Association Between a Hospital’s Quality Performance for In-Hospital Cardiac Arrest and Common Medical Conditions

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Background—Public reporting on hospital quality has been widely adopted for common medical conditions. Adding a measure of inpatient survival after cardiac arrest is being considered. It is unknown whether this measure would be redundant, given evidence that hospital organization and culture can have hospital-wide effects on quality. Therefore, we sought to evaluate the correlation between inpatient survival after cardiac arrest and 30-day risk-standardized mortality rates for common medical conditions.

Methods and Results—Using data between 2007 and 2010 from a national in-hospital cardiac arrest registry, we calculated risk-standardized in-hospital survival rates for cardiac arrest at each hospital. We obtained risk-standardized 30-day mortality rates for acute myocardial infarction, heart failure, and pneumonia from Hospital Compare for the same period. The relationship between a hospital’s performance on cardiac arrest and these other medical conditions was assessed using weighted Pearson correlation coefficients. Among 26,270 patients with in-hospital cardiac arrest at 130 hospitals, survival rates varied across hospitals, with a median risk-standardized hospital survival rate of 22.1% and an interquartile range of 19.7% to 24.2%. There were no significant correlations between a hospital’s outcomes for its cardiac arrest patients and its patients admitted for acute myocardial infarction (correlation, −0.12; P=0.16), heart failure (correlation, −0.05; P=0.57), or pneumonia (correlation, −0.15; P=0.10).

Conclusions—Hospitals that performed better on publicly reported outcomes for 3 common medical conditions did not necessarily have better cardiac arrest survival rates. Public reporting on cardiac arrest outcomes could provide new information about hospital quality. (Circ Cardiovasc Qual Outcomes. 2013;6:700-707.)

Key Words: heart failure ■ myocardial infarction ■ resuscitation

Public reporting on mortality has been widely adopted for a few inpatient medical conditions, and there is some evidence that it can improve outcomes when combined with appropriate incentives.1 In this context, broadening the scope of public reporting to include other conditions, such as cardiac arrest, is now being considered. Cardiac arrest would be a natural condition to add, as treated cardiac arrest affects 200,000 hospitalized adults in the United States each year,2 and about one fifth of such patients survive to discharge.3 Furthermore, wide variation in risk-standardized in-hospital survival rates4 suggests that there is room for improvement. Indeed, hospitals hoping to improve survival after cardiac arrest have begun to implement resuscitation-specific interventions, including identification of errors during resuscitation5,6 and prompt defibrillation with appropriate energy.7,8

However, given growing evidence that more general aspects of hospital organization and culture (eg, health information technology adoption) can affect quality of care for multiple conditions9–11 it is possible that a publicly reported measure of in-hospital survival after cardiac arrest would be redundant. For example, fair to good agreement exists among the mortality rates of 3 publicly reported conditions: acute myocardial infarction (AMI), heart failure (HF), and pneumonia.12 In the case of in-hospital survival after cardiac arrest, it is unknown whether a tight correlation exists with publicly reported measures of mortality for AMI, HF, and pneumonia. A strong
WHAT IS KNOWN

- Public reporting on hospital quality has been widely adopted for common medical conditions.
- It is unknown whether adding a measure of inpatient survival after cardiac arrest would be redundant.

WHAT THE STUDY ADDS

- Hospitals that performed better on publicly reported outcomes for 3 common medical conditions did not necessarily have better cardiac arrest survival rates.
- Public reporting on cardiac arrest outcomes could provide new information about hospital quality.

correlation would suggest that finite resources should not be devoted to expanding public reporting to include cardiac arrest. It would also indicate that improving survival after cardiac arrest depends on identifying hospital factors that plausibly influence multiple disease states. However, a weak correlation between outcomes for common medical conditions and cardiac arrest would suggest that the quality signal from cardiac arrest is distinct. This would support the inclusion of cardiac arrest in public reports and the value of resuscitation-specific quality improvement efforts.

