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FOCUS ON CARDIAC ARREST

Differences in Out-of-Hospital Cardiac Arrest Management and Outcomes across Urban, Suburban, and Rural Settings

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ABSTRACT

Background: Rural prehospital care settings are underrepresented in the out-of-hospital cardiac arrest (OHCA) literature. This study aimed to describe treatment patterns and the odds of a favorable patient outcome (e.g., return of spontaneous circulation (ROSC) or being presumptively alive at the end of the incident) among rural OHCA patients in the U.S.

Methods: Using the 2018 National Emergency Medical Services Informational System (NEMSIS) dataset, we analyzed OHCA incidents where an emergency medical services (EMS) unit provided cardiopulmonary resuscitation (CPR) and either terminated the resuscitation or completed transport. We excluded traumatic injuries, pediatric patients, and incidents with response time >60 minutes. The primary outcome was ROSC at any time during the EMS incident. The secondary outcome was a binary end-of-event indicator previously described for use in NEMSIS to estimate longer-term outcomes. Multivariable logistic regression was performed for each outcome measure comparing rural, suburban, and urban settings while controlling for key factors.

Results: A total of 64,489 OHCA incidents were included, with 5,601 (8.9%) in rural settings. Among the full sample of OHCA incidents, ROSC was achieved in 20,578 (33.6%) cases, including 29.2% in rural settings and 34.1% in urban or suburban settings ($p < 0.001$). Advanced life support units responded to 95.3% of all calls, and a greater proportion of rural OHCA incidents were managed by basic life support units (7.4% vs. 4.2%, $p < 0.001$). Rural OHCA incidents had longer response times (7.5 vs. 5.9 minutes, $p < 0.001$), and rural patients were less likely to receive epinephrine (69.3% vs. 73.3%, $p < 0.001$). Further, EMS clinicians in rural areas were more likely to use mechanical CPR (29.5% vs. 27.6%, $p < 0.01$) and were less likely to perform advanced airway management (48.5% vs. 54.2%, $p < 0.001$). Rural patients had lower odds of achieving ROSC than urban patients after controlling for other factors (OR 0.81, 95% CI: 0.75–0.87). Rural patients also had lower odds of having a positive end-of-event outcome (i.e., presumptively alive) after controlling for other factors (OR 0.86, 95% CI: 0.79–0.93).

Conclusion: In this national sample of EMS-treated OHCAs, rural patients had lower odds of a favorable outcome (e.g., ROSC or presumptively alive) compared to those in urban settings.

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Introduction

Out-of-hospital cardiac arrest (OHCA) is a common and deadly condition in the U.S., with roughly 180,000 OHCAs treated by emergency medical services (EMS) in 2018 (1). Among EMS-treated OHCA patients, the overall rate of return of spontaneous circulation (ROSC) is estimated at 27.9% (2), and the rate of survival to hospital discharge is approximately 10% (3). Optimization of prompt and effective delivery of EMS care has been identified as a key aspect of the 2020 American Heart Association Chain of Survival, aimed at improving survival and neurological outcomes in OHCA patients (4).

Rural areas present distinct challenges to these efforts, since the unique characteristics and conditions in these settings may increase time to critical interventions for OHCA. For example, a recent study of 1,138 OHCA patients in Norway demonstrated lower rates of survival to hospital admission among OHCA patients in rural settings compared to those in urban settings (5). Several other publications have commented on the relationship between urbanicity and OHCA outcomes, but these studies have tended to be limited by relatively smaller samples sizes or focus on primary aims other than urbanicity (6–13). Currently, large scale evaluations of the management and outcomes of rural cardiac arrest care in the U.S. are lacking. Therefore, the ways in which rural cardiac arrest events differ from arrests in urban settings remain unclear.

To this end, this study aimed to accomplish two objectives: (1) to evaluate the hypothesis that rural OHCA

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Supplemental data for this article is available online at https://doi.org/10.1080/10903127.2021.2018076 patients have lower odds of a favorable outcome (e.g., achieving ROSC or being presumptively alive at the end of the EMS incident) compared to urban patients, and (2) to characterize differences in patient, setting, and treatment characteristics that might account for disparate outcomes between these populations. Our overarching goal was to describe the spectrum of prehospital cardiac arrest management in the U.S. across urban and rural settings in order to generate research questions and stimulate dedicated investigations into causal relationships and possible interventions to improve rural prehospital cardiac arrest care.

Methods

Study Design & Data Source

We conducted a retrospective analysis of a nationwide sample of OHCA incidents. Data were extracted from the 2018 National EMS Information System (NEMSIS) Version 3.4 Public-Release Research Dataset, administered by the National Highway Traffic Safety Administration and maintained by the University of Utah School of Medicine. This dataset is a convenience sample of prehospital patient care report data submitted by EMS agencies throughout the US. The 2018 dataset includes EMS incidents that occurred January 1 to December 31, 2018, submitted from 9,599 EMS agencies (out of an estimated 23,000 total EMS agencies in the U.S.) across 43 states (14,15). Unlike other hospital-based datasets, this dataset allows for evaluation of OHCA events during the prehospital phase of care across a diverse array of settings. Each record in this dataset corresponds to one EMS unit dispatched to a reported incident. This study was reviewed by the Harvard Longwood Campus Institutional Review Board and deemed exempt because the NEMSIS dataset used to complete this study is de-identified and publicly accessible. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guidelines were used when designing and reporting on this study (16).

