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# Decreases in out of hospital cardiac arrest (OHCA) outcome metrics persist when known COVID patients are excluded from analysis

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ABSTRACT

*Objective:* A decline in OHCA performance metrics during the pandemic has been reported in the literature but the cause is still not known. The Montgomery County Fire and Rescue Service (MCFRS) observed a decline in both the rate of return of spontaneous circulation (ROSC) and the proportion of resuscitations that resulted in cerebral performance category (CPC) 1 or 2 discharge of the patient beginning in March of 2020. This study examines whether the decline in these performance metrics persists when known COVID positive patients are excluded from the analysis.
*Methods:* Two samples of OHCA patients for similar time periods (one year apart) before and after the start of the COVID pandemic were developed. A database of known COVID positive patients among EMS encounters was used to identify and exclude COVID positive patients. OHCA outcomes in these two groups were then compared using a Chi-square test and Fisher's exact test for difference in proportions and Analysis of Variance (ANOVA) for difference in means. A two-stage multivariable logistic regression model was used to develop odds ratios for achieving ROSC and CPC 1 or 2 discharge in each period.
*Results:* After excluding known COVID patients, 32.5% of the patients in the pre-COVID period achieved ROSC compared to 25.1% in the COVID period ($p = 0.007$). 6% of patients in the pre-COVID period were discharged with CPC 1 or 2 compared to 3.2% from the COVID era ($p = 0.026$). Controlling for all available patient characteristics, patients undergoing OHCA resuscitation prior to be beginning of the pandemic were 1.2 times more likely to achieve ROSC and 1.6 times more likely to be discharged with CPC 1 or 2 than non-COVID patients in the pandemic era sample.
*Conclusions:* When known COVID patients are excluded, pre-pandemic OHCA resuscitation patients were more likely to achieve ROSC and CPC 1 or 2 discharge. The prevalence of known COVID positive patients among all OHCA resuscitations during the pandemic was not sufficient to fully account for the marked decrease in both ROSC and CPC 1 or 2 discharges. Other causative factors must be sought.


## 1. Introduction

The Montgomery County (MD) Fire and Rescue Service, a municipal fire department and EMS system in suburban Washington DC routinely calculates and monitors OHCA metrics including return of spontaneous circulation (ROSC) percentages and the proportion of patients who are discharged from the hospital following OHCA with a cerebral performance category (CPC) of 1 or 2 (good cerebral performance or moderate cerebral disability). Monthly ROSC percentages and CPC 1 or 2 discharges for MCFRS patients decreased beginning in March of 2020, which corresponded with the local start of the COVID-19 pandemic (Fig. 1).

The level of influence that COVID patients were having on our OHCA metrics was unknown. OHCA resuscitation is a complex process with many confounding variables. Disease presence in the OHCA population, increased time burdens to don elevated PPE; the effects of lockdowns and social isolation on witnessed arrest status, bystander CPR, and AED application; and patient hesitancy to seek both routine and emergent medical care were all posited as potential contributing factors to the observed decline.

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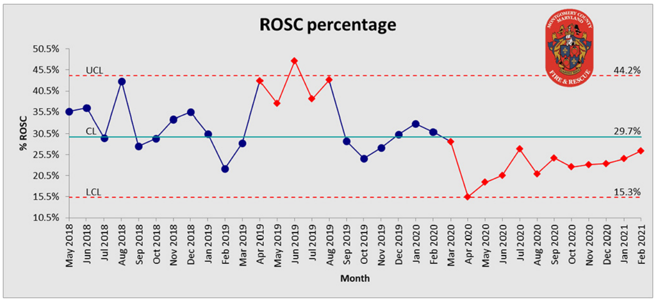


**Fig. 1.** ROSC Percentage May 2018 to February 2021.

Our goal was to understand if the observed decreases in OCHA performance persisted when COVID positivity was eliminated as one of those variables.

## 2. Methods

This retrospective chart review was approved with a waiver of consent by the Adventist Healthcare Institutional Review Board, Gaithersburg MD. Adventist Healthcare IRB serves as the IRB of Record for the Montgomery County Fire and Rescue Service.

