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Trends in Survival After In-Hospital Cardiac Arrest

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Abstract

BACKGROUND—Despite numerous advances in resuscitation care in recent years, it remains **unknown** whether survival and **neurological function** after in-hospital cardiac arrest has improved over time.

METHODS—We identified all adults with an index in-hospital cardiac arrest at 374 hospitals in the Get With The Guidelines-Resuscitation registry between 2000 and 2009. Using multivariable regression, we examined temporal trends in risk-adjusted rates of survival to discharge. Additional analyses explored whether trends: (1) were due to improved survival during the acute resuscitation or post-resuscitation care and (2) occurred at the expense of greater neurological disability among survivors.

RESULTS—Among 84,625 hospitalized patients with cardiac arrest, 67,135 (79.3%) had an initial rhythm of asystole or pulseless electrical activity while 17,490 (20.7%) had ventricular fibrillation or pulseless ventricular tachycardia. The proportion of cardiac arrests due to asystole or pulseless electrical activity increased over time (*P* for trend <0.001). Risk-adjusted **rates of** survival to discharge **in the overall cohort** increased from **13.7% in 2000 to 22.4% in 2009 (adjusted rate-ratio per 1-year:** 1.04, 95% CI [1.02–1.05]; *P* for trend <0.001). Survival improvement was similar in both rhythm groups and largely due to **improved** survival **from** the acute **resuscitation (risk-adjusted rates: 42.7% in 2000, 54.1% in 2009;** adjusted rate-ratio per 1-year: 1.03, 95% CI [1.02–1.04]; *P* for trend <0.001). **Importantly, rates** of neurological disability among survivors decreased over time (**risk-adjusted rates: 32.9% in 2000, 28.1% in 2009;** *P* for trend=0.02).

CONCLUSIONS—Both survival and neurological outcomes after in-hospital cardiac arrest have improved over the past decade.

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INTRODUCTION

Advances in resuscitation care over the last decade have led to higher rates of survival for patients with out-of-hospital cardiac arrest.[1–4] In the in-hospital setting, quality improvement efforts have included the use of routine mock codes, post-resuscitation debriefing, defibrillation by non-medical personnel, and participation in quality improvement registries, such as Get with the Guidelines–Resuscitation (GWTG-Resuscitation).[5–9] Whether overall survival for patients with in-hospital cardiac arrest has improved with these efforts remains unknown.

To date, only one study has examined temporal trends in survival after in-hospital cardiac arrests. This study found no change in survival to discharge among hospitalized Medicare patients undergoing cardiopulmonary resuscitation (CPR) from 1992 through 2005.[10] Although large and nationally representative, this study used administrative claims data and may have included patients without cardiac arrest (e.g., patients undergoing CPR for bradycardia) or excluded patients for whom a procedure code for CPR was not submitted. Moreover, information on the initial cardiac arrest rhythm, which has likely changed over time, was not available. This is important because advances in the management of acute myocardial infarction and heart failure may have led to a decline in the proportion of in-hospital cardiac arrests due to ventricular fibrillation (VF) and pulseless ventricular tachycardia (VT). Since these rhythms are associated with better survival, [9, 11, 12] it is possible that overall survival in that study did not change, even as rhythm-specific survival improved.

Therefore, we examined temporal trends in rates of survival to hospital discharge within a large, national quality improvement registry of in-hospital cardiac arrests. Because improved survival in these patients may occur at the expense of worsened neurological function, we also explored temporal trends in rates of neurological disability among survivors at discharge. Understanding how outcomes are changing over time in this population has important implications for improving resuscitation care at hospitals across the United States.

METHODS

Data Source and Study Population

Formerly known as the National Registry of Cardiopulmonary Resuscitation (NRCPR), GWTG-Resuscitation is a large, prospective, hospital-based, clinical registry of patients with in-hospital cardiac arrests in the U.S. The design of the registry has been previously described in detail.[9] Briefly, all hospitalized patients with a confirmed cardiac arrest (defined as the absence of a palpable central pulse, apnea, and unresponsiveness), without Do-Not-Resuscitate (DNR) orders, and who received cardiopulmonary resuscitation are identified and enrolled by specially trained personnel. To ensure that all cases in a hospital are captured, multiple case finding approaches are used including centralized collection of cardiac arrest flow sheets, review of hospital page system logs, and routine checks of code carts, pharmacy tracer drug records, and hospital billing charges for use of resuscitation medications.[13] The registry uses standardized Utstein-style definitions for defining clinical variables and outcomes.[14, 15] Data completeness and accuracy is ensured by rigorous training and certification of hospital staff, use of standardized software with internal data checks and a periodic re-abstraction process.

