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The impact of COVID-19 on incidence and outcomes from out-of-hospital cardiac arrest (OHCA) in Texas



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ABSTRACT

Introduction: Emerging research demonstrates lower rates of bystander cardiopulmonary resuscitation (BCPR), public AED (PAD), worse outcomes, and higher incidence of OHCA during the COVID-19 pandemic. We aim to characterize the incidence of OHCA during the early pandemic period and the subsequent long-term period while describing changes in OHCA outcomes and survival.

Methods: We analyzed adult OHCA in Texas from the Cardiac Arrest Registry to Enhance Survival (CARES) during March 11–December 31 of 2019 and 2020. We stratified cases into pre-COVID-19 and COVID-19 periods. Our prehospital outcomes were bystander cardiopulmonary resuscitation (BCPR), public AED use (PAD), sustained ROSC, and prehospital termination of resuscitation (TOR). Our hospital survival outcomes were survival to hospital admission, survival to hospital discharge, good neurological outcomes (CPC Score of 1 or 2) and Utstein bystander survival. We created a mixed effects logistic regression model analyzing the association between the pandemic on outcomes, using EMS agency as the random intercept.

Results: There were 3619 OHCA (45.0% of overall study population) in 2019 compared to 4418 (55.0% of overall study population) in 2020. Rates of BCPR (46.2% in 2019 to 42.2% in 2020, $P < 0.01$) and PAD (13.0% to 7.3%, $p < 0.01$) decreased. Patient survival to hospital admission decreased from 27.2% in 2019 to 21.0% in 2020 ($p < 0.01$) and survival to hospital discharge decreased from 10.0% in 2019 to 7.4% in 2020 ($p < 0.01$). OHCA patients were less likely to receive PAD (aOR = 0.5, 95% CI [0.4, 0.8]) and the odds of field termination increased (aOR = 1.5, 95% CI [1.4, 1.7]).

Conclusions: Our study adds state-wide evidence to the national phenomenon of long-term increased OHCA incidence during COVID-19, worsening rates of BCPR, PAD use and survival outcomes.

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1. Introduction

Out-of-hospital cardiac arrest (OHCA) is a leading cause of death in the United States, accounting for more than 300,000 occurrences per year [1,2]. Decades of research has shown few interventions that consistently improve outcomes—early initiation of bystander cardiopulmonary resuscitation (BCPR) and automated external defibrillator use (AED)—yet

survival rates have remained relatively constant (<10%) [3–6]. Prior research estimates that close to half of OHCA patients receive BCPR while public AED rates hover around 9–12% [7–10]. As such, these are high-yield targets for public health efforts to increase interventions that are key to improving OHCA survival rates.

Emerging studies are beginning to show the tremendous impact of the SARS-CoV-2 pandemic (COVID-19) on OHCA outcomes. These previous studies demonstrate lower rates of BCPR (8.94% decrease from 2020 to 2019) and public AED (PAD) usage, corresponding to lower rates of sustained return of spontaneous circulation (ROSC) (23.0% in 2020 versus 29.8% in 2019; adjusted rate ratio, 0.82 [95% CI,

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0.78–0.87]; $P < 0.001$), lower survival to hospital discharge (6.6% in 2020 versus 9.8% in 2019; adjusted RR, 0.83 [95% CI, 0.69–1.00]; $P = 0.048$) and in general, higher incidence of OHCA during the COVID-19 pandemic compared to prior years [11–13]. However, most of these studies were conducted during the early months of COVID-19 and it is unclear whether these trends continue to persist on a statewide level.

In this study, we aim to characterize the incidence of OHCA during the pandemic period compared to the prior year and describe changes, if any, in OHCA outcomes and survival. This study can help fill the gap regarding long-term impacts of the pandemic beyond the initial first wave on cardiac arrest care and patient outcomes.

