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Long-Term Survival Trends of Medicare Patients After In-Hospital Cardiac Arrest: Insights from Get With The Guidelines-Resuscitation®

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Abstract

Background—Although rates of survival to hospital discharge after in-hospital cardiac arrest (IHCA) have improved over the last decade, it is unknown if these survival gains are sustained after hospital discharge.

Objective—To examine 1-year survival trends overall and by rhythm after IHCA.

Methods—Using Medicare beneficiaries (age ≥ 65 years) with IHCA occurring between 2000 and 2011 at Get With The Guidelines®-Resuscitation Registry participating hospitals we used multivariable regression, to examine temporal trends in risk-adjusted rates of 1-year survival.

Results—Among 45,567 patients with IHCA, the unadjusted 1-year survival was 9.4%. Unadjusted 1-year survival was 21.8% among the 9,223 (20.2%) of patients with Ventricular Fibrillation or Pulseless Ventricular Tachycardia (VF/VT) and 6.2% among the 36,344 (79.8%) of patients with Pulseless Electrical Activity or asystole (PEA/asystole). After adjustment for patient and arrest characteristics, 1-year survival increased over time for all IHCA from 8.9% in 2000–2001 to 15.2% in 2011 (adjusted rate ratio [RR] per year, 1.05; 95% CI, 1.03–1.06; $P < 0.001$ for trend). Improvements in 1-year risk adjusted survival were also observed for VF/VT (19.4% in 2000–2001 to 25.6% in 2011 [RR per year, 1.02; 95% CI, 1.01–1.04; $P = 0.004$ for trend]) and PEA/

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Conflict of interest

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asystole arrests (4.7% in 2000–2001 to 10.2% in 2011 [RR per year, 1.07; 95% CI, 1.05–1.08; $P < 0.001$ for trend]).

Conclusion—Among Medicare beneficiaries in the GWTG-Resuscitation registry, 1-year survival after IHCA has increased for over the past decade. Temporal improvements in survival were noted for both shockable and non-shockable presenting arrest rhythms.

Keywords

In-Hospital cardiac arrest Outcomes Survival Resuscitation

Introduction

In-hospital cardiac arrest (IHCA) is common, affecting over 200,000 patients annually in the U.S., with fewer than 1 in 4 surviving to hospital discharge [1,2]. However, rates of survival to discharge following IHCA have significantly improved in the past decade, with a recent study reporting an increase in risk adjusted survival from 13.7% in 2000 to 22.3% in 2009 [2]. Whether improvements in short-term outcomes of IHCA have translated into greater long-term survival remains unknown.

Evaluation of trends in long-term survival after IHCA may provide important insights on the impact of improving short-term survival after IHCA. If long-term survival after IHCA is improving concurrently with improvements in short-term survival, it may suggest that improvements in resuscitation care impacted sustained survival improvements in this high-risk population. In contrast, if long-term survival is not improving after IHCA, the short-term survival gains seen at discharge may belie long-term implications of IHCA and suggest the need for greater attention to post-discharge care.

Using data from a large, national, contemporary registry linked with Medicare claims files, we evaluated temporal trends of 30-day and 1-year survival among Medicare beneficiaries with IHCA. Due to the changing epidemiology of in-hospital cardiac arrest with a declining proportion of arrests due to shockable rhythms (ventricular fibrillation [VF] and pulseless ventricular tachycardia [VT]), we also evaluated temporal trends of 1-year survival by initial cardiac-arrest rhythm [3,4].

Methods

Data source

The Get With The Guidelines®-Resuscitation (GWTG-R) Registry is a large, contemporary, quality-improvement registry of in-hospital cardiac arrests. The design of the registry has been described previously [5]. Briefly, hospitals voluntarily participate and report data on patients without do-not-resuscitate orders who suffer a cardiac arrest (defined as lack of a palpable central pulse, apnea, and unresponsiveness) and receive cardiopulmonary resuscitation (CPR). Multiple methods are used to identify cases including collection of cardiac-arrest flow sheets, review of hospital paging-system logs, and routine checks of code materials, pharmacy tracer drug records, and hospital billing charges for resuscitation medications [6]. Standardized definitions are used for patient variables and outcomes that

adhere to Utstein-style templates for cardiac arrest data [6]. Data accuracy evaluation is completed through certification by trained hospital staff and standardized software with data checks [6].

