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## Clinical paper

# Resuscitation practices in hospitals caring for children: Insights from get with the guidelines-resuscitation



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## Abstract

**Background:** Resuscitation practices in pediatric hospitals have not been compared, and whether practices differ between freestanding pediatric only hospitals and combined hospitals (which care for adults and children) is unknown.

**Methods:** We surveyed hospitals that submit data on pediatric in-hospital cardiac arrest (IHCA) to Get-With-The Guidelines<sup>®</sup>-Resuscitation, to elicit information on resuscitation practices. Hospitals were categorized as pediatric only and combined hospitals, and rates of resuscitation practices were compared.

**Results:** Thirty-three hospitals with  $\geq 5$  IHCA events between 2017–2019 completed the survey, of which 9 (27.3%) were pediatric only and 24 (72.7%) were combined hospitals. Overall, 18 (54.5%) hospitals used a device to measure chest compression quality, 16 (48.5%) had a staff member monitor chest compression quality, 10 (30.3%) used lanyards or hats to designate code leaders during a resuscitation, 16 (48.5%) routinely conducted code debriefings immediately after a resuscitation, and 7 (21.2%) conducted mock codes at least quarterly with 17 (51.5%) reporting no set schedule. Pediatric only hospitals were more likely to employ a device to measure chest compressions (88.9% vs. 41.7%;  $P = 0.02$ ), conduct code debriefings always or frequently after resuscitations (77.8% vs. 37.5%,  $P = 0.04$ ), use lanyards or a hat to designate the code team leader during resuscitations (66.7% vs. 16.7%,  $P = 0.006$ ), and allow nurses to defibrillate using an AED (77.8% vs. 29.2%,  $P = 0.01$ ). There were no differences in simulation frequency or other resuscitation practices between the two hospital groups.

**Conclusions:** Across hospitals caring for children, substantial variation exists in resuscitation practices, with notable differences between pediatric only and combined hospitals.

**Keywords:** Cardiac arrest, In-hospital, Pediatric, Resuscitation practices

## Introduction

An estimated 7,100 pediatric patients experience an in-hospital cardiac arrest (IHCA) annually in the United States.<sup>1</sup> Most prior research on hospital resuscitation practices has focused on adult resuscitation

teams. Recent hospital surveys have described differences in resuscitation response among adult hospitals,<sup>2,3</sup> and some studies have identified resuscitation practices associated with higher survival rates for IHCA.<sup>3,4</sup> Less is known about resuscitation practices in hospitals that care for children.

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A better understanding of resuscitation practices in pediatric hospitals would provide important data on the prevalence of debriefing after resuscitation, the frequency of resuscitation simulations ('mock codes') and IHCA case review, the use of intra-arrest devices and other strategies to optimize cardiopulmonary resuscitation (CPR), and the design of resuscitation teams. Moreover, hospitals which care for children can be either pediatric only hospitals or combined hospitals (which care for both children and adults), and whether resuscitation practices differ between these two types of hospitals is unknown. Finally, data on hospital resuscitation practices may provide initial insights as to why IHCA survival varies across hospitals which care for children.<sup>5</sup> To date, few studies have reported site-level frequency of resuscitation practices in pediatric hospitals.<sup>6,7</sup>

Accordingly, we surveyed hospitals which care for children and submit data to a large national registry of IHCA to determine contemporary rates of key resuscitation practices. We compared whether rates of these practices differed between pediatric only hospitals and hospitals which care for both adults and children.

## Methods

The institutional review board of Saint Luke's Hospital's Mid America Heart Institute approved the study protocol (IRB protocol number 14-177) for this study.