2. Methods

2.1. Data source

We analyzed adult OHCA in Texas from the Cardiac Arrest Registry to Enhance Survival (CARES) during March 11–December 31 of 2019 and 2020. The CARES database is a collaboration between Emory University and the Centers for Disease Control and Prevention, which aims to improve cardiac arrest outcomes by using OHCA surveillance data. Data is voluntarily reported by EMS agencies and hospitals from across the country. CARES has standardized quality measurements for benchmarking and quality improvement efforts on the local, state and national level [14,15]. The national CARES database captures 51% about the U.S. population, approximately 167 million people [14,15]. The study was approved by the University of Texas Health Science Center at Houston IRB and the CARES Data Sharing Committee (HSC-MS-19-0601).

2.2. Selection of subjects

We stratified cases into different groups of interest: pre-COVID-19 (March 11, 2019 to December 31, 2019) and COVID-19 period (March 11, 2020 to December 31, 2020), representing the period after the emergence and persistence of COVID-19 and a matched period during the prior years. We used March 11, 2020 as the cutoff date as this is when COVID-19 was declared a pandemic by the World Health Organization [16]. We excluded cases witnessed by 9–1–1 responders, arrests occurring at healthcare facilities and pediatric cases (<18 years old). We excluded 2 EMS agencies who did not participate in CARES for the entire study period, representing 0.003% of the original data set.

2.3. Study variables and outcomes

Cardiac arrest characteristics were defined as age, gender, race/ethnicity (White, Black, Hispanic, Other), witnessed arrest, initial rhythm type (shockable, non-shockable) and location type (home/residence, public). Our prehospital outcomes of interest were BCPR, public AED use, sustained ROSC, and prehospital termination of resuscitation (TOR). Our hospital survival outcomes of interest were survival to hospital admission, survival to hospital discharge, good neurological outcomes (CPC Score of 1 or 2) and Utstein bystander survival rate (patients surviving to hospital discharge with witnessed bystander arrest, initial shockable rhythm receiving BCPR and/or AED) [17].

2.4. Statistical analysis

We analyzed the patient arrest characteristics and prehospital care data using descriptive statistics stratified by pre-pandemic and pandemic periods. We calculated the median and interquartile ranges for patient ages. We used Pearson's χ^2 tests to determine association of variables with the two study years. Similarly, we used Fisher's exact tests for variables with expected frequencies less than 5 to evaluate their association with the two study years. We built mixed multivariable logistic regression models to estimate the adjusted odds ratio (aOR) of

outcomes of interest comparing the pre-pandemic and pandemic periods, and stratifying by EMS agency as the random intercept. The models were controlled for the following confounders: age, gender, race/ethnicity, witnessed arrest, initial rhythm type and location type. All statistical analyses were conducted with STATA 16.1.

3. Results

As shown in Figs. 1, 8037 patients were included in the analysis. (Fig. 1). There were 3619 OHCA (45.0%) in 2019 compared to 4418 (55.0%) in 2020 for a total of 8037 cases (Table 2). Across the two study periods, median age, race/ethnicity and witnessed arrest were consistent. From 2019 to 2020, the proportion of arrests occurring at home or at a residence increased from 80.9% to 86.7% ($P < 0.01$) (Table 1). Additionally, there were slightly more cardiac arrests occurring in the COVID-19 period thought to be related to respiratory causes (8.2% in 2019 vs 8.4% in 2020) while OHCA secondary to a cardiac etiology decreased (85.1% in 2019 vs 84.6% in 2020) ($P = 0.04$) (Table 1).