To determine outcomes after hospital discharge, we relied on vital status information from Medicare denominator files, as GWTG-Resuscitation collects information on only in-hospital outcomes. Based on prior work, patient level data from the GWTG-R registry was linked with Medicare inpatient files using six identifiers: the dates of hospital admission and discharge, the patient's age and sex, the admitting hospital, and the diagnosis and procedure codes in the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM). Medicare files were linked if they included a diagnosis code for cardiac arrest (427.5), ventricular fibrillation (427.41), or ventricular flutter (427.42) or a procedure code for cardiopulmonary resuscitation (99.60), defibrillation (99.62), or closed chest massage (99.63). For each linked patient, Medicare denominator files and inpatient files from 2000 to 2012 were obtained.

Study population

We identified 187,713 adult patients suffering IHCA at 525 hospitals participating in GWTG-R between January 1, 2000 and December 31, 2011. We excluded 79,952 patients who were younger than 65 years old, leaving 107,761 Medicare age-eligible patients (age 65 years). Consistent with prior studies that evaluated trends in survival of IHCA to hospital discharge, we restricted our sample to patients with cardiac arrests occurring in an intensive care unit or inpatient ward and excluded 20,009 patients with arrests that occurred in operating rooms, procedural suites, or emergency departments, as cardiac arrests in these settings have distinct clinical circumstances and outcomes [2]. Additionally, given that the initial arrest rhythm is a primary predictor of survival we excluded 12,578 patients without documented initial rhythm. Among patients with multiple in-hospital cardiac arrests (5130), we restricted our analysis to the index event. After excluding 29,607 patients who we were unable to link to Medicare claims data, our final analytic cohort consisted of 45,567 patients with matched Medicare claims data (Fig. 1).

Primary outcome

The primary outcome was 1-year survival after IHCA. Vital status was determined using Medicare denominator files. Secondary outcomes were survival to discharge obtained from GWTG registry data and 30-day survival after IHCA from Medicare denominator files.

Statistical analysis

For descriptive purposes, changes in patient, hospital, and arrest characteristics were evaluated by three time periods (2000–2004, 2004–2008, and 2008–2011) using the Mantel-Haenszel trend test for categorical variables and linear trend test for continuous variables.

To determine whether rates of risk-adjusted 1-year survival after IHCA have improved over time, hierarchical generalized linear models with hospital as a random effect to account for clustering of patients within hospitals were constructed for all patients with IHCA. We directly estimated rate ratios using Zou's method by specifying a Poisson distribution and

including a robust variance estimate in our models [7,8]. Based on prior literature, covariates for risk-adjustment in the models included: patient demographics (age [<75 , $75-<85$, 85], sex, race [white, black, other]), arrest characteristics (initial cardiac arrest rhythm, time of day and day of week of the arrest, location of the arrest), conditions present 24 h prior to the arrest (hepatic insufficiency, renal insufficiency, hypotension, sepsis, heart failure, diabetes mellitus, respiratory insufficiency, or metastatic or hematologic cancer), and interventions present at the time of arrest (requirement for mechanical ventilation and vasoactive medication use). Our independent variable of interest, calendar year, was included as a categorical variable with 2000–2001 as the reference year. We multiplied the adjusted rate ratio for each year by the observed 1-year survival rate for the reference year to obtain yearly risk-adjusted 1-year survival rates for the study period. Further, we evaluated calendar year as a continuous variable to obtain adjusted rate ratios for year-to-year survival trends. These analyses were then repeated, first stratified according to initial presenting cardiac-arrest rhythm: shockable (VF/VT) versus non-shockable (pulseless electrical activity [PEA] and asystole). A sensitivity analysis was conducted limited to those hospitals with continuous participation (>8 years) in the GWTG-R to ensure trends were not affected by changes in the hospitals participating in the registry over time.