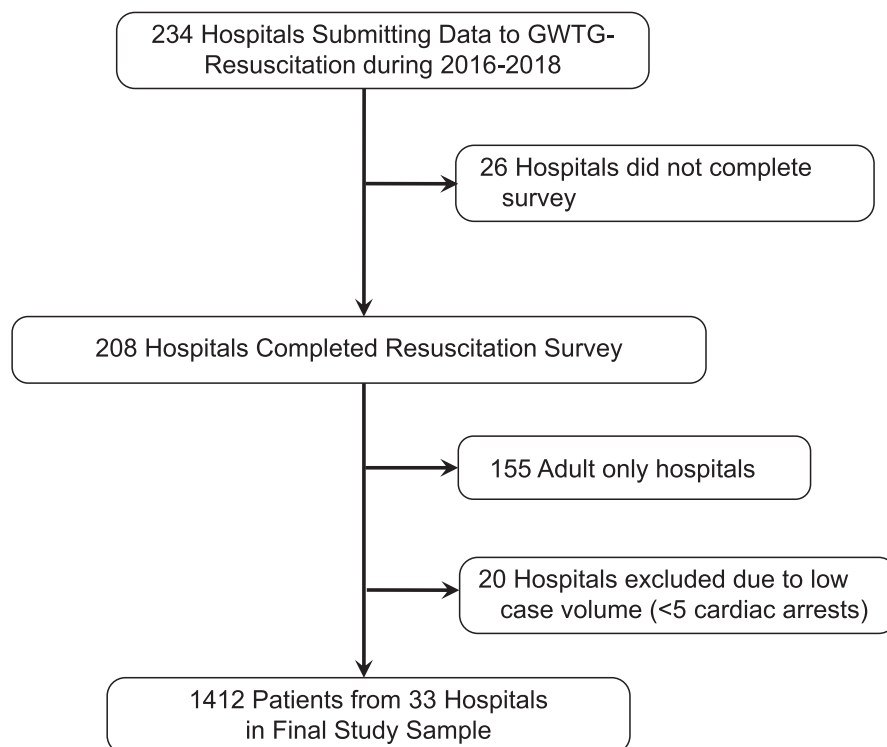
### Study population

Get With The Guidelines<sup>®</sup>-Resuscitation (GWTG-Resuscitation) is a large, prospective, national quality-improvement registry of IHCA and is provided by the American Heart Association. Its design has been described in detail previously.<sup>8</sup> In brief, hospitals participating

in the registry submit clinical information regarding the medical history, hospital care, and outcomes of consecutive patients hospitalized for cardiac arrest using an online, interactive case report form and Patient Management Tool<sup>™</sup> (IQVIA, Parsippany, New Jersey). Trained quality-improvement hospital personnel identify all patients without do-not-resuscitate orders with a cardiac arrest (defined as absence of a palpable central pulse, apnea, and unresponsiveness) who undergo cardiopulmonary resuscitation (CPR). Cases are identified by multiple methods, including centralized collection of cardiac arrest flow sheets, reviews of hospital paging system logs, and routine checks of code carts, pharmacy tracer drug records, and hospital billing charges for resuscitation medications.<sup>8</sup>

GWTG-Resuscitation uses standardized Utstein-style definitions for all patient variables and outcomes to facilitate uniform reporting across hospitals.<sup>9,10</sup> Data accuracy is ensured by rigorous certification of hospital staff and use of standardized software with data checks for completeness and accuracy. IQVIA serves as the data collection (through their Patient Management Tool – PMT<sup>™</sup>) and coordination center for the American Heart Association/American Stroke Association Get With The Guidelines<sup>®</sup> programs. The University of Pennsylvania serves as the data analytic center and has an agreement to prepare the data for research purposes

As IHCA survival has improved over the past decade,<sup>11</sup> we used data from the 234 hospitals within GWTG-Resuscitation which entered cases throughout the period of January 1, 2017 and December 31, 2019 (Fig. 1). As this study was based on hospital responses to a survey on resuscitation practices, we restricted our cohort to the 208 (88.9%) hospitals that completed the survey (see below). As our focus was on pediatric IHCA, we excluded 155 adult only hospitals and included only freestanding pediatric hospitals and combined adult and pediatric hospitals that submitted at least 5 cases of



**Fig. 1 – Definition of the Study Cohort**

pediatric IHCA during the study period to the registry (20 hospitals excluded). Our final study cohort comprised 33 hospitals, representing 1412 children with IHCA.