Therefore, we used data from a large, national in-hospital cardiac arrest registry and the Centers for Medicare and Medicaid Services Hospital Compare reports of hospital-level outcomes to examine the association between a hospital’s survival rate for cardiac arrest and its mortality rate for AMI, HF, and pneumonia. A better understanding of this relationship would help providers assess whether in-hospital mortality after cardiac arrest adds new information on hospital quality, and whether resuscitation-specific interventions around cardiac arrest have the potential to contribute to efforts to decrease in-hospital mortality.13

Methods

Data Sources

We conducted our study using 2 data sources. First, we examined hospital resuscitation outcomes using Get With The Guidelines (GWTG)-Resuscitation, which previously was called the National Registry of Cardiopulmonary Resuscitation. GWTG-Resuscitation is a large, prospective registry of US patients with in-hospital cardiac arrest.14 Patients qualify for inclusion in the registry if they have a pulseless cardiac arrest that is defined as the absence of a palpable central pulse, apnea, and unresponsiveness in patients without do-not-resuscitate orders. At participating hospitals, quality improvement personnel use standardized Utstein-style definitions15,16 to collect information on the clinical characteristics and outcomes of consecutive inpatients with cardiac arrest. To enhance data accuracy, research personnel are certified, software supports standardized data collection, and data are routinely reabstracted for quality assurance purposes.

To obtain 30-day hospital rates of risk-standardized mortality for AMI, HF, and pneumonia, we also used data from the Centers for Medicare and Medicaid Services on the Hospital Compare website at www.hospitalcompare.hhs.gov. Hospital outcomes for cardiac arrest, AMI, HF, and pneumonia were then linked by the data coordinating center for GWTG-Resuscitation (University of Pennsylvania) by matching the American Hospital Association identification numbers present in both data sets. Data on hospital characteristics were obtained from the American Hospital Association Annual Survey.

Study Population

Between July 1, 2007, and June 30, 2010, we identified 40,907 patients aged 21 years at 368 hospitals within GWTG-Resuscitation with clinical information on an index in-hospital cardiac arrest (Figure 1). Because we were interested in examining the association between risk-standardized hospital survival rates for cardiac arrest and 30-day mortality rates for AMI, HF, and pneumonia, we excluded 148 patients with missing data on survival after cardiac arrest and 273 patients with missing data on location or time of cardiac arrest—critical variables used in deriving risk-standardized hospital survival rates after cardiac arrest. We additionally excluded 99 hospitals representing 8785 cardiac arrest cases because information on hospital performance for AMI, HF, and pneumonia was not available on Hospital Compare. Nineteen percent of the excluded hospitals were military or Veterans Administration hospitals. Excluded hospitals, on average, had fewer cardiac arrest cases than hospitals included in the study cohort. Other differences between the excluded and included hospitals are summarized in Appendix Table I in the online-only Data Supplement. As noted in Figure 1, after additional exclusions, our final study cohort included 26,270 adults from 130 hospitals.

Study Variables

GWTG-Resuscitation collects data on multiple patient characteristics, including age, race (white, black, and other), sex, initial cardiac arrest rhythm (asystole, pulseless electric activity, ventricular fibrillation, or pulseless ventricular tachycardia), year of admission, location of arrest (intensive care unit, monitored unit, nonmonitored unit, emergency department, and other), and time of arrest (night versus day, weekend versus weekday). In addition, the registry collects information on the presence or absence of the following conditions

Figure 1. Study cohort. AMI indicates acute myocardial infarction; and HF, heart failure.
within 24 hours of the cardiac arrest: HF; myocardial infarction, or ischemia; arrhythmia; hypertension; renal, hepatic, or respiratory insufficiency; diabetes mellitus; metabolic or electrolyte abnormality; acute central nervous system event (stroke or other); pneumonia; sepsis; major trauma; and malignancy.

Hospital characteristics available from the American Hospital Association data set included teaching status (major, minor, and nonteaching), ownership (other nonprofit, church, state/local government, and investor), location (urban versus rural), geographic region (North and Mid-Atlantic, South and Atlantic, North Central, South Central, and Mountain/Pacific), number of beds (<250, 250–499, and ≥500), as well as the ratio of full-time-equivalent registered nurses to beds at the hospital.

Study Outcomes

Our outcome of interest was the correlation between a hospital’s risk-standardized survival-to-discharge rate for cardiac arrest and its 30-day risk-standardized mortality rates for AMI, HF, and pneumonia. We used hospital 30-day risk-standardized mortality rates for AMI, HF, and pneumonia from July 2007 to June 2010, as reported on Hospital Compare.20–22 These mortality rates are adjusted for patient demographic and comorbid conditions, as has been previously described,12,18 and reflect death from any cause within 30 days of admission.