In secondary analyses we used similar models to evaluate trends in survival outcomes at 30-days after discharge.

Overall rates of missing data were low, with race having the highest percentage of missing data at 2.5%. Missing covariate data was assumed to be missing at random and imputed with a single imputation dataset. All statistical analysis was performed at Mid-America Heart Institute (Kansas City, MO) using SAS software 9.4 (SAS Institute) or IVEware (University of Michigan) [9].

Results

Table 1 shows temporal trends in patient characteristics by time period. The mean age of the study cohort was 77.2 ± 7.4 years, 55.5% were male, and 3 in 4 patients were of white race. In the overall cohort, non-shockable cardiac arrest rhythms (PEA 42.2% and asystole 37.6%) were more common than shockable rhythms (VF 12.5% and VT 7.8%) and the majority of IHCA occurred in an ICU setting (53.6%). Over time, patients with IHCA were more likely to have renal insufficiency or sepsis and less likely to have congestive heart failure, myocardial infarction, an electrolyte abnormality, and occur in telemetry units (all $P < 0.001$).

Overall, 4,283 (9.4%) survived to one year. Unadjusted survival at 1-year after IHCA increased significantly with each successive year, from 8.9% in 2000–2001 to 10.6% in 2011 (Fig. 2). Compared with patients with an IHCA in 2000/2001, patients with an IHCA in 2011 were 71% more likely to survive to one year (adjusted RR, 1.71; 95% Confidence Interval [CI], 1.44–2.02 $P < 0.001$) (Table 2). When calendar year was modeled as a continuous variable, relative 1-year survival increased by 5% each year overall (adjusted RR per year, 1.05; 95% CI, 1.03–1.06; $P < 0.001$ for trend) (Table 2).

Stratified by presenting rhythm, the unadjusted 1-year survival for shockable (VT/VF) was 21.8% and for non-shockable rhythms (PEA/Asystole) was 6.2%. Unadjusted 1-year survival increased significantly with each successive year, from 19.4% in 2000–2001 to 22.7% in 2011 for shockable rhythms and from 4.4% in 2000–2001 to 8.1% in 2011 for non-shockable rhythms (Fig. 2). Compared with patients with shockable IHCA in 2000/2001, patients in 2011 with shockable IHCA were 32% more likely to survive to 1-year. Patients with non-shockable presenting rhythm in 2011 were 117% more likely to be alive at 1-year in comparison with patients with non-shockable IHCA in 2000/2001 (adjusted RR, 1.32, 95% CI 1.05–1.67 and 2.17, 95% CI 1.71 to 2.77%, $p < 0.001$ for both trends, respectively) (Table 2). The risk-adjusted relative 1-year survival increased by 2% each successive year for shockable (adjusted RR per year, 1.02; 95% CI, 1.01–1.04; $P = 0.004$ for trend) and 7% for non-shockable arrests (adjusted RR per year, 1.07; 95% CI, 1.05–1.08; $P < 0.001$ for trend) (Table 2). Patients with asystole and PEA arrest had similar increases in 1-year survival (adjusted RR per year, 1.08; 95% CI, 1.06–1.11 and 1.05; 95% CI 1.03–1.07, respectively).

Overall, 7564 (16.6%) patients survived to discharge and 6200 (13.6%) survived to 30 days. Survival to discharge and survival to 30-day after IHCA both increased by a relative 5% each year (adjusted RR per year, 1.05; 95% CI, 1.04–1.06; $P < 0.001$ for trend, for both outcomes) (Table 2). The relative differences in survival to discharge, 30-day, and 1-year over time were similar, although absolute differences over time were greatest in survival to discharge. (Table 3)

The results of the sensitivity analysis restricted to hospitals with >8 years continuous GWTG-R participation over the period of study (hospitals 112, patients 23,213) demonstrated findings similar to the primary analysis (Table 4).

