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ORIGINAL ARTICLE

Gender Disparities Among Adult Recipients of Bystander Cardiopulmonary Resuscitation in the Public

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BACKGROUND: Bystander cardiopulmonary resuscitation (BCPR) improves survival from out-of-hospital cardiac arrest (OHCA), yet BCPR rates remain low. It is unknown whether BCPR delivery disparities exist based on victim gender. We measured BCPR rates by gender in private and public environments, hypothesizing that females would be less likely than males to receive BCPR in public settings, with an associated difference in survival to hospital discharge.

METHODS AND RESULTS: We analyzed data from adult, nontraumatic OHCA events within the Resuscitation Outcomes Consortium registry (2011–2015). Using logistic regression, we modeled the likelihood of receiving BCPR by gender, including patient-level variables, stratified by location. A cohort of 19 331 OHCAs was assessed. Mean age was 64±17 years, and 63% (12 225/19 331) were male. Overall, 37% of OHCA victims received bystander CPR. In public locations, 39% (272/694) of females and 45% (1170/2600) of males received BCPR (P<0.01), whereas in private settings, 35% (2198/6328) of females and 36% (3364/9449) of males received BCPR (P=NS). Among public OHCAs, males had significantly increased odds of receiving BCPR compared with females (odds ratio, 1.27; 95% CI, 1.05–1.53; P=0.01); this was not the case in the private setting (odds ratio, 0.93; 95% CI, 0.87–1.01; P=NS). Controlling for site, age, and race, BCPR was significantly associated with survival to hospital discharge (odds ratio, 1.69; 95% CI, 1.54–1.85; P<0.01); in this model, males had 29% increased odds of survival compared with females (odds ratio, 1.29; 95% CI, 1.17–1.42; P<0.01).

CONCLUSIONS: Males had an increased likelihood of receiving BCPR compared with females in public. BCPR improved survival to discharge, with greater survival among males compared with females.

Key Words: adult ■ cardiopulmonary resuscitation ■ myocardial infarction ■ out-of-hospital cardiac arrest ■ patients

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WHAT IS KNOWN

- Bystander cardiopulmonary resuscitation (BCPR) improves survival from out-of-hospital cardiac arrest, yet BCPR rates are low.
- It is unknown whether BCPR delivery disparities exist based on victim gender.

WHAT THE STUDY ADDS

- Analyzing data from the Resuscitation Outcomes Consortium (n=19 331), layperson BCPR was administered in 37% of events; males had an increased likelihood of receiving BCPR compared with females in public locations (odds ratio, 1.27; 95% CI, 1.05–1.53; *P*=0.01). Furthermore, males had a 23% increased odds of survival compared with females (odds ratio, 1.23; 95% CI, 1.12–1.36; *P*<0.01).
- These findings identify an important gender disparity in the public response to cardiac arrest and delivery of CPR, a crucial factor that is linked to survival outcomes.

Recent investigations have affirmed that prompt delivery of bystander cardiopulmonary resuscitation (BCPR) increases survival from out-of-hospital cardiac arrest (OHCA), yet BCPR rates remain low in many US communities.[1–4] Epidemiological studies have demonstrated disparities in BCPR rates by neighborhood-level characteristics, such as racial composition or socioeconomic status.[5–8] Improving BCPR training and delivery have been highlighted as crucial national objectives in statements from the National Academy of Medicine and the American Heart Association,[9–11] with the goal of increasing survival from OHCA, an abrupt condition that strikes >400 000 victims each year in the United States.[12]

There is evidence that gender disparities persist when examining treatment for other forms of cardiovascular disease, such as percutaneous coronary intervention for ST-segment–elevation myocardial infarction.[13–16] Further, studies suggest that men are more likely than women to receive treatment in other time-sensitive medical conditions, alluding to a potential gender bias in emergent responses.[17,18] Although studies suggest gender differences exist among arrest victims with regard to chance of survival,[19–21] little work has primarily examined layperson BCPR delivery or this relationship in the public and home environment. Understanding whether BCPR gender variation persists in these 2 environments may present important considerations for future training and public messaging around layperson CPR, a critical and potentially modifiable link in the cardiac arrest chain of survival.[22]

We conducted a retrospective cohort study to assess whether there is variation in layperson BCPR rates by gender for OHCA in both the home and public environments. We hypothesized that females would be less likely than males to receive BCPR in the public environment. We then sought to measure whether BCPR variation was associated with differences in clinical outcomes, hypothesizing that females have lower survival to hospital discharge.