Study Population

We included incidents in which EMS performed cardiopulmonary resuscitation (CPR). Incidents were excluded if patient age was <18 years or if traumatic injury was documented. Incidents with EMS response time—defined as time from initial dispatch of an EMS unit to arrival on scene—exceeding 60 minutes were excluded because they likely reflect a delay that lies outside routine EMS practice, such as vehicle failure or on-scene hazards. Finally, we only included incidents in which one EMS unit provided treatment until the end of the event, either until the patient was transported to a receiving facility or if resuscitative efforts were attempted but terminated by the responding unit prior to transport. This criterion was developed to maximize the odds that each OHCA patient was included only once in the study, given that multiple non-transporting units can be dispatched to a single incident, each with its own record in NEMSIS.

Measures & Statistical Analysis

The setting of each OHCA incident was classified as urban, suburban, rural, or wilderness based on 2013 Urban Influence Codes published by the US Department of Agriculture, as coded in the NEMSIS dataset (17,18). Given the small number of wilderness incidents, these calls were reclassified as rural in the main analyses. A summary of how 2013 Urban Influence Codes map onto NEMSIS designations and how the U.S. population is distributed across these categories is included in Appendix 1, Supplementary Material. The primary outcome was whether ROSC was documented at any point during the EMS incident for any duration. The secondary outcome used in this study was a composite indicator of whether the patient was presumptively alive at the end of the EMS event that has been previously described and validated for use with the NEMSIS dataset by Miller et al. (19) This end-of-event indicator uses a combination of variables to generate a binary assessment of patient outcomes for cardiac arrest incidents recorded in NEMSIS. The composite variable described in Miller et al. was used with the addition of the two outcome variables that were used to validate their approach (NEMSIS fields eOutcome.01 and eOutcome.02, which report patient disposition at time of departure from the emergency department and from the hospital, respectively). The NEMSIS variables used to generate this composite variable are described in Appendix 2, Supplementary Material. We also used the originally proposed composite variable in a sensitivity analysis that is reported in Appendix 3, Supplementary Material. Along with patient demographics, response time, EMS level of care, and incident location type (private residence vs. all other settings considered public), we included resuscitation-specific variables included in the NEMSIS dataset based on the Utstein style guidelines (20,21).

Descriptive statistics were calculated and stratified by rural versus urban/suburban setting, with comparisons made using χ^2 tests for categorical variables and two-sided Student's t-tests for continuous variables. Multivariable logistic regression was performed for the primary and secondary outcome measures for EMS-treated OHCA in rural, suburban, and urban settings while controlling for the included covariates. Complete case analysis was used for the primary modeling. Due to the large sample size, we assessed model fit with the Hosmer-Lemeshow goodness-of-fit test using random subsets of the overall dataset (22,23). After fitting the full model, we used the coefficients to conduct the Hosmer-Lemeshow test in 100 random samples (with replacement) of $n = 1000$. We determined that >10 subsets with significant results would indicate evidence of a lack of fit (23).

As a sensitivity analysis, we repeated the multivariable logistic regression model with urban, suburban, rural, and wilderness treated as separate categories, as initially included in NEMSIS, in order to ensure that wilderness incidents did