Data for this study came from the MCFRS Patient Care Reporting and Records Management systems and a local de-identified copy of Cardiac Arrest Registry to Enhance Survival (CARES) data limited to patients transported by our agency. Additionally, we used a database primarily developed for occupational exposure notifications to identify OHCA patients who ultimately tested COVID positive. This database received COVID test results for EMS patients through the regional health information exchange, direct hospital notifications and post termination of resuscitation testing via nasal swab specimen collection at the scene.

Two cohorts for retrospective analysis were identified from similar seven-month time periods, one year apart. Dates were chosen so that the COVID era cohort began with the start of post-TOR testing by MCFRS. The "pre-COVID" cohort included patients encountered July 1, 2019 to February 28, 2020 ($n = 499$) and the "COVID era" cohort included patients encountered from July 1, 2020 to February 28, 2021 ($n = 617$). Both groups included all OHCA patients where resuscitation was attempted by MCFRS. Known COVID positive patients and those where outcome data was not available in the CARES registry were excluded.

Variables including presence of shockable first rhythm (Y/N), presence of documented medications in the history (Y/N), presence of three or more documented medical history items (Y/N), gender, resuscitation location at a Skilled Nursing Facility (Y/N), age in years, time from first arriving unit to rhythm evaluation, time from first arriving unit to first epinephrine dose, and the number of medications documented in the medical history were all identified and evaluated. Additionally, the proportion of unwitnessed arrests, rates of bystander and family CPR and automated external defibrillator application prior to EMS arrival were examined.

Using a Chi-square test and Fisher's exact test for difference in proportions and Analysis of Variance (ANOVA) for difference in means we compared patient characteristics between the pre-COVID and COVID era cohorts. Bivariate relationships with ROSC and CPC 1 or 2 discharge for each of the variables were further explored.

A two-stage multivariable logistic regression was used to control for the effects of these variables. We constructed a regression model for each of the outcomes (ROSC and CPC 1 or 2 discharge) where we entered the main binary factor (pre-COVID/ COVID era) on the first stage. On the *sec*ond stage we entered the control block with stepwise selection of the variables with significant effect ($p < 0.05$). The control block consisted of the following available patient level variables: Shockable First Rhythm, Any Medication (Y/N), Any Medical History (Y/N), Female, SNF (Y/N), Age, Time 1: 1st on scene to 1st leads on (sec), Time 2: 1st on scene to 1st Epinephrine, and number of medications.

## 3. Results

Changes to patient characteristics between the pre-COVID and COVID era cohorts were significant in the areas of shockable first rhythm (12.2% pre-COVID vs. 8.4% COVID-era $p = 0.037$), presence of documented medications in the history (48.7% vs. 76.0% $p < 0.001$), average time to first rhythm interpretation (293 s vs. 376 s $p < 0.001$), and average time to first epinephrine (593 s vs. 731 s $p = 0.001$).

No differences in rates of witnessed arrests, bystander and family CPR, or automated external defibrillator application were observed between the two groups. Unwitnessed arrests accounted for 53.7% of pre-pandemic cases and 54.9% in the COVID era ($p = 0.69$). The bystander CPR rate for the pre-COVID cohort was 14.0% vs. 12.3% in the COVID era ($p = 0.40$), and CPR by a family member occurred in 12.8% of pre-COVID cases compared to 13.0% in the COVID era ($p = 0.92$). Similar rates of AED application occurred in both groups as well, 21.2% vs. 21.4% ($p = 0.94$). (Table 1).

The analysis of bivariate relationships between ROSC and each of the variables showed significant effect for shockable first rhythm (19.2% of ROSC patients presented with a shockable rhythm vs. 6.5% of non-ROSC patients $p < 0.001$), presence of documented medications in the history (55.5% of ROSC patients vs. 67.1% of non-ROSC patients $p < 0.001$), location of the resuscitation at a Skilled Nursing Facility (SNF) (17.7% of ROSC patients vs. 23.9% of non-ROSC $p = 0.024$) and average number of medications listed in the patient's medical history (2 for the ROSC patients and 3 for the non-ROSC patients $p < 0.001$) (Table 2).

