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Short paper

Impact of the three COVID-19 surges in 2020 on in-hospital cardiac arrest survival in the United States

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Abstract

Background: Studies have reported lower survival for in-hospital cardiac arrest (IHCA) during the initial COVID-19 surge. Whether the pandemic reduced IHCA survival during subsequent surges and in areas with lower COVID-19 rates is unknown.

Methods: Within Get-With-The-Guidelines®-Resuscitation, we identified 22,899 and 79,736 IHCAs during March to December in 2020 and 2015–2019, respectively. Using hierarchical regression, we compared risk-adjusted rates of survival to discharge in 2020 vs. 2015–19 during five COVID-19 periods: Surge 1 (March to mid-May), post-Surge 1 (mid-May to June), Surge 2 (July to mid-August), post-Surge 2 (mid-August to mid-October), and Surge 3 (mid-October to December). Monthly COVID-19 mortality rates for each hospital's county were categorized, per 1,000,000 residents, as very low (0–10), low (11–50), moderate (51–100), or high (>100).

Results: During each COVID-19 surge period in 2020, rates of survival to discharge for IHCA were lower, as compared with the same period in 2015–2019: Surge 1: adjusted OR: 0.81 (0.75–0.88); Surge 2: adjusted OR: 0.88 (0.79–0.97), Surge 3: adjusted OR: 0.79 (0.73–0.86). Lower survival was most pronounced at hospitals located in counties with moderate to high monthly COVID-19 mortality rates. In contrast, during the two post-surge periods, survival rates were similar in 2020 vs. 2015–2019: post-Surge 1: adjusted OR 0.93 (0.83–1.04) and post-Surge 2: adjusted OR 0.94 (0.86–1.03), even at hospitals with the highest county-level COVID-19 mortality rates.

Conclusions: During the three COVID-19 surges in the U.S. during 2020, rates of survival to discharge for IHCA dropped substantially, especially in communities with moderate to high COVID-19 mortality rates.

Keywords: Cardiac arrest, COVID-19, Survival, Outcomes, In-hospital arrest

Introduction

Initial studies from hospitals severely affected by the novel coronavirus 2019 (COVID-19) pandemic reported low survival rates for in-hospital cardiac arrest (IHCA).[1–5] However, whether the pandemic was associated with lower survival for IHCA during the three COVID-19 surges in 2020 across a range of hospitals is unknown but critical to understand as COVID-19 will likely be endemic in the U.S. with recurrent surges over time. Further, if IHCA survival was lower, it

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[1] The members of the American Heart Association's Get With the Guidelines_-Resuscitation Investigators Collaborators are listed in the supplementary material in Appendix A.

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Table 1 – Patient characteristics during the surge and post-surge periods. Variables that differed in frequency between 2020 and 2015–19 (standardized differences > 10%) for each of the periods are shaded in gray.