Statistical Analyses

We divided hospitals in the GWTG-Resuscitation data set into quartiles of unadjusted hospital survival rates for cardiac arrest. We then described patient and hospital characteristics in each quartile, comparing continuous variables using 1-way ANOVA and categorical variables using χ² or Fisher’s exact test.

Similar to the methodology that the Centers for Medicare and Medicaid Services uses to calculate risk-standardized mortality for AMI, HF, and pneumonia,15–18 we estimated risk-standardized cardiac arrest survival rates at hospitals adjusting for the patient characteristics described above. To ensure proper adjustment for clustering of patients within hospitals, 2-level hierarchical logistic regression models were constructed, with survival to discharge as the dependent variable. In these analyses, individual hospitals were modeled as random effects and patient characteristics as fixed effects within each hospital. From the multivariable model, hospital-specific random intercepts were used to calculate predicted survival rates for each hospital. The risk-standardized survival rate was then calculated as follows: (predicted survival rate at a hospital/expected survival rate at the same hospital)×average unadjusted survival rate at all hospitals in our sample. We used predicted versus expected survival rates because this approach likely provides more accurate risk-standardized estimates for hospitals with low case volumes than an observed versus expected approach likely provides more accurate risk-standardized estimates for hospitals with low case volumes than an observed versus expected approach.

In unadjusted analyses, there were no significant associations between a hospital’s cardiac arrest survival rate and its 30-day risk-standardized mortality rate for AMI (correlation, −0.11; P = 0.13), HF (correlation, 0.03; P = 0.46), or pneumonia (correlation, −0.12; P = 0.66). After risk-standardization of hospital cardiac arrest survival rates, we found weak but statistically insignificant negative correlations between a hospital’s cardiac arrest survival rate and its mortality rates for AMI (correlation, −0.12; P = 0.16), HF (correlation, −0.05; P = 0.57), and pneumonia (correlation, −0.15; P = 0.10; Figures 3A–3C). In sensitivity analyses, results were similar using the Spearman correlation coefficient.

In contrast, 30-day risk-standardized mortality rates for AMI, HF, and pneumonia were all positively correlated (for AMI and HF: correlation, 0.40; for AMI and pneumonia: correlation, 0.37; and for HF and pneumonia: correlation, 0.49), and these correlations were statistically significant (all P values < 0.001).

Discussion

Given wide variation in hospital survival rates for cardiac arrest, we examined whether hospitals that perform well for common medical conditions also excel in outcomes for cardiac arrest. We found no significant correlations between a hospital’s publicly reported 30-day mortality rates for AMI, HF, or pneumonia and its in-hospital survival rate for cardiac arrest survival to discharge. Compared with patients treated at hospitals in the lowest quartile of survival, those in the highest quartile of survival were more likely to be white, have an initial rhythm of ventricular fibrillation or pulseless ventricular tachycardia, arrest in a monitored unit or the emergency department, and arrest on a weekend (Tables 1 and 2). The pre-existing characteristics of patients differed as well, with those patients treated at hospitals in the highest quartile of survival more likely to have arrhythmias, hypertension, metabolic or electrolyte abnormalities, and an acute central nervous system nonstroke event. Compared with hospitals in the lowest quartile of survival, those in the highest quartile of survival were also less likely to be located in the South (Table 3).
These findings suggest that the quality signal from cardiac arrest is distinct from that conveyed by the other measures. Because of this, it is likely that public reporting on in-hospital cardiac arrest would add to existing information on hospital quality. Our findings are also consistent with value in resuscitation-specific interventions to improve in-hospital cardiac arrest survival.