We identified 113,514 adults at 553 hospitals who were 18 years of age or older with an index cardiac arrest event between January 1, 2000 and November 19, 2009 (Figure 1). We restricted our sample to cardiac arrests occurring in an intensive care unit or inpatient ward and excluded 24,377 arrests from operating rooms, procedural suites or emergency departments, as this latter group represents distinct clinical circumstances and outcomes. As we were interested in examining trends in survival over time, we also excluded 4292 patients from 179 hospitals with fewer than 3 years of data submission or low case volumes (< 5 per year). Finally, we excluded patients missing information on survival (n=148) and calendar year (n=72). Our final sample comprised 84,625 patients from 374 hospitals (see eTable 1 for hospital characteristics).

Study Outcome

The primary outcome was survival to discharge. As survival from a VF or pulseless VT cardiac arrest differs from asystole or pulseless electrical activity (PEA),[9, 11, 12] all analyses are reported for the overall cohort and separately by rhythm type. To better understand which specific phase of resuscitation care may have led to improvement in survival, we separately examined rates of acute resuscitation survival (defined as return of spontaneous circulation for at least 20 contiguous minutes at any time from the initial pulseless arrest) and post-resuscitation survival (defined as survival to hospital discharge among patients who survived the acute resuscitation). We also examined temporal trends in time to defibrillation in VF and pulseless VT patients.[16]

To confirm that any temporal trend in survival was clinically important, we also examined rates of neurological disability among survivors. This was assessed using previously developed cerebral performance category (CPC) scores.[17] A CPC score of 1 denotes patients with mild to no neurological disability, 2 for moderate neurological disability, 3 for severe neurological disability, and 4 for coma or vegetative state. We examined temporal trends for significant (discharge CPC score of > 1) and severe neurological disability (discharge CPC score ≥2). [16, 18]

Statistical Analyses

To evaluate changes in baseline characteristics by calendar year, we used the Mantel-Haenszel test of trend for categorical variables and linear regression for continuous variables. To assess whether survival to discharge has improved over time, multivariable regression models using generalized estimation equations (GEE) were constructed for the overall cohort and by rhythm type. These models account for clustering of patients within hospitals. Since survival exceeded 10%, we used Zou's methodology to directly estimate rate-ratios instead of odds ratios by specifying a Poisson distribution and including a robust variance estimate in our models. [19, 20] Our independent variable, calendar year, was included as a categorical variable, with year 2000 as the reference year. We multiplied the adjusted rate-ratios for each year (2001 through 2009) with the observed survival rate for the reference year (2000) to obtain yearly risk-adjusted survival rates for the study period. These rates represent what the survival would be for each year if the patient case-mix were identical to the baseline year (i.e. 2000). We also evaluated calendar year as a continuous variable to obtain adjusted rate-ratios for year-over-year survival trends.

In our models, we adjusted for age, sex, race [white, black, other], co-morbidities (congestive heart failure; myocardial infarction; diabetes mellitus; renal, hepatic, or respiratory insufficiency; admission CPC score [neurological status pre-arrest]; baseline evidence of motor; cognitive, or functional deficits [CNS depression]; acute stroke; pneumonia; hypotension; arrhythmia; sepsis; trauma; metabolic or electrolyte abnormality; cancer), therapeutic interventions in place at the time of cardiac arrest (use of mechanical ventilation; anti-arrhythmic drugs; intravenous vasopressors; dialysis; pulmonary artery catheter, intra-aortic balloon pump), cardiac arrest characteristics (initial cardiac arrest rhythm; hospital location [ICU, monitored, non-monitored]; time [work hours: 7am–10:59pm vs. after hours: 11pm–6:59am] and day [weekday vs. weekend] of cardiac arrest;

use of a hospital-wide cardiopulmonary arrest alert [i.e., “Code Blue”], amiodarone use during resuscitation, time to defibrillation [only for VF and VT arrests]) and select hospital characteristics (geographic region [Northeast, Southeast, Midwest, Southwest, West], urban vs. rural hospital, ownership [private, government, not-profit], hospital bed size [<250, 250–499, ≥ 500], teaching status [major, minor, none]). To confirm that any survival trends were independent of the duration of a hospital’s participation in the registry, we adjusted for the number of years a hospital had participated within GWTG-Resuscitation for each arrest. We also examined whether survival trends differed by age group (≥ 65 years vs. < 65 years), race, and sex by including an interaction term with calendar year in the model. Lastly, to exclude the possibility that our findings were due to enrollment of better-performing hospitals over time, we performed these analyses only for patients at hospitals with at least 8 years of registry participation.

