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Outcomes of In-Hospital Cardiac Arrest Among Hospitals With and Without Telemedicine Critical Care

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Abstract

Background: Survival rates following in-hospital cardiac arrest (IHCA) are lower during nights and weekends (off-hours), as compared to daytime on weekdays (on-hours). Telemedicine Critical Care (TCC) may provide clinical support to improve IHCA outcomes, particularly during off-hours.

Objective: To evaluate the association between hospital availability of TCC and IHCA survival.

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CONFLICTS OF INTEREST
Dr. Joynt Maddox serves on the Health Policy Advisory Council for the Centene Corporation (St. Louis, MO). All other authors have declared no conflict of interest
All GWTG participating institutions were required to comply with local regulatory and privacy guidelines and, if required, to secure institutional review board approval. Because data were used primarily at the local site for quality improvement, sites were granted a waiver of informed consent under the common rule.

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Methods: We identified 44,585 adults at 280 U.S. hospitals in the *Get With The Guidelines*® - *Resuscitation* registry who suffered IHCA in an Intensive Care Unit (ICU) or hospital ward between July 2017 and December 2019. We used 2-level hierarchical multivariable logistic regression to investigate whether TCC availability was associated with better survival, overall, and during on-hours (Monday–Friday 7:00 a.m.−10:59 p.m.) vs. off-hours (Monday–Friday 11:00 p.m.−6:59 a.m., and Saturday-Sunday, all day, and US national holidays).

Results: 14,373 (32.2%) participants suffered IHCA at hospitals with TCC, and 27,032 (60.6%) occurred in an ICU. There was no difference between TCC and non-TCC hospitals in acute resuscitation survival rate or survival to discharge rates for either IHCA occurring in the ICU (acute survival odds ratio [OR] 1.02, 95% CI 0.92–1.15; survival to discharge OR 0.94 [0.83–1.07]) or outside of the ICU (acute survival OR 1.03 [0.91–1.17]; survival to discharge OR 0.99 [0.86–1.12]. Timing of cardiac arrest did not modify the association between TCC availability and acute resuscitation survival ($P = .37$ for interaction) or survival to discharge ($P = .39$ for interaction).

Conclusions: Hospital availability of TCC was not associated with improved outcomes for in-hospital cardiac arrest.

Keywords

Cardiopulmonary arrest; Cardiopulmonary resuscitation; Telehealth; Telemedicine; Critical Care; Tele-ICU; Tele-Critical Care

INTRODUCTION

In-hospital cardiac arrest (IHCA) affects approximately 300,000 patients annually in the United States.[1] Survival after IHCA is dependent on early recognition, prompt initiation of resuscitation protocols, and high-quality post-resuscitation care. Patient outcomes following IHCA remain extremely poor, with survival to discharge rates of 20% nationwide.[2] Further, survival rates are lower for the > 50% of IHCA occurring during nights and weekends,[3,4] when the ability of hospital staff to recognize deteriorating patients, prevent IHCA, or quickly initiate resuscitation protocols may be reduced.[5,6]

Telemedicine Critical Care (TCC) combines audiovisual technologies with electronic medical records access to enable the remote provision of critical care.[7] This has the potential to improve patient outcomes by assisting bedside caregivers in detecting clinical instability and in executing care plans. Additionally, TCC improves access to trained intensive care physicians,[8] whose presence in an intensive care unit (ICU) has been associated with improved survival.[9]

Thus far, studies evaluating the effect of TCC on broad ICU outcomes have shown mixed results.[10–18] To our knowledge, the association between TCC availability and improved outcomes for specific critical care syndromes, such as IHCA, has not been investigated. We hypothesized that a care delivery model which can derive operational intelligence and support from TCC could impact outcomes by enabling earlier recognition of clinical deterioration, and more efficient activation of clinical responses. Characterizing the association between TCC and IHCA outcomes could have implications on its continued nationwide rollout, as well as on quality efforts targeted at improving resuscitation care.

Therefore, the specific objectives of this study were to investigate (**1**) whether hospital availability of TCC was associated with better survival outcomes for IHCA, and (**2**) whether timing of the cardiac arrest modified the strength of any associations between TCC availability and IHCA survival outcomes. We hypothesized that hospital availability of TCC would be associated with better IHCA survival outcomes, and that this association would be stronger for IHCA events that occur during night-time or weekends when hospitals are understaffed.

To address this knowledge gap, we used data from the *Get With The Guidelines® -Resuscitation* (GWTG-R) registry — a large national database of IHCA events — linked with the American Hospital Association (AHA) Annual survey, which provided data on hospital availability of TCC.