### Measures and data collection

From April to June of 2018, we conducted a detailed survey of hospital resuscitation practices among actively participating hospitals within GWTG-Resuscitation (Supplementary Appendix Figure 1). At each site, the director of the hospital's resuscitation committee (e.g., 'Code Blue' committee) was asked to provide survey responses. This current survey was developed based on clinical expertise in our team, results from our prior resuscitation survey primarily for adult hospitals in 2014,<sup>3</sup> and outside experts. Resuscitation practices in this survey focused on prevention and treatment of IHCA (e.g., use of simulation training, intra-arrest monitoring devices of CPR quality, post-event debriefing), design and leadership of resuscitation teams, whether nurses are allowed to defibrillate patients before doctors arrive, and resuscitation champion type.

### Statistical analysis

This was primarily a descriptive study comparing resuscitation practices between pediatric only and combined hospitals (those which

care for adults and children); therefore, the independent variable for this study was the pediatric hospital type. Hospitals which care for adults and children but are recognized as a specialized pediatric center would be classified as a pediatric hospital in this study. Differences in hospital characteristics and resuscitation practices were compared between the two hospital types using chi-square statistics for categorical variables and students' t-tests for continuous variables.

Besides a description of the overall prevalence of different resuscitation practices and a comparison of these practice rates between pediatric only and combined hospitals, we also examined the hospital's proportion of patients with IHCA who survived to hospital discharge. For each facility, we calculated risk-standardized survival rates to discharge for their pediatric IHCA cases using our previously validated methodology using multivariable hierarchical logistic regression models.<sup>12</sup> Briefly, this validated model considered a total of 26 variables to predict survival to discharge after IHCA. Using multivariable hierarchical logistic regression, a final model yielded 13 predictors to predict survival to discharge with a c-statistic of 0.71. These 13 predictors were age; sex; illness category; initial cardiac arrest rhythm; hospital location of arrest; hypotension, sepsis, metabolic or electrolyte abnormality, acute non-stroke central nervous system event, trauma, and renal insufficiency within 24 hours of car-

**Table 1 – Structural characteristics of hospitals, stratified by hospital type.**

Hospital Characteristic	Total (n = 33)	Pediatric (n = 9)	Combined (n = 24)	P
No. of IHCAs per Hospital	42.8 ± 47.7	82.1 ± 58.3	28.1 ± 33.9	0.002
Mean ± SD	21.0	68.0	12.5	
Median (IQR)	(8.0, 65.0)	(40.0, 119.0)	(7.0, 31.5)	
U.S. Census Region				0.72
North Mid-Atlantic	9 (31.0%)	2 (28.6%)	7 (31.8%)	
South Atlantic	5 (17.2%)	1 (14.3%)	4 (18.2%)	
North Central	4 (13.8%)	1 (14.3%)	3 (13.6%)	
South Central	8 (27.6%)	2 (28.6%)	6 (27.3%)	
Mountain/Pacific	3 (10.3%)	1 (14.3%)	2 (9.1%)	
Missing	4	2	2	
Academic teaching status				0.21
Major teaching (fellows and residents)	20 (69.0%)	3 (42.9%)	17 (77.3%)	
Minor teaching (residents)	8 (27.6%)	4 (57.1%)	4 (18.2%)	
Non-teaching	1 (3.4%)	0 (0.0%)	1 (4.5%)	
Missing	4	2	2	
No. of Hospital Beds				< 0.001
100–199	1 (3.4%)	1 (14.3%)	0 (0.0%)	
250–299	3 (10.3%)	2 (28.6%)	1 (4.5%)	
300–349	1 (3.4%)	1 (14.3%)	0 (0.0%)	
350–499	5 (17.2%)	2 (28.6%)	3 (13.6%)	
500+	19 (65.5%)	1 (14.3%)	18 (81.8%)	
Missing	4	2	2	
No. of Cardiac Beds				0.41
0	3 (10.7%)	1 (16.7%)	2 (9.1%)	
6–10	4 (14.3%)	1 (16.7%)	3 (13.6%)	
11–15	4 (14.3%)	1 (16.7%)	3 (13.6%)	
16–20	2 (7.1%)	0 (0.0%)	2 (9.1%)	
21–30	8 (28.6%)	3 (50.0%)	5 (22.7%)	
31+	7 (25.0%)	0 (0.0%)	7 (31.8%)	
Missing	5	3	2	
Trauma Center Level				0.83
Regional	19 (70.4%)	4 (66.7%)	15 (71.4%)	
Community	8 (29.6%)	2 (33.3%)	6 (28.6%)	
Missing	6	3	3	

