

Table 3 One-year survival by characteristic

	<1-year survival	1-year survival	p (χ^2) (significant)*
Gender ($n = 539$)			
Male	307	13 (4%)	0.223
Female	205	14 (7%)	
Race ($n = 492$)			
White	258	16 (6%)	0.670
Black	182	8 (4%)	
Other	26	2 (8%)	
Witnessed arrest ($n = 531$)			
Not witnessed	275	11 (4%)	0.329
Fire/police	9	0 (0%)	
Bystander	221	15 (7%)	
CPR started by ($n = 536$)			
EMS	207	5 (2%)	0.045*
Fire/police	207	12 (6%)	
Bystander	96	9 (9%)	
First defibrillation by ($n = 536$)			
EMS	187	15 (8%)	0.064
Fire	39	4 (10%)	
Bystander	1	0 (0%)	
Not defibrillated	282	8 (3%)	
First rhythm ($n = 535$)			
Asystole	246	5 (2%)	0.008*
VF/VT	160	15 (9%)	
Other	103	6 (6%)	
Age ($n = 539$)			
Age (median)	67	64	Rank sum $p = 0.053$ (median $p = 0.447$)
Call-response interval ($n = 539$)			
9 min or less	501	25 (5%)	0.242
Greater than 9 min	38	2 (5%)	
Demographics ($n = 539$)			
Median income	25726	26155	0.68 (rank sum)
% finished HS	29% (mean)	31% (mean)	0.557 (t-test)
% unemployed	5% (mean)	4% (mean)	0.393 (t-test)

Note: Cases were excluded within each analysis if the information for that category could not be obtained.
* Statistical significance ($p < 0.05$).

Logistic regression results are reported in Table 4. The following variables were significantly associated with survival to 1 year: younger age, CPR started prior to EMS arrival, and VF/VT as presenting rhythm. The provider of initial defibrillation was excluded because it correlated strongly with the patient's initial cardiac rhythm.

Discussion

We found an overall 5% survival at 1 year for OHCA patients in the medium-sized city of Rochester, NY, with a 9% survival among patients presenting with ventricular fibrillation, and a 9% survival among patients who received bystander CPR. With the notable exception of data from King County, Washington, this rate is comparable to or higher than most American cities with published data (see Table 5). Assuming that survival to 1 year is comparable to survival to discharge, two locations in the US that have reported a higher survival rate are Portland, OR (6—10% survival to discharge, mean call-response interval 3—4 min),[17] and Tucson, AZ (8.4% survival to discharge, 93% call-response interval less than 9 min).[18] Although we were not able

Table 4 Logistic regression model of survival to 1 year ($n = 466^*$)

Characteristic	Odds ratio	95% confidence interval	*p*-Value
Age (by year)	0.96	0.93—0.98	0.001*
Gender: female	1.76	0.69—4.49	0.234
Race			
White	Reference	—	—
Black	0.48	0.171—1.34	0.159
Other	1.15	0.22—6.03	0.868
Witnessed arrest[a]			
Not witnessed	Reference	—	—
Bystander	1.22	0.463—3.20	0.691
CPR started by			
EMS	Reference	—	—
Fire/police	3.65	1.10—12.1	0.035*
Bystander	4.99	1.49—16.7	0.009*
First rhythm			
Asystole	Reference	—	—
VF/VT	6.85	1.91—24.5	0.003*
Other	2.9	0.71—11.9	0.14
Call- response interval (CRI)			
CRI 9 min or less	1.01	0.19—5.29	0.992

Note: All cases with unknown findings for any variable included in the regression were excluded from the analysis.
[a] Witnessed by fire/police predicted failure/death perfectly therefore was dropped from model.
* Statistical significance ($p < 0.05$).

Table 5 Call-response interval and survival in selected large OHCA studies ($n > 300$)

Study	*N*	Call-response interval	Survival	Outcome
Amsterdam[4]	1046	Mean: 9 min	9%	Survival to discharge
Chicago, IL[31]	3221	Mean: 5 min (±2)	2%	Survival to discharge
Chicago, IL[32]	6451	Mean: 6 min	Black: 0.8%; white: 2.6%	Survival to discharge
Copenhagen[33]	703	Median ALS: 6 min	n/a	Overall survival rate not reported
Houston, TX[34]	300	Mean: 4.5 min BLS, 9.4 min ALS	2.0%	Survival to discharge
Indiana[35]	388	Mean: 6.3 min	5.4%	Survival to discharge
King County, WA[36]	487 (186 ALS)	Mean: 8 min (ALS area)	20.4%	Survival to discharge
King County, WA[37]	1029	Mean: 9 min	16%	Survival to discharge
King County, WA[38]		Mean: 4.0 min BLS, 10.0 min ALS	16%	Survival to discharge
Memphis, TN[39]	1068	Mean: 3.5 min ALS, 5.8 min BLS	6—9%	Survival to discharge
Michigan[27]	1317	81.7%, <9 min	4.9%	Survival to discharge
New York[40]	2329	Median: 9.9 min	1.4%	Survival to discharge
Toronto (OPALS I)[41]	4690	76.8%, ≤8 min	3.9%	Survival to discharge
Toronto (OPALS II)[3]	1641	92.5%, ≤8 min	5.2%	Survival to discharge
Osaka, Japan[42]	982	Median: 5 min	3.2%	1-Year survival
Portland, OR[17]	322	Mean: 4.6—3.5 min	6—10%	Survival to discharge
Scotland[24]	13822	91%, <15 min	5%	Survival to discharge
Seattle, WA[43]	1224	Mean: 3.4 min BLS, 4.6 min ALS	10.2—16.7%	Survival to discharge
Tucson, AZ[18]	298	93%, <9 min	8.4%	Survival to discharge