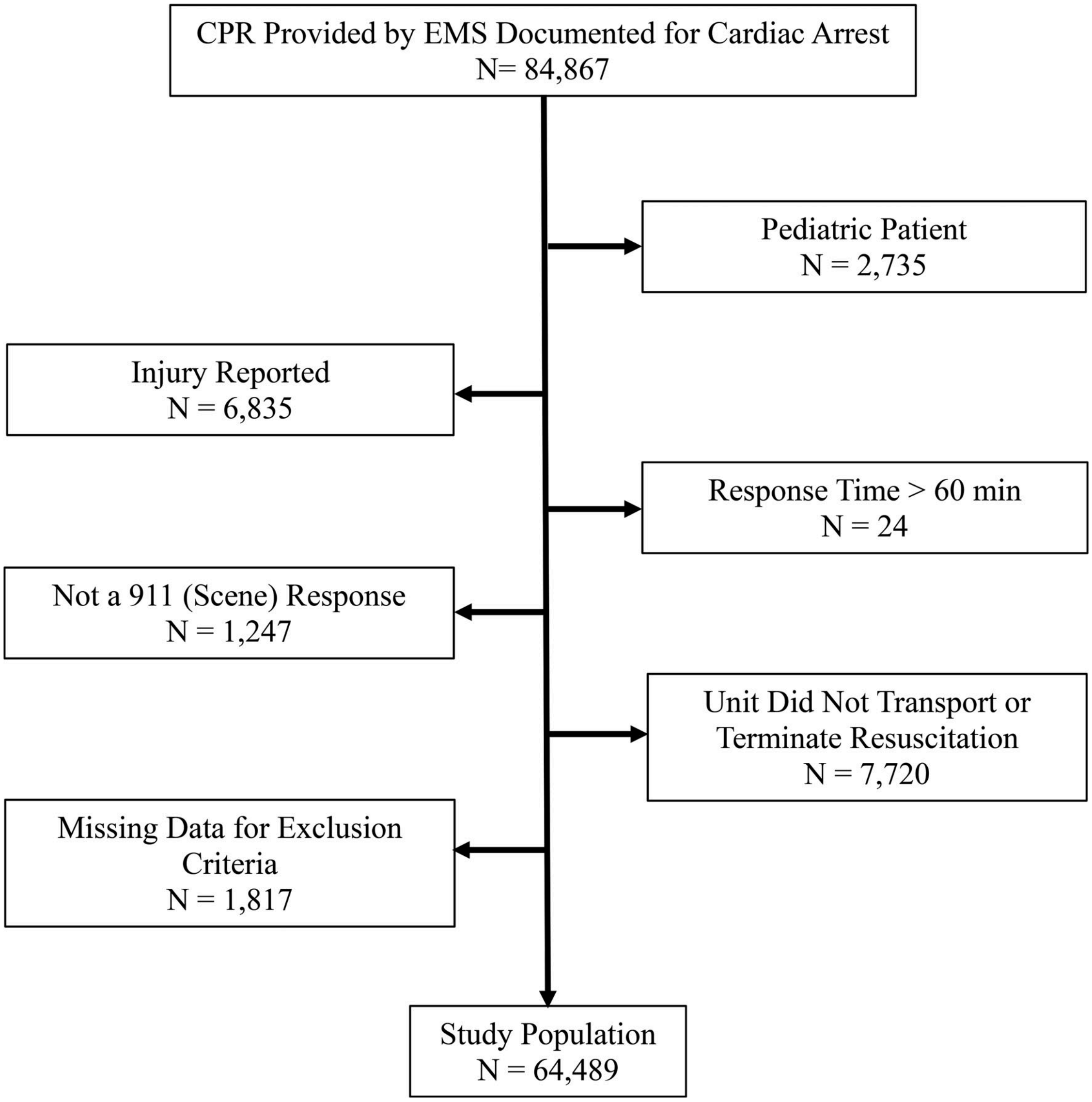

Figure 1. Selection criteria for incidents included in the study.
Abbreviations: CPR, cardiopulmonary resuscitation.

not skew our main findings regarding rural prehospital care. Finally, we also repeated the modeling after multiple imputation to handle missing data, assuming a missing at random mechanism. We used $m = 25$ imputations using multiple imputation with chained equations to impute the missing variables (Appendix 4, Supplementary Material). Imputation diagnostics were assessed, including comparison of observed and imputed values. For all analyses, $p < 0.05$ was considered statistically significant. All statistical analyses were performed using Stata version 15.0 (StataCorp, College Station, TX) and R version 3.6.2 (R Foundation for Statistical Computing, Vienna, Austria).

Results

A total of 64,489 OHCA incidents were included in the study (Figure 1). Only 5,601 (8.9%) OHCA incidents took place in a rural setting (including 1,113 [1.8%] initially classified as wilderness). ROSC was achieved in 20,578 incidents (33.6%) (Table 1). Rural OHCA patients achieved ROSC in 29.2% of incidents, compared to 34.1% in urban/suburban settings ($p < 0.001$). Neither age nor gender significantly differed between settings. The majority of all OHCA incidents took place in a private rather than public setting, with a slightly greater proportion occurring in a public location within urban settings (29.6% vs. 27.4%, $p < 0.01$). Response times were longer in rural OHCA incidents (7.5 vs. 5.9 minutes, $p < 0.001$). We also compared response times for BLS and ALS units, which showed that response times were shorter for BLS level of care (5.2 vs. 6.0 minutes, $p < 0.001$). Rural OHCA incidents were more likely to be managed by a basic life support (BLS) unit (7.4% vs. 4.2%, $p < 0.001$). Rural OHCA patients were less likely to receive epinephrine (69.3% vs. 73.3%, $p < 0.001$). Further, OHCA patients in rural settings were roughly 6% less likely to receive successful advanced airway management than those in urban and suburban areas (41.9% vs. 49.1%, $p < 0.001$), and were more likely to experience failed attempts to establish an advanced airway (6.6% vs. 6.1%, $p < 0.05$). Mechanical CPR devices were used with slightly greater

Table 1. Characteristics of EMS-treated OHCA incidents in rural versus urban/suburban prehospital settings. P-value calculated using chi square test, unless otherwise noted.