	Surge 1		Post-Surge 1		Surge 2		Post-Surge 2		Surge 3	
	2020 (n=5949)	2015-19 (n=20,510)	2020 (n=2686)	2015-19 (n=11,233)	2020 (n=3480)	2015-19 (n=11,410)	2020 (n=4505)	2015-19 (n=15,523)	2020 (n=6279)	2015-19 (n=21,060)
DEMOGRAPHICS										
Age, mean ± SD	64.6 ± 15.2	65.2 ± 15.3	64.3 ± 15.8	64.7 ± 15.7	64.0 ± 15.4	64.6 ± 15.7	64.8 ± 15.3	65.0 ± 15.5	65.5 ± 15.2	65.2 ± 15.5
Female sex	39.4%	41.3%	40.6%	41.9%	40.5%	40.7%	41.2%	41.1%	39.3%	40.9%
Race										
White	58.2%	67.0%	60.5%	66.4%	62.2%	68.3%	63.2%	68.7%	64.8%	68.0%
Black	28.9%	24.7%	29.3%	24.8%	25.3%	22.8%	24.9%	22.7%	22.7%	23.0%
Other	2.2%	2.2%	2.4%	2.4%	3.7%	2.5%	3.4%	2.4%	3.8%	2.7%
Missing	10.6%	6.1%	7.7%	6.3%	8.7%	6.5%	8.5%	6.2%	8.7%	6.3%
CARDIAC ARREST FACTORS										
Location of arrest										
Intensive care unit	46.5%	47.0%	46.7%	46.9%	48.6%	48.1%	46.8%	48.8%	47.7%	47.3%
Telemetry unit	13.0%	13.8%	11.8%	13.8%	14.1%	13.9%	14.2%	14.0%	14.3%	14.4%
Non-monitored hospital unit	18.4%	16.0%	15.7%	16.3%	14.6%	14.9%	15.1%	14.6%	15.5%	15.1%
Emergency room	14.2%	12.3%	16.2%	12.4%	14.4%	12.8%	1450.0%	12.6%	14.0%	13.0%
Procedural area	6.2%	9.0%	7.9%	8.7%	6.8%	8.4%	7.6%	8.1%	6.4%	8.1%
Other	1.7%	1.9%	1.8%	1.9%	1.6%	1.8%	1.8%	190.0%	2.2%	2.1%
Time of Arrest										
Night (11 PM to 6:59 AM)	29.6%	30.2%	31.2%	30.4%	31.4%	31.6%	30.6%	31.3%	29.8%	31.0%
Weekend	31.7%	30.7%	31.8%	31.3%	30.9%	31.0%	30.4%	31.0%	31.3%	30.4%
Initial Cardiac Arrest Rhythm										
Asystole	27.3%	25.1%	26.5%	24.1%	25.7%	25.1%	26.3%	24.8%	26.4%	24.6%
Pulseless electrical activity	58.2%	57.8%	58.0%	58.9%	60.2%	57.3%	58.6%	57.1%	59.8%	58.8%
Ventricular fibrillation	7.0%	7.6%	7.2%	7.4%	7.1%	9.7%	8.0%	9.9%	7.0%	9.2%
Pulseless VT	7.5%	9.5%	8.3%	9.5%	7.0%	7.9%	7.1%	8.2%	6.8%	7.5%
Hospital-wide response activated	72.0%	68.8%	68.9%	69.4%	72.2%	70.4%	72.3%	70.8%	74.5%	72.0%
PRE-EXISTING CONDITIONS										
Illness Category										
Medical cardiac	32.8%	37.1%	34.9%	36.5%	30.7%	37.6%	33.9%	38.4%	30.8%	37.4%
Medical non-cardiac	54.0%	43.6%	49.1%	43.2%	53.3%	42.4%	49.5%	42.2%	55.1%	43.9%
Surgical cardiac	3.6%	6.3%	4.3%	5.9%	4.6%	6.2%	4.2%	6.0%	4.1%	5.9%
Surgical non-cardiac	6.4%	9.5%	7.5%	10.3%	7.5%	9.4%	8.7%	9.3%	6.5%	9.1%
Other	3.2%	3.5%	4.1%	4.0%	3.9%	4.4%	3.7%	4.1%	3.5%	3.7%
Heart failure this admission	11.5%	15.1%	12.7%	14.3%	11.6%	14.1%	13.0%	14.2%	11.1%	14.3%
Heart failure prior to admission	21.3%	25.0%	23.6%	24.2%	23.0%	23.3%	25.1%	23.2%	23.1%	24.5%
MI this admission	13.0%	14.3%	12.5%	14.1%	13.8%	15.3%	13.4%	15.2%	12.1%	15.3%
MI prior to admission	14.1%	15.5%	14.1%	14.2%	14.7%	14.7%	15.1%	14.8%	14.3%	14.8%
Hypotension	32.8%	29.7%	32.9%	30.1%	34.5%	30.5%	33.3%	30.1%	32.4%	29.4%
Respiratory insufficiency	56.2%	48.5%	50.3%	48.3%	54.6%	49.4%	53.5%	48.3%	55.6%	47.7%
Renal insufficiency	37.9%	37.1%	39.9%	36.5%	38.7%	35.8%	38.9%	35.9%	38.0%	36.7%
Hepatic insufficiency	9.1%	8.7%	10.3%	9.1%	12.0%	9.7%	11.0%	9.8%	10.9%	9.6%
Metabolic/electrolyte abnormality	29.7%	26.3%	31.7%	27.2%	34.1%	28.0%	31.6%	27.3%	31.2%	27.6%
Diabetes mellitus	38.2%	35.6%	37.1%	35.0%	37.2%	34.8%	38.1%	30.1%	38.8%	35.3%
Baseline depression in CNS function	7.8%	7.7%	7.9%	7.4%	7.4%	7.9%	8.1%	7.7%	7.3%	7.4%
Major trauma	3.6%	4.4%	5.0%	5.4%	5.4%	5.5%	5.2%	5.1%	5.2%	4.9%
Acute stroke	4.0%	4.0%	4.0%	3.8%	4.1%	3.6%	4.4%	4.0%	3.7%	4.2%
Pneumonia	27.1%	14.5%	18.5%	13.1%	24.4%	12.8%	20.4%	12.9%	26.8%	13.8%
Septicemia	24.6%	24.6%	23.9%	24.1%	26.0%	18.7%	23.9%	19.3%	25.7%	19.3%
Metastatic/hematologic malignancy	9.7%	10.7%	10.6%	10.8%	10.9%	12.0%	11.7%	11.0%	11.0%	11.3%
SARS COV-2 (COVID-19)	25.3%	0.0%	15.6%	0.0%	22.0%	0.0%	16.6%	0.0%	28.3%	0.0%
INTERVENTIONS IN PLACE AT TIME OF ARREST										
Continuous intravenous vasopressor	30.8%	26.6%	31.7%	27.4%	34.1%	28.0%	32.5%	28.7%	31.7%	27.4%
Assisted or Mechanical ventilation	53.3%	47.7%	52.3%	47.6%	53.5%	47.7%	50.8%	47.5%	53.6%	46.6%
Hemodialysis	3.1%	3.0%	4.1%	3.1%	4.2%	3.4%	4.2%	3.2%	3.7%	3.2%