METHODS

Study Design

We conducted a retrospective cohort study, examining differences in BCPR rates based on victim's gender among adult, nontraumatic cardiac arrest events that occurred in the out-of-hospital setting. To assess this, we used data collected prospectively for several clinical trials by the US sites of the Resuscitation Outcomes Consortium (ROC) from April 2011 to June 2015, including Alabama, Dallas, Milwaukee, San Diego, Pittsburgh, Portland, and Seattle-King County. The study protocol was determined to be exempt from review by the University of Pennsylvania Institutional Review Board.

Data Sources

ROC represented a National Institutes of Health–funded clinical trial network focused on OHCA cardiopulmonary arrest and traumatic injury, ending in 2015. Since 2006, ROC collected data from 11 municipal regions in the United States and Canada. All participating Emergency Medical Services (EMS) agencies within ROC sites prospectively collected patient-level data on people treated for OHCA. Detailed methods for EMS data collection have been previously described.[23] Collected variables at the patient level included BCPR and other time-sensitive OHCA data elements. ROC epidemiological data have been reported in various clinical trial publications previously.[24–26]

Patient-Level Variables

We defined a victim who received BCPR as anyone who received BCPR from a layperson excluding those from police, healthcare workers, EMS, or other first responders. We excluded pediatric victims (age <18 years) and those who experienced OHCA from traumatic injury. We also excluded arrest events that occurred in a residential institution (eg, skilled nursing facility) or healthcare center and those that were witnessed by EMS. Gender was defined as male or female. To avoid collinearity, race and ethnicity were combined as a categorical variable defined as white non-Hispanic, black non-Hispanic, Hispanic, and other race, similar to methods conducted previously in the literature.[27,28] Age was modeled both continuously and as a categorical variable (by age deciles). Location of cardiac arrest included whether the event occurred in the home, street/highway, public building, place of recreation, other public location, and other nonpublic environment. Public location was then defined as a street/highway, public building, place of recreation, or other public location. Event time of day was grouped based on assumed daily activity similar to previous studies from our group (6:00 AM–8:59 AM, 9:00 AM–3:59 PM, 4:00 PM–6:59 PM, 7:00 PM–10:59 PM, 11:00 PM–5:59 AM).[29] We calculated the duration of time to arrival of EMS in minutes from the time that a

dispatch center received the 9-1-1 call to when the first EMS dispatched unit arrived on scene.

Statistical Analysis

The data, analytics methods, and study materials will be made available to other researchers on request for the purposes of reproducing the results or replicating the procedure. Data were analyzed using a statistical software package (STATA 14; StataCorp, College Station, TX). The data set was missing 3.8% of the primary outcome, and variation of the dependent variables from 0 to 3.9% with the exception of race which is missing 41.2%, which is consistent with prior ROC studies where ascertainment of race is difficult[30]; we analyzed differences in the covariates by missingness and assessed the final model, including the missing variables for race as an unknown category. As a sensitivity analysis, we used multiple imputations to impute the missing covariates of interest. To conduct the sensitivity analysis, we imputed the data using multiple imputations with 20 imputations and a multivariate normal regression algorithm. Once imputed, we estimated the logistic regression with the imputed data set. Our final primary hypothesis of interest, patient-level gender and likelihood of receipt of BCPR in public, did not change with imputation of the datasets (data not shown).

Using logistic regression modeling, we analyzed whether there were differences in layperson BCPR rates by gender. We built models for the likelihood of overall BCPR delivery and examined the likelihood of BCPR delivery in the home and public locations. Covariates were assessed in a univariate analysis with admission into the larger model based on a cutoff of $P<0.15$. The final regression model included layperson BCPR, site, time of event, location of event, patient demographics (age, race/ethnicity, gender), EMS time to arrival, and whether the event was witnessed. Because we were primarily concerned with controlling for site differences, site was modeled and tested as a fixed effect in the final regression equation. Furthermore, site A was arbitrarily selected as the reference group. We used postestimation methods, including goodness of fit tests and predicted probability figures to examine final regression model fit.