T Abbreviations: IHCA, in-hospital cardiac arrest; IQR, interquartile range; SD, standard deviation.

diac arrest; and treatment with mechanical ventilation or continuous intravenous vasopressors at the time of cardiac arrest). Using the hospital-specific random intercept estimates derived from this hierarchical model, a risk-standardized survival rate for each hospital was determined by multiplying the registry's unadjusted survival rate by the ratio of a hospital's predicted to expected survival rate.<sup>13</sup> We then compared whether risk-standardized survival rates differed between pediatric only and combined hospitals. If there were significant survival differences, we planned to examine whether differences in resuscitation practices between the two types of hospitals explained survival differences by further adjustment of these hospital practices in the hierarchical logistic regression models.

All study analyses were performed with SAS 9.2 (SAS Institute, Cary, NC) and R version 2.10.0.<sup>14</sup> The hierarchical models were fitted with the use of the GLIMMIX macro in SAS and evaluated at a 2-sided significance level of 0.05. Dr. Paul Chan had full access to the data and takes responsibility for its integrity.

## Results

A total of 33 hospitals comprised the study cohort, of which 9 (27.3%) were pediatric only hospitals and 24 (72.7%) were combined hospi-

tals. Overall, 18 (54.5%) hospitals used a device to measure chest compression quality, 2 (6.1%) used a mechanical device to deliver chest compressions, 6 (18.2%) routinely monitored diastolic pressures during resuscitations, 16 (48.5%) had a staff member monitor chest compression quality, 10 (30.3%) used lanyards or hats to designate leaders during a resuscitation, 16 (48.5%) routinely conducted immediate code debriefings, and 7 (21.2%) conducted mock codes at least quarterly with 17 (51.5%) reporting no set schedule. Overall, pediatric only hospitals treated more IHCA during the 3-year time period (mean of 82; standard deviation [SD], 58) than combined hospitals (mean of 28 [SD, 34]). Pediatric only hospitals had fewer total hospital beds than combined hospitals, but the total bed count for combined hospitals included adult beds. Otherwise, there were no significant differences in 'structural characteristics' between the two hospital types with regards to U.S. geographic region, academic teaching status, total number of cardiac beds, and trauma center level designation (Table 1).

When comparing practices during acute resuscitations for IHCA, pediatric only hospitals employed a dedicated code team design (code team members designated before work shift begins on a given day) whereas combined hospitals were more likely to employ a variety of approaches, including not having members of a code team determined prior to an IHCA. Pediatric hospitals were also more