Comparing prehospital characteristics from 2019 to 2020, the proportion of prehospital CPR (EMS 20.1% in 2019, 22.5% in 2020; first responder 33.7% in 2019, 35.3% in 2020) and AED (EMS: 88.8% in 2019, 94.1% in 2020) initiated by EMS or first responders increased ($p < 0.01$). There were decreases in bystander CPR (46.2% in 2019 vs 42.2% in 2020) and bystander AED application (13.0% in 2019 vs 7.3% in 2020). Patients were more likely to present in asystole than any other rhythm (51.3% in 2019 vs 58.2% in 2020) ($P < 0.01$), and the proportion of non-shockable rhythms increased (79.9% in 2019 vs 84.7% in 2020) ($P < 0.01$). In terms of outcome, patients were less likely to have sustained ROSC during the pandemic period compared to 2019 (28.8% in 2019 vs 21.1% in 2020) ($P < 0.01$). They were more likely to have an advanced airway placed in 2020 (90.7% in 2019 vs 92.6% in 2020) ($P < 0.01$). There was also an increase in field terminations in 2020 (37.3% in 2019 vs 46.7% in 2020) ($P < 0.01$). Comparing patient survival outcomes, we found both patient survival to hospital admission (27.2% in 2019 vs 21.0% in 2020) ($p < 0.01$) and patient survival to hospital discharge (10.0% in 2019 to 7.4% in 2020) ($P < 0.01$) decreased in 2020. The proportion of patients with good neurologic outcomes remained consistent (70.0% in 2019 vs 67.6% in 2020) ($P = 0.5$). While the Utstein bystander survival rate decreased in 2020 compared to 2019, this did not reach statistical significance (38.5% in 2019 vs 31.4% in 2020) ($P = 0.06$) (Table 2).

Utilizing mixed multivariable logistic regression to compare care between 2019 and 2020, we found patients were slightly less likely to have bystander CPR in 2020 (aOR = 0.9, 95% CI [0.8, 0.95]). OHCA patients were about half as likely to benefit from PAD in 2020 (aOR = 0.5, 95% CI [0.4, 0.8]). Patients were also less likely to have sustained ROSC during the COVID-19 period compared to 2019 (aOR = 0.7, 95% CI [0.6, 0.8]). In terms of survival, the odds of field termination were 1.5 times greater during COVID-19 (aOR = 1.5, 95% CI [1.4, 1.7]). Patients were also less likely to survive to hospital admission (aOR = 0.7, 95% CI [0.7, 0.8]) and hospital discharge (aOR = 0.8, 95% CI [0.7, 0.96]) during COVID-19. While odds of patients having good CPC scores remained consistent (aOR = 0.99, 95% CI [0.7, 1.5]), the odds Utstein bystander survival slightly decreased during the COVID-19 period (aOR = 0.8, 95% CI [0.5, 1.0]) (Table 3).

4. Discussion

Emerging data suggests worsening OHCA outcomes on a national level during the COVID-19 pandemic, but it is not clear if this trend persists on the state level [13]. We hypothesized public interventions, especially those shown to improve OHCA outcomes such as BCPR and PAD would decrease while survival outcomes would worsen. To date, no other state-wide studies have been comparable in terms of geographic size, patient population or temporal length. By utilizing such a comprehensive reach, this study adds to the evidence that OHCA care and