In clinical areas other than resuscitation, there is growing interest in identifying how the organizational and cultural traits of hospitals, such as nurse staffing, leadership, safety culture, and

### Table 1. Patient Characteristics, Stratified by Quartiles of In-Hospital Cardiac Arrest Survival Rates

<table>
<thead>
<tr>
<th>In-Hospital Cardiac Arrest Survival, %</th>
<th>Quartile 1 (Low), N=36 (n=6544)</th>
<th>Quartile 2, N=31 (n=6538)</th>
<th>Quartile 3, N=24 (n=6509)</th>
<th>Quartile 4, (High), N=39 (n=6679)</th>
<th>P Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.4 to &lt;18.1</td>
<td>65±16.6</td>
<td>66±15.7</td>
<td>66±16.0</td>
<td>65±15.9</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

**Demographics**

- **Age**
  - Mean±SD: 65±16.6, 66±15.7, 66±16.0, 65±15.9
  - Median (IQR): 67 (54.0–78.0), 68 (56.0–79.0), 67 (55.0–78.0)
- **Men**
  - 3751 (57.3%), 3736 (57.1%), 3814 (58.6%), 3992 (59.8%)
- **Race**
  - White: 3881 (59.3%), 4744 (72.6%), 4849 (74.5%), 5060 (75.8%)
  - Black: 1915 (29.3%), 1534 (23.5%), 1201 (18.5%), 886 (13.3%)
  - Other: 202 (3.1%), 134 (2.0%), 163 (2.5%), 196 (2.9%)

**Pre-existing conditions**

- **Respiratory insufficiency**
  - 2122 (32.4%), 2723 (41.6%), 3115 (47.9%), 2806 (42.0%)
- **Renal insufficiency**
  - 2052 (31.4%), 2229 (34.1%), 2285 (35.1%), 2116 (33.2%)
- **Arrhythmia**
  - 1433 (21.9%), 2008 (30.7%), 2120 (32.6%), 2156 (32.3%)
- **Diabetes mellitus**
  - 1854 (28.3%), 2155 (33.0%), 2013 (30.9%), 2216 (33.2%)
- **Hypotension**
  - 1129 (17.3%), 1833 (28.0%), 1898 (29.3%), 2140 (32.9%)
- **Heart failure this admission**
  - 929 (14.2%), 1184 (18.1%), 1225 (18.8%), 1123 (16.8%)
- **Heart failure before admission**
  - 1165 (17.8%), 1317 (20.1%), 1390 (21.4%), 1273 (19.1%)
- **MI this admission**
  - 772 (11.8%), 1026 (15.7%), 1344 (20.6%), 1230 (18.4%)
- **MI before admission**
  - 645 (9.9%), 801 (12.3%), 1449 (22.3%), 1029 (15.4%)
- **Metabolic/electrolyte abnormality**
  - 711 (10.9%), 1042 (15.9%), 846 (13.0%), 1102 (16.5%)
- **Septicemia**
  - 1149 (17.6%), 1054 (16.1%), 1118 (17.2%), 1148 (17.2%)
- **Pneumonia**
  - 764 (11.7%), 1005 (15.4%), 809 (12.4%), 897 (13.4%)
- **Metastatic/hematologic malignancy**
  - 836 (12.8%), 800 (12.2%), 748 (11.5%), 788 (11.8%)

**Interventions in place**

- **Assisted/mechanical ventilation**
  - 2411 (36.8%), 1914 (29.3%), 2375 (36.5%), 2277 (34.1%)
- **IV vasoactive agents**
  - 2043 (31.2%), 1825 (27.9%), 2035 (31.3%), 1970 (29.5%)
- **IV antiarrhythmics**
  - 367 (5.6%), 367 (5.6%), 468 (7.2%), 498 (7.5%)
- **Pulmonary artery catheter**
  - 84 (1.3%), 120 (1.8%), 241 (3.7%), 221 (3.3%)
- **Dialysis/extracorporeal filtration**
  - 267 (4.1%), 209 (3.2%), 228 (3.5%), 237 (3.5%)
- **Intra-aortic balloon pump**
  - 69 (1.1%), 78 (1.2%), 156 (2.4%), 143 (2.1%)
- **Internal cardiac defibrillator**
  - 113 (1.7%), 116 (1.8%), 104 (1.6%), 113 (1.7%)

Numbers do not sum to sample total for every row because some characteristics had missing data. Interventions in place refers to interventions already in place when need for chest compressions or defibrillation was first recognized. CNS indicates central nervous system; IV, intravenous; IQR, interquartile range; MI, myocardial infarction; N is number of hospitals, and n is number of patients.

