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ORIGINAL RESEARCH

Bystander Cardiopulmonary Resuscitation Quality: Potential for Improvements in Cardiac Arrest Resuscitation

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BACKGROUND: Bystander cardiopulmonary resuscitation (CPR) is a critical intervention to improve survival following out-of-hospital cardiac arrest. We evaluated the quality of bystander CPR and whether performance varied according to the number of bystanders or provision of telecommunicator CPR (TCPR).

METHODS AND RESULTS: We investigated non-traumatic out-of-hospital cardiac arrest occurring in a large metropolitan emergency medical system during a 6-month period. Information about bystander care was ascertained through review of the 9-1-1 recordings in addition to emergency medical system and hospital records to determine bystander CPR status (none versus TCPR versus unassisted), the number of bystanders on-scene, and CPR performance metrics of compression fraction and compression rate. Of the 428 eligible out-of-hospital cardiac arrest, 76.4% received bystander CPR including 43.7% unassisted CPR and 56.3% TCPR; 35.2% had one bystander, 33.3% had 2 bystanders, and 31.5% had ≥3 bystanders. Overall compression fraction was 59% with a compression rate of 88 per minute. CPR differed according to TCPR status (fraction=52%, rate=87 per minute for TCPR versus fraction=69%, rate=102 for unassisted CPR, $P<0.05$ for each comparison) and the number of bystanders (fraction=55%, rate=87 per minute for 1 bystander, fraction=59%, rate=89 for 2 bystanders, fraction=65%, rate=97 for ≥3 bystanders, test for trend $P<0.05$ for each metric). Additional bystander actions were uncommon to include rotation of compressors (3.1%) or application of an automated external defibrillator (8.0%).

CONCLUSIONS: Bystander CPR quality as gauged by compression fraction and rate approached guideline goals though performance depended upon the type of CPR and number of bystanders.

Key Words: dispatch-assisted cardiopulmonary resuscitation ■ out of hospital cardiac arrest ■ quality in health care ■ telecommunicator cardiopulmonary resuscitation

The prognosis of out-of-hospital cardiac arrest (OHCA) remains poor; overall survival is ≈10%.[1] Key strategies can improve survival.[1] These interdependent strategies are described as "the links in the chain of survival". The first 3 links are early recognition and activation of the Emergency Response System (emergency medical system [EMS]), early cardiopulmonary resuscitation (CPR), and rapid defibrillation. Collectively these interventions provide the best opportunity to improve OHCA survival.[2–4] Given the unexpected nature and out-of-hospital setting, these initial time-critical links typically rely on action by laypersons.

As the primary point of contact with the community in a medical emergency, the telecommunicator has an important role to help the bystander recognize OHCA, initiate CPR, and potentially retrieve and apply an automated external defibrillator (AED). Current practices have the telecommunicator ask about consciousness and breathing to identify

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CLINICAL PERSPECTIVE

What Is New?

- Assessing bystander cardiopulmonary resuscitation (CPR) quality gauged by compression fraction and compression rate.
- Bystander CPR performance depended upon the type of CPR and number of bystanders.

What Are the Clinical Implications?

- Bystander CPR quality can be ascertained through review of 9-1-1 recordings to determine compression fraction and compression rate.
- Telecommunicators may have opportunities to coach better CPR quality and early defibrillation and in turn improve prognosis.

Nonstandard Abbreviations and Acronyms

OHCA	out-of-hospital cardiac arrest
TCPR	telecommunicator CPR

potential arrest, provide instruction about patient and rescuer positioning, and then coach chest compressions via telecommunicator CPR (TCPR) instruction. Little is known about the characteristics of the bystanders or their CPR performance and potentially whether there are opportunities to improve care.[5–9] For example, care might be improved if multiple bystanders were available to rotate chest compressions or to retrieve an AED before EMS arrival. If bystander CPR performance is not optimal, telecommunicators may have opportunities to coach better CPR quality and in turn improve prognosis.[10–12]

We hypothesized that bystander scene characteristics were variable, associated with CPR performance, and may be amenable to telecommunicator intervention and coaching. The aim of this study was to describe bystander characteristics and CPR quality with the goal to identify opportunities where care might be improved.

METHODS

Data are available on request from the authors.

Study Design and Population

We conducted a retrospective cohort investigation of non-traumatic OHCA occurring in a large metropolitan EMS system in greater King County, WA during a 6-month period from January to June 2017. We a priori excluded OHCA that occurred after EMS arrival and cases that were not in cardiac arrest at the time of the 9-1-1 call. The study was approved by the appropriate Institutional Review Boards at Public Health—Seattle & King County and the University of Washington.