METHODS

Data Sources:

The GWTG-R is a prospective, voluntary, multi-site registry of IHCA resuscitation events.[19] Multiple case-finding approaches ensure that all cases within a hospital are captured.[20,21] Data collection is based on the Utstein template for uniform reporting guidelines and is standardized across participating sites.[20,22] Data completeness and accuracy is ensured using a rigorous training and certification process, the use of standardized software, internal data checks, and periodic re-abstraction.

The AHA survey dataset is derived from voluntarily completed annual surveys of all AHA-registered U.S. hospitals. Information on TCC availability was included in the AHA data starting in fiscal year 2018 (July 2017 – June 2018) through a survey question on availability of "eICU" as a hospital facility or service. Similar to prior studies,[23,24] we categorized a hospital as having TCC (hereafter referred to as TCC hospitals) if they responded yes for that specific year (eTable 1). We linked the GWTG-R data to the survey data using AHA hospital identifiers. This study was deemed exempt by the Human Subjects Protection Office at the Washington University School of Medicine.

Study Population:

We identified 70,881 patients 18 years or older with an index pulseless IHCA between July 1, 2017, and December 31, 2019. We excluded arrests at hospitals that did not respond to the AHA surveys or had missing information on TCC availability; at hospitals with less than 10 cardiac arrests over the study period; that occurred outside of an ICU or hospital ward (e.g., emergency room and operating room); and in patients with an implantable cardioverter-defibrillator. Additionally, we excluded patients with missing information related to arrest time or survival. The final study sample was comprised of 44,585 arrests occurring in the ICU or general inpatient unit at 280 participating hospitals (Figure 1). TCC as currently implemented in most US hospitals,[23] typically targets beds within the physical confines of an ICU. However, to enable us to evaluate the robustness of any findings of improved survival among TCC hospitals, we *a priori* included arrests outside of the ICU as "controls".

Study Variables and Outcomes:

Our primary exposure variable was TCC availability at GWTG-R participant hospitals for 2018 and 2019. We assumed that hospitals with TCC availability during 2019 had it for the entire 2019 calendar year (i.e., inclusive of July–December 2019). The primary outcome variable was acute resuscitation survival (defined as return of spontaneous circulation [ROSC] for at least 20 contiguous minutes at any time after the initial pulseless arrest). Our secondary outcome was survival to hospital discharge.

Patient-level data were obtained from the GWTG-R and included demographics (age, sex, race), co-morbidities and pre-existing medical conditions (current or prior myocardial infarction, current or prior heart failure, diabetes mellitus, hypotension, metabolic and electrolyte abnormalities, respiratory failure, renal insufficiency, hepatic insufficiency, metastatic or hematologic malignancy, septicaemia, pneumonia, major trauma, acute stroke, baseline depression in neurological function), cardiac arrest characteristics (initial arrest rhythm [asystole, pulseless electrical activity, ventricular fibrillation, pulseless ventricular tachycardia], hospital location of cardiac arrest [intensive care unit, non-intensive care unit (monitored ward, non-monitored ward)], time of arrest [on-hours: 7.00 a.m.–10:59 p.m., Monday–Friday; or off-hours:11.00 p.m.–6.59 a.m., Monday–Friday, or anytime on weekends and US national holidays], whether the event was witnessed, use of hospital-wide cardiac arrest alert) and interventions in place prior to time of cardiac arrest (assisted or mechanical ventilation, vasoactive agent, anti-arrhythmic, pulmonary artery catheter, and renal dialysis). We also obtained data on rates of delayed defibrillation (> 2minutes) for shockable IHCA and delayed (> 5 minutes) first dose of adrenaline (epinephrine) for non-shockable IHCA, time to ROSC, and total duration of cardiopulmonary resuscitation (CPR). Hospital-level variables included geographic location, hospital setting, ownership, bed size, teaching status, physician services (adult cardiology, cardiac surgery, interventional cardiac catheterization, hospitalist, intensivist), staffing, and intensive care beds. The rate of missing data was < 1% for all variables, except race and for hospital ownership type. Unknown or missing data on race were treated as separate "Unknown" categories. Missing values for hospital ownership type were imputed using multiple imputation.

Statistical Analysis:

Comparisons of patient and cardiac arrest characteristics between TCC and non-TCC hospitals were performed using t-tests for continuous variables and chi square tests for categorical variables. Due to large sample sizes, we used standardized difference (SD) in covariate means to compare hospital groups with and without TCC.[25] A SD of > 10% suggests a covariate imbalance.