**Table 2 – Intra-Arrest Resuscitation Practices, Stratified by Hospital Type.**

Intra-Arrest Resuscitation Practices	Total (n = 33)	Pediatric (n = 9)	Combined (n = 24)	P
Code team design				0.002
Designated code team	17 (51.5%)	0 (0.0%)	17 (70.8%)	
Dedicated code team	15 (45.5%)	9 (100.0%)	6 (25.0%)	
Code team response unplanned	1 (3.0%)	0 (0.0%)	1 (4.2%)	
Use lanyards, hats, or identifiers for code leaders during codes				0.006
Yes	10 (30.3%)	6 (66.7%)	4 (16.7%)	
No	23 (69.7%)	3 (33.3%)	20 (83.3%)	
Attending physicians typically respond to pediatric codes	24 (72.7%)	7 (77.8%)	17 (70.8%)	0.69
Anesthesia typically respond to pediatric codes	21 (63.6%)	3 (33.3%)	18 (75.0%)	0.03
Critical care nurses typically respond to pediatric codes	31 (93.9%)	9 (100.0%)	22 (91.7%)	0.38
Who typically leads codes				0.36
Attending physicians	14 (42.4%)	5 (55.6%)	9 (37.5%)	
Residents and fellows	19 (57.6%)	4 (44.4%)	15 (62.5%)	
Code team members know who is doing chest compressions				0.21
Yes	16 (48.5%)	6 (66.7%)	10 (41.7%)	
No	17 (51.5%)	3 (33.3%)	14 (58.3%)	
Staff member who is usually assigned to do chest compressions				0.95
No staff member assigned	16 (48.5%)	4 (44.4%)	12 (50.0%)	
Critical care nurse	2 (6.1%)	0 (0.0%)	2 (8.3%)	
Floor nurses	4 (12.1%)	1 (11.1%)	3 (12.5%)	
Fellows	5 (15.2%)	3 (33.3%)	2 (8.3%)	
Residents	1 (3.0%)	0 (0.0%)	1 (4.2%)	
Students	3 (9.1%)	1 (11.1%)	2 (8.3%)	
Other	2 (6.1%)	0 (0.0%)	2 (8.3%)	
CPR process measure device used	18 (54.5%)	8 (88.9%)	10 (41.7%)	0.02
Mechanical CPR device used	2 (6.1%)	0 (0.0%)	2 (8.3%)	0.38
No CPR assist devices used	8 (24.2%)	0 (0.0%)	8 (33.3%)	0.05
Monitoring of diastolic pressures	6 (18.2%)	2 (22.2%)	4 (16.7%)	0.72
An individual besides code team leader monitors CPR quality				0.29
Yes	10 (30.3%)	4 (44.4%)	6 (25.0%)	
No	23 (69.7%)	5 (55.6%)	18 (75.0%)	
Nurses can defibrillate patients in AED mode	14 (42.4%)	7 (77.8%)	7 (29.2%)	0.01
Physicians can defibrillate patients in AED mode	17 (51.5%)	7 (77.8%)	10 (41.7%)	0.07

T Abbreviations: CRP, cardiopulmonary resuscitation; AED, automated external defibrillator.

likely to have code leaders identified with a lanyard, hat or other marker (66.7%) as compared with combined hospitals (16.7%,  $p = 0.006$ ). Pediatric hospitals were more likely to employ a device to assess CPR quality during a resuscitation as compared with combined hospitals (88.9% vs 41.7%,  $p = 0.02$ ) whereas combined hospitals were more likely to not use any CPR device to measure or deliver CPR as compared with pediatric hospitals (33% vs. 0%;  $p = 0.05$ , Table 2). Pediatric hospitals were also more likely to allow nurses to defibrillate patients in automated external defibrillator (AED) mode before a physician arrived as compared with combined hospitals (77.8% vs 29.2%,  $p = 0.01$ ). Notably, there were no significant differences between pediatric and combined hospitals as to whether attending physicians or house staff led resuscitations, who was assigned to perform chest compressions during resuscitations, monitoring of diastolic pressures during resuscitations, use of a mechanical CPR device, and other practices (Table 2).

When looking at resuscitation practices related to quality improvement, there were no significant differences between the two hospital types in resuscitation champion type or whether cardiac arrest data were routinely reviewed, but pediatric hospitals were more likely to perform debriefing immediately after a resuscitation as compared with combined hospitals (33.3% vs 12.5%,  $p = 0.04$ ). With regard to the conduct of resuscitation simulations, there were no significant differences between the two hospital types as to how

often staff were required to participate in mock codes, whether mock codes were held with an interdisciplinary team (e.g., between physicians, nurses, and respiratory therapists), whether staff were informed in advance when mock codes would occur, or whether mock codes were conducted outside of normal workday hours (Table 3).

A comparison of patients cared for at pediatric vs. combined hospitals is summarized in Table 4, and the multivariable model for computing hospital rates of risk-standardized survival is shown in Supplementary Appendix Table I. When comparing rates of survival to discharge for IHCA, the mean unadjusted hospital rate of survival to discharge was 34.7% (SD, 13.4) for pediatric hospitals and 34.7% (SD, 13.3%) in combined hospitals. After risk adjustment for patient complexity across hospitals, the mean risk-standardized survival rate remained similar: pediatric hospitals, 39.9% (SD, 6.9%); combined hospitals, 37.2% (SD, 4.0%);  $p = 0.17$ . At the patient level, rates of survival to discharge were also not significantly different: 41.7% for pediatric hospitals and 38.7%;  $P = 0.26$ .