Discussion

In this large national registry of IHCA linked to Medicare claims data, 1-year survival after IHCA has improved significantly over the past decade. These gains were realized despite an increasing proportion of non-shockable arrest rhythms during the study period that are associated with lower survival. Collectively, our findings suggest trends of improving survival to hospital discharge after IHCA have been robust and sustained after hospital discharge.

Contemporary studies suggest survival to hospital discharge after IHCA has improved in the past decade, consistent with improvements in resuscitation and in-hospital post-resuscitation care [2]. Prior to our study, it was unknown if these survival gains were maintained after hospital discharge. Our findings suggest that advancements in resuscitation care also have led to improvement in long-term outcomes. Using an estimate of 200,000 IHCA annually we projected that an additional 12,600 patients were alive 1-year after IHCA in 2011 compared to 2001 (on the basis of an 6.3% absolute improvement in risk-adjusted survival) [10,11].

The greatest relative improvements in long-term survival were observed in those with non-shockable rhythms who are at highest risk of poor outcomes. In our study, 1-year survival

for non-shockable rhythms nearly doubled from 4.7% to 10.2% between 2000 and 2011. These temporal improvements in survival for non-shockable rhythms likely reflect changes in the culture of medical practice as well as improvements in resuscitation care. Historically, non-shockable rhythms were often viewed as futile. Yet, the near doubling of the 1-year survival after non-shockable IHCA over the past decade suggests there has been improvement in resuscitation of these patients. Since medications and resuscitation algorithms for non-shockable rhythms are largely unchanged over the period of study, these improvements may be driven by increases in other aspects of resuscitation care, such as the quality of CPR or increased access to medications with Medicare expansion.

Compared with non-shockable rhythms, improvements in 1-year survival for shockable rhythms were similar on an absolute scale. Prior studies have demonstrated gaps in processes of resuscitation for shockable rhythms, such as time to first defibrillation [12,13]. Within GWTG-R, time to defibrillation has improved over time and has been associated with improvements in survival to discharge [14,15]. The present study suggests these improvements have translated into longer term survival of for those with shock-able IHCA.

Resuscitation care is a composite of intra-arrest care, post-arrest in-hospital management, and post-discharge care. Currently, the majority of IHCA interventions are aimed at the time of the arrest (i.e. decreased time to defibrillation, higher quality chest compressions without interruptions) or post-arrest in-hospital management (i.e. better ICU care, improved temperature management, and centers of resuscitation excellence) [12,16–19]. The impact of intra-arrest and post-arrest interventions would be evident at hospital discharge, and temporal improvements in survival to hospital discharge are suggestive of improvements in resuscitation and in-hospital post-resuscitation care. Although the relative survival improvements at discharge, 30-days, and 1- year after IHCA were similar, the absolute increase in survival trends was largest for in-hospital outcomes (i.e. survival to discharge). This may reflect an opportunity to further define effective post-discharge care of IHCA patients that maximizes long-term survival outcomes.

Several limitations must be considered when interpreting the findings of our study. First, although prospectively collected, this study used observational data and residual confounding cannot be excluded. However, there was little evidence for changes in patient characteristics over time that would be expected to explain our observed survival trends. Further, our results were robust to adjustment for patient characteristics and in sensitivity analysis evaluating only those hospitals with continuous GWTG-R participation. As a result of the observational site-driven nature of data collection in our study, we are missing data on some patient characteristics (i.e. presenting rhythm) that required patient exclusions from the analysis cohort. However, we observed no trends in patient characteristics that suggest patient exclusions have influenced our results. Second, we are unable to account for rates of do not resuscitate (DNR) orders at admission that could introduce selection bias in the population at risk of resuscitation for in-hospital cardiac arrest over time. The relative similarity of patient characteristics over the time period of study makes this less likely. Third, we are unable to assess the factors that may contribute most to improved survival such as resuscitation process measures, in-hospital post-resuscitation care, or post-discharge care. Continued research to identify care delivery processes that may improve long-term