Bivariate relationships between CPC 1 or 2 discharges and each of the variables a showed significant effect of shockable first rhythm (50% of CPC 1 or 2 discharges vs 8.3% of non-CPC 1 or 2 discharges $p < 0.001$), mean age in years (55.8 years for CPC 1 or 2 discharges vs. 67.9 for non-CPC 1 or 2 discharges $p < 0.001$), location of the resuscitation at a SNF (6.0% for CPC 1 or 2 discharges vs. 22.9% of non-CPC 1 or 2 discharges $p = 0.005$), and mean number of medications documented in the history (1.6 for CPC 1 or 2 discharges and 2.8 for non-CPC 1 or 2 discharges $p = 0.026$) (Table 3).

With known COVID positive patients excluded, the pre-COVID cohort had better outcomes compared to the COVID era. 32.5% of the patients from the pre-COVID cohort achieved ROSC compared to 25.1% in the COVID era ($p = 0.007$). Similarly, the pre-COVID patients yielded a 6% CPC 1 or 2 discharge proportion vs. 3.2% during the COVID era ($p = 0.026$).

Pre-COVID patients on average had 1.36 times higher probability (95% CI 1.04–1.8) of achieving ROSC and 1.8 times higher probability (95% CI 0.98–3.1) of being discharged from the hospital with CPC 1 or 2 compared to COVID period. After controlling for other factors, the effect decreases slightly to 1.2 times more likely (95% CI 0.98–3.1) for ROSC and 1.6 times more likely (95% CI 0.9–3.0) for CPC 1 or 2 discharge (Table 4). Due to the smaller sample size of ROSC and CPC 1 or 2 groups, the lower limits of the 95% CI reach and cross 1.0 but the direction of the effect is very consistent.

In a sub-analysis conducted for comparison, known COVID positive patients ($n = 48$) also fared much worse than patients without known COVID positive status from the same period ($n = 569$). The patients without known COVID positive status on average were 2.5 times more likely (95% CI 1.03–6.0) to achieve ROSC compared to COVID positive patients. After controlling for other variables, the effect remains the same. A CPC 1 or 2 outcome model could not be constructed because none of the known COVID positive patients were discharged with a CPC 1 or 2, compared to 8% of the patients without known COVID. (Table 5).

**Table 1**
Patient description.

| Patient Characteristics | Measure | pre-COVID $N = 499$ | COVID era N = 617 | Significance $p$-value |
|---|---|---|---|---|
| Any Medication (Y/N) | n (%) | 243 (48.7) | 469 (76.0) | <0.001 |
| Time 1: 1st on scene to 1st leads on (*sec*) | Mean (std) | 293 (239) | 376 (299) | <0.001 |
| Time 2: 1st on scene to 1st Epinephrine | Mean (std) | 593 (276) | 731 (375) | <0.001 |
| Shockable First Rhythm | n (%) | 61 (12.2) | 52 (8.4) | 0.037 |
| Any Medical History (Y/N) | n (%) | 76 (15.2) | 89 (14.4) | 0.7 |
| Female | n (%) | 206 (41.2) | 241 (39.1) | 0.4 |
| Skilled Nursing Facility (Y/N) | n (%) | 107 (21.4) | 140 (22.7) | 0.6 |
| Age | Mean (std) | 67.6 (20.6) | 67.2 (19.9) | 0.7 |
| Number of medications | Mean (std) | 2.6 (3.8) | 2.8 (3.4) | 0.4 |
| Bystander CPR | n (%) | 70 (14.0) | 76 (12.3) | 0.4 |
| Unwitnessed | n (%) | 268 (53.7) | 338 (54.9) | 0.7 |
| Family CPR | n (%) | 64 (12.8) | 80 (13.0) | 0.9 |
| AED use | n (%) | 106 (21.2) | 132 (21.4) | 0.9 |