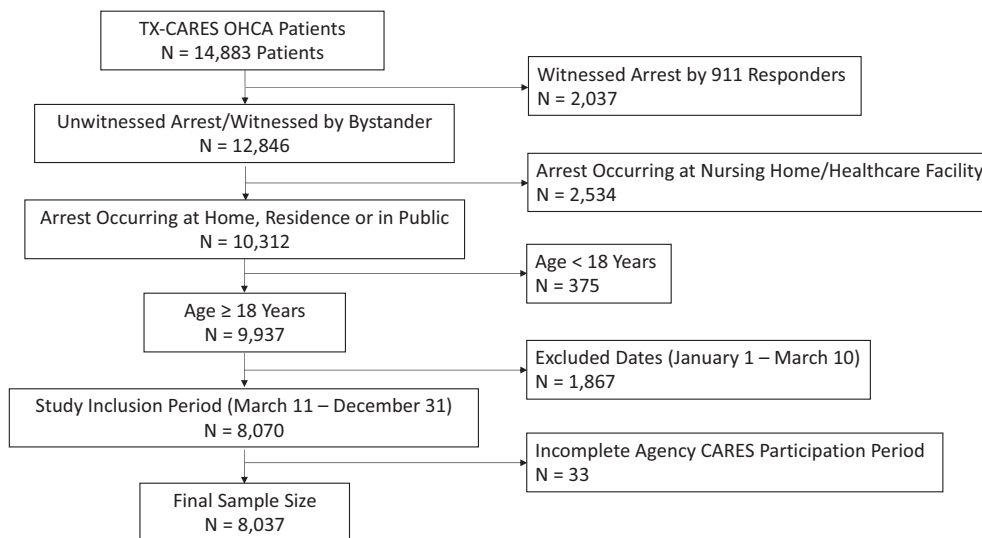


Fig. 1. Patient Selection Flowchart.

outcomes has continued to worsen in the COVID-19 pandemic period. Better characterization of which aspects of pre-hospital cardiac care have deteriorated due to the pandemic can help drive quality improvement efforts and restore the chain of the survival.

Between the two study periods, the patient demographics (age, gender, race & ethnicity) were similar. However, the total number of cardiac arrests increased from 3627 in 2019 to 4443 in 2020, an absolute 22.5% increase. Because the same EMS agencies participated in both study periods, this suggests an absolute increase in cardiac arrests as it cannot be attributed to agency participation. While this general increase is consistent with other studies, estimates of differences in OHCA incidence range from -3% to 191.4% during the early months of the pandemic [18]. In a systematic review by Teoh, et al., the pooled annual OHCA incidence increased by 39.5% ($P < 0.001$), which is more in-line with our calculations [19].

In this study, we used a series of mixed effect logistic regression models, with EMS agency as the random intercept, adjusting for covariates,

Table 1 Patient cardiac arrest characteristics, stratified by year.

	2019	2020	
Total Arrests	3619 (45.0%)	4418 (55.0%)	
Median Age (Years) (IQR) ¹	63 (51–74)	63 (51–74)	$P = 0.7$
Male Gender ²	2307 (63.8%)	2781 (63.0%)	$P = 0.5$
Race & Ethnicity ²			
White	1591 (44.0%)	1857 (42.0%)	
Black/African-American	901 (24.9%)	1128 (25.5%)	$P = 0.2$
Hispanic/Latino	935 (25.8%)	1217 (27.6%)	
Other	192 (5.3%)	216 (4.9%)	
Location Type ²			
Home/Residence	2926 (80.9%)	3831 (86.7%)	$P < 0.01$
Public	693 (19.2%)	587 (13.3%)	
Arrest Witnessed Status ²			
Unwitnessed	1938 (53.5%)	2338 (52.9%)	$P = 0.6$
Witnessed by Bystander	1682 (46.5%)	2080 (47.1%)	
Presumed Cardiac Arrest Etiology ²			
Drowning/Submersion	18 (0.5%)	26 (0.6%)	
Drug Overdose	168 (4.6%)	169 (3.8%)	
Electrocution	3 (0.1%)	8 (0.2%)	
Exsanguination/Hemorrhage	15 (0.4%)	33 (0.7%)	$P = 0.04$
Other	41 (1.1%)	76 (1.7%)	
Presumed Cardiac Etiology	3079 (85.1%)	3736 (84.6%)	
Respiratory/Asphyxia	295 (8.2%)	370 (8.4%)	

¹ P-value determined using Wilcoxon rank sum test.

² P-value determined using Pearson's χ^2 test.

to calculate adjusted odds ratios and thus the impact of the pandemic on OHCA outcomes of interest. We found that life-saving bystander interventions, BCPR and PAD, worsened relative to the pre-pandemic period and

Table 2 Prehospital Care & Hospital outcomes, stratified by year.