survival is needed. Fourth, our analysis was limited to a population of Medicare patients and thus findings may not be generalizable to the entire population. Finally, our study is limited to survival outcomes in longitudinal follow-up. Although it is encouraging that patients after IHCA appear to be benefitting long-term from improvements in resuscitation care, survival alone does not reflect important patient outcomes of functional status and health related quality of life. Systematic approaches to capture of patient health status (i.e. symptoms, functional status, and health related quality of life), disposition location (e.g home, skilled nursing facility, long term acute rehabilitation, etc.), and post-hospitalization care (e.g. follow-up visits, home nursing services, physical therapy) is needed to facilitate a better understanding of the implications of improving long-term survival of IHCA.

Conclusions

Over the past decade there have been improvements in risk-adjusted 1-year survival after IHCA from 8.9% in 2000–2001 to 15.2% in 2011. These improvements were noted for both shock-able and non-shockable presenting arrest rhythms. Further study is needed to understand whether these gains reflect improvements in resuscitation, post-resuscitation, or post-discharge care to guide future gains in patient survival of this high-risk condition.

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Abbreviations

CPR	Cardiopulmonary Resuscitation
GWTG-R	Get With The Guidelines [®] -Resuscitation
IHCA	In-Hospital Cardiac Arrest
PEA	Pulseless Electrical Activity
VF	Ventricular Fibrillation
VT	Pulseless Ventricular Tachycardia

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Fig. 1.

Study Design Flowsheet.

Abbreviations: GWTG-R = Get With The Guidelines-Resuscitation® ; IHCA = in-hospital cardiac arrest.

Fig. 2. Unadjusted Rates of Discharge, 30-day, and 1-Year Survival after In-Hospital Cardiac Arrest Overall and By Presenting Rhythm. Figure includes 45,567 patients with In-Hospital Cardiac Arrest at 525 Get With the Guideline-Resuscitation Hospital's between 2000 and 2011. Figure demonstrates unadjusted discharge, 30-day, and 1-year survival rates. Abbreviations: Asystole/PEA = asystole or pulseless electrical activity; VT/VF = Pulseless Ventricular Tachycardia or Ventricular Fibrillation

Table 1

Baseline Demographics From 2000–2011 by Tertile.

	Year				P-Value For trend
	Total N = 45,567 (%)	2000–2003 N = 11,243 (%)	2004–2008 N = 18,556 (%)	2008–2011 N = 15,588 (%)	
Demographics					
Age (years)					
Mean ± SD	77.2 ± 7.4	77.2 ± 7.3	77.3 ± 7.4	77.3 ± 7.6	0.21
65–74	17,685 (38.8)	4346 (38.0)	7155 (38.6)	6184 (39.7)	0.62
75–85	19,654 (43.1)	5146 (45.0)	8067 (43.5)	6441 (41.3)	
> 85	8228 (18.1)	1931 (16.9)	3334 (18.0)	2963 (19.0)	
Male	25,309 (55.5)	6237 (54.6)	10,290 (55.5)	8782 (56.3)	< 0.01
Race					
White	34,973 (76.9)	8783 (77.7)	14,181 (76.4)	12,009 (77.0)	0.15
Black	7006 (15.4)	1668 (14.8)	2858 (15.4)	2480 (15.9)	
Other	1241 (2.7)	222 (2.0)	600 (3.2)	419 (2.7)	
Unknown	2229 (4.9)	634 (5.6)	915 (4.9)	680 (4.4)	
Missing	118	116	2	–	
Comorbidities					
Respiratory Insufficiency	19,193 (42.1)	4681 (41.0)	8170 (44.0)	6342 (40.7)	0.25
Renal Dysfunction	16,425 (36.0)	3904 (34.2)	6755 (36.4)	5766 (37.0)	< 0.01
Diabetes Mellitus	14,836 (32.6)	3573 (31.3)	6188 (33.3)	5075 (32.6)	0.06
Hypotension	11,901 (26.1)	2909 (25.5)	5293 (28.5)	3699 (23.7)	< 0.01
Heart Failure					
At admission	10,334 (22.7)	2841 (24.9)	4354 (23.5)	3139 (20.1)	< 0.01
Prior to admission MI	12,178 (26.7)	3,534 (30.9)	4841 (26.1)	3803 (24.4)	< 0.01
At admission	8820 (19.4)	2627 (23.0)	3655 (19.7)	2538 (16.3)	< 0.01
Prior to admission	9452 (20.7)	2897 (25.4)	3822 (20.6)	2733 (17.5)	< 0.01
Electrolyte Abnormality	7152 (15.7)	1996 (17.5)	3173 (17.1)	1983 (12.7)	< 0.01
Septicemia	6950 (15.3)	1328 (11.6)	3051 (16.4)	2571 (16.5)	< 0.01
Pneumonia	7192 (15.8)	1781 (15.6)	2917 (15.7)	2494 (16.0)	0.35
Malignancy	5619 (12.3)	1289 (11.3)	2406 (13.0)	1924 (12.3)	0.02