## 4. Discussion

Montgomery County Maryland covers 500 mile$^2$ with a population of roughly 1.1 million people and encompassing urban, suburban, and rural population densities. Emergency Medical Services are provided by the Montgomery County Fire and Rescue Service (MCFRS) using EMTs and paramedics deployed on advanced and basic life support transport units, ALS engines and ALS chase cars. MCFRS is an accredited fire department with a robust quality improvement and data surveillance program that routinely tracks process and outcome metrics. Medical aspects of OHCA resuscitation are defined by the Maryland Medical Protocols for EMS Clinicians [8] and procedural aspects are prescribed by a local incident response policy [9].

The decline in OHCA metrics, specifically ROSC rates has been well documented in the literature since the beginning of the pandemic [2,6,7,12]. Specifically, definitive increases in the community incidence of OHCA, the number of arrests occurring in the home and EMS response times have been reported along with varied levels of decreases in bystander CPR and shockable initial rhythms [4,6,8,11,12]. Any one of these reported changes in patient characteristics could be prognostic indicators of worsened survivability from OHCA.

A subset of contemporary studies looking at the pandemic era cardiac arrest population have described declines in the metric of ROSC in various communities. Other works report decreases in survival with functional CPC scores [2,3]. Overall, direct and indirect factors have been frequently implicated, with direct components attributable to viral disease heavily suspected to be at play, but strong proof of correlation or direct causation has been elusive.

Many other investigators have found the metrics we studied were unfavorably affected during the timeframe of the pandemic [1-6,8,10,11,12]. However, we aimed to investigate the effects directly associated with COVID on these measures. To date, we were unable to find a study which undertook this exact type of analysis.

The decline in odds of achieving ROSC or CPC 1 or 2 discharge demonstrated in this study attest to the fact that OHCA resuscitation is a complex process with many confounding variables. The prevalence of COVID positive patients among our OHCA resuscitation patients is not sufficient to be the sole cause of the declines we originally observed. If the disease alone is not the causative agent, then other influencing factors of the pandemic should be explored.

Social isolation, distancing and mandated lockdowns were realities of the pandemic. While the COVID era study period did not cover the height of full government mandated lockdowns, social interaction and public gathering during the COVID era study period was certainly not as it had been prior to March of 2020. It is intuitive that as isolation increases, the number of witnessed arrests would decrease and that a decrease in witnessed arrests could contribute to the decreased odds ratios of ROSC and CPC 1 or 2 discharges seen in the pandemic era cohort. However, witness status of OHCAs was similar across both groups.

Rates of bystander and family member CPR were unchanged as well. There was some speculation that bystanders and family members may have been more reluctant to intervene in OHCA, especially prior to the development and widespread distribution of vaccines. Because the delivery of early chest compressions correlates with increased survival, any decrease in the rate at which bystander or family members provided care prior to the arrival of EMS could contribute to a decline in outcome metrics. The data, however, does not support that there was any decrease in bystander or family willingness to intervene. Little if any variation exists in these measures between the pre-COVID and COVID era cohorts, although the local rate of bystander CPR in both cohorts is significantly lower than the national bystander CPR rate reported in the CARES registry. (41.2% in 2019 and 40.2% in 2020).

Automated external defibrillator application during the pandemic could have also been influenced by both social isolation and bystander fear of disease transmissibility. Isolated people generally do not suffer cardiac arrests in places where AEDs are available. The types of places where we have typically advocated for public access defibrillators such as malls, gyms and movie theatres were all closed for a great deal of the COVID era study period. Additionally, just like chest compressions, it is intuitive that a fearful public would be hesitant to engage in bystander resuscitation. Yet, the data does not support these theories