## Discussion

We found variable uptake for a range of resuscitation practices at hospitals which care for children. Only about half of hospitals used

**Table 3 – Quality Improvement Resuscitation Practices, Stratified by Hospital Type.**

Quality Improvement Practice	Total (n = 33)	Pediatric (n = 9)	Combined (n = 24)	P
<b>Resuscitation champion type</b>				<b>0.49</b>
Very active physician champion	13 (39.4%)	5 (55.6%)	8 (33.3%)	
Very active non-physician champion	7 (21.2%)	2 (22.2%)	5 (20.8%)	
Not active champion or no champion	13 (39.4%)	2 (22.2%)	11 (45.8%)	
<b>Are cardiac arrest data routinely reviewed</b>				<b>0.81</b>
Yes	30 (90.9%)	8 (88.9%)	22 (91.7%)	
No	3 (9.1%)	1 (11.1%)	2 (8.3%)	
<b>Code debriefing immediately performed</b>				<b>0.04</b>
Always or almost always (81–100%)	6 (18.2%)	3 (33.3%)	3 (12.5%)	
Frequently (61–80%)	10 (30.3%)	4 (44.4%)	6 (25.0%)	
Occasionally (21–60%)	7 (21.2%)	1 (11.1%)	6 (25.0%)	
Rarely to never (0–20%)	10 (30.3%)	1 (11.1%)	9 (37.5%)	
<b>Frequency of mock codes</b>				<b>0.54</b>
No set schedule	17 (51.5%)	5 (55.6%)	12 (50.0%)	
At least monthly	3 (9.1%)	1 (11.1%)	2 (8.3%)	
At least quarterly	4 (12.1%)	1 (11.1%)	3 (12.5%)	
At least semi-annually	5 (15.2%)	1 (11.1%)	4 (16.7%)	
At least annually	3 (9.1%)	1 (11.1%)	2 (8.3%)	
Mock codes not conducted at all	1 (3.0%)	0 (0.0%)	1 (4.2%)	
<b>Mock codes held with interdisciplinary team</b>				<b>0.25</b>
Yes	28 (84.8%)	9 (100.0%)	19 (79.2%)	
No	4 (12.1%)	0 (0.0%)	4 (16.7%)	
Mock codes not conducted	1 (3.0%)	0 (0.0%)	1 (4.2%)	
<b>Staff informed in advance of mock code</b>				<b>0.39</b>
Yes, given a specific time	6 (18.2%)	1 (11.1%)	5 (20.8%)	
Yes, but no pre-specified time	4 (12.1%)	2 (22.2%)	2 (8.3%)	
No warning	22 (66.7%)	6 (66.7%)	16 (66.7%)	
Mock codes not conducted	1 (3.0%)	0 (0.0%)	1 (4.2%)	
<b>Mock codes routinely held after hours</b>				<b>0.28</b>
Yes	19 (57.6%)	7 (77.8%)	12 (50.0%)	
No	13 (39.4%)	2 (22.2%)	11 (45.8%)	
Mock codes not conducted	1 (3.0%)	0 (0.0%)	1 (4.2%)	