	Year				P-Value For trend
	Total N = 45,567 (%)	2000–2003 N = 11,243 (%)	2004–2008 N = 18,556 (%)	2008–2011 N = 15,588 (%)	
Baseline Neurologic Dysfunction	6237 (13.7)	1617 (14.2)	2784 (15.0)	1836 (11.8)	<0.01
Hepatic Insufficiency	2121 (4.7)	500 (4.4)	949 (5.1)	672 (4.3)	0.52
Acute Neurologic Event	3191 (7.0)	721 (6.3)	1578 (8.5)	892 (5.7)	0.003
Acute Stroke	2026 (4.4)	516 (4.5)	871 (4.7)	639 (4.1)	0.06
Major Trauma	990 (2.2)	177 (1.5)	435 (2.3)	378 (2.4)	<0.01
Arrest Characteristics					
Initial Arrest Rhythm					
Non-Shockable					
Asystole	17,136 (37.6)	4549 (39.8)	7317 (39.4)	5270 (33.8)	0.05
PEA	19,208 (42.2)	4134 (36.2)	7468 (40.2)	7606 (48.8)	
Shockable					
VF	5677 (12.5)	1995 (17.5)	2142 (11.5)	1540 (9.9)	
PVT	3546 (7.8)	745 (6.5)	1629 (8.8)	1172 (7.5)	<0.01
Location					
ICU	24,417 (53.6)	5925 (51.9)	9982 (53.8)	8510 (54.6)	
Monitored	11,508 (25.3)	3755 (32.9)	4182 (22.5)	3571 (22.9)	
Non-Monitored	9642 (21.2)	1743 (15.3)	4392 (23.7)	3507 (22.5)	
Arrest Time					0.15
Day	20,822 (46.0)	5156 (45.5)	8416 (45.6)	7250 (46.8)	
Night	9229 (20.4)	2376 (21.0)	3786 (20.5)	3067 (19.8)	
Weekend	15,245 (33.7)	3806 (33.6)	6256 (33.9)	5183 (33.4)	
Missing	271	85	98	88	

* All data presented as numbers with percentages except for age which is also represented as mean $\pm$ standard deviation

[†] Baseline Neurologic Dysfunction: defined as a pre-existing condition prior to arrest

[‡] Abbreviations: MI = Myocardial Infarction; PEA = pulseless electrical activity; PVT = pulseless ventricular tachycardia; SD = standard deviation; VF = ventricular fibrillation;

Overall Risk Adjusted Rates of Survival After In-Hospital Cardiac Arrest by Calendar Year.