**Table 2**
Bivariate Relationship with ROSC

| Patient Characteristics | Measure | No ROSC $N = 799$ | ROSC $N = 317$ | Significance p-value |
|---|---|---|---|---|
| Shockable First Rhythm | % (n) | 6.5 (52) | 19.2 (61) | <0.001 |
| Any Medication (Y/N) | % (n) | 67.1 (536) | 55.5 (176) | <0.001 |
| Number of medications | Mean (std) | 3.0 (3.8) | 2.0 (3.0) | <0.001 |
| Skilled Nursing Facility (Y/N) | % (n) | 23.9 (191) | 17.7 (56) | 0.024 |
| Female | % (n) | 38.6 (308) | 43.8 (139) | 0.106 |
| Age | Mean (std) | 68.0 (20.4) | 65.8 (19.6) | 0.109 |
| Time 1: 1st on scene to 1st leads on (sec) | Mean (std) | 342 (260) | 331 (315) | 0.5 |
| Time 2: 1st on scene to 1st Epinephrine | Mean (std) | 668 (325) | 681 (387) | 0.6 |

**Table 3**
Bivariate Relationship with CPC 1 or 2

| Patient Characteristics | Measure | CPC > 2<br>$N = 1066$ | CPC = 1 or 2<br>$N = 50$ | Significance<br>p-value |
|---|---|---|---|---|
| Shockable First Rhythm | % (n) | 8.3 (88) | 50.0 (25) | <0.001 |
| Age | Mean (std) | 67.9 (20.1) | 55.8 (19.4) | <0.001 |
| Skilled Nursing Facility (Y/N) | % (n) | 22.9 (244) | 6.0 (3) | 0.005 |
| Number of medications | Mean (std) | 2.8 (3.6) | 1.6 (2.6) | 0.026 |
| Any Medication (Y/N) | % (n) | 64.4 (687) | 50.0 (25) | 0.038 |
| Any Medical History (Y/N) | % (n) | 15.2 (162) | 6.0 (3) | 0.073 |
| Female | % (n) | 40.4 (430) | 34.0 (17) | 0.4 |
| Time 2: 1st on scene to 1st Epinephrine | Mean (std) | 671 (341) | 707 (414) | 0.6 |
| Time 1: 1st on scene to 1st leads on (sec) | Mean (std) | 339 (275) | 338 (301) | 0.9 |

either with similar proportions of AED application present in both the pre-COVID and COVID era groups.

Significant factors to resuscitation success include the time intervals to critical tasks in resuscitation. MCFRS used a three-tiered approach to personal protective equipment (PPE) during the pandemic based on risk (low, medium, high). All OHCA resuscitations required high risk PPE consisting of gloves, N-95 mask, eye protection, isolation gown and face shield. Time to rhythm analysis and the time to first epinephrine were both elevated in the COVID era cohort, inversely correlating with the outcome metrics we measured. High risk PPE adds an increased time burden for responding crews' assembly. It is not surprising that these two intervals increased as crews had to spend more time preparing to resuscitate. This is one area where EMS leaders could have a significant impact by developing strategies to reduce these time intervals. Tactics could include having one member of each crew don PPE during response, routine practice and familiarity with the equipment, and embracing future innovations in the equipment that lead to ease of use. Still, the logistical regression took the elevations in these intervals into account and the odds ratios still favored the pre-pandemic cohort. Beyond the delays seen in time to rhythm analysis and time to first epinephrine there are still other factors at work.

Community-based and patient centered factors are much more difficult to measure. Variables such as failure to seek medical attention for serious symptoms prior to arrest, missed medical screening exams, or postponement of the treatment of chronic illness could have all contributed to the effects we are observing. Unfortunately, it is nearly impossible to infer the effects of those variables from the EMS data set. Further study on these types of factors could be fruitful for future pandemic response if correlation can be established.

There were some limitations to this study that should be noted. The retrospective nature of the analysis prohibits developing conclusions about causality. We know that removing the known COVID positives from our sample does not correct the decline in outcome metrics but the exact reason for the decline or lack of correction is without definitive or known cause.