*Continuous variables compared using 1-way ANOVA. Categorical variables compared using χ² or Fisher’s exact test.
implementation of health information technology, may affect a broad range of patient outcomes.9–11,24–26 For example, Bradley et al27 found that certain aspects of a hospital’s organizational environment (eg, openness to creative problem solving) were associated with lower 30-day risk-standardized mortality rates for AMI. Others have demonstrated an association between health information technology and hospital-wide quality.9–11 One might postulate that a hospital’s cultural and organizational environment could also affect the quality of care for resuscitation. However, most prior work in cardiac arrest has sought to describe and improve hospital processes of care that apply only to resuscitation.6–8 Empirical evidence to support such a focused approach has been lacking. It is plausible that high-performing hospitals for some diseases (eg, HF, AMI, and pneumonia) are not the same hospitals that excel in the care of cardiac arrest patients, thereby necessitating different types of quality improvement interventions. For example, standing orders and electronic reminders may be helpful for AMI, HF, and pneumonia (all of which have long lead times between diagnosis and discharge) but of little use for cardiac arrest, where prompt recognition and rapid response times (eg, defibrillation and cardiopulmonary resuscitation) are associated with improved survival.8,28

In our data, lack of correlation between high-performing hospitals for HF, AMI, and pneumonia, and those for cardiac arrest indicate that general efforts to improve quality for common medical conditions do not—in and of themselves—translate into high quality for cardiac arrest. At a minimum, our results suggest that wide variation in 30-day mortality rates for AMI, HF, and pneumonia among hospitals is not because of differences in achieving survival to discharge after cardiac arrest. Our findings could further be interpreted as supporting the need to pursue resuscitation-specific efforts to improve survival for patients with in-hospital cardiac arrest. Such interventions may include those targeted at preventing cardiac arrests (eg, hospital monitoring, rapid response teams, remote intensive care unit monitoring), improving acute resuscitation care (eg, times to defibrillation and vasopressors, high-quality chest compressions with minimal interruptions), and optimizing postresuscitation survival, as well as strengthening resuscitation systems of care (eg, simulations of and debriefing after cardiac arrest). Although leadership and culture no doubt lay the foundation for quality improvement efforts across a variety of domains, our results are consistent with the hypothesis that these factors are necessary but not sufficient for improved cardiac arrest survival. Future studies are needed to determine which resuscitation-specific interventions have the greatest effect on cardiac arrest survival, and how each of these interventions interacts with broader determinants of hospital quality.

Our results are in keeping with prior work that has found hospitals’ performance on a variety of quality measures

### Table 2. Event Characteristics, Stratified by Quartiles of In-Hospital Cardiac Arrest Survival Rates

<table>
<thead>
<tr>
<th>In-Hospital Cardiac Arrest Survival, %</th>
<th>Quartile 1 (Low), N=36 (n=6544)</th>
<th>Quartile 2, N=31 (n=6538)</th>
<th>Quartile 3, N=24 (n=6509)</th>
<th>Quartile 4 (High), N=39 (n=6679)</th>
<th>P Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.4 to &lt;18.1</td>
<td>18.1 to &lt;21.7</td>
<td>21.7 to &lt;25.6</td>
<td>25.6 to &lt;35</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Event Characteristics**

**Admission year**

2007 2135 (32.6%) 2152 (32.9%) 1990 (30.6%) 2224 (33.3%) 0.008

2008 2202 (33.6%) 2255 (34.5%) 2333 (35.8%) 2311 (34.6%)

2009 2207 (33.7%) 2131 (32.6%) 2186 (33.6%) 2144 (32.1%)

**Arrest time**

Day 3108 (47.5%) 3333 (51.0%) 3340 (51.3%) 3425 (51.3%) <0.001

Night 1267 (19.4%) 1232 (18.8%) 1195 (18.4%) 1214 (18.2%)

Weekend 2169 (33.1%) 1973 (30.2%) 1974 (30.3%) 2040 (30.5%)

**Location**

ICU 3427 (52.4%) 3041 (46.5%) 3166 (48.6%) 3036 (45.5%) <0.001

Monitored 905 (13.8%) 1072 (16.4%) 932 (14.3%) 1219 (18.3%)

Nonmonitored 1197 (18.3%) 1306 (20.0%) 1173 (18.0%) 926 (13.9%)

ER 548 (8.4%) 583 (8.9%) 641 (9.8%) 825 (12.4%)

Procedural 339 (5.2%) 400 (6.1%) 495 (7.6%) 549 (8.2%)