to capture survival to discharge data in our study, it has been suggested that survival to 1 year under-represents survival to discharge by 1—2%.[19] Survival in our system may therefore also be comparable to these two systems. The identified survival rate is also comparable to a previously reported 6% OHCA survival rate in the greater Rochester metropolitan prior to the introduction of SSM. Unfortunately, a direct comparison of this study with ours is not possible since the first study used different methodology (pre-Utstein) and encompassed a much larger geographic region.[20]

We are not aware of any other study to date that reported the epidemiology and outcomes of OHCA in a system exclusively utilizing the system status management (SSM) dispatch model. SSM is thought to create similarities in response times among all demographic groups since ambulances are redistributed depending on how many are available, although this principle is theoretical and has not been definitively shown in the literature.[21—23] We found a call-response interval of 9 min or less 93% of the time, and with the exception of two outliers (17 and 21 min), the call-response intervals ranged from 0 to 15 min. Although this appears generally shorter and more uniform than most other systems reported in the literature (see Table 5), the research design did not allow a direct comparison.

Previous studies have shown that shorter ambulance call-response intervals are independently associated with OHCA survival.[24,25] Many authors report only the mean call-response interval, a statistic that may be misleading if there is significant skewing of the data.[26] More recently, some authors have reported call-response intervals in terms of percentage over a threshold. For example, one study reported that ALS arrived in less than 9 min 81% of the time.[27] The superiority of the percentile method over the mean is best illustrated by comparing the OPALS phase I and phase II data. In this Canadian series, the largest OHCA study to date, the mean call-response interval improved only slightly between phase I and phase II, from 6.7 to 6.5 min. However, when the proportion of cases with a call-response interval of 8 min or less was considered, they found a dramatic improvement. During phase 1 the call-response interval was 8 min or less 76.7% of the time, but jumped to 92.5% during phase 2.[3] Of note, this improvement in response time corresponded with a statistically significant increase in OHCA survival, from 3.9% to 5.2%. Our SSM-based system demonstrates relatively short call-response intervals using either measure: the mean and median of 5 min and 93rd percentile of 9 min or less are both shorter than most reported in the literature (see Table 5). Our study revealed no significant difference in survival rates in the group with slower response intervals (5% survival) compared to that with faster response intervals (5%). Although this is inconsistent with some previous studies, it may be because we had relatively low numbers in the long call-response interval (>9 min), with only 38 cases, two of which survived.

Disparity among income-levels in cardiovascular disease has been shown to be a great burden in the US, particularly for non-Hispanic blacks.[28,29] The demographics of cardiac arrest victims in this study were not different from city demographics, except for females who had a lower incidence of OHCA but statistically similar survival rate compared to males. Blacks and whites had proportionally similar incidence and no difference in survival rates. In this study race is not a significant predictor of survival. The impact that race and socioeconomic factors have on OHCA survival has been controversial in the literature. Becker et al. demonstrated a strong association between survival and race even though the mean call-response intervals between blacks and whites were the same (6 min), though a secondary analysis showed a significantly different distribution (shorter for whites), which suggested that response time may have affected survival.[30] One possible explanation that has been offered for differences in survival between races is a disparity in response times. In this study the call-response intervals between blacks and whites, and between zip codes were not found to be different and there was no difference in survival by race.

Limitations

There are limitations to our study that are important to discuss. First, this was a retrospective chart review. Despite the use of well-established standards for chart review, we were dependent upon the accurate and complete documentation of patient care. Because of the study design, we used EMS provider interpretations for most clinical data, such as rhythm strips and presenting rhythm information. Additionally, information was sometimes omitted from the patient care report and not all demographic information was reported by subject or their proxy. In some cases it may have been estimated by the provider. For instance, race information was unavailable in 47 cases, and, when available, was determined by the EMS providers or emergency department registration clerks, not by the patients themselves.

Second, we were unable to compare our findings to a non-SSM control group. Thus, we are not able to draw definitive conclusions regarding the affect of SSM on OHCA survival; we are able to report the epidemiology and survival in a system that utilizes SSM and contrast it to non-SSM systems reported in the literature.

Third, although there is strong precedent in the medical literature, the use of the SSDI for outcomes data is not perfect. However, we believe that we greatly increased our accuracy by using medical examiner and hospital medical record data when patient demographic data were missing and when the patients were not found within the SSDI database.

Conclusions

This study reveals a 5% overall survival to 1 year among OHCA patients in Rochester, NY, with a 9% survival among patients with a presenting rhythm of VF/VT or who received bystander CPR. In this system which utilized system status management there was no difference in survival based on race, gender, or socioeconomic status of patients, or in patients defibrillated by fire department personnel, witnessed collapse, or call-response intervals greater than 9 min.

Conflict of interest

The authors report no real or perceived conflicts of interest.

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