**Table 4 – Comparison of Patients with IHCA, Stratified by Hospital Type.**

	Total N = 1413	Pediatric n = 739	Combined n = 674	P value
<b>Demographics</b>				
Age group				0.14
Neonate (<30 days)	221 (15.6%)	107 (14.5%)	114 (16.9%)	
Infant (31 days to 1 year)	462 (32.7%)	259 (35.0%)	203 (30.1%)	
Young children (1 to 8 years)	307 (21.7%)	164 (22.2%)	143 (21.2%)	
Older children (8 to < 18 years)	423 (29.9%)	209 (28.3%)	214 (31.8%)	
Sex				0.22
Male	804 (56.9%)	409 (55.3%)	395 (58.6%)	
Female	609 (43.1%)	330 (44.7%)	279 (41.4%)	
Race				< 0.001
White	743 (52.6%)	382 (51.7%)	361 (53.6%)	
Black	374 (26.5%)	144 (19.5%)	230 (34.1%)	
Other	77 (5.4%)	51 (6.9%)	26 (3.9%)	
Unknown	219 (15.5%)	162 (21.9%)	57 (8.5%)	
<b>Pre-Existing Conditions</b>				
Respiratory insufficiency	919 (65.0%)	424 (57.4%)	495 (73.4%)	< 0.001
Renal insufficiency	193 (13.7%)	88 (11.9%)	105 (15.6%)	0.04
Diabetes mellitus	15 (1.1%)	4 (0.5%)	11 (1.6%)	0.045
Hypotension	426 (30.1%)	201 (27.2%)	225 (33.4%)	0.01
Prior history of heart failure	74 (5.2%)	13 (1.8%)	61 (9.1%)	< 0.001
Heart failure this admission	106 (7.5%)	20 (2.7%)	86 (12.8%)	< 0.001
MI prior to admission	2 (0.1%)	1 (0.1%)	1 (0.1%)	1.00
MI this admission	15 (1.1%)	6 (0.8%)	9 (1.3%)	0.34
Metabolic or electrolyte abnormality	342 (24.2%)	148 (20.0%)	194 (28.8%)	< 0.001
Sepsis	161 (11.4%)	78 (10.6%)	83 (12.3%)	0.49
Pneumonia	91 (6.4%)	34 (4.6%)	57 (8.5%)	0.003
Metastatic or hematologic malignancy	90 (6.4%)	56 (7.6%)	34 (5.0%)	0.051
Baseline depression in CNS function	219 (15.5%)	106 (14.3%)	113 (16.8%)	0.21
Acute CNS non-stroke event	120 (8.5%)	49 (6.6%)	71 (10.5%)	0.008
Hepatic insufficiency	73 (5.2%)	45 (6.1%)	28 (4.2%)	0.11
Acute stroke	27 (1.9%)	11 (1.5%)	16 (2.4%)	0.22
Major trauma	151 (10.7%)	39 (5.3%)	112 (16.6%)	< 0.001
<b>Characteristics of arrest</b>				
Initial cardiac arrest rhythm				0.09
Asystole	468 (33.1%)	225 (30.4%)	243 (36.1%)	
Pulseless electrical activity	762 (53.9%)	410 (55.5%)	352 (52.2%)	
Ventricular fibrillation	82 (5.8%)	50 (6.8%)	32 (4.7%)	
Pulseless ventricular tachycardia	101 (7.1%)	54 (7.3%)	47 (7.0%)	
Location of cardiac arrest				< 0.001
ICU	1019 (72.2%)	529 (71.6%)	490 (72.8%)	
Delivery or procedure areas	139 (9.8%)	87 (11.8%)	52 (7.7%)	
Emergency room	145 (10.3%)	62 (8.4%)	83 (12.3%)	
Monitored telemetry unit	9 (0.6%)	1 (0.1%)	8 (1.2%)	
Unmonitored general floor	85 (6.0%)	48 (6.5%)	37 (5.5%)	
Other	15 (1.1%)	12 (1.6%)	3 (0.4%)	
Missing	1		1	
Timing of arrest				0.005
Weekday (7AM to 10:59 PM)	752 (53.5%)	424 (57.6%)	328 (49.0%)	
Weeknight (11PM to 6:59 AM)	249 (17.7%)	120 (16.3%)	129 (19.3%)	
Weekend	404 (28.8%)	192 (26.1%)	212 (31.7%)	
Missing	8	3	5	
Illness category				< 0.001
Medical cardiac	214 (15.2%)	136 (18.4%)	78 (11.6%)	
Medical non-cardiac	649 (46.0%)	344 (46.5%)	305 (45.3%)	
Surgical cardiac	275 (19.5%)	157 (21.2%)	118 (17.5%)	
Surgical non-cardiac	137 (9.7%)	76 (10.3%)	61 (9.1%)	
Other	137 (9.7%)	26 (3.5%)	111 (16.5%)	

**Table 4 (continued)**

	Total	Pediatric	Combined	
	N = 1413	n = 739	n = 674	P value
Missing	1		1	
<b>Interventions in place at time of arrest</b>				
Assisted or mechanical ventilation	1135 (80.5%)	589 (79.8%)	546 (81.3%)	0.49
Missing	3	1	2	
Continuous intravenous vasopressor	601 (42.6%)	310 (42.0%)	291 (43.3%)	0.62
Missing	3	1	2	