	All Incidents	Rural	Urban/Suburban	P-Value
Total included	64,489	5,601 (8.9%)	57,016 (91.1%)	–
Ever achieved ROSC, n (%)	20,578 (33.6%)	1,558 (29.2%)	18,451 (34.1%)	<0.001
Presumed alive, n (%)	14,704 (22.8%)	1,128 (20.1%)	13,111 (23.0%)	<0.001
Age in years, mean (SD)*	64.6 (16.8)	64.7 (15.7)	64.6 (16.9)	0.75
Male, n (%)	39,563 (61.5%)	3,462 (62.0%)	34,959 (61.5%)	0.41
Public setting, n (%)	18,113 (29.4%)	1,514 (27.4%)	16,101 (29.6%)	0.001
Response time in minutes, mean (SD)*	6.0 (4.3)	7.5 (6.2)	5.9 (4.0)	<0.001
ALS level of care, n (%)	61,429 (95.3%)	5,188 (92.6%)	54,620 (95.8%)	<0.001
CPR prior to EMS arrival, n (%)	36,716 (59.7%)	3,227 (59.7%)	32,502 (59.9%)	0.78
Patient transported to hospital, n (%)	44,807 (69.5%)	4,177 (74.6%)	39,368 (69.0%)	<0.001
Arrest witnessed by EMS, n (%)	11,666 (19.0%)	1,022 (18.7%)	10,286 (19.0%)	0.69
Shockable initial rhythm, n (%)	9,952 (17.5%)	866 (18.1%)	8,806 (17.4%)	0.25
Epinephrine administered, n (%)	43,650 (72.9%)	3,447 (69.3%)	39,045 (73.3%)	<0.001
Mechanical CPR, n (%)	17,949 (27.8%)	1,651 (29.5%)	15,753 (27.6%)	0.003
Advanced airway management, n (%)				<0.001
None	29,994 (46.5%)	2,883 (51.5%)	26,118 (45.8%)	
Failed Attempt	4,005 (6.2%)	370 (6.6%)	3,495 (6.1%)	
Supraglottic airway	8,631 (13.4%)	515 (9.2%)	7,965 (14.0%)	
Endotracheal intubation	21,859 (33.9%)	1,833 (32.7%)	19,438 (34.1%)	

*P-value calculated using two-sample t-test.

Abbreviations: ALS, advanced life support; CPR, cardiopulmonary resuscitation; EMS, emergency medical services; OHCA, out-of-hospital cardiac arrest; ROSC, return of spontaneous circulation.

frequency in rural settings (29.5% vs. 27.6%, $p < 0.01$). Rural OHCA incidents were more likely to be transported to the hospital (74.6% vs. 69.0%, $p < 0.001$). There were no significant differences in rates of CPR before EMS arrival, OHCA witnessed by EMS, or shockable initial rhythm in rural versus urban/suburban settings.

Multivariable logistic regression was performed for the primary outcome measure of ROSC using 47,666 complete records (16,823 incidents [26.1%] were excluded due to missing data, summarized in Appendix 4, Supplementary Material). We found a significant Hosmer-Lemeshow test statistic in 6 of the 100 random subsets, with an average p-value of 0.46, suggesting there was no evidence of lack of fit of the model. On adjusted analysis, rural OHCA patients had 19% lower odds of achieving ROSC at any time than urban patients after controlling for other factors (Table 2; odds ratio [OR] 0.81, 95% CI: 0.75–0.87). Additional factors associated with ROSC are shown in Table 2.

We then performed multivariable logistic regression for the secondary outcome measure of being presumptively alive at the end of the event using the same covariates. We found a significant Hosmer-Lemeshow test statistic in 3 of the 100 random subsets, with an average p-value of 0.54, suggesting there was no evidence of lack of fit of the model. Rural OHCA patients had 14% lower odds of being presumptively alive after controlling for other factors (Table 2; OR 0.86, 95% CI: 0.79–0.93). Additional factors associated with positive secondary outcome measure are included in Table 2. In the sensitivity analysis using the originally-coded urbanicity variable in NEMSIS (urban, suburban, rural, and wilderness) we found that both rural and wilderness incidents each had inferior adjusted odds ratios for the primary and secondary outcome measures (Appendix 5, Supplementary Material).

We also performed a sensitivity analysis using multiple imputation to address missing data. We first subjected the dataset of imputed missing data to our descriptive analysis and found no significant changes to our findings. We then performed multivariable logistic regression analysis on the primary and secondary outcome measures to evaluate whether findings were similar in the complete case and imputed datasets. In the adjusted analysis using multiple imputation, we found that rural incidents had similarly decreased odds of ROSC (OR 0.80, 95% CI: 0.75–0.85) and presumptively alive status (OR 0.83, 95% CI: 0.77–0.89), and found no other significant differences in between the two approaches.

Discussion

Rural OHCA patients were less likely to achieve ROSC than those in urban settings. The two factors most strongly associated with increased odds of ROSC in this study—shockable initial rhythm and arrest witnessed by EMS—were evenly distributed between settings. However, rural OHCA patients experienced longer EMS response times and were less likely to receive epinephrine and successful advanced airway management. ALS level of care was also strongly associated with increased odds of ROSC, and rural OHCA incidents were more likely to be managed exclusively by BLS providers. On multivariable logistic regression, rural setting was significantly associated with decreased odds of ROSC after controlling for relevant factors. Findings were similar when using a composite end-of-event outcome indicator variable of being presumptively alive as the outcome measure. These findings suggest that disparities exist in prehospital management and outcomes for rural OHCA patients.

Urban-rural disparities have been previously identified in prehospital care, and increased overall prehospital time is a known driver of worse outcomes for rural prehospital patients with time-sensitive conditions including stroke, traumatic injuries, and cardiac arrest (5–8,24–26). Early evaluations of rural OHCA outcomes as part of the Sodium Bicarbonate Study Group from 1992–1996 demonstrated that survival to hospital arrival for patients in rural settings

Table 2. Crude and adjusted odds of ever achieving ROSC and favorable composite end-of-event outcome measure (i.e., presumed not dead) among patients with OHCA.