Next, we calculated unadjusted proportions of acute resuscitation survival and survival to discharge between TCC and non-TCC hospitals. We then estimated a multivariable generalized linear mixed regression model with binomial distribution, with hospital sites included as random effects, and patient- and hospital-level covariates as fixed effects.

We used the variance components covariance structure for random hospital site effect in the model. We calculated risk-adjusted survival proportions, accounting for confounding by patient and cardiac arrest characteristics and clustering of patients within hospitals. The model included a categorical variable for calendar year, the location (ICU/non-ICU) and timing (on-hours/off-hours) of arrest, and the interaction terms for arrest location (TCC*location) and timing (TCC*time of arrest). Hospital-level variables that were not statistically significant were excluded from the final models. We reported survival outcomes primarily for arrests that occurred in the ICU.

Sensitivity and Exploratory Analyses:

To ensure that survival estimates were not biased by inclusion of cardiac arrests that occurred in the first half of fiscal year 2020, we evaluated the robustness of our primary analysis by excluding arrests that occurred between July and December 2019. To test the hypothesis that TCC may have the greatest benefits among smaller, less resourced hospitals and among patient subgroups, we performed 3 exploratory analyses: i) stratified by hospital size, (ii) among the subgroup of patients with non-shockable rhythms, and iii) among the subgroup of patients who survived acute resuscitation, to evaluate post resuscitation survival.

All analyses were performed using SAS version 9.4 for Windows (SAS Institute Inc. Cary, NC) and R version 4.0. All hypothesis tests were 2-sided with a significance threshold level of 0.05.

RESULTS

Of 44,585 study participants, 14,373 (32.2%) suffered IHCA at a TCC hospital. The mean age was 65.6 years; 41.2% were female and 22.5% were black. Most cardiac arrest events were witnessed (86.5%), associated with use of hospital wide cardiac arrest alert (80.8%), and occurred in an intensive care setting (60.6 %). Cardiac arrests occurred equally during on-hours vs. off-hours (53% vs. 47%). Ventricular fibrillation and pulseless ventricular tachycardia (shockable IHCA) accounted for 14.5% of all cardiac arrests. Other than a higher proportion of patients at TCC hospitals experiencing delayed defibrillation for shockable rhythms (31.1 vs. 26.3%) and having a pulmonary catheter in place prior to cardiac arrest (16.5 vs. 9.9%) compared to non-TCC hospitals, standardized differences in baseline and cardiac arrest characteristics between both patient groups were small (less than 10%, Table).

Among 280 GWTG-R participant hospitals, 86 (30.7%) had TCC capability, almost all (99.3%) were located in non-rural areas, approximately three-quarters (75.7%) were non-profit hospitals, the majority were teaching hospitals (81.1%), and had adult cardiology (95.7%), adult cardiac surgery (82.1%), adult interventional cardiac catheterization (93.6%), hospitalist (90.7%), and intensivist (84.6%) services. The hospitals were equally distributed across the geographic regions of the U.S. Compared to non-TCC hospitals, TCC hospitals were more likely to be large (> 500 total beds) and to have adult cardiac surgery, intensivist, and resident physician services (eTable 2). Compared to respondent hospitals, cardiac arrests at non-respondent hospitals were more likely to occur in the ICU or other monitored unit, to be witnessed, and to be associated with the use of hospital wide cardiac arrest alerts (eTable 3).

Acute Resuscitation Survival

Compared to non-TCC hospitals, patients suffering IHCA in an ICU at TCC hospitals had significantly higher unadjusted acute resuscitation survival (76.0% vs. 74.0%, *SD*=2.0, eTable 4). However, after adjusting for hospital, patient, and cardiac arrest characteristics, there was no significant difference in acute resuscitation survival rates (odds ratio [OR] 1.02, 95% confidence interval [CI] 0.91–1.15, Figure 2). Similarly, there was no difference in acute resuscitation survival rates for ICU arrests during on-hours (OR 1.05 [0.92–1.21]) or off hours (OR 1.00 [0.88–1.13]).

We found marked variation in the association of TCC with adjusted acute survival across individual hospitals (Figure 3A). This association was however not modified by any cardiac arrest or hospital characteristic, including whether the event was witnessed, the activation of a hospital wide response for the arrest, hospital ownership type, bed size, and teaching status ($P > 0.05$ for all interactions). Sensitivity analyses that excluded cardiac arrests between July and December 2019 yielded similar results, as did the exploratory analysis stratified by hospital size and among patient subgroup with non-shockable arrest rhythms (eTables 5,6,7).