Abbreviations: CNS, central nervous system; MI, myocardial ischemia; SD, standard deviation; VT, ventricular tachycardia remains unclear whether lower survival occurred primarily in areas with very high COVID-19 mortality rates in the community. Accordingly, within a large U.S. registry of IHCA, we evaluated IHCA survival outcomes during three surge and two post-surge periods in 2020 compared with 2015–2019 to better understand whether and where survival rates for IHCA were lower during the COVID-19 surge periods.

Methods

The study was approved by Saint Luke's Hospital's IRB, which waived the requirement for informed consent as the study involved deidentified data.

Get With The Guidelines (GWTG)-Resuscitation® is a large, prospective, national quality-improvement registry of IHCA. Its design has been previously described.[6] Briefly, trained hospital personnel identify all patients without do-not-resuscitate orders with a pulseless cardiac arrest who undergo cardiopulmonary resuscitation. Cases are identified through cardiac arrest flow sheets, reviews of hospital paging system logs, and routine checks of code carts.[6] Standardized Utstein-style definitions are used for all patient variables and outcomes to facilitate uniform reporting across hospitals.[7,8]

Within GWTG-Resuscitation, we compared survival outcomes for 22,899 IHCAs between March-December 2020 (COVID-19 pandemic months) to 79,736 IHCAs during corresponding months in 2015–2019 (control periods) after confirming IHCA survival was stable between 25 and 26% annually during 2015–2019. We divided 2020 into five periods based on national reporting of each COVID-19 surge and examination of national COVID-19 mortality rates:[9] first surge (March 1-May 15), post-first surge (May 16-June 30), second surge (July 1-August 15), post-second surge (August 16-October 15), and third surge (October 16-December 31). The primary outcome was survival to hospital discharge. The secondary outcome was sustained return of spontaneous circulation for (ROSC) $\geq$ 20 min. The independent variable was time of arrest: 2020 vs. control time period of 2015–2019.