RESULTS

Characteristics of OHCA Events

From 2011 to 2015, there were 19331 adult, nontraumatic OHCA events in the 7 US ROC sites that did not occur in an institutional or healthcare facility and were not EMS witnessed. Of these, 17% (3297/19331) occurred in a public location, whereas 82% (15788/19331) occurred in private environments (eg, patient homes). Mean victim age was 64±17 years. Overall, 63% (12225/19331) of the arrest victims were male (Table 1).

Unadjusted Analysis of BCPR Delivery

Among the total cohort, 37% (7096/19331) of the population received BCPR, whereas 44% (1444/3297) received BCPR in public, and 35% (5564/15788) received BCPR in private settings. Among all events, 35% (2487/7086) of females and 38% (4605/12225) of males received BCPR ($P<0.01$), whereas 35% (2198/6328) of females and 36% (3364/9449) of males received BCPR in private (P=NS). In contrast, 39% (272/694) of females and 45% (1170/2600) of males received BCPR in public locations ($P<0.01$).

Multivariable Logistic Regression of BCPR and Gender

We examined all arrest events in a multivariable logistic regression controlling for site, time of day of the event, age, race/ethnicity, witnessed status, and time to arrival of EMS (Table 2). This relationship varied when assessing BCPR delivery in a multivariable logistic regression by gender in the public environment with males having a significant association with receiving BCPR delivery compared with females (odds ratio [OR], 1.27; 95% CI, 105-153; P=0.01; Table 2). In contrast, this difference was not found when evaluating BCPR delivery in the home environment (OR, 0.93; 95% CI, 0.87–1.01; P=NS; Table 2).

Patient-Level Survival

Examining all arrest events regardless of arrest location in a logistic regression model, including gender, receiving BCPR was significantly associated with survival to hospital discharge (OR, 2.03; 95% CI, 1.86 -2.22; $P<0.01$); in the same model, male gender was significantly associated with survival compared with females (OR, 1.33; 95% CI, 1.21 -1.46; $P<0.01$). While controlling for site, age and race in a multivariable logistic regression model, BCPR was associated with a 1.69 (95% CI, 1.54–1.85) increased odds of survival to hospital discharge ($P<0.01$); males had a 1.29 (95% CI, 1.17–1.42) increased chance of survival compared with females ($P<0.01$).

DISCUSSION

In this investigation of BCPR delivery for nontraumatic OHCA within the US, males had a significantly increased likelihood of receiving BCPR compared with females among arrests that occurred in public locations. Furthermore, survival was greater among those that received BCPR and among males compared with females. Interestingly, this gender disparity of BCPR delivery was not found in the home environment, where lay responders are more likely to be family members. To our knowledge, this is the first demonstration of national gender disparities in BCPR delivery. It is estimated that >100000 individuals suffer OHCA in public locations each year in the United States.[12] When taken together with the large effect size of BCPR on survival to hospital discharge, this suggests an important gender dispar-