In addition, we know that most patients whose resuscitation was terminated in the field received post TOR testing but there were a small number who did not. These patients were either being referred for autopsy or were not attended by a person authorized and equipped to collect the sample for testing. We assume that every patient who was transported (or autopsied) in the study period received testing and we believe that we received notification of all COVID positive patients by one of the conduits we have established to receive that information.

Additionally, due to the delayed implementation of post TOR testing, the study period falls outside the known peak of disease in our patient population which occurred on or about May 4, 2020. This date range results in a relatively low number of known COVID positive patients among those patients on whom resuscitation was attempted.

EMS system design does influence the applicability of this study to other organizations. MCFRS represents a well resourced and developed system that was experiencing high performance with regards to the studied metrics prior to the pandemic. Other EMS systems may not have observed as dramatic of a performance decline depending on their individual baseline performance. Likewise, different system designs and operational cultures may have been more readily adaptable and, consequently, blunted the alterations to contributing variables that caused the observed declines.

Nonetheless, when examining cohorts that exclude known COVID patients, there is a decline in the percentage of patients achieving ROSC and the percentage of patients who are discharged with CPC 1 or 2 after the beginning of the pandemic. After adjusting for confounding variables there are still lower odds of achieving ROSC or CPC 1 or 2

**Table 4**
Multivariable logistic regression models.

| Outcomes | ROSC | CPC 1 or 2 |
|---|---|---|
| Factors | Odds Ratio (95%CI) | Odds Ratio (95%CI) |
| $N = 1068$ | | |
| 1 = Pre-COVID, 0 = COVID era<br>No Control Block | 1.36<br>(1.04–1.8) | 1.8<br>(0.98–3.1) |
| 1 = Pre-COVID, 0 = COVID era<br>With Control Block:<br>Stepwise selection of:<br>Shockable First Rhythm, Any Medication (Y/N), Any Medical History (Y/N), Female, Skilled Nursing Facility (Y/N), Age, Time 1: 1st on scene to 1st leads on (sec), Time 2: 1st on scene to 1st Epinephrine, Number of medications) | 1.2<br>(0.9–1.6)<br>* | 1.6<br>(0.9–3.0) |

* Due to the smaller sample size of ROSC and CPC 1 or 2 groups, the lower limits of the 95% CI reach and cross 1.0 but the direction of the effect is very consistent.

**Table 5**
Multivariable Logistic Regression Models for COVID Positive Patients

| Outcomes | ROSC | CPC 1 or 2 |
|---|---|---|
| Factors | Odds Ratio (95%CI) | Odds Ratio (95%CI) |
| Compare COVID pos. Patients (n = 48) vs COVID neg. Patients (n = 569) during COVID era | | |
| 1 = COVID negative, 0 = COVID positive<br>No Control Block | 2.5<br>(1.04–6.0) | N.A.<br>No COVID positive patient had CPC 1 or 2 |
| 1 = COVID negative, 0 = COVID positive<br>With Control Block:<br>Stepwise selection of:<br>Shockable First Rhythm, Any Medication (Y/N), Any Medical History (Y/N), Female, Senior Nursing Facility (Y/N), Age, Time 1: 1st on scene to 1st leads on (*sec*), Time 2: 1st on scene to 1st Epinephrine, Number of medications. | 2.5<br>(1.03–6.0) | |

discharge for the COVID era compared to pre-COVID resuscitations. Disease presence alone is not a sufficient explanation of what we have seen.

It is important to note that these results do not indicate that known COVID patients have similar outcomes to non-COVID patients, nor are we drawing that conclusion. Other variables, or more likely a confluence of many, must be contributing to the overall decline that we are experiencing.

As the prevalence of the disease wanes in our patient population and the proportion of the workforce that has achieved immunity through vaccination increases, EMS leaders must re-evaluate the risk assessment to determine if measures once thought to be necessary to protect healthcare providers continue to be necessary. Ongoing reassessment of any risk calculus is certainly an essential best-practice. Given that this work seems implicate variables other than the disease itself as the causative agent in our performance decline, this reassessment takes on new urgency.

## Declaration of Competing Interest

None of the authors has conflicts of interest to declare.

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