Survival to Discharge

Compared to non-TCC hospitals, TCC hospitals had significantly higher survival to discharge for IHCA occurring in ICU locations in unadjusted analysis (21.7% vs. 20.8%, *SD* = 0.8, eTable 4) but not after risk adjustment (OR 0.94 [0.83–1.07]). There was also no difference in survival to discharge rates for ICU arrests during on-hours (OR 0.95 [0.83–1.09]) vs. off hours (OR 0.93 [0.81–1.07], Figure 2). The association of TCC with discharge survival also varied widely across individual hospitals (Figure 3B). Exploratory analysis of discharge survival among patients who survived acute resuscitation yielded similar results (eTable 8).

Cardiac Arrests Outcomes in Non-ICU Locations

Unadjusted acute resuscitation survival and survival to discharge rates for arrests occurring outside of the ICU were significantly higher at TCC hospitals, in comparison to non-TCC hospitals (74.2% vs. 72.6%, *SD*=1.6; 28.7% vs. 27.5%, *SD*=1.1 respectively, eTable 4), but not in adjusted analysis, (Acute resuscitation OR 1.03 [0.91–1.17]; Survival to discharge OR 0.99 [0.86–1.12], Figure 2). There was also no difference in outcomes for non-ICU arrests during on-hours vs. off hours at TCC hospitals compared to non-TCC hospitals (Acute resuscitation OR on-hours: 1.05 [0.92–1.21]; off-hours 1.01 [0.89–1.13], Survival to discharge OR on-hours: 1.00 [0.87 – 1.15]; off-hours 0.97 [0.85 – 1.12], Figure 2).

DISCUSSION:

In this study of > 40,000 patients experiencing IHCA at 280 hospitals, availability of TCC was associated with both a higher unadjusted acute resuscitation survival rate and survival to discharge rate among cardiac arrests that occurred in an ICU. However, these associations were small and were not statistically significant in risk-adjusted analyses, regardless of the timing of arrest.

We had hypothesized that TCC availability would improve IHCA outcomes. Many factors contribute to poor IHCA survival during nights and weekends, including changes in hospital staffing patterns,[26–29] and the impact of shift work, particularly during nighttime, on the performance of skilled activities, such as CPR.[30–33] These factors, which can potentially be mitigated by TCC, likely affect the ability of hospital staff to recognize deteriorating patients and prevent IHCA, or quickly initiate resuscitation following IHCA, all of which may impact survival.[3]

Despite these putative mechanisms, our study failed to demonstrate a clear association between TCC availability and improved IHCA survival outcomes. One possibility is that the beneficial effects of TCC occur upstream of IHCA. TCC may reduce the occurrence of IHCA among monitored ICU patients.[34] It is therefore possible that IHCAs taking place at TCC hospitals are mostly unpreventable, perhaps due to a sicker patient cohort, whose care is already maximized in the ICU, and whose care trajectories leading to IHCA could not be further modified by TCC. Our study found that 67% more patients experiencing IHCA at TCC hospitals had pulmonary artery catheters placed, supporting the idea that IHCAs at TCC hospitals may have occurred in sicker patients.

Another possibility lies in the variable nature of TCC coverage models, and in the manner of remote TCC provider involvement during IHCA. Coverage models range from continuous surveillance requiring direct observation through fixed-installation video cameras, to a consultation service model, using mobile telemedicine carts that are brought to the patient on an as-needed basis.[35–37] The detection of patient deterioration or of active IHCA is more likely with continuous monitoring. Our study found a higher proportion of patients with delayed defibrillation shocks at TCC hospitals compared to non-TCC hospitals. Although noteworthy, this finding cannot be meaningfully interpreted without data on the type of TCC monitoring in place. Also, the active role of TCC providers during CPR for IHCA varies from de facto team leaders to “copilots” who assist the bedside code team leaders.[38] Whether or not TCC consultation during IHCA improves CPR quality remains a subject of research interest.[39]

These differences likely explain the mixed results that have been observed in other studies evaluating the effectiveness of TCC.[17,18] One of these, a large national study using administrative data, reported a small overall reduction in mortality, but also found wide variation in TCC effect across adopting hospitals.[17] It is therefore possible that TCC implementation characteristics may directly influence the overall effectiveness of TCC as an intervention, and its effectiveness for specific critical care syndromes, like IHCA.[40,41]