Besides an overall comparison of IHCA outcomes between 2020 and 2015–2019 during the surge and post-surge periods, we also examined whether differences in IHCA survival during the pandemic were confined to communities with high COVID-19 mortality rates. Daily county-level COVID-19 mortality data were obtained from the New York Times COVID-19 database.[9] For each county, we calculated monthly COVID-19 mortality rates per 1,000,000 residents by dividing the total number of COVID-19 deaths occurring monthly by the number of residents in the county, based on our prior work.[10] Each GWTG-Resuscitation hospital was geocoded to a U.S. county based on its zip code using a crosswalk file from the Department of Housing and Urban Development[11] to link each patient to their hospital's county-level COVID-19 mortality rate.

Statistical analysis

Given the large sample size, baseline differences for patients with IHCA during the surge and post-surge periods in 2020 vs. the same period in 2015–2019 were compared using standardized differences. Standardized differences of >10% were considered clinically significant.[12]

For each of the five periods, we constructed multivariable hierarchical logistic regression models to compare IHCA survival in 2020 to 2015–2019, with hospital as a random effect to account for clustering of patients. Models adjusted for age, sex, race, initial cardiac arrest rhythm, location of cardiac arrest, illness category, comorbid conditions (prior heart failure or myocardial infarction, index admission heart failure or myocardial infarction, diabetes mellitus, baseline depression in central nervous system function, acute stroke, pneumonia, and metastatic or hematologic malignancy), medical conditions present within 24 h of cardiac arrest (renal insufficiency, hepatic insufficiency, respiratory insufficiency, hypotension, septicemia, and metabolic or electrolyte abnormality) and interventions in place at the time of cardiac arrest (continuous intravenous vasopressor, assisted or mechanical ventilation, and hemodialysis) (see Supplementary Appendix Table I for definitions of select variables). Models also adjusted for whether the IHCA occurred during nighttime or a weekend.[13]

We then included an interaction term between year (2020 vs. 2015–2019) and the hospital's county-level monthly COVID-19 mortality rate to determine if survival rates varied by the severity of the COVID-19 pandemic. COVID-19 mortality rates were calculated per 1,000,000 residents per month and categorized as low (0–10 COVID-19 deaths), moderate (11–50), high (51–100), or very high (>100), except for the third surge where an additional stratum of > 200 was added.

For each analysis, the null hypothesis was evaluated at a 2-sided significance level of 0.05. All statistical analyses were conducted using SAS Version 9.1.3 (SAS Institute, Cary, NC).

Results

The trajectory of COVID-19 deaths in the U.S. during the study period is shown in Supplementary Appendix Figure I, with mortality spikes correlating with the surge periods. Generally, patients in surge periods in 2020 were sicker than in 2015–2019, with higher rates of respiratory insufficiency, pneumonia, sepsis prior to IHCA, along with higher rates of a non-shockable cardiac arrest rhythm and mechanical ventilation at the time of IHCA (Table 1). Notably, the proportion of IHCAs occurring in intensive care units did not increase during the surge periods.