	Ever achieved ROSC		Presumed alive	
	Crude OR (95% CI)	Adjusted OR* (95% CI)	Crude OR (95% CI)	Adjusted OR# (95% CI)
Urbanicity				
Urban		REFERENT		
Suburban	0.95 (0.88–1.02)	0.92 (0.85–1.01)	1.01 (0.94–1.10)	1.02 (0.92–1.12)
Rural	0.79 (0.75–0.84)	0.81 (0.75–0.87)	0.85 (0.79–0.90)	0.86 (0.79–0.93)
Age				
First Quartile (18–54 years)		REFERENT		
Second Quartile (55–65)	1.01 (0.96–1.06)	0.99 (0.94–1.05)	0.96 (0.91–1.01)	0.95 (0.89–1.01)
Third Quartile (66–76)	1.02 (0.98–1.07)	1.00 (0.95–1.06)	0.94 (0.89–0.99)	0.93 (0.87–0.99)
Fourth Quartile (77+)	0.93 (0.89–0.97)	0.89 (0.84–0.94)	0.86 (0.81–0.90)	0.80 (0.75–0.86)
Gender				
Female		REFERENT		
Male	0.79 (0.77–0.82)	0.75 (0.72–0.78)	0.81 (0.78–0.84)	0.76 (0.72–0.79)
Location Type				
Private		REFERENT		
Public	1.16 (1.12–1.20)	0.98 (0.94–1.03)	1.17 (1.13–1.22)	1.00 (0.95–1.06)
Response Time, minutes	0.99 (0.98–0.99)	0.99 (0.98–0.99)	0.98 (0.98–0.99)	0.99 (0.98–0.99)
Bystander/First Responder CPR				
No CPR Prior to EMS Arrival		REFERENT		
CPR Prior to EMS Arrival	0.93 (0.90–0.96)	0.98 (0.94–1.02)	0.86 (0.83–0.89)	0.90 (0.86–0.95)
Level of EMS Care				
Basic Life Support		REFERENT		
Advanced Life Support	1.75 (1.60–1.91)	1.68 (1.47–1.92)	1.27 (1.15–1.39)	1.63 (1.40–1.91)
Arrest Classification				
Not Witnessed by EMS		REFERENT		
Witnessed by EMS	2.06 (1.97–2.14)	2.07 (1.96–2.18)	2.03 (1.94–2.13)	1.98 (1.87–2.09)
CPR Method				
Manual CPR		REFERENT		
Mechanical CPR	0.92 (0.88–0.95)	0.98 (0.94–1.03)	0.91 (0.88–0.95)	1.01 (0.96–1.06)
Initial Rhythm				
Not Shockable		REFERENT		
Shockable	2.32 (2.22–2.43)	2.54 (2.42–2.67)	2.28 (2.17–2.39)	2.47 (2.34–2.61)
Airway Management				
None		REFERENT		
Attempted but Unsuccessful	0.74 (0.68–0.80)	0.75 (0.68–0.82)	0.69 (0.63–0.75)	0.75 (0.68–0.83)
Supraglottic Airway	0.88 (0.83–0.93)	1.02 (0.96–1.08)	0.68 (0.63–0.72)	0.83 (0.77–0.89)
Endotracheal Intubation	1.32 (1.27–1.37)	1.50 (1.43–1.57)	1.12 (1.07–1.16)	1.40 (1.33–1.47)
Epinephrine				
Not Administered		REFERENT		
Administered	0.91 (0.88–0.94)	0.95 (0.91–1.00)	0.66 (0.64–0.69)	0.78 (0.74–0.82)

*Average p-value from Hosmer-Lemeshow goodness of fit test in 100 random subsamples of $n = 1000$ was 0.46 with 94/100 subsets demonstrating no evidence of lack of fit.

#Average p-value from Hosmer-Lemeshow goodness of fit test in 100 random subsamples of $n = 1000$ was 0.54 with 97/100 subsets demonstrating no evidence of lack of fit.

Abbreviations: CPR, cardiopulmonary resuscitation; EMS, emergency medical services; OHCA, out-of-hospital cardiac arrest;ROSC, return of spontaneous circulation.

was worse in comparison to those in suburban and urban settings, with these worsened outcomes associated with increased EMS response times (9). This association has also been observed in other rural and low population density regions where survival rates are low and response times are long (7,10,11). One important exception emerged from a Swedish OHCA study where increased EMS response times were associated with decreased population density, but no association was found between population density and survival at 1 month from OHCA (12). Higher rates of bystander CPR in less populated areas of Sweden were cited as a possible explanation for this lack of a rural-urban gap in survival, highlighting its importance as an early predictor of OHCA outcomes.