Data were complete for all covariates, except race (6.6%), admission CPC score (14.6%), time of cardiac arrest (0.9%) and hospital variables (4.5%). Missing patient-level data were assumed to be missing at random and were imputed using multiple imputation.[21] Results with and without imputation were not meaningfully different, so only the former are presented.

All statistical analyses were conducted using SAS Version 9.1.3 (SAS Institute, Cary, NC), IVEWARE (University of Michigan, MI), and R Version 2.6.0 (Free Software Foundation, Boston, MA). All hypothesis tests were 2-sided with a significance level of 0.05. The Institutional Review Board at University of Iowa approved the study.

Author contributions were as follows: study design (SG, PSC); data acquisition (PSC); data analysis and interpretation (SG, BKN, JAS, YL, HMK, PSC); drafting the manuscript (SG, PSC); and critical revision of the manuscript (SG, BKN, JAS, YL, HMK, PSC). Dr. Saket Girotra vouches for the integrity of the data and accuracy of the results. All authors have approved the manuscript for publication. Although the American Heart Association oversees GWTG-Resuscitation, it had no role in the study design, data analysis or interpretation, or manuscript preparation.

RESULTS

Among 84,625 patients, the initial cardiac arrest rhythm was asystole or PEA in 67,135 (79.3%) and VF or pulseless VT in 17,490 (20.7%). Over the study period, the proportion of cardiac arrests due to asystole or PEA increased from 68.7% in 2000 to 82.4% in 2009 (eFigure 1, *P* for trend <0.001). Table 1 describes temporal trends in patient characteristics. While there was a trend for younger age and less baseline neurological disability, illness severity increased over time with a higher prevalence of sepsis, use of mechanical ventilation, and intravenous vasopressors before the arrest event (*P* for trend <0.001 for all comparisons).

Survival to Discharge

The overall rate of survival to discharge was 17.0% (14,357/84,625), which improved significantly during the study period (Figure 2; eTable 2). After adjusting for temporal trends in patient and hospital characteristics, overall survival increased from 13.7% in 2000 to 22.3% in 2009 (adjusted rate-ratio per 1-year, 1.04; 95% confidence interval [CI], 1.02–1.05; *P* for trend <0.001; Table 2). Full model results are displayed in eTable 3. The temporal trends in survival were consistent in both rhythm groups (eTable 4) and were similar by age group (≥ 65 years vs. < 65 years), race (black vs. white) and sex (male vs. female) (*P* for all interactions > 0.10). Importantly, our findings were unchanged when we restricted the analyses to the 85 hospitals (33,464 patients) that participated in GWTG-Resuscitation for at least 8 years (eTable 5).

Secondary Outcomes

Rates of acute resuscitation survival also improved substantially in the overall cohort (risk-adjusted rate: 42.7% in 2000, 54.1% in 2009; adjusted rate-ratio per 1-year, 1.03; 95% CI, 1.02–1.04; *P* for trend <0.001; Table 2) and by rhythm type (eTable 4). In contrast, temporal improvement in post-resuscitation survival was much smaller (Table 2; eTable 4). In patients with VF and pulseless VT, there was no change in time to defibrillation (eFigure 2).

While rates of survival to discharge increased, rates of significant neurological disability (discharge CPC score >1) among survivors decreased over time in the overall cohort (risk-adjusted rate: 32.9% in 2000, 28.1% in 2009; adjusted rate-ratio per 1-year, 0.98; 95% CI, 0.97–1.00; *P* for trend=0.02; Table 2) and in patients with VF and pulseless VT (eTable 4). Rates of severe neurological disability (discharge CPC score >2), however, were unchanged over time (Table 2; eTable 4).