Unadjusted rates of survival to discharge in 2020 vs. 2015–2019 are depicted in Figure 1. After risk adjustment, IHCA survival was lower during each COVID-19 surge period as compared with 2015–2019: Surge 1: 19.6% vs. 26.0% (adjusted OR: 0.81 [95% CI: 0.75–0.88]); Surge 2: 20.7% vs. 25.6% (adjusted OR: 0.88 [0.79–0.97]), and Surge 3: 18.9% vs. 24.5% (adjusted OR: 0.79 [0.73–0.86]). Lower IHCA survival rates during COVID-19 surges were primarily at hospitals with moderate or high monthly COVID-19 mortality rates in the community (Table 2). In contrast, IHCA survival during the post-surge periods in 2020 was comparable to 2015–2019 overall: post-Surge 1: 22.3% vs. 25.8% (adjusted OR 0.93 [0.83–1.04]) and post-Surge 2: 23.0% vs. 25.7% (adjusted OR

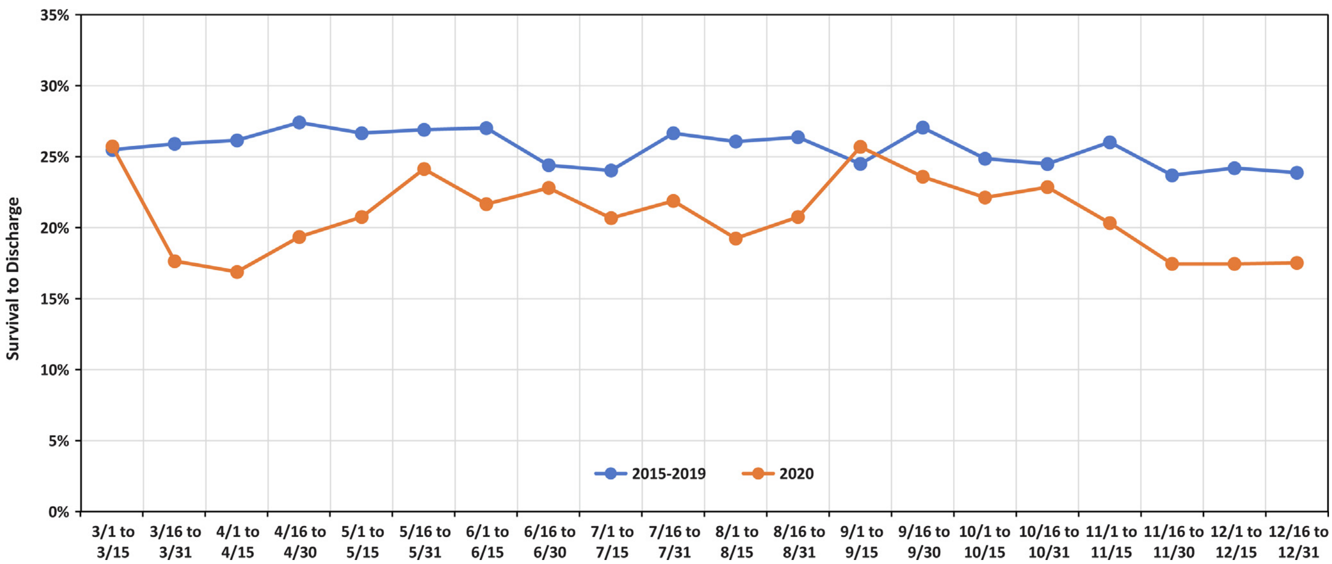

Fig. 1 – Survival Rates for IHCA in 2020 vs. 2015–2019. Unadjusted survival rates for IHCA for each half-month period between March to December are depicted for 2020 and the control period of 2015–2019.

Table 2 – Association of the COVID-19 pandemic on rates of survival to discharge for IHCA during five periods in 2020 vs. 2015–2019, overall and stratified by county-level mortality rates of COVID-19.