In our study, we replicated previous findings that rural patients experienced longer EMS response times. Multivariable models in our sample of OHCA patients demonstrate that prolonged response time was a key factor associated with decreased odds of ROSC and being presumptively alive at the end of the event. As noted above, differences in response time could be mitigated by CPR prior to EMS arrival since lay bystander CPR may improve outcomes by 2–3 fold (13,27). We found no difference in rates of bystander CPR (which includes CPR performed by non-EMS first responders such as firefighters) between rural and urban areas, but it is important to note that we could not evaluate the time between OHCA and initiation of bystander CPR. These findings further support the need for continued implementation and optimization of telecommunicator CPR so that, in all settings, victims of cardiac arrest may receive CPR as early as possible (28).

Other findings from this study seem to oppose observations typically reported in the literature. We found strong associations between ALS management of OHCA and better outcomes. This finding contrasts with a Sanghavi et. al. study that reported superior outcomes for OHCA patients treated by BLS compared to ALS (29). Sanghavi et. al. attributed their finding to multiple factors that included prolonged prehospital time and the potential harm of prehospital intubation for OHCA, particularly in the case of unrecognized esophageal intubation. Interestingly, we found that successful endotracheal intubation was associated with superior outcomes, and found that ALS care was associated with superior outcomes despite significantly longer response times compared to BLS care. We also found that the administration of epinephrine (compared to no administration) was associated with worse outcomes, which conflicts with multiple prior studies that reported survival benefits associated with the prehospital use of epinephrine for OHCA (30–32). However, our finding is most likely mediated by the indication of ephinephrine, rather than by the administration of epinephrine, since we did not capture whether epinephrine was held because ROSC was achieved prior to its administration. In addition, we found no association between bystander CPR and achievement of ROSC or positive end-of-event indicator of being presumptively alive. This finding is likely due to the fact that we studied bystander CPR as a binary variable because our dataset did not capture the timing of bystander CPR. Therefore, it remains possible that our sample of OHCA incidents marked by bystander CPR includes a combination of cases where it was delivered both immediately and after a delay, and that the delayed cases diluted the beneficial effects of prompt bystander CPR (27). Future studies using data that accurately captures the timing of these prehospital events—such as witnessed arrest, initiation of CPR, administration of treatments, and achievement of ROSC—would be helpful to address these questions with greater precision.

There were several other differences in prehospital care provided by paramedics in rural versus urban areas. Patients in rural areas were less likely to receive epinephrine than patients in urban areas, which may indicate that patients in rural areas were less likely to receive care consistent with current guidelines, perhaps in part due to the higher rate of BLS management of OHCA in rural settings (33). Similarly, rural patients were less likely to receive an advanced airway and had more failed airway attempts, which may reflect a relative lack of experience in airway management among rural paramedics. Decreased rates of advanced airway management in rural areas has also been previously noted in the literature, suggesting that this may present a gap in rural prehospital care (7).

Limitations

This study has several limitations. First, ROSC is a limited measure of OHCA outcomes that does not capture longer term morbidity and mortality. However, one challenge in studying rural OHCA is the lack of structured datasets in rural settings with complete outcome data. The use of ROSC allows for a short-term outcome evaluation of resuscitation in this prehospital setting. Moreover, we used a previously validated end-of-event outcome indicator of being presumptively alive as a secondary outcome measure in an attempt to extend the practical applicability of our study (19). Future studies using other sources of data with more reliable long-term patient outcome monitoring are recommended to further address this limitation. Second, the NEMSIS dataset did not provide sufficient detail to address all Utstein criteria, such as the nature of CPR provided before EMS arrival (e.g., immediate versus delayed), details of post-EMS care, and longer-term outcome measures. Third, there is a significant amount of missing data, particularly when using complete case analysis for our multivariable logistic regression models. We attempted to address this issue by performing multiple imputation analysis and found no significant changes in any of our findings; in some cases, odds ratios became more extreme with smaller confidence intervals, but there were no changes in direction for any of our anlyses. Fourth, the NEMSIS dataset relies upon voluntary submission of routine documentation recorded by clinicians with variation in documentation standards. Therefore, this nationwide sample is neither random nor complete (NEMSIS includes data submitted from less than half the EMS agencies in the U.S.) so the generalizability of our findings is limited. Similarly, our observational design cannot be used to draw conclusions about causation. However, the NEMSIS dataset provides an immense nationwide sample of OHCA incidents, enabling us to perform the largest known study of EMS-treated OHCA in the rural US.

Conclusions

In this national sample of EMS-treated OHCA, rural patients were less likely to achieve ROSC than patients in urban settings. Similarly, we found that rural OHCA patients were less likely to have indications of being presumptively alive at the end of the event compared to those in urban settings. While patient demographics were similar, average EMS response time was longer in rural areas, and there were several differences in EMS treatment patterns including increased rates of BLS management, decreased epinephrine administration, and decreased rates of successful advanced airway management. Further research is needed to assess longer-term outcome measures and further characterize potential differences in bystander response and time to CPR and defibrillation in these settings. These findings indicate an ongoing need to invest in the development of strategies to address disparities in OHCA management and outcomes between rural and urban settings in the US. We hope the findings from this large-scale retrospective analysis of prehospital cardiac arrest management in the U.S. will inform future work to identify interventions to improve rural prehospital care.

Meeting Presentations

This work was presented at the American Heart Association Resuscitation Science Symposium 2020.