	2019	2020	
Party Initiating CPR ¹			
Bystander	1670 (46.2%)	1863 (42.2%)	
EMS	728 (20.1%)	995 (22.5%)	$P < 0.01$
First Responder	1221 (33.7%)	1559 (35.3%)	
Who First Applied AED ¹			
Bystander	57 (5.0%)	17 (1.4%)	
Family Member	3 (0.3%)	1 (0.1%)	
Healthcare Provider (Non-911 Responder)	32 (2.8%)	25 (2.0%)	$P < 0.01$
Law Enforcement First Responder	37 (3.2%)	31 (2.5%)	
Non-Law Enforcement First Responder	1020 (88.8%)	1182 (94.1%)	
Public AED ¹	90/693 (13.0%)	43/587 (7.3%)	$P < 0.01$
First Monitored Rhythm ¹			
Asystole	1856 (51.3%)	2571 (58.2%)	
Idioventricular/PEA	871 (24.1%)	1057 (23.9%)	
Unknown Shockable Rhythm	110 (3.0%)	64 (1.5%)	$P < 0.01$
Unknown Unshockable rhythm	166 (4.6%)	115 (2.6%)	
Ventricular Fibrillation	579 (16.0%)	572 (13.0%)	
Ventricular Tachycardia	37 (1.0%)	39 (0.9%)	
Initial Rhythm Type ¹			
Non-Shockable	2893 (79.9%)	3743 (84.7%)	$P < 0.01$
Shockable	726 (20.1%)	675 (15.3%)	
Sustained ROSC ¹	2582 (28.8%)	3503 (21.1%)	$P < 0.01$
Advanced Airway Successfully Placed ²			
No	316 (9.3%)	302 (7.4%)	
Used existing tracheostomy	0 (0.0%)	1 (0.0%)	$P < 0.01$
Yes	3094 (90.7%)	3776 (92.6%)	
Pre-Hospital Outcome ¹			
Dead in Field	1349 (37.3%)	2063 (46.7%)	$P < 0.01$
Ongoing Resuscitation in ED	1496 (41.3%)	1513 (34.3%)	
Pronounced Dead in ED	774 (21.4%)	842 (19.1%)	
Survival to Hospital Admission ¹	981 (27.2%)	923 (21.0%)	$P < 0.01$
Survival to Hospital Discharge ¹	360 (10.0%)	326 (7.4%)	$P < 0.01$
Good CPC Score ¹	250/357 (70.0%)	220/326 (67.6%)	$P = 0.5$
Utstein Bystander Survival Rate ¹	124/322 (38.5%)	87/279 (31.4%)	$P = 0.06$

¹ P-value determined using Pearson's χ^2 test.

² P-value determined using Fisher's exact test.

Table 3
Generalized outcomes, stratified by year.

	aOR [95% CI]
Bystander CPR	aOR = 0.9 [0.8, 0.95]
Public AED	aOR = 0.5 [0.4, 0.8]
Sustained ROSC	aOR = 0.7 [0.6, 0.7]
Field Termination	aOR = 1.5 [1.4, 1.7]
Survival to Hospital Admission	aOR = 0.7 [0.7, 0.8]
Survival to Hospital Discharge	aOR = 0.8 [0.7, 0.96]
Good CPC Score	aOR = 0.99 [0.7, 1.4]
Utstein Bystander Survival Rate	aOR = 0.7 [0.5, 1.0]

arrests were more likely to occur at home during the COVID-19 period. This is comparable to other estimates which also found decreases in AED usage (OR = 1.78, 95% CI 1.06–2.98) in the pre-COVID-19 period [12,18]. However, study of BCPR has yielded mixed results, with some research suggesting BCPR did not differ significantly during the pandemic period to prior, while others found a decrease (COVID-19: 33.0% versus non-COVID-19: 41.3%, $P < 0.001$) [12,13,18]. A study from Lim, et al. found that OHCA during the COVID-19 pandemic were more likely to occur at home (aOR = 1.48, 95% CI 1.24–1.75) and less likely to receive BCPR (aOR = 0.70, 95% CI 0.61–0.81) although 65% of witnessed arrests were by a family member [18]. We would expect for a pandemic spread by a virus with close physical contact, that the frequency of interventions requiring laypersons to be in close proximity to patients (i.e. performing CPR or applying an AED) would decrease due to hesitancy of virus transmission [11,12,20]. Because there are less arrests occurring in public settings, the likelihood of a trained layperson able to perform CPR and/or apply an AED would also decrease [11,21,22].