	2020 n = 22,899	2015–2019 n = 79,736	Adjusted OR (95% CI)	P	Interaction P
Surge 1					
Overall	1164/5949 (19.6%)	5342/20,510 (26.0%)	0.81 (0.75, 0.88)	<0.001	
Monthly COVID-19 Mortality Rate					
0–10 per 1,000,000	353/1493 (23.6%)	1459/5794 (25.2%)	1.04 (0.90, 1.20)	0.61	<0.001
11–50 per 1,000,000	344/1502 (22.9%)	1654/6172 (26.8%)	0.97 (0.84, 1.12)	0.67	
51–100 per 1,000,000	217/1060 (20.5%)	1130/3834 (29.5%)	0.72 (0.60, 0.86)	<0.001	
>100 per 1,000,000	250/1894 (13.2%)	1099/4710 (23.3%)	0.58 (0.49, 0.68)	<0.001	
Post-Surge 1					
Overall	599/2686 (22.3%)	2898/11,233 (25.8%)	0.93 (0.83, 1.04)	0.18	
Monthly COVID-19 Mortality Rate					
0–10 per 1,000,000	150/612 (24.5%)	600/2577 (23.3%)	1.16 (0.93, 1.46)	0.19	0.16
11–50 per 1,000,000	177/750 (23.6%)	920/3355 (27.4%)	0.91 (0.74, 1.11)	0.35	
51–100 per 1,000,000	108/527 (20.5%)	583/2296 (25.4%)	0.84 (0.65, 1.09)	0.19	
>100 per 1,000,000	164/797 (20.6%)	795/3005 (26.5%)	0.85 (0.69, 1.04)	0.12	
Surge 2					
Overall	719/3480 (20.7%)	2924/11410 (25.6%)	0.88 (0.79, 0.97)	0.01	
Monthly COVID-19 Mortality Rate					
0–10 per 1,000,000	56/248 (22.6%)	295/1057 (27.9%)	0.91 (0.62, 1.31)	0.60	0.03
11–50 per 1,000,000	263/1166 (22.6%)	1010/4010 (25.2%)	0.99 (0.83, 1.19)	0.99	
51–100 per 1,000,000	195/895 (21.8%)	800/3029 (26.4%)	0.96 (0.79, 1.18)	0.70	
>100 per 1,000,000	205/1171 (17.5%)	819/3314 (24.7%)	0.69 (0.57, 0.84)	<0.001	
Post-Surge 2					
Overall	1036/4505 (23.0%)	3991/15523 (25.7%)	0.94 (0.86, 1.03)	0.19	
Monthly COVID-19 Mortality Rate					
0–10 per 1,000,000	118/489 (24.1%)	488/1807 (27.0%)	0.91 (0.70, 1.19)	0.50	0.63
11–50 per 1,000,000	324/1300 (24.9%)	1192/4452 (26.8%)	0.97 (0.82, 1.14)	0.69	
51–100 per 1,000,000	398/1684 (23.6%)	1511/5919 (25.5%)	0.98 (0.86, 1.14)	0.90	
>100 per 1,000,000	196/1032 (19.0%)	800/3345 (23.9%)	0.85 (0.70, 1.03)	0.10	
Surge 3					
Overall	1187/6279 (18.9%)	5150/21060 (24.5%)	0.79 (0.73, 0.86)	<0.001	
Monthly COVID-19 Mortality Rate					
0–50 per 1,000,000	79/308 (25.7%)	268/998 (26.9%)	1.06 (0.76, 1.48)	0.74	0.11
51–100 per 1,000,000	335/1625 (20.6%)	1507/6030 (25.0%)	0.84 (0.72, 0.98)	0.03	
101–200 per 1,000,000	520/2792 (18.6%)	2347/9739 (24.1%)	0.80 (0.71, 0.90)	0.002	
>200 per 1,000,000	253/1554 (16.3%)	1028/4293 (24.0%)	0.69 (0.58, 0.82)	<0.001	

Table 3 – Association of the COVID-19 Pandemic on rates of ROSC for IHCA during five periods in 2020 vs. 2015–2019, overall and stratified by county-level mortality rates of COVID-19