Table 1. Demographic Characteristics

	All Subjects	Public BCPR Yes	Public BCPR No	*P* Value	Home BCPR Yes	Home BCPR No	*P* Value
N	19331	1444 (44%)	1853 (56%)		5564 (35%)	10224 (65%)	
Male	12225 (63%)	1170 (81%)	1430 (77%)	*	3364 (60%)	6085 (60%)	*
Site				*			*
A	1032 (6%)	52 (3%)	104 (6%)		196 (4%)	660 (6%)	
B	5324 (28%)	310 (22%)	550 (30%)		1153 (21%)	3268 (32%)	
C	2604 (13%)	103 (7%)	247 (13%)		302 (5%)	1914 (19%)	
D	1607 (8%)	146 (10%)	157 (8%)		412 (7%)	880 (8%)	
E	2244 (12%)	196 (14%)	120 (6%)		1014 (18%)	894 (9%)	
F	2571 (13%)	237 (16%)	271 (15%)		834 (15%)	1187 (12%)	
G	3949 (20%)	400 (28%)	404 (22%)		1653 (30%)	1421 (14%)	
Time of day				*			*
11:00 PM–5:59 AM	3631 (19%)	93 (6%)	219 (12%)		1201 (22%)	2084 (21%)	
6:00 AM–8:59 AM	2650 (14%)	163 (12%)	204 (11%)		754 (14%)	1500 (15%)	
9:00 AM–3:59 PM	6601 (34%)	688 (48%)	790 (43%)		1694 (31%)	3328 (33%)	
4:00 PM–6:59 PM	2919 (15%)	276 (19%)	316 (17%)		845 (15%)	1443 (14%)	
7:00 PM–10:59 PM	3386 (18%)	214 (15%)	312 (17%)		1024 (18%)	1796 (17%)	
Location type				*			*
Street, highway	892 (4%)	274 (19%)	618 (33%)		…	…	
Public building	329 (2%)	149 (10%)	180 (10%)		…	…	
Place of recreation	396 (2%)	231 (16%)	165 (9%)		…	…	
Home	15788 (82%)	…	…		5564 (100%)	10224 (100%)	
Other public	1680 (9%)	790 (55%)	890 (48%)		…	…	
Other nonpublic	150 (1%)	…	…		…	…	
Age, y				*			*
18–29	756 (4%)	47 (4%)	80 (5%)		273 (5%)	338 (4%)	
30–39	1099 (6%)	66 (5%)	145 (8%)		334 (6%)	537 (5%)	
40–49	1985 (10%)	186 (13%)	245 (13%)		593 (11%)	926 (9%)	
50–59	3714 (19%)	328 (23%)	470 (25%)		1075 (19%)	1781 (17%)	
60–69	4335 (22%)	419 (29%)	487 (26%)		1195 (22%)	2185 (21%)	
70–79	3419 (18%)	241 (17%)	240 (13%)		968 (17%)	1935 (19%)	
80+	4012 (21%)	156 (11%)	185 (10%)		1125 (20%)	2520 (25%)	
Race				*			*
White, non-Hispanic	6349 (33%)	516 (36%)	557 (30%)		2035 (37%)	3164 (31%)	
Black, non-Hispanic	3148 (16%)	108 (7%)	301 (16%)		537 (10%)	2173 (21%)	
Hispanic	872 (5%)	59 (4%)	83 (4%)		194 (3%)	524 (5%)	
Other	629 (3%)	38 (3%)	47 (3%)		253 (4%)	283 (3%)	
Unknown	8333 (43%)	723 (50%)	865 (47%)		2545 (46%)	4080 (40%)	
Not Witnessed	10419 (57%)	340 (24%)	817 (46%)		2934 (54%)	6239 (65%)	
Time from initial call, min				*			*
First arrival of EMS, min	5.27±2.35	5.18±2.63	4.78±2.34		5.61±2.43	5.20±2.23	
First arrival EMS <4 min, no (%)	5673 (30%)	480 (34%)	745 (42%)		1174 (22%)	3114 (32%)	
First EMS Compression, min	7.78±3.43	7.40±3.72	7.60±4.61		7.83±2.98	7.82±3.29	
Initial rhythm				*			*
Shockable (VF/pVT)	4474 (24%)	760 (55%)	691 (38%)		1297 (23%)	1647 (16%)	
Non-shockable (PEA/asystole)	14385 (75%)	595 (44%)	1111 (61%)		4169 (76%)	8361 (83%)	
Cannot determine	199 (1%)	17 (1%)	17 (1%)		46 (1%)	114 (1%)	

(*Continued*)

Table 1. Continued

	All Subjects	Public BCPR Yes	Public BCPR No	*P* Value	Home BCPR Yes	Home BCPR No	*P* Value
ROSC present at arrival to ED				*			*
Yes	5531 (47%)	664 (55%)	629 (43%)		1752 (54%)	2397 (42%)	
Survival at hospital discharge				*			*
Yes	2261 (12%)	475 (33%)	374 (20%)		666 (12%)	690 (7%)	

BCPR indicates bystander cardiopulmonary resuscitation; ED, emergency department; EMS, Emergency Medical Services; PEA, pulseless electrical activity; ROSC, return of spontaneous circulation; and VF/pVT, ventricular fibrillation/pulseless ventricular tachycardia.