Other 128 (2.0%) 136 (2.1%) 102 (1.6%) 124 (1.9%)

**Initial rhythm**

Asystole 2348 (35.9%) 2207 (33.8%) 2065 (31.7%) 1948 (29.2%) <0.001

PEA 3212 (49.1%) 3167 (48.4%) 3061 (47.0%) 3217 (48.2%)

VF 579 (8.8%) 680 (10.4%) 843 (13.0%) 911 (13.6%)

PVT 405 (6.2%) 484 (7.4%) 540 (8.3%) 603 (9.0%)

Numbers do not sum to sample total for every row because some characteristics had missing data. CNS indicates central nervous system; ER, emergency room; ICU, intensive care unit; N, number of hospitals, n, number of patients; PEA, pulseless electric activity; PVT, pulseless ventricular tachycardia; and VF, ventricular fibrillation.

*Continuous variables compared using 1-way ANOVA. Categorical variables compared using χ² or Fisher’s exact test.
is not always tightly correlated. For example, the correlation between hospital performance on process measures for AMI, HF, and pneumonia is modest. Others have found that hospital performance on process measures is weakly correlated with outcome measures. In contrast, a more limited number of studies has found that hospital mortality rates across a variety of surgical procedures may be related. Similar to prior work, we also found that 30-day risk-standardized mortality rates for AMI, HF, and pneumonia were correlated among hospitals. To date, however, few studies have described the association between hospital performance on quality outcomes in different clinical domains (e.g., resuscitation and medicine). Although we found that outcomes for AMI, HF, and pneumonia are not tightly correlated with outcomes for cardiac resuscitation, additional research will be needed to identify what set of quality measures for which conditions provides the best picture of overall hospital quality at a reasonable cost.

Our study has several important limitations. First, we used data collected at hospitals enrolled in GWTG-Resuscitation, so our findings may not be generalizable. However, GWTG-Resuscitation includes acute care hospitals located throughout the United States, which makes the data more representative of the broader population. Second, our study was cross-sectional, and causal relationships cannot be inferred from these data. Third, the sample size for some outcomes was limited, which may have affected the power of our analyses. Further research with larger sample sizes is needed to confirm our findings and to explore the factors that contribute to the variation in hospital performance.

### Table 3. Hospital Characteristics, Stratified by Quintiles of In-Hospital Cardiac Arrest Survival Rates

<table>
<thead>
<tr>
<th>In-Hospital Cardiac Arrest Survival, %</th>
<th>Quartiles of In-Hospital Cardiac Arrest Survival Rates</th>
<th>P Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Quartile 1 (Low), N=36 (n=6544)</td>
<td></td>
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<tr>
<td></td>
<td>Quartile 2, N=31 (n=6538)</td>
<td></td>
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<td></td>
<td>Quartile 3, N=24 (n=6509)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Quartile 4 (High), N=39 (n=6679)</td>
<td></td>
</tr>
<tr>
<td>Hospital Characteristics</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teaching status</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Major teaching</td>
<td>6 (16.7%)</td>
<td>0.21</td>
</tr>
<tr>
<td>Minor teaching</td>
<td>14 (38.9%)</td>
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</tr>
<tr>
<td>Nonteaching</td>
<td>16 (44.4%)</td>
<td></td>
</tr>
<tr>
<td>Ownership</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other nonprofit</td>
<td>17 (47.2%)</td>
<td>0.13</td>
</tr>
<tr>
<td>Church</td>
<td>2 (5.6%)</td>
<td></td>
</tr>
<tr>
<td>State/local government</td>
<td>7 (19.4%)</td>
<td></td>
</tr>
<tr>
<td>Investor</td>
<td>10 (27.8%)</td>
<td></td>
</tr>
<tr>
<td>Region</td>
<td></td>
<td></td>
</tr>
<tr>
<td>North and Mid-Atlantic</td>
<td>5 (13.9%)</td>
<td>0.03</td>
</tr>
<tr>
<td>South Atlantic</td>
<td>14 (38.9%)</td>
<td></td>
</tr>
<tr>
<td>North Central</td>
<td>6 (16.7%)</td>
<td></td>
</tr>
<tr>
<td>South Central</td>
<td>8 (22.2%)</td>
<td></td>
</tr>
<tr>
<td>Mountain/Pacific</td>
<td>3 (8.3%)</td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>34 (94.4%)</td>
<td>0.35</td>
</tr>
<tr>
<td>Full-time equivalent nurse ratio</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;1</td>
<td>2 (5.6%)</td>
<td>0.08</td>
</tr>
<tr>
<td>1 to &lt;1.5</td>
<td>15 (41.7%)</td>
<td></td>
</tr>
<tr>
<td>1.5 to &lt;2</td>
<td>11 (30.6%)</td>
<td></td>
</tr>
<tr>
<td>2.5 to &lt;3</td>
<td>7 (19.4%)</td>
<td></td>
</tr>
<tr>
<td>≥3</td>
<td>0 (0.0%)</td>
<td></td>
</tr>
<tr>
<td>Number of beds</td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;250</td>
<td>16 (44.4%)</td>
<td>0.43</td>
</tr>
<tr>
<td>250–499</td>
<td>13 (36.1%)</td>
<td></td>
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<tr>
<td>≥500</td>
<td>7 (19.4%)</td>
<td></td>
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</tbody>
</table>