	2020 n = 22,899	2015–2019 n = 79,736	Adjusted OR (95% CI)	*P*	Interaction *P*
Surge 1					
Overall	3534/5949 (59.4%)	13,833/20,510 (67.4%)	0.73 (0.69, 0.78)	<0.001	
Monthly COVID-19 Mortality Rate					
0–10 per 1,000,000	931/1493 (62.4%)	3928/5794 (67.8%)	0.81 (0.71, 0.91)	0.001	<0.001
11–50 per 1,000,000	951/1502 (63.3%)	4166/6172 (67.5%)	0.84 (0.74, 0.95)	0.005	
51–100 per 1,000,000	674/1060 (63.6%)	2624/3834 (68.4%)	0.83 (0.72, 0.97)	0.02	
>100 per 1,000,000	978/1894 (51.6%)	3115/4710 (66.1%)	0.56 (0.50, 0.63)	<0.001	
Post-Surge 1					
Overall	1745/2686 (65.0%)	7573/11,233 (67.4%)	0.93 (0.85, 1.02)	0.12	
Monthly COVID-19 Mortality Rate					
0–10 per 1,000,000	396/612 (64.7%)	1750/2577 (67.9%)	0.89 (0.74, 1.08)	0.24	0.72
11–50 per 1,000,000	498/750 (66.4%)	2256/3355 (67.2%)	0.98 (0.83, 1.17)	0.85	
51–100 per 1,000,000	356/527 (67.6%)	1560/2296 (67.9%)	0.99 (0.81, 1.22)	0.94	
>100 per 1,000,000	495/797 (62.1%)	2007/3005 (66.8%)	0.88 (0.75, 1.04)	0.14	
Surge 2					
Overall	2162/3480 (62.1%)	7550/11410 (66.2%)	0.86 (0.79, 0.94)	0.007	
Monthly COVID-19 Mortality Rate					
0–10 per 1,000,000	159/248 (64.1%)	709/1057 (67.1%)	0.85 (0.62, 1.16)	0.30	0.002
11–50 per 1,000,000	745/1166 (63.9%)	2680/4010 (66.9%)	0.91 (0.78, 1.05)	0.20	
51–100 per 1,000,000	591/895 (66.0%)	2002/3029 (66.1%)	1.08 (0.91, 1.28)	0.39	
>100 per 1,000,000	667/1171 (57.0%)	2159/3314 (65.2%)	0.69 (0.60, 0.81)	<0.001	
Post-Surge 2					
Overall	2860/4505 (63.5%)	10192/15523 (65.7%)	0.91 (0.84, 0.98)	0.01	
Monthly COVID-19 Mortality Rate					
0–10 per 1,000,000	297/489 (60.7%)	1201/1807 (66.5%)	0.71 (0.57, 0.89)	0.003	0.054
11–50 per 1,000,000	811/1300 (62.4%)	2948/4452 (66.2%)	0.86 (0.75, 0.99)	0.04	
51–100 per 1,000,000	1093/1684 (64.9%)	3878/5919 (65.5%)	1.00 (0.89, 1.13)	0.99	
>100 per 1,000,000	659/1032 (63.9%)	2165/3345 (64.7%)	0.92 (0.79, 1.08)	0.32	
Surge 3					
Overall	3834/6279 (61.1%)	13863/21060 (65.8%)	0.83 (0.78, 0.89)	<0.001	
Monthly COVID-19 Mortality Rate					
0–50 per 1,000,000	196/308 (63.6%)	671/998 (67.2%)	0.80 (0.60, 1.07)	0.13	0.84
51–100 per 1,000,000	996/1625 (61.3%)	3932/6030 (65.2%)	0.86 (0.76, 0.97)	0.01	
101–200 per 1,000,000	1723/2792 (61.7%)	6463/9739 (66.4%)	0.85 (0.77, 0.93)	<0.001	
>200 per 1,000,000	919/1554 (59.1%)	2797/4293 (65.2%)	0.80 (0.70, 0.91)	<0.001	

0.94 [0.86–1.03]), even in counties with high monthly COVID-19 mortality rates (Table 2).

For ROSC, a similar pattern of lower rates were observed during all three surge periods in 2020 vs. 2015–2019, with lower ROSC rates even at hospitals with moderate monthly COVID-19 mortality rates in the community during the first and third surge periods (Table 3). Rates of ROSC were similar in 2020 vs. 2015–2019 during the first post-surge period but were lower during the second post-surge period.