DISCUSSION

During the past decade, survival from in-hospital cardiac arrest has improved substantially among patients at hospitals enrolled in a national quality improvement registry. These gains have been achieved primarily through increased survival during the acute resuscitation event and have been accompanied by a decrease in the rate of significant neurological disability among survivors. Using a conservative estimate of 200,000 in-hospital cardiac arrests annually in the U.S.,[22] our findings suggest that an additional 17,200 patients would have survived to hospital discharge in 2009, compared to 2000 (based on 8.6% absolute improvement in risk-adjusted survival during this period). We also estimate that over 3500 cases of significant neurological disability would have been avoided.

To our knowledge, this is the first study to document temporal trends for higher survival following in-hospital cardiac arrest. The unadjusted survival rate of 17.0% in our study was lower than the 18.3% survival found in a recent study of Medicare patients[10] largely because we excluded cardiac arrests in the emergency room and procedural areas - which are known to have higher survival.[23, 24] Although the Medicare study did not detect survival trends,[10] several factors likely explain our different findings. Since that study used procedure codes for CPR to identify cardiac arrest patients, it is possible that some patients who received CPR for bradycardia (and not cardiac arrest) were included. Moreover, the Medicare study was unable to adjust for initial cardiac arrest rhythm, which we found has changed over time. Finally, although we adjusted for the duration of a hospital's participation within GWTG-Resuscitation, we cannot distinguish whether our findings are a consequence of motivated hospitals participating in a quality improvement registry or part of a nationwide trend arising from other factors (such as changes in clinical practice, equipment, early recognition of illness acuity, etc).

We found that improvement in cardiac arrest survival was largely driven by increased survival from the acute resuscitation, and this trend was seen regardless of whether the initial cardiac arrest rhythm was treatable by defibrillation or not. In patients with VF or pulseless VT, improvement in survival over time was not accompanied by shorter defibrillation times suggesting that other factors during resuscitation may have accounted for this improvement. These factors may include earlier recognition of cardiac arrest, shorter response times, greater availability of trained personnel, and provision of higher quality chest compressions with fewer interruptions. In fact, many of these processes have been emphasized in the American Heart Association Guidelines for CPR over the past decade.[25, 26] Future studies are needed to better understand which specific factors are responsible for improvements in cardiac arrest survival so that survival gains can be consolidated and expanded to all hospitals.

Several issues also merit further discussion. First, the increase in survival may simply reflect a decrease in baseline risk over time. However, we found little evidence that this was occurring. Although patients in our study were younger by 1.5 years at the end of the decade compared to the beginning, they were also sicker, with higher rates of sepsis, mechanical ventilation, and use of vasopressor medications prior to the arrest. Moreover, our results were consistent even after adjustment for temporal changes in patient factors over time, including age. Second, increasing use of advanced directives and DNR orders could have introduced selection bias in the patients who undergo resuscitation for a cardiac arrest over time. Yet again, our observed temporal increase in the proportion of patients on mechanical ventilation and vasopressor medications prior to cardiac arrest makes this less likely. Moreover, a recent study found that the proportion of in-hospital deaths that are preceded by CPR has actually increased over time.[10] Lastly, our findings are unlikely due to enrollment of better-performing hospitals over time, since we found similar results when we restricted our analyses to hospitals that participated in GWTG-Resuscitation for 8 years or longer.

Our findings should be interpreted in light of the following potential limitations. First, although data in GWTG-Resuscitation allowed us to adjust for a number of key variables, the possibility of residual confounding still remains. Second, we did not have detailed information on specific resuscitation process variables (e.g., quality of chest compressions), treatments (e.g., use of hypothermia or cardiac catheterization) and quality improvement initiatives at hospitals (e.g., use of routine mock codes) to better understand the reasons for improved rates of survival. These are often difficult to document accurately and future studies are required to examine the role of these factors in explaining the temporal increase in survival. Third, our neurological assessments at discharge may not predict long-term quality of life since neurological function may evolve after discharge.[27] Lastly, although we found that improved survival trends were independent of the duration of a hospital's participation within GWTG-Resuscitation, our study cohort was likely comprised of hospitals motivated for quality improvement; therefore, our findings may not be generalizable to all U.S. hospitals.