Finally, the efficacy of TCC may depend not only on its implementation, but also on the broader context into which it is added. TCC may be particularly useful in improving outcomes at small rural hospitals that lack critical care expertise, or urban hospitals experiencing temporary surges, such as during the COVID-19 pandemic, but may not further improve outcomes in already-fully-staffed hospitals, such as those participating in

GWTG-R. However, rural and community access hospitals—arguably the most likely to benefit— remain the least likely to have implemented this technology.[23] An improved understanding of how and where to optimally implement TCC interventions is crucial for continued adoption in rural and other hospitals for whom costs remain a significant barrier to implementation.[36,42] Our study highlights the need to further investigate the implementation and contextual characteristics of TCC programs to better drive policy-relevant research in this field[43] and the importance of resuscitation training, regardless of TCC availability.

Our study has several limitations. Firstly, our study design does not support conclusions about causal links between TCC availability and IHCA outcomes. This is especially relevant due to the potential of TCC to reduce the incidence of IHCA. The GWTG-R registry does not capture data on the total number of hospitalizations, which are necessary to determine incidence of IHCA. Secondly, because our datasets lacked information on TCC program characteristics, we are unable to adjust for different TCC models of care or to perform pre- and post-implementation comparisons to determine if TCC led to improvement in IHCA outcomes over time. It is therefore possible that TCC hospitals originally had significantly poorer outcomes than non-TCC hospitals, which improved after TCC adoption. Thirdly, we evaluated TCC as a hospital-level intervention. At a patient-level, we do not know whether or to what extent TCC was involved in resuscitation or post-resuscitation care. We also do not have data on the response times or the leaders of the cardiac arrest response teams — critical components of quality CPR. Fourthly, our study may not generalize beyond GWTG-R hospitals who having made a commitment to data collection and quality improvement, are not representative of all hospitals nationwide. Finally, not all hospitals in the GWTG-R registry responded to the AHA annual surveys, which introduces the possibility of non-response bias, especially given the differences in arrest characteristics between AHA survey-respondent and non-respondent hospitals among the GWTG-R hospitals.

CONCLUSIONS:

In risk-adjusted analyses, we did not find an association between hospital TCC availability and outcomes for IHCA in the ICU, either overall or within the subset of IHCA occurring during off-hours. Future studies are needed to address the impact of specific TCC organizational and implementation characteristics on IHCA prevention and outcomes, and contextual factors that might impact TCC effectiveness, as it relates to IHCA.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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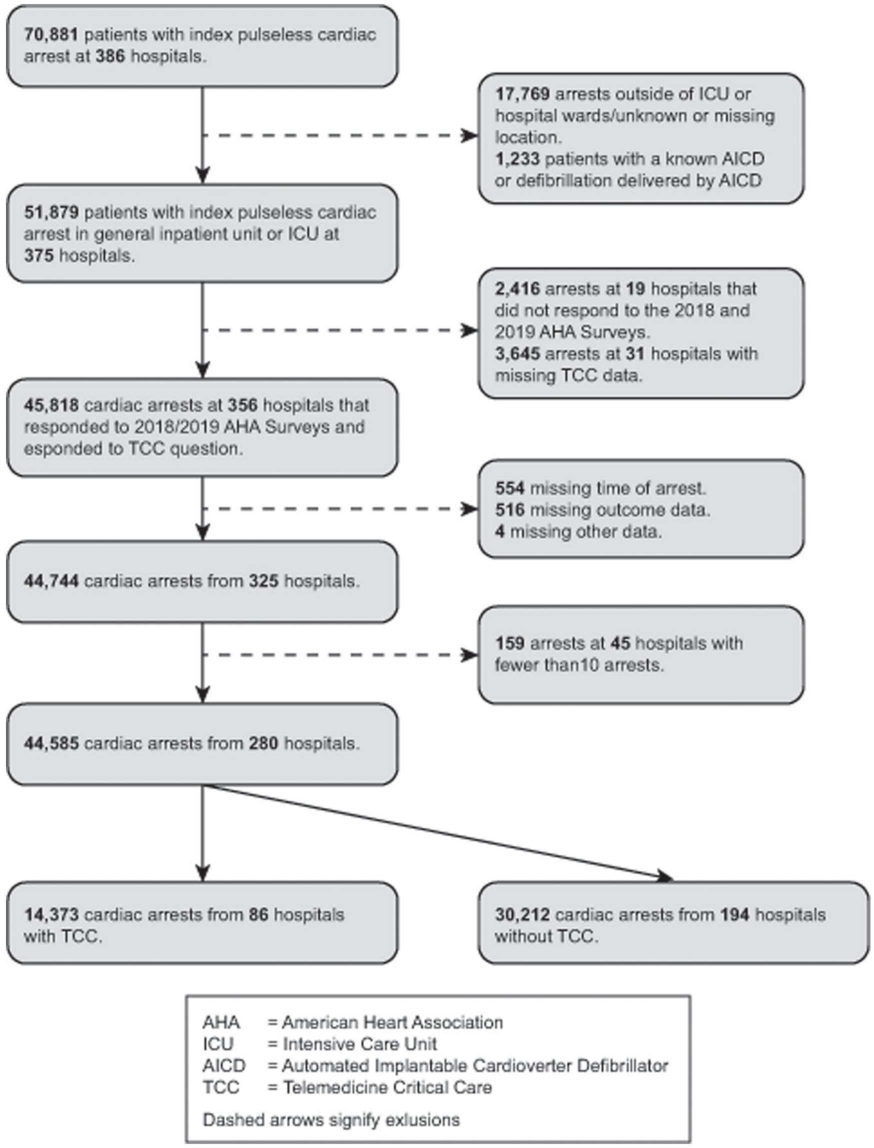
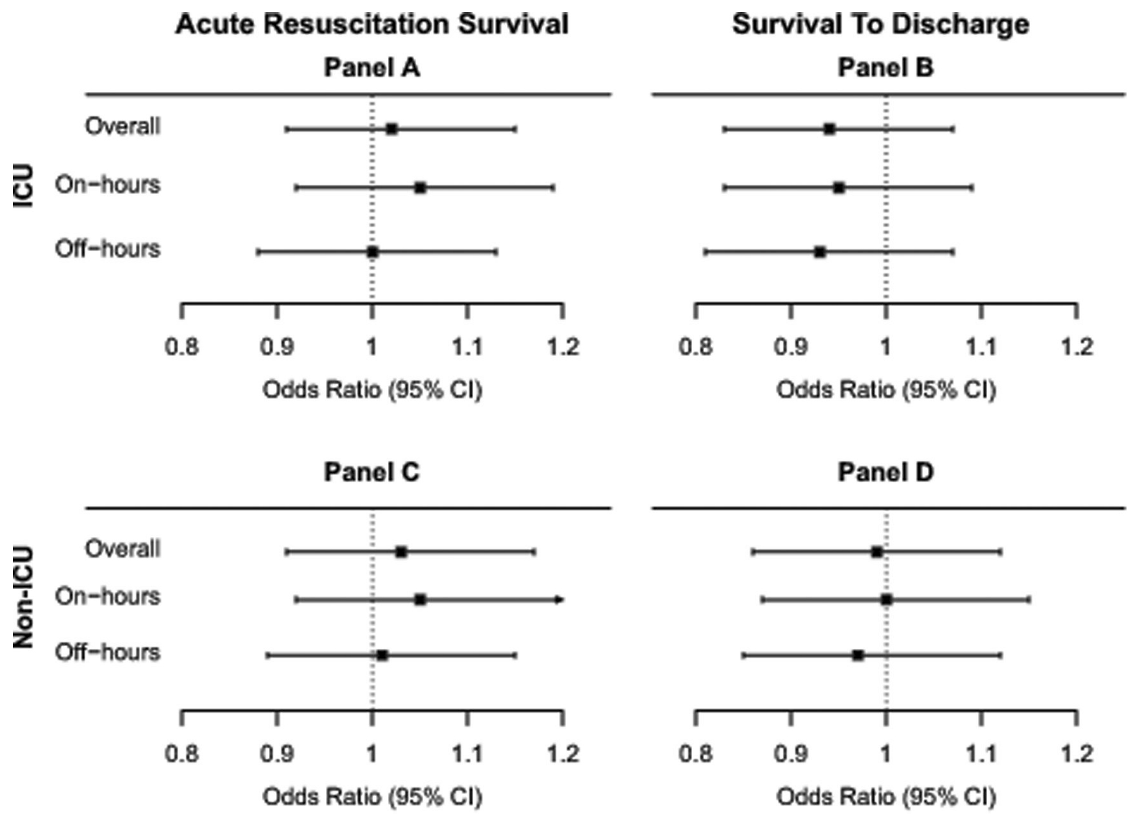