**P* value: significance of 0.05 or less, χ^2 applied to categorical variables, and *t* test to continuous variables.

ity with broad clinical impact for resuscitation care and patient outcomes.[1,4]

Our work extends the findings of prior investigations that demonstrated disparities of BCPR delivery by neighborhood-level characteristics, such as race and socioeconomic status. For example, studies have examined geographic and racial differences in survival from OHCA and suggested a correlation with these

Table 2. Multivariable Logistic Regression Demonstrating Likelihood of Receiving BCPR

	All Locations (n=17 560)			Public (n=3060)			Home (n=14 123)		
	OR (95% CI)	Global *P* Value	Individual *P* Value	OR (95% CI)	Global *P* Value	Individual *P* Value	OR (95% CI)	Global *P* Value	Individual *P* Value
Male	0.97 (0.90–1.04)		0.34	1.27 (1.05–1.53)		0.01	0.93 (0.87–1.01)		0.07
Site (baseline: A)		<0.01		…	<0.01	…		<0.01	
B	1.42 (1.16–1.73)		<0.01	1.29 (0.84–1.98)		0.25	1.47 (1.17–1.84)		<0.01
C	0.67 (0.54–0.84)		<0.01	0.88 (0.55–1.41)		0.60	0.61 (0.48–0.79)		<0.01
D	1.72 (1.38–2.14)		<0.01	1.84 (1.15–2.96)		0.01	1.68 (1.30–2.16)		<0.01
E	4.08 (3.30–5.05)		<0.01	3.42 (2.11–5.56)		<0.01	4.23 (3.32–5.40)		<0.01
F	2.70 (2.18–3.33)		<0.01	2.00 (1.27–3.15)		<0.01	2.90 (2.28–3.70)		<0.01
G	3.60 (2.95–4.41)		<0.01	2.07 (1.35–3.20)		<0.01	4.21 (3.33–5.30)		<0.01
Time of day (baseline: 11:00 PM–5:59 AM)		0.10			<0.01			0.43	
6:00 AM–8:50 AM	1.02 (0.91–1.14)		0.76	1.65 (1.16–2.34)		<0.01	0.95 (0.84–1.07)		0.40
9:00 AM–3:59 PM	1.09 (0.99–1.20)		0.08	1.69 (1.27–2.26)		<0.01	1.01 (0.91–1.12)		0.90
4:00 PM–6:59 PM	1.15 (1.03–1.30)		0.01	1.87 (1.36–2.58)		<0.01	1.07 (0.95–1.22)		0.26
7:00 PM–10:59 PM	1.05 (0.94–1.17)		0.40	1.40 (1.01–1.94)		0.04	1.04 (0.93–1.17)		0.48
Age, y (baseline: 18–29)		<0.01			0.32			<0.01	
30–39	0.77 (0.62–0.95)		0.01	0.75 (0.45–1.24)		0.26	0.73 (0.58–0.93)		0.01
40–49	0.81 (0.67–0.98)		0.03	1.00 (0.64–1.57)		0.98	0.73 (0.59–0.90)		<0.01
50–59	0.77 (0.64–0.92)		<0.01	0.91 (0.59–1.38)		0.65	0.67 (0.55–0.82)		<0.01
60–69	0.72 (0.60–0.86)		<0.01	1.05 (0.69–1.59)		0.83	0.59 (0.48–0.72)		<0.01
70–79	0.61 (0.51–0.74)		<0.01	1.10 (0.71–1.72)		0.67	0.50 (0.41–0.61)		<0.01
80+	0.50 (0.42–0.60)		<0.01	0.86 (0.54–1.37)		0.53	0.41 (0.34–0.50)		<0.01
Race (baseline: white, non-Hispanic)		<0.01			<0.01			<0.01	
Black, non-Hispanic	0.58 (0.51–0.64)		<0.01	0.50 (0.38–0.66)		<0.01	0.59 (0.52–0.67)		<0.01
Hispanic	0.68 (0.58–0.81)		<0.01	0.78 (0.53–1.15)		0.21	0.65 (0.54–0.79)		<0.01
Other	0.99 (0.83–1.19)		0.96	0.91 (0.56–1.47)		0.70	1.03 (0.85–1.26)		0.74
Unknown	0.82 (0.76–0.88)		<0.01	0.81 (0.68–0.96)		0.02	0.84 (0.77–0.91)		<0.01
Not witnessed	0.57 (0.53–0.62)		<0.01	0.37 (0.31–0.44)		<0.01	0.63 (0.59–0.68)		<0.01
Time to first arrival of EMS, min	1.04 (1.03–1.06)		<0.01	1.06 (1.02–1.09)		<0.01	1.04 (1.02–1.05)		<0.01
Location type	1.05 (1.03–1.07)		<0.01	…		…	…		…