Table 2

Year	Risk Adjusted Rates (%) ^b										Adjusted Rate Ratio per Year (95% CI) ^c	P-value for trend
	2000–2001 (Ref)	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	
Survival to Discharge	14.5	17.5	19.4	19.3	21.2	21.0	21.5	25.1	24.1	26.7	25.1	<0.001
30-day Survival	12.4	14.3	15.9	16.0	18.0	17.5	17.5	20.4	19.9	22.0	20.4	<0.001
1-year Survival	8.9	10.4	11.9	12.0	12.8	11.9	12.5	14.6	13.8	15.9	15.2	<0.001
By Initial Rhythm 1-Year Survival												
Shockable	19.4	22.9	24.1	23.9	26.6	25.6	25.0	26.6	27.6	26.1	25.6	0.004
Non-Shockable	4.7	5.7	7.0	7.2	7.4	6.6	7.5	9.4	8.3	10.7	10.2	<0.001

* Abbreviation: RR = rate ratio; CI = confidence interval; Shockable = Initial rhythm ventricular tachycardia or ventricular fibrillation; Non-Shockable = initial rhythm pulseless electrical activity or asystole

[†] Risk adjusted rates of survival for discharge, 30-day, and 1-year are reported for the overall cohort. 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 2001–2011 from the model with calendar year as a categorical variable

[‡] Adjusted rate ratio per year and p value for trend are from model with year modeled as a continuous variable.

[§] Models were adjusted for patient demographics (age [< 75 , 75 – < 85 , 85], sex, race [white, black, other]), arrest characteristics (initial cardiac arrest rhythm, time of day and day of week of the arrest, location of the arrest), conditions present 24 h prior to the arrest (hepatic insufficiency, renal insufficiency, hypotension, sepsis, heart failure, diabetes mellitus, respiratory insufficiency, or metastatic or hematologic cancer), and interventions present at the time of arrest (requirement for mechanical ventilation and vasoactive medication use).

Table 3

Unadjusted Rates of Survival by Year and Absolute Differences in Survival Between 2011 and 2000–2001.

Year	Number of Patients who Survived (%)											P-value
	2000–2001 (Ref)	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	
Overall n (%)	2996	3721	4706	4866	4718	4564	4408	4369	4228	3403	3588	45567
Survival to Discharge	433 (14.5)	558 (15.0)	723 (15.4)	747 (15.4)	765 (16.2)	720 (15.8)	713 (16.2)	813 (18.6)	772 (18.3)	646 (19.0)	674 (18.8)	7564 (16.6)
30-day Survival	373 (12.4)	455 (12.2)	585 (12.4)	612 (12.6)	643 (13.6)	595 (13.0)	575 (13.0)	655 (15.0)	635 (15.0)	527 (15.5)	545 (13.3)	6200 (13.6)
1-year Survival	268 (8.9)	328 (8.8)	415 (8.8)	435 (8.9)	441 (9.3)	390 (8.5)	394 (8.9)	448 (10.3)	425 (10.1)	358 (10.5)	381 (10.6)	4283 (9.4)
By Initial Rhythm												
Shockable n (%)	866	865	1009	1052	949	888	882	800	780	541	618	9223
Survival to Discharge	246 (28.4)	278 (32.1)	333 (33.0)	350 (33.3)	320 (33.7)	300 (33.8)	297 (33.7)	291 (36.4)	312 (40.0)	187 (36.4)	217 (35.1)	3131 (33.9)
30-day Survival	218 (25.2)	238 (27.5)	280 (27.8)	293 (27.9)	288 (30.3)	267 (30.1)	253 (28.7)	245 (30.6)	272 (34.9)	155 (30.2)	189 (30.7)	2698 (29.3)
1-year Survival	168 (19.4)	183 (21.2)	206 (20.4)	214 (20.3)	218 (23.0)	199 (22.4)	190 (21.5)	182 (22.8)	196 (25.1)	118 (23.0)	140 (22.7)	2014 (21.8)
Non-Shockable n (%)	2130	2856	3697	3814	3769	3676	3526	3569	3448	2889	2970	36344
Survival to Discharge	187 (8.8)	280 (9.8)	390 (10.5)	397 (10.4)	445 (11.8)	420 (11.4)	416 (11.8)	522 (14.6)	460 (13.3)	459 (15.9)	457 (15.4)	4433 (12.2)
30-day Survival	155 (7.3)	217 (7.6)	305 (8.2)	319 (8.4)	355 (9.4)	328 (8.9)	322 (9.1)	410 (11.5)	363 (10.5)	372 (12.9)	356 (12.0)	3502 (9.6)
1-year Survival	100 (4.7)	145 (5.1)	209 (5.7)	221 (5.8)	223 (5.9)	191 (5.2)	204 (5.8)	266 (7.5)	229 (6.6)	240 (8.3)	241 (8.1)	2269 (6.2)