Numbers do not sum to sample total for every row because some characteristics had missing data. N indicates number of hospitals; and n, number of patients.

*Categorical variables compared using χ² or Fisher’s exact test.
In summary, we found that a hospital’s 30-day mortality rates for HF, AMI, and pneumonia were not correlated with its in-hospital survival rate for in-hospital cardiac arrest. This supports current efforts to make in-hospital cardiac arrest a publicly reported measure because it would likely yield new information about hospital quality. It further supports the need for resuscitation-specific interventions to improve in-hospital cardiac arrest survival rates.

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Disclosures

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for the American Heart Associations Get With The Guidelines-Resuscitation Investigators

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Supplemental Material

American Heart Association Get With the Guidelines—Resuscitation (formerly National Registry of Cardiopulmonary Resuscitation) Investigators:

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## Appendix Table 1. Characteristics of Included and Excluded Hospitals

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Excluded Hospitals</th>
<th>Included Hospitals</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Patients with Index Cardiac Arrest</td>
<td></td>
<td></td>
<td>0.001</td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>88.7 ± 112.2</td>
<td>143.4 ± 150.8</td>
<td></td>
</tr>
<tr>
<td>Median (IQR)</td>
<td>36.0 (7.0, 143.0)</td>
<td>97.0 (41.0, 203.0)</td>
<td></td>
</tr>
<tr>
<td>Teaching Status</td>
<td></td>
<td></td>
<td>0.80</td>
</tr>
<tr>
<td>Major teaching</td>
<td>23 (27.4%)</td>
<td>53 (23.9%)</td>
<td></td>
</tr>
<tr>
<td>Minor teaching</td>
<td>25 (29.8%)</td>
<td>72 (32.4%)</td>
<td></td>
</tr>
<tr>
<td>Non-teaching</td>
<td>36 (42.9%)</td>
<td>97 (43.7%)</td>
<td></td>
</tr>
<tr>
<td>Missing</td>
<td>15</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Ownership</td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Other Non-Profit</td>
<td>33 (39.3%)</td>
<td>127 (57.2%)</td>
<td></td>
</tr>
<tr>
<td>Church</td>
<td>15 (17.9%)</td>
<td>33 (14.9%)</td>
<td></td>
</tr>
<tr>
<td>State/Local Gov't</td>
<td>7 (8.3%)</td>
<td>28 (12.6%)</td>
<td></td>
</tr>
<tr>
<td>Investor</td>
<td>13 (15.5%)</td>
<td>34 (15.3%)</td>
<td></td>
</tr>
<tr>
<td>VA/Military</td>
<td>16 (19.0%)</td>
<td>0 (0.0%)</td>
<td></td>
</tr>
<tr>
<td>Missing</td>
<td>15</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Region</td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>North and Mid-Atlantic</td>
<td>8 (9.5%)</td>
<td>37 (16.7%)</td>
<td></td>
</tr>
<tr>
<td>South Atlantic</td>
<td>12 (14.3%)</td>
<td>66 (29.7%)</td>
<td></td>
</tr>
<tr>
<td>North Central</td>
<td>2 (2.4%)</td>
<td>58 (26.1%)</td>
<td></td>
</tr>
<tr>
<td>South Central</td>
<td>21 (25.0%)</td>
<td>39 (17.6%)</td>
<td></td>
</tr>
<tr>
<td>Mountain/Pacific</td>
<td>41 (48.8%)</td>
<td>22 (9.9%)</td>
<td></td>
</tr>
<tr>
<td>Missing</td>
<td>15</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td></td>