Site legend is described in Table 1. BCPR indicates bystander cardiopulmonary resuscitation; EMS, Emergency Medical Services; and OR, odds ratio.

variables and BCPR delivery rates.[31–34] Other investigations measuring BCPR delivery have found disparities related to geography, socioeconomic status, and racial composition.[5,35,36] Specifically, a recent study found that individuals living in low-income black neighborhoods were much less likely to receive BCPR compared with the national population (OR, 0.49; 95% CI, 0.41–0.58).[5] Although other works have suggested OHCA survival differences by gender,[37–40] BCPR delivery and its association to victim gender was not characterized in these studies.

Past studies have examined survival differences by gender and the effect of estrogen on outcomes from sudden cardiac arrest.[19–21,41,42] Understanding survival differences is complicated, however, by the confluence of both biological factors (estrogen and gender differences in ischemia-reperfusion response) and responder factors (delivery of CPR, other chain-of-survival metrics). In this analysis, we primarily examined the likelihood of receiving layperson BCPR delivery based on victim's gender to better understand responder factors that might influence survival by gender. The BCPR differences found in our work, specifically in the public location compared with the home, may speak to different types of responders and motivation of the lay responders in the public compared with the home. It is highly probable that individuals that respond in the home are family members of the victim, whereas those that are responding in public may represent unrelated members of the general public. Because BCPR rates were higher among men than women in the public setting, it may suggest inherent barriers to BCPR delivery or other biases among the responder population that remain to be elucidated. Few studies have characterized laypersons who performed BCPR or laypersons who witnessed OHCA events but failed to do so[43]; further work to characterize lay responders and barriers to BCPR delivery is needed.

Because BCPR was more prelevent among male victims in the public environment, this finding also presents an opportunity to improve messaging of CPR from emergency dispatchers. Dispatchers are often trained to offer guidance to encourage BCPR during an arrest event (often termed dispatch-assisted or telecommunicator-assisted CPR). In most cases, the dispatch instructions follow a uniform script but do not address physical characteristics or gender-related issues pertaining to either rescuer or victim. It is unknown through this analysis whether dispatch-assisted CPR was more prevalent among victims of one gender or the other. The findings of gender disparity in BCPR may present an actionable opportunity for OHCA in public settings to allow for scripting and additional interventions around targeting and improving BCPR rates to address OHCA victim gender.

Overall, these findings highlight an important knowledge gap in resuscitation science: understanding of layperson response to OHCA events. In our work, the gender of rescuers was unreported, as is common in most investigations of OHCA care. In addition, few studies have evaluated motivational factors among laypersons and barriers to actual performance, nor have investigations characterized the quality of layperson response. Few studies, for example, have evaluated CPR quality during layperson BCPR. Given the significant impact of BCPR on eventual outcome, further work to measure layperson BCPR delivery, and the quality of rescuer performance, represents a crucial priority. Next steps may include designing a study that understands bystander motivation and, more generally, layperson CPR quality.

There are limitations inherent in this retrospective cohort analysis. Confounders of the relationship of BCPR and victim gender may have influenced our findings. For example, we were unable to control for socioeconomic status in this analysis because the individual-level socioeconomic information was not present in our data set. Despite this, measures were taken to minimize bias by analyzing the data as a multivariable analysis, although there may be unmeasured confounding because this was not the primary outcome of interest for the set of ROC investigations. Further, as described above, this data set did not include rescuer demographic data, such as age or gender, and, therefore, it is unknown if male or female rescuers are more likely to perform BCPR. Finally, it is unknown whether the results from layperson response within the ROC consortium sites adequately represent the wider landscape of OHCA in the United States; however, other findings from our investigation, such as patient demographic data and survival rates are consistent with national reports,[12] suggesting that our work is likely generalizable.

In conclusion, males had a significantly increased likelihood of receiving BCPR compared with females in public locations. Survival was associated with BCPR delivery and was higher among males compared with females. It is possible that these measured disparities reflect inherent biases among the responder population that delivered BCPR. These findings could inform future messaging to lay, responders, healthcare providers, and dispatchers about public BCPR delivery.

ARTICLE INFORMATION

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