Discussion

Within a national registry of hospitals, we found markedly lower rates of survival to discharge and ROSC during the three COVID-19 surges in 2020, particularly at hospitals with moderate to high COVID-19 mortality rates in the community. Importantly, we found overall survival during the post-surge periods was not significantly different as compared to similar periods during 2015–2019, although rates of ROSC were lower during the second post-surge period. Collectively, our study quantified the extent to which the COVID-19 pandemic affected survival rates for patients with IHCA during the surge periods in 2020 when there was likely stress on hospital systems overwhelmed with critically ill patients and a shortage of ICU beds, ventilators and critical care personnel.

To date, published reports have primarily examined the impact of the COVID-19 pandemic during the initial first surge in 2020.[1–5] Our study extends this literature by examining the association of the pandemic throughout three surge and two post-surge periods in 2020. We also examined the differential impact of the severity of the COVID-19 pandemic on IHCA survival during each of the study periods. Lower rates of IHCA survival during the surge periods were likely due to decreased survival of patients with concurrent COVID-19 infection (which represented 25% of the 2020 study cohort) and the indirect effects of a pandemic surge on patients without COVID-19 infection who were treated at hospitals with high

COVID-19 disease burden. This is supported by the fact that IHCA survival was lower at hospitals with moderate to high COVID-19 mortality rates during the surge periods.

Importantly, we found overall rates of survival to discharge for IHCA during the post-surge periods were comparable to prior years, underscoring the critical role of public health measures to reduce future COVID-19 infection surges and restore IHCA survival to pre-pandemic levels. Until then, given that the impact of the COVID-19 pandemic has been uneven across the U.S. and has varied with each surge, our findings have implications for ongoing hospital benchmarking efforts in this quality improvement registry. Moreover, future research on temporal trends analyses of IHCA survival in GWTG-Resuscitation will need to consider the impact of the COVID-19 pandemic on survival rates after 2019, as IHCA survival will remain lower than pre-pandemic periods until severe COVID-19 surges can be avoided.

Limitations include that our analyses reflect IHCA survival only in hospitals participating in this national quality improvement registry although there is no reason to believe that the pandemic has not affected non-participating hospitals. Second, we adjusted for variables that may have been mediators of the effect of COVID-19 on IHCA survival, such as non-shockable rhythm and pneumonia. Since these variables could be both confounders and mediators, our findings likely represent a conservative estimate of the impact of the COVID-19 pandemic surges on IHCA survival. Third, although COVID-19 mortality is a more accurate marker of the pandemic's severity than incidence (given geographic variability in testing), COVID-19 mortality is a lagging indicator of the pandemic's severity in communities; therefore, our interaction analyses by COVID-19 mortality strata in the post-surge periods should be interpreted with this limitation in mind. We also lacked information on hospital occupancy rates, ICU bed availability and staff shortages during the surge periods which may have accounted for our study's findings. Finally, GWTG-Resuscitation collects data only on patients with IHCAs who undergo cardiopulmonary resuscitation. If rates of do-not-attempt-resuscitation orders had increased during the surge period,[14] our study may have underestimated the effect of the pandemic on IHCA survival.

Conclusion

During the three COVID-19 surges in the U.S. in 2020, rates of survival to discharge for IHCA dropped substantially, especially in communities with moderate to high COVID-19 mortality rates.

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.

Acknowledgments and Disclosures

The Get With The Guidelines® programs are provided by the American Heart Association. 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™ (IQVIA, Parsippany, New Jersey). IQVIA serves as the data collection (through their Patient Management Tool – PMT™) and coordination center for the American Heart Association/American Stroke Association Get With The Guidelines® programs. The University of Pennsylvania serves as the data analytic center and has an agreement to prepare the data for research purposes.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.resuscitation.2021.11.025.

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