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References

1. Benjamin EJ, Virani SS, Callaway CW, Chamberlain AM, Chang AR, Cheng S, Chiuve SE, Cushman M, Delling FN, Deo R, et al. Heart disease and stroke statistics-2018 update: a report from the American Heart Association. Circulation. 2018;137(12):e67–492. doi:10.1161/CIR.0000000000000558.
2. Yan S, Gan Y, Jiang N, Wang R, Chen Y, Luo Z, Zong Q, Chen S, Lv C. The global survival rate among adult out-of-hospital cardiac arrest patients who received cardiopulmonary resuscitation: a systematic review and meta-analysis. Crit Care. 2020;24(1):61. doi:10.1186/s13054-020-2773-2.
3. Dyson K, Brown SP, May S, Smith K, Koster RW, Beesems SG, Kuisma M, Salo A, Finn J, Sterz F, et al. International variation in survival after out-of-hospital cardiac arrest: A validation study of the Utstein template. Resuscitation. 2019;138:168–81. doi:10.1016/j.resuscitation.2019.03.018.
4. Berg KM, Cheng A, Panchal AR, Topjian AA, Aziz K, Bhanji F, Bigham BL, Hirsch KG, Hoover AV, Kurz MC, et al. Part 7: systems of care: 2020 American Heart Association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. Circulation. 2020;142(16_suppl_2):S580–S604. doi:10.1161/CIR.0000000000000918.
5. Mathiesen WT, Bjørshol CA, Kvaløy JT, Søreide E. Effects of modifiable prehospital factors on survival after out-of-hospital cardiac arrest in rural versus urban areas. Crit Care. 2018;22(1):99. doi:10.1186/s13054-018-2017-x.
6. Masterson S, Wright P, O'Donnell C, Vellinga A, Murphy AW, Hennelly D, Sinnott B, Egan J, O'Reilly M, Keaney J, et al. Urban and rural differences in out-of-hospital cardiac arrest in Ireland. Resuscitation. 2015;91:42–7. doi:10.1016/j.resuscitation.2015.03.012.
7. Jennings PA, Cameron P, Walker T, Bernard S, Smith K. Out-of-hospital cardiac arrest in Victoria: rural and urban outcomes. Med J Aust. 2006;185(3):135–9. doi:10.5694/j.1326-5377.2006.tb00498.x.
8. Stapczynski JS, Svenson JE, Stone CK. Population density, automated external defibrillator use, and survival in rural cardiac arrest. Acad Emerg Med. 1997;4(6):552–8. doi:10.1111/j.1553-2712.1997.tb03577.x.
9. Vukmir RB, Sodium Bicarbonate Study GroupThe influence of urban, suburban, or rural locale on survival from refractory prehospital cardiac arrest. Am J Emerg Med. 2004;22(2):90–3. doi:10.1016/j.ajem.2003.12.008.
10. Ro YS, Shin SD, Song KJ, Lee EJ, Kim JY, Ahn KO, Chung SP, Kim YT, Hong SO, Choi J-A, et al. A trend in epidemiology and outcomes of out-of-hospital cardiac arrest by urbanization level: a nationwide observational study from 2006 to 2010 in South Korea. Resuscitation. 2013;84(5):547–57. doi:10.1016/j.resuscitation.2012.12.020.
11. Nehme Z, Andrew E, Cameron PA, Bray JE, Bernard SA, Meredith IT, Smith K. Population density predicts outcome from out-of-hospital cardiac arrest in Victoria, Australia. Med J Aust. 2014;200(8):471–5. doi:10.5694/mja13.10856.
12. Strömsöe A, Svensson L, Claesson A, Lindkvist J, Lundström A, Herlitz J. Association between population density and reported incidence, characteristics and outcome after out-of-hospital cardiac arrest in Sweden. Resuscitation. 2011;82(10):1307–13. doi:10.1016/j.resuscitation.2011.04.025.
13. Sasson C, Rogers MAM, Dahl J, Kellermann AL. Predictors of survival from out-of-hospital cardiac arrest: a systematic review and meta-analysis. Circ Cardiovasc Qual Outcomes. 2010;3(1):63–81. doi:10.1161/CIRCOUTCOMES.109.889576.
14. NASEMSO. National Emergency Medical Services Assessment [Internet]. National Association of State EMS Officials; 2020. Available from: https://nasemso.org/wp-content/uploads/2020-National-EMS-Assessment_Reduced-File-Size.pdf.
15. Mann C. News Release: 2018. NEMSIS Public-Release Dataset is Now Available [Internet]. NEMSIS; 2019 [cited 2021 Sep 22]. Available from: https://nemsis.org/wp-content/uploads/2019/09/2018-Public-Release-Research-Dataset_news-release.pdf.
16. von Elm E, Altman DG, Egger M, Pocock SJ, Gøtzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. Ann Intern Med. 2007;147(8):573–7. doi:10.7326/0003-4819-147-8-200710160-00010.
17. Mann NC, Kane L, Dai M, Jacobson K. Description of the 2012 NEMSIS public-release research dataset. Prehosp Emerg Care. 2015;19(2):232–40. doi:10.3109/10903127.2014.959219.
18. USDA. USDA Economic Research Service – Urban Influence Codes [Internet]. 2019. [cited 2021 Nov 26]. Available from: https://www.ers.usda.gov/data-products/urban-influence-codes/.
19. Miller ML, Lincoln EW, Brown LH. Development of a binary end-of-event outcome indicator for the NEMSIS public release research dataset. Prehosp Emerg Care. 2021;25(4):504–11.
20. Cummins RO, Chamberlain DA, Abramson NS, Allen M, Baskett PJ, Becker L, Bossaert L, Delooz HH, Dick WF, Eisenberg MS, et al. Recommended guidelines for uniform reporting of data from out-of-hospital cardiac arrest: the Utstein Style. A statement for health professionals from a task force of the American Heart Association, the European Resuscitation Council, the Heart and Stroke Foundation of Canada, and the Australian Resuscitation Council. Circulation. 1991;84(2):960–75. doi:10.1161/01.cir.84.2.960.
21. Jacobs I, Nadkarni V, Bahr J, Berg RA, Billi JE, Bossaert L, Cassan P, Coovadia A, D'Este K, Finn J, et al. Cardiac arrest and cardiopulmonary resuscitation outcome reports: update and simplification of the Utstein templates for resuscitation registries: a statement for healthcare professionals from a task force of the International Liaison Committee on Resuscitation (American Heart Association, European Resuscitation Council, Australian Resuscitation Council, New Zealand Resuscitation Council, Heart and Stroke Foundation of Canada, InterAmerican Heart Foundation, Resuscitation Councils of Southern Africa). Circulation. 2004;110(21):3385–97. doi:10.1161/01.CIR.0000147236.85306.15.
22. Paul P, Pennell ML, Lemeshow S. Standardizing the power of the Hosmer-Lemeshow goodness of fit test in large data sets. Stat Med. 2013;32(1):67–80. doi:10.1002/sim.5525.
23. Bartley AC. Evaluating goodness-of-fit for a logistic regression model using the Hosmer-Lemeshow test on samples from a large data set. [Internet]. The Ohio State University; 2014. [cited 2020 Nov 9]. Available from: https://etd.ohiolink.edu/apexprod/rws_olink/r/1501/10?p10_accession_num=osu1396951135.
24. Jarman MP, Hashmi Z, Zerhouni Y, Udyavar R, Newgard C, Salim A, Haider AH. Quantifying geographic barriers to trauma care: Urban-rural variation in prehospital mortality. J Trauma Acute Care Surg. 2019;87(1):173–80. doi:10.1097/TA.0000000000002335.
25. Leira EC, Hess DC, Torner JC, Adams HP. Rural-urban differences in acute stroke management practices: a modifiable disparity. Arch Neurol. 2008;65(7):887–91. doi:10.1001/archneur.65.7.887.
26. Mell HK, Mumma SN, Hiestand B, Carr BG, Holland T, Stopyra J. Emergency Medical Services response times in rural, suburban,