<td></td>
<td>0.045</td>
</tr>
<tr>
<td>Rural</td>
<td>4 (4.8%)</td>
<td>28 (12.6%)</td>
<td></td>
</tr>
<tr>
<td>Urban</td>
<td>80 (95.2%)</td>
<td>194 (87.4%)</td>
<td></td>
</tr>
<tr>
<td>Missing</td>
<td>15</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Full-time Equivalent Nurse Ratio</td>
<td></td>
<td></td>
<td>0.33</td>
</tr>
<tr>
<td>&lt;1</td>
<td>3 (3.6%)</td>
<td>15 (6.8%)</td>
<td></td>
</tr>
<tr>
<td>1-&lt;1.5</td>
<td>26 (31.0%)</td>
<td>71 (32.0%)</td>
<td></td>
</tr>
<tr>
<td>1.5-2</td>
<td>22 (26.2%)</td>
<td>74 (33.3%)</td>
<td></td>
</tr>
<tr>
<td>2-&lt;2.5</td>
<td>23 (27.4%)</td>
<td>42 (18.9%)</td>
<td></td>
</tr>
<tr>
<td>2.5-&lt;3</td>
<td>4 (4.8%)</td>
<td>12 (5.4%)</td>
<td></td>
</tr>
<tr>
<td>3+</td>
<td>6 (7.1%)</td>
<td>8 (3.6%)</td>
<td></td>
</tr>
<tr>
<td>Missing</td>
<td>15</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Number of Beds</td>
<td></td>
<td></td>
<td>0.06</td>
</tr>
<tr>
<td>&lt;250</td>
<td>43 (51.2%)</td>
<td>86 (38.7%)</td>
<td></td>
</tr>
<tr>
<td>250 - 499</td>
<td>31 (36.9%)</td>
<td>86 (38.7%)</td>
<td></td>
</tr>
<tr>
<td>500+</td>
<td>10 (11.9%)</td>
<td>50 (22.5%)</td>
<td></td>
</tr>
<tr>
<td>Missing</td>
<td>15</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>In-hospital Cardiac Arrest Survival Rate</td>
<td></td>
<td></td>
<td>0.86</td>
</tr>
<tr>
<td>Mean ± SD</td>
<td>0.21 ± 0.19</td>
<td>0.22 ± 0.11</td>
<td></td>
</tr>
<tr>
<td>Median (IQR)</td>
<td>0.18 (0.11, 0.25)</td>
<td>0.21 (0.16, 0.26)</td>
<td></td>
</tr>
</tbody>
</table>

Continuous variables compared using Student’s T-test. Categorical variables compared using chi-square or Fisher’s exact test.
Appendix Table 2. Formula for Calculating Risk-Standardized Hospital Survival Rates

1) To calculate the expected survival rate for the patient, first determine the sum of all the predictor coefficients, which will be designated as ‘Patient Beta’ for each patient. The expected survival rate for the patient can then be calculated by the following formula:

\[
\text{Exponent (Patient Beta)} \\
(1 + \text{exponent [Patient Beta]})
\]

2) To calculate the expected survival rate for a given hospital, calculate the expected survival rate for each patient with an in-hospital cardiac arrest (#1 above) and then determine the average of the expected survival rates of all patients in a given hospital.

3) To calculate the predicted survival rate for a given hospital, the hospital’s specific random effect intercept is used (not shown, as it is specific to each participating hospital in a given study sample), rather than the average hospital intercept from the formula above.

4) The hospital’s risk-standardized survival rate is then calculated as the ratio of the hospital’s predicted to expected survival rate, multiplied by the unadjusted rate for the entire study sample.
Appendix Figure 1A. Distribution of 30-day risk-standardized hospital mortality rates for acute myocardial infarction (AMI)
Appendix Figure 1B. Distribution of 30-day risk-standardized hospital mortality rates for heart failure (HF)
Appendix Figure 1C. Distribution of 30-day risk-standardized hospital mortality rates for pneumonia.