* Abbreviation: RR = rate ratio; CI = confidence interval; Shockable = Initial rhythm ventricular tachycardia or ventricular fibrillation; Non-Shockable = initial rhythm pulseless electrical activity or asystole;

[†] Unadjusted differences in survival rates were calculated by subtracted the observed survival in 2000–2001 from the observed survival in 2011

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[‡]Risk adjusted rates of survival for each calendar year were obtained by multiplying the observed rate for the reference year (2000–2001) by the corresponding rate ratios for 2011 with calendar year modeled as a categorical variable to get the adjusted absolute difference the risk adjusted rate in 2011 was subtracted from the baseline rate in 2000–2011

[§]Adjusted rate ratios per year and p value for trend are from model with year modeled as a continuous variable.

Table 4

Risk Adjusted Rate Ratio for 1-year Survival in Hospitals with Continuous GWTG-R Participation.

		Risk Adjusted Rate Ratio (95% CI) ^b										Adjusted Rate Ratio per Year (95% CI) ^c	P-value for trend
Year	2000–2001 (Ref)	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011		
1-year Survival	1.0	1.15 (0.88–1.49)	1.47 (1.15–1.87)	1.42 (1.11–1.81)	1.44 (1.14–1.83)	1.37 (1.07–1.74)	1.37 (1.07–1.74)	1.81 (1.43–2.29)	1.41 (1.10–1.80)	1.88 (1.47–2.41)	1.68 (1.3–2.18)	1.04 (1.02–1.06)	<0.001
By Initial Rhythm													
1-year Survival													
Shockable	1.0	1.17 (0.84–1.64)	1.33 (0.97–1.82)	1.27 (0.93–1.74)	1.28 (0.94–1.75)	1.22 (0.90–1.68)	1.09 (0.79–1.51)	1.51 (1.11–2.05)	1.38 (1.01–1.88)	1.29 (0.91–1.84)	1.21 (0.85–1.73)	1.02 (0.99–1.04)	
Non-Shockable	1.0	1.17 (0.77–1.79)	1.74 (1.19–2.53)	1.70 (1.17–2.48)	1.74 (1.20–2.52)	1.64 (1.12–2.38)	1.80 (1.24–2.60)	2.30 (1.60–3.29)	1.56 (1.07–2.28)	2.62 (1.80–3.78)	2.34 (1.60–3.44)	1.06 (1.04–1.09)	<0.001

^a Abbreviation: RR = rate ratio; CI = confidence interval; Shockable = Initial rhythm ventricular tachycardia or ventricular fibrillation; Non-Shockable = initial rhythm pulseless electrical activity or asystole, IHCA = In-hospital cardiac arrest

^b Risk adjusted rates ratios of survival are reported for the overall cohort for 2001–2011 from the model with calendar year as a categorical variable

^c Adjusted rate ratio per year and p value for trend are from model with year modeled as a continuous variable.

^d Analysis included 112 hospitals and 23,213 patients who had IHCA at a hospital which occurred at a GWTG-R hospital with at least 8 years of continuous participation. Models were adjusted for patient demographics (age [<75, 75–<85, 85], sex, race [white, black, other]), arrest characteristics (initial cardiac arrest rhythm, time of day and day of week of the arrest, location of the arrest), conditions present 24 h prior to the arrest (hepatic insufficiency, renal insufficiency, hypotension, sepsis, heart failure, diabetes mellitus, respiratory insufficiency, or metastatic or hematologic cancer), and interventions present at the time of arrest (requirement for mechanical ventilation and vasoactive medication use).