and urban areas. JAMA Surg. 2017;152(10):983–4. doi:10.1001/jamasurg.2017.2230.
27. Viereck S, Møller TP, Ersbøll AK, Baekgaard JS, Claesson A, Hollenberg J, Folke F, Lippert FK. Recognising out-of-hospital cardiac arrest during emergency calls increases bystander cardiopulmonary resuscitation and survival. Resuscitation. 2017;115:141–7. doi:10.1016/j.resuscitation.2017.04.006.
28. American Heart Association. Telecommunicator CPR Recommendations and Performance Measures [Internet]. cpr.heart.org. [cited 2020 Nov 30]. Available from: https://cpr.heart.org/en/resuscitation-science/telecommunicator-cpr/telecommunicator-cpr-recommendations-and-performance-measures.
29. Sanghavi P, Jena AB, Newhouse JP, Zaslavsky AM. Outcomes after out-of-hospital cardiac arrest treated by basic vs advanced life support. JAMA Intern Med. 2015;175(2):196–204. doi:10.1001/jamainternmed.2014.5420.
30. Jacobs IG, Finn JC, Jelinek GA, Oxer HF, Thompson PL. Effect of adrenaline on survival in out-of-hospital cardiac arrest: a randomised double-blind placebo-controlled trial. Resuscitation. 2011;82(9):1138–43. doi:10.1016/j.resuscitation.2011.06.029.
31. Perkins GD, Ji C, Deakin CD, Quinn T, Nolan JP, Scomparin C, Regan S, Long J, Slowther A, Pocock H, et al. A randomized trial of epinephrine in out-of-hospital cardiac arrest. N Engl J Med. 2018;379(8):711–21. doi:10.1056/NEJMoa1806842.
32. Lin S, Callaway CW, Shah PS, Wagner JD, Beyene J, Ziegler CP, Morrison LJ. Adrenaline for out-of-hospital cardiac arrest resuscitation: A systematic review and meta-analysis of randomized controlled trials. Resuscitation. 2014;85(6):732–40. doi:10.1016/j.resuscitation.2014.03.008.
33. Panchal AR, Bartos JA, Cabañas JG, Donnino MW, Drennan IR, Hirsch KG, Kudenchuk PJ, Kurz MC, Lavonas EJ, Morley PT, et al. Part 3: adult basic and advanced life support: 2020 American Heart Association Guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. Circulation. 2020;142(16_suppl_2):S366–S468.