In conclusion, we found that survival after in-hospital cardiac arrest has improved significantly over the past decade at hospitals participating in a large, national quality improvement registry. This improvement was largely attributed to increased survival during acute resuscitation and was accompanied by a parallel decrease in rates of neurological disability over time. Identifying the factors responsible for these improved trends and expanding these processes to other facilities is warranted.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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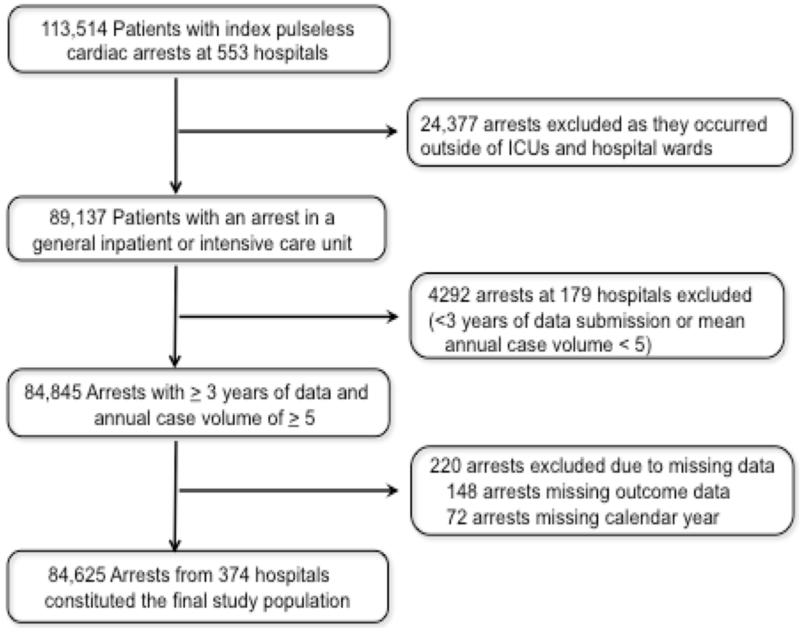

Figure 1.
Study Cohort

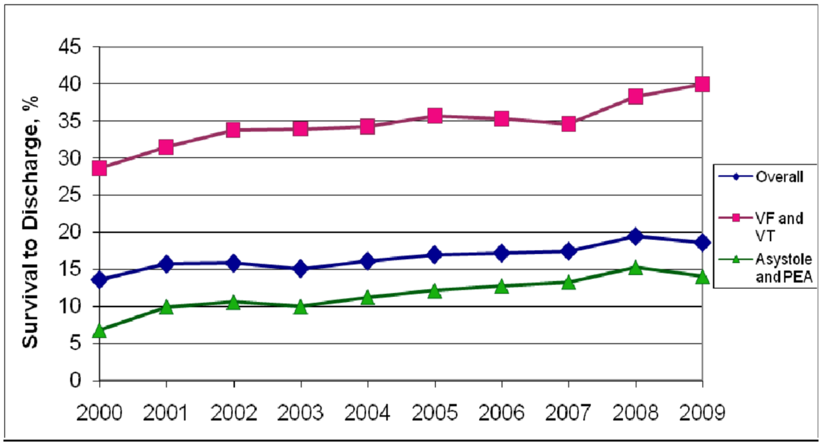

Figure 2. Unadjusted Rates of Survival to Hospital Discharge By Calendar Year

Observed (crude) rates for survival to discharge are displayed for the overall cohort and separately for shockable (ventricular fibrillation [VF] and pulseless ventricular tachycardia [VT]) and non-shockable (asystole and pulseless electrical activity [PEA]) cardiac arrest rhythms. The *P* for trend was <0.001 for each survival curve.

Table 1
Trends in Baseline Characteristics in Patients with an In-hospital Cardiac Arrest

For illustrative purposes, trends in baseline characteristics are presented as 3 time periods. The *P* for trend is for temporal changes in these characteristics by calendar year.