Figure 1: Derivation of the Study Cohort



	Acute Resuscitation Survival	Survival To Discharge
ICU (all)	**1.02 (0.92-1.15)**	**0.94 (0.83-1.07)**
On-hours	1.05 (0.92-1.21)	0.95 (0.83-1.09)
Off-hours	1.00 (0.88-1.13)	0.93 (0.81-1.07)
Non-ICU (all)	**1.03 (0.91-1.17)**	**0.99 (0.86-1.12)**
On-hours	1.05 (0.92-1.21)	1.00 (0.87-1.15)
Off-hours	1.01 (0.89-1.15)	0.97 (0.85-1.12)

Figure 2: Survival Rates following In-Hospital Cardiac Arrest

Odds Ratios and 95% Confidence Intervals showing differences between TCC and non-TCC hospitals overall, and during on- or off-hours, for (**A&C**) Acute Resuscitation Survival rate, and (**B&D**) Survival to Discharge rate, for IHCA occurring in either (**A&B**) ICU, or (**C&D**) non-ICU locations.

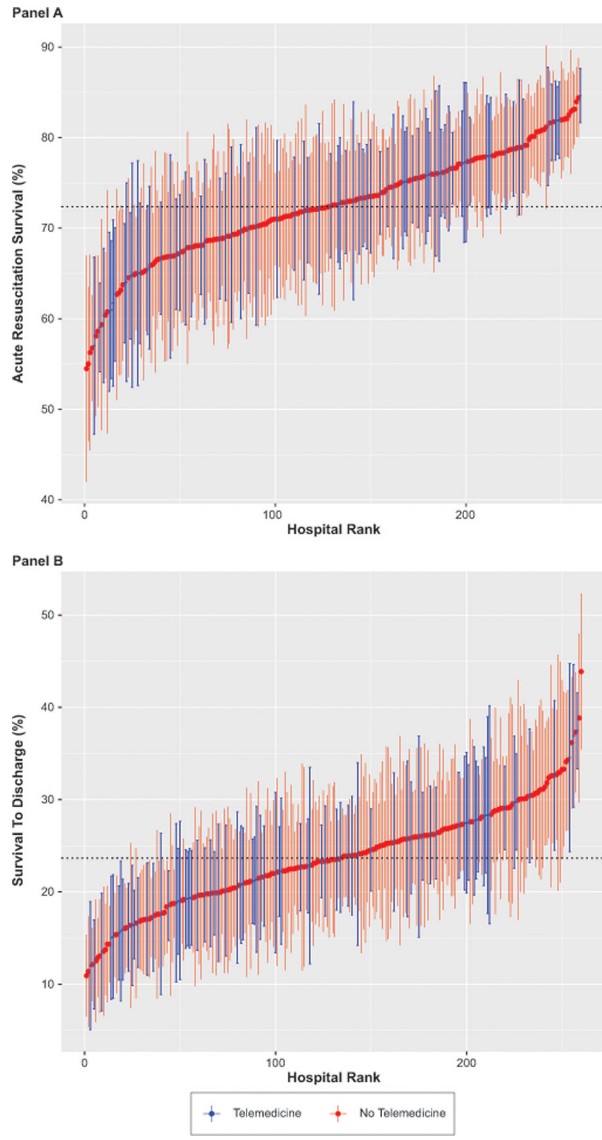


Figure 3: Hospital-level Variation in Survival rates

This figure shows the (**A**) Risk-Adjusted Acute Resuscitation Survival rates, and (**B**) Survival to Discharge rates for individual TCC (blue) or non-TCC (red) hospitals. Error lines indicate 95% confidence intervals. The dotted horizontal line indicates mean survival rate.

Table:

Patient Baseline and Cardiac Arrest Characteristics

Demographic characteristics	**Overall (N = 44585)**	**Telemedicine Critical Care (N = 14373)**	**No Telemedicine Critical Care (N = 30212)**	**Standardized Differences**
Demographic characteristics				
Age (years)	65.6 (15.2)	65.5 (15.4)	65.6 (15.1)	0.01
Sex				0.01
Female	18361 (41.2)	5873 (40.9)	12488 (41.3)	
Male	26224 (58.8)	8500 (59.1)	17724 (58.7)	
Race				0.14
White	29992 (67.3)	9235 (64.3)	20757 (68.7)	
Black/African American	10050 (22.5)	3450 (24.0)	6600 (21.8)	
Other	1395 (3.1)	380 (2.6)	1015 (3.4)	
Unknown	3148 (7.1)	1308 (9.1)	1840 (6.1)	
Cardiac Arrest Characteristics				
Initial Arrest rhythm				0.04
Asystole	10072 (22.6)	3161 (22.0)	6911 (22.9)	
Pulseless electrical activity	25054 (56.2)	8037 (55.9)	17017 (56.3)	
Pulseless ventricular tachycardia	3192 (7.2)	1048 (7.3)	2144 (7.1)	
Ventricular fibrillation	3239 (7.3)	1071 (7.5)	2168 (7.2)	
Unknown	3028 (6.8)	1056 (7.3)	1972 (6.5)	
Location of cardiac arrest				0.05
Intensive care unit	27032 (60.6)	8742 (60.8)	18290 (60.5)	
Monitored unit	8239 (18.5)	2795 (19.4)	5444 (18.0)	
Non-monitored unit	9314 (20.9)	2836 (19.7)	6478 (21.4)	
Time of Arrest				0.01
On-hours	20955 (47.0)	6800 (47.3)	14155 (46.9)	
Off-hours	23630 (53.0)	7573 (52.7)	16057 (53.1)	
Event observation				
Witnessed	38573 (86.5)	12261 (85.3)	26312 (87.1)	0.05
Response to event				
Use of hospital wide cardiac arrest alert	36031 (80.8)	11210 (78.0)	24821 (82.2)	0.10
Delayed defibrillation[a]	1270 (27.8)	459 (31.1)	811 (26.3)	0.11
Delayed first dose of adrenaline[b]	426 (7.6)	163 (9.1)	263 (6.9)	0.08
Time to ROSC[c,d]	7 (4,12)	7 (4,12)	7 (4.12)	.01
CPR Duration[c,e]	12, (5,25)	13 (6,26)	12 (5,25)	.01
Pre-existing medical conditions:				
Current myocardial infarction	6293 (14.1)	1683 (11.7)	4610 (15.3)	0.10

Demographic characteristics	Overall (N = 44585)	Telemedicine Critical Care (N = 14373)	No Telemedicine Critical Care (N = 30212)	Standardized Differences
Prior myocardial infarction	6733 (15.1)	2183 (15.2)	4550 (15.1)	0.00
Current heart failure	7186 (16.1)	2162 (15.0)	5024 (16.6)	0.04
Prior heart failure	11376 (25.5)	3738 (26.0)	7638 (25.3)	0.02
Hypotension	14123 (31.7)	4408 (30.7)	9715 (32.2)	0.03
Metabolic or electrolyte abnormality	13438 (30.1)	4349 (30.3)	9089 (30.1)	0.00
Respiratory failure	22537 (50.5)	6900 (48.0)	15637 (51.8)	0.08
Renal insufficiency	17913 (40.2)	5334 (37.1)	12579 (41.6)	0.09
Hepatic insufficiency	4905 (11.0)	1541 (10.7)	3364 (11.1)	0.01
Septicaemia	3904 (8.8)	1176 (8.2)	2728 (9.0)	0.03
Pneumonia	7224 (16.2)	2131 (14.8)	5093 (16.9)	0.06
Diabetes mellitus	16638 (37.3)	5394 (37.5)	11244 (37.2)	0.01
Acute Stroke	1935 (4.3)	709 (4.9)	1226 (4.1)	0.04
Baseline depression in CNS function	3525 (7.9)	1062 (7.4)	2463 (8.2)	0.03
Major trauma	1989 (4.5)	553 (3.8)	1436 (4.8)	0.05
Metastatic/hematologic malignancy	5509 (12.4)	1817 (12.6)	3692 (12.2)	0.01
Interventions prior to arrest				
Assisted or mechanical ventilation	21764 (48.8)	6882 (47.9)	14882 (49.3)	0.03
Vasoactive agent	14496 (32.5)	4636 (32.3)	9860 (32.6)	0.01
Intravenous anti-arrhythmic therapy	2 (0.0)	0 (0.0)	2 (0.0)	0.01
Pulmonary artery catheter	5369 (12.0)	2369 (16.5)	3000 (9.9)	0.19
Dialysis	1809 (4.1)	503 (3.5)	1306 (4.3)	0.04

Values are n (%), except for Age, mean (SD)

CNS – central nervous system; ROSC – return of spontaneous circulation

[a] time to defibrillation >2 minutes for shockable rhythms. N = 4562 for comparisons

[b] time to first dose of adrenaline > 5 minutes for non-shockable rhythms. N = 5624 for comparisons

[c] Minutes, median (interquartile range)

[d] N = 32,284 (excludes 690 arrests with ROSC but missing time of ROSC)

[e] N = 73, 923 (excludes 662 arrests where CPR duration could not be determined)