T Abbreviations: CNS, central nervous system; MI, myocardial infarction.

a device to measure chest compression quality, had a staff member monitor chest compression quality during resuscitations, and routinely conducted immediate code debriefings. Moreover, most hospitals performing resuscitations in children did not use lanyards, hats, or other props to designate leaders during a resuscitation, conducted mock codes infrequently (less often than once quarterly), did not use a mechanical CPR device, and did not routinely monitor diastolic pressures during resuscitations. There were notable differences in certain resuscitation practices between pediatric only and combined hospitals. Pediatric hospitals were more likely to use a device to measure chest compressions, conduct code debriefings immediately after resuscitations, use lanyards or a hat to designate the code team leader during resuscitations, and allow nurses to defibrillate using an AED. Despite these differences, there were no significant differences in risk-standardized survival rates for IHCA between pediatric only and combined hospitals.

This study provides one of the first descriptions of resuscitation practices in hospitals caring for children. We reported the prevalence of these practices overall, and by hospital type. Whether adoption of many of these practices improves survival outcomes for pediatric IHCA is less clear. Many have been advocated in the resuscitation literature,<sup>15–24</sup> and all are observational in nature, limiting inferences on causality. Moreover, most have been conducted in hospitals caring for adults with IHCA. Nonetheless, it is instructive that only 30% of hospitals caring for children had systems in place to visibly identify the code leader, 70% did not have a designated individual to monitor CPR quality during resuscitations, and 82% did not routinely monitor diastolic pressures during resuscitations. Moreover, 30% of hospitals rarely or never performed immediate debriefings after resuscitations and half of hospitals had no set schedule for the conduct of mock codes.

Our study did not detect a difference in hospital rates of risk-standardized survival for IHCA. One likely reason is the small sample size of hospitals (9 pediatric only and 24 combined hospitals); therefore, our analysis of survival outcomes at the hospital level was underpowered and should be considered exploratory. Another is the small number of pediatric IHCA events in some combined hospitals, which can lead to estimates of risk-standardized survival for these hospitals to be closer to the mean of the entire hospital cohort due to “shrinkage estimates” in our hierarchical models, thereby limiting our ability to detect survival differences between the two hospital types. We included some smaller volume combined hospitals in the study cohort as the focus was on description of resuscitation practices among hospitals caring for children with IHCA, and not on survival outcomes. We also did not detect a difference in survival rates between the two hospital types at the *patient level*, although another patient-level analysis of resuscitation events in children from the Uni-

ted Kingdom found higher rates of survival to discharge for children at specialized pediatric hospitals.<sup>25</sup>

Our study should be interpreted in the context of the following limitations. First, the survey data were reported by a single respondent in collaboration with other staff at the hospital, and the reported policies and practices were not independently confirmed. However, survey respondents were typically the director of each hospital’s Code Blue committee and were therefore among the most knowledgeable individuals to evaluate their institution’s resuscitations practices. Second, our study population was limited to hospitals participating in a quality improvement registry for IHCA and our findings may not apply to non-participating hospitals. Specifically, the prevalence of some resuscitation strategies may be lower in non-participating hospitals. Third, our comparison of survival rates between pediatric only and combined hospitals was underpowered. Moreover, there may be unmeasured confounding between freestanding pediatric hospitals and combined hospitals that were not accounted for in our calculation of survival outcomes between sites, or misclassification of hospitals as being pediatric only or a combined hospital. Additional studies are needed to determine if differences in resuscitation practices between these two hospital types are associated with differences in hospital rates of survival for pediatric IHCA.

In conclusion, across hospitals caring for pediatric patients, substantial variation exists in resuscitation practices. Pediatric hospitals were more likely to employ some resuscitation practices as compared with hospitals which care for both adults and children, although the significance of these practice differences deserves further study as we found no differences in risk-standardized survival for IHCA between pediatric only and combined hospitals.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## Appendix A. Supplementary material

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.resplu.2021.100199>.

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