In addition to lower rates of BCPR and PAD, we found lower rates of sustained ROSC, increased odds of termination and worsening survival outcomes [13,22–24]. Our estimates of sustained ROSC are consistent with what has been reported in the literature thus far (aOR = 0.61–0.67) [13,19,21,22]. Our study found the odds of field termination to be slightly lower than that reported in Detroit (OR = 2.36, 95% CI 1.36–4.07) or other studies (OR = 2.46, 95% CI 1.62–3.74) [19,22]. Across the US, Chan et al. found the rate of field termination to be higher in 2020, (53.9% in 2020 versus 39.9% in 2019) increasing not only in areas with high and very high COVID-19 mortality, but even those with the lowest COVID-19 mortality rates [13]. This increase in field termination is similar to our results.

We found survival to hospital admission and hospital discharge to decrease, while good neurologic outcomes remained unchanged. Our study found rates of survival to hospital admission (OR = 0.56–0.65) and survival to hospital discharge (OR = 0.46–0.68) to be slightly higher than what is reported in the literature [13,19,24,25]. While the rates of good neurologic scores did not change significantly in our study, conflicting research exists, demonstrating worse or unchanged CPC scores compared to the pre-COVID-19 period [12,26].

In Texas, public interventions shown to improve OHCA survival were less frequent during the pandemic and survival outcomes worsened. Odds of field termination increased. Although more arrests occurred at home and non-shockable rhythm was more common, good neurologic outcomes remained unchanged. Future research efforts should identify contributing factors to decreased BCPR and PAD in order to develop targeted education to restrengthen the cardiac chain of survival. Clarifying reasoning behind the increase in field terminations may also shed light on decision making in resource-limited situation or with limited information. This study helps to provide additional explanations as to why OHCA worsened during the pandemic.

5. Limitations

Our study had several limitations. Our study was limited to those participants within the Texas CARES catchment, which covers approximately 40.1% of the population. Those participants served by EMS

agencies not participating in CARES may have different characteristics leading to a change in study results. The data set does not assess for any variations in quality or processes that may have led to differences in outcomes. For instance, any instance of BCPR is included, but measurements related to compression quality or type of CPR (i.e. compressions only) are not reported. We did not account for individual COVID seropositivity or medical comorbidities, which could affect survival outcomes. Because we conducted our analysis on the aggregate state level, we were unable to account for the microlevel impacts of human geography, which could mask trends on a smaller level.

6. Conclusion

Our study adds state-wide evidence to the national phenomenon of increased OHCA incidence during COVID-19, along with worsening rates of BCPR, PAD use and outcomes. The significance of this study lies in its novelty of geographic size, temporal scope and comprehensive nature of EMS agencies by being part of the CARES database. Our results corroborate prior findings that bystander interventions, field terminations and survival outcomes worsened during the pandemic.

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Credit authorship contribution statement

Summer Chavez: Writing – review & editing, Writing – original draft, Conceptualization, Formal analysis, Funding acquisition, Methodology. **Ryan Huebinger:** Writing – review & editing, Formal analysis, Conceptualization. **Hei Kit Chan:** Formal analysis. **Joseph Gill:** Data curation. **Lynn White:** Data curation. **Donna Mendez:** Writing – review & editing. **Jeffrey L. Jarvis:** Data curation. **Veer D. Vithalani:** Data curation. **Lloyd Tannenbaum:** Data curation. **Rabab Al-Araji:** Data curation. **Bentley Bobrow:** Conceptualization, data curation, Study conception and design, data acquisition.

Declaration of Competing Interest

None.

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