	Year Groups			
	2000–2003 n= 23,633	**2004–2006 n= 32,603**	**2007–2009 n= 28,389**	***P* for Trend**
Demographics				
Age, Mean (SD)	67.3 (15.4)	66.5 (15.6)	65.9 (15.8)	< 0.001
Male Sex, %	13,582 (57.5)	19,050 (58.4)	16,546 (58.3)	0.07
Black Race, %	4723 (21.8)	6581 (21.4)	6048 (22.7)	< 0.001
Cardiac Arrest Characteristics, %				
Initial Cardiac Arrest Rhythm				< 0.001
Asystole	9423 (39.9)	12,576 (38.6)	9915 (34.9)	
Pulseless Electrical Activity	8663 (36.7)	13,343 (40.9)	13,215 (46.5)	
Ventricular Fibrillation	3999 (16.9)	3878 (11.9)	2952 (10.4)	
Pulseless Ventricular Tachycardia	1548 (6.6)	2806 (8.6)	2307 (8.1)	
Amiodarone Use in Resuscitation	3290 (13.9)	5275 (16.2)	5169 (18.2)	< 0.001
Assessed with AED	1094 (4.6)	3545 (10.9)	5169 (18.2)	< 0.001
Arrest at Night (11pm to 7am)	8369 (35.9)	11,410 (35.3)	9880 (35.1)	0.09
Arrest on Weekend	7570 (32.0)	10,470 (32.1)	9049 (31.9)	0.12
Hospital Location of Arrest				< 0.001
Intensive Care Unit	13,189 (55.8)	18,852 (57.8)	16,859 (59.4)	
Monitored unit	4735 (20.0)	7269 (22.3)	7160 (25.2)	
Non-monitored unit	5709 (24.2)	6482 (19.9)	4370 (15.4)	
Hospital-wide response activated	21,013 (88.9)	28,182 (86.4)	23,559 (83.0)	< 0.001
CPC Category on Admission				
1	9769 (50.8)	14,524 (49.8)	12,902 (54.2)	
2	5882 (30.6)	9047 (31.0)	6496 (27.3)	
3	2531 (13.2)	4090 (14.0)	3004 (12.6)	
4 or 5	1042 (5.4)	1529 (5.2)	1413 (5.9)	
Pre-Existing Conditions, %				
Heart Failure, this admission	4919 (20.8)	6702 (20.6)	5113 (18.0)	< 0.001
Prior Heart Failure	6131 (25.9)	7305 (22.4)	5743 (20.2)	< 0.001
Myocardial Infarction, this admission	4602 (19.5)	5792 (17.8)	4263 (15.0)	< 0.001
Prior Myocardial Infarction	5000 (21.2)	5771 (17.7)	4261 (15.0)	< 0.001
Arrhythmia	7850 (33.2)	12,052 (37.0)	8887 (31.3)	< 0.001
Hypotension	6353 (26.9)	10,065 (30.9)	7566 (26.7)	< 0.001
Respiratory Insufficiency	9799 (41.5)	14,930 (45.8)	11,943 (42.1)	< 0.001
Renal Insufficiency	8076 (34.2)	11,999 (36.8)	10,062 (35.4)	< 0.001
Hepatic Insufficiency	1771 (7.5)	2947 (9.0)	2342 (8.2)	< 0.001

	Year Groups			
	2000–2003 n= 23,633	2004–2006 n= 32,603	2007–2009 n= 28,389	*P* for Trend
Metabolic or Electrolyte Abnormality	4601 (19.5)	6646 (20.4)	4367 (15.4)	< 0.001
Diabetes Mellitus	7183 (30.4)	10,550 (32.4)	8944 (31.5)	< 0.001
Baseline Depression in CNS Function	3216 (13.6)	4706 (14.4)	3347 (11.8)	< 0.001
Acute Stroke	1037 (4.4)	1454 (4.5)	1155 (4.1)	0.148
Pneumonia	3591 (15.2)	5015 (15.4)	4239 (14.9)	< 0.001
Septicemia	3367 (14.2)	6037 (18.5)	5363 (18.9)	< 0.001
Major Trauma	693 (2.9)	1164 (3.6)	1121 (3.9)	< 0.001
Cancer	2909 (12.3)	4529 (13.9)	3846 (13.5)	< 0.001
Interventions in Place Prior to the Arrest, %				
Mechanical Ventilation	6388 (27.0)	10,300 (31.6)	9702 (34.2)	< 0.001
Intravenous Vasopressor Medication	6804 (28.8)	9175 (28.1)	9060 (31.9)	< 0.001
Intravenous Antiarrhythmic Therapy	1435 (6.1)	1944 (6.0)	1953 (6.9)	< 0.001
Dialysis	897 (3.8)	1421 (4.4)	1118 (3.9)	< 0.001
Intra-Aortic Balloon Pump	394 (1.7)	534 (1.6)	449 (1.6)	0.651
Pulmonary Artery Catheter	1346 (5.7)	1534 (4.7)	869 (3.1)	< 0.001
Hospital Characteristics, %				
Geographic Region *				< 0.001
Northeast	2536 (11.7)	4616 (14.7)	3531 (12.7)	
Southeast	6604 (30.5)	8549 (27.2)	7828 (18.2)	
Midwest	5782 (26.7)	7694 (24.5)	6186 (22.3)	
Southwest	3524 (16.3)	5022 (16.0)	5874 (21.2)	
West	3215 (14.8)	5522 (17.6)	4329 (15.6)	
Location *				
Urban	20,320 (93.8)	29,722 (94.6)	26,387 (95.1)	< 0.001
Rural	1341 (6.2)	1681 (5.4)	1361 (4.9)	
Ownership *				< 0.001
Private	1768 (8.2)	3213 (10.2)	3547 (12.8)	
Government	3493 (16.1)	5205 (16.6)	4919 (17.7)	
Non-profit	16,400 (75.7)	22,985 (73.2)	19,282 (69.5)	
Hospital Bed Size **				< 0.001
< 250	5074 (23.0)	6649 (20.9)	4916 (17.5)	
250–499	8546 (38.7)	13,573 (42.6)	12,250 (43.6)	
≥ 500	8443 (38.3)	11,607 (36.5)	10,920 (38.9)	
Academic Hospital **				< 0.001
Hospital with fellowship program (Major)	6278 (28.5)	10,794 (33.9)	11,241 (40)	
Hospital with residency program (Minor)	7485 (33.9)	10,674 (33.5)	8445 (30.1)	
Non-teaching hospital	8300 (37.6)	10,361 (32.6)	8400 (29.9)	

Abbreviations: AED, automated external defibrillator; CNS, central nervous system; CPC, cerebral performance category; SD, standard deviation.

* Geographic Region, Location and Ownership data were missing for 3813 (4.5%) patients.

** Hospital Bed Size and Academic Status data were missing for 2647 (3.1%) patients.

Table 2

Trends in Survival and Neurological Outcomes

Risk-adjusted rates of survival to discharge, acute resuscitation survival, post-resuscitation survival, and neurological disability for each calendar year are reported for the overall cohort. Rates are adjusted for temporal changes in patient and hospital characteristics [see eTable 3 for all model covariates].

	Risk-Adjusted Rates*										Adjusted RR per 1-year** (95% CI)	*P* for Trend**
	2000	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**		
OVERALL												
Survival to Discharge, %	13.7	17.1	18.2	17.8	18.9	20.0	20.5	21.2	23.3	22.3	1.04 (1.03, 1.06)	<0.001
Acute Resuscitation Survival†, %	42.7	45.1	45.4	46.0	47.0	48.6	49.7	52.5	55.2	54.1	1.03 (1.02, 1.04)	<0.001
Post-Resuscitation Survival‡, %	32.0	38.3	40.0	39.0	40.8	42.1	42.4	41.5	43.6	42.9	1.02 (1.01, 1.03)	0.001
Neurological Outcome in Survivors, %												
Significant Disability# (CPC > 1), %	32.9	35.7	31.9	34.3	34.0	33.1	33.0	32.7	31.8	28.1	0.98 (0.97, 1.00)	0.02
Severe Disability¶ (CPC > 2), %	10.1	10.5	9.8	10.5	11.5	11.5	9.7	12.2	11.7	10.7	1.01 (0.98, 1.04)	0.37

Abbreviations: CI, confidence interval; CPC, cerebral performance category; RR, rate-ratio.

* Risk-adjusted rates for each calendar year were obtained by multiplying the observed rate for the reference year (2000) by the corresponding rate-ratios for 2001 through 2009 from a model evaluating calendar year as a categorical variable

** Determined from a model evaluating calendar year as a continuous variable

† Acute Resuscitation Survival was determined by the number of patients with return of spontaneous circulation for at least 20 minutes divided by the number of patients with a cardiac arrest.

‡ Post-resuscitation Survival was determined by the number surviving to hospital discharge divided by the number surviving the acute resuscitation.

Significant Disability was defined as the proportion of patients surviving to hospital discharge with a CPC Score of > 1.

¶ Severe Disability was defined as the proportion of patients surviving to hospital discharge with a CPC Score of > 2.