Study Setting and EMS System

The study involves a large metropolitan area that provides emergency medical response for 1.5 million people who reside in urban, suburban, and rural areas. Oversight for the EMS system is provided by the EMS Division of Public Health—Seattle & King County. EMS response is activated by calling 9-1-1 and connecting with an emergency communication center. The region is served by a 2-tiered EMS response system coordinated by 3 emergency communication centers. The first tier consists of fire engines or aid units staffed with firefighters who are trained in basic life support and are capable of providing defibrillation using automated or manual defibrillators. The second tier consists of emergency units staffed with paramedics who are trained in advanced life support care. In the case of a suspected cardiac arrest, first and second tier units are dispatched simultaneously and, upon scene arrival, follow the American Heart Association basic life support and advanced life support guidelines.[13]

Dispatch Program

Since 1989, the EMS has used Criteria Based Dispatch Guidelines to determine the level of EMS resource and provide pre-arrival instructions. The telecommunicator begins the call by determining the address of the event and obtaining and/or verifying a call-back number. In the study system, telecommunicators prioritize 2 questions to identify possible OHCA: (1) is the patient conscious? and (2) is the patient breathing normally? Consistent with guideline recommendations, if the patient is not conscious and not breathing normally,[14,15] then the dispatcher engages the caller to position the patient and begin CPR while activating the EMS response. TCPR instruction for adult arrest consists of chest compressions during which the telecommunicator coaches the rescuer to count out loud in cycles of 4 compressions (“1-2-3-4-1-2-3-4….”). Rescue breathing is reserved for pediatric OHCA or adult circumstances where there is a high suspicion of a primary respiratory mechanism (ie, drowning or strangulation). The telecommunicator attempts to stay on the line with the caller to provide support and coaching until EMS arrives in instances when TCPR instruction is provided and often when unassisted bystander CPR is ongoing.

Data Collection and Definitions

The study system has an established registry of all EMS-treated OHCA that is organized according to the Utstein template.[16] The registry uses information from the audio dispatch recording, the EMS report, the electronic defibrillator recording, and the hospital record. For the current study, we reviewed each 9-1-1 audio call using a uniform abstraction form to assess: (1) characteristics of bystanders (ie, the number at scene and relationship to the patient); (2) bystander actions (patient positioning, instruction relay, chest compressions unassisted or assisted by TCPR, bystanders alternate compressions, AED retrieval and/or application); and (3) timing of TCPR and bystander action (arrest recognition, chest compressions, chest compression interruption). We determined the compression fraction and compression rate for each case using the interval from call pick-up to call completion. A time stamp was recorded for each start and stop of compressions. During each compression interval, we counted the number of compressions for up to 30 seconds to provide an estimate of rate. A summary rate for each case was calculated by weighting each compression interval rate according to the duration of the compression interval. We conducted an assessment of inter-reviewer reliability involving chest compression count and rate in 30 cases. The intraclass correlation coefficient was 0.89 for CPR fraction (P<0.01) and 0.69 for compression rate (P<0.01). Appropriate Institutional Review Boards approved the investigation and with waiver of informed consent.

Clinical Outcomes

The primary outcomes were CPR quality as assessed by compression fraction and compression rate.

Statistical Analysis

Continuous data were expressed as mean±SD and categorical data were expressed as frequencies and percentages. We evaluated the bystander and OHCA characteristics according to bystander CPR status using either Student *t*-test for continuous variables or a χ^2 test for categorical variables. To test for trend among the number of bystanders we used the Cochran–Armitage test and the Kruskal–Wallis test for categorical and continuous variable, respectively. We evaluated whether CPR performance (rate and fraction) might be modified through an interaction between type-specific bystander CPR (unassisted versus TCPR) and bystander count (1 versus ≥2). For each of the CPR performance outcomes, we used linear regression modeling the CPR performance metric as the outcome with the predictors of (1) type-specific bystander CPR (unassisted or instructed CPR), (2) the bystander count (1 versus ≥2) and (3) an interaction term between type-specific bystander CPR and the number of rescuers.

All analyses were 2-sided and a P value of <0.05 was considered statistically significant. Statistical analysis was performed using R studio software including the R version 3.6.3 (R Development Core Team [2019]. R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

During the study period, 453 OHCA occurred before EMS arrival. Of these, 25 (5.5%) were not in cardiac arrest at the outset of the call and were excluded (Figure 1). Among the eligible cohort (n=428), 23.6% of OHCA received no bystander CPR, 42.9% received TCPR, and 33.4% received unassisted bystander CPR (without telecommunicator assistance). Overall, patients were on average 62.9 (±16.6) years, 31.5% were women, and 36.2% had documented cardiac comorbidities. OHCA occurred most often at home (66.6%). The OHCA was attended by 1 rescuer in 39.3%, 2 rescuers in 30.4%, and ≥3 rescuers 29.4%. Those who received bystander CPR had on average more bystanders on scene, were more likely to present with shockable rhythm, and survive with normal functional status (Table 1).

Compared with OHCA with TCPR, the unassisted bystander CPR group had more bystanders on scene (Table 2). Among the TCPR group, the telecommunicator recognized the arrest on average 77 seconds after the call receipt, and first compression occurred 147 seconds after call receipt. Compared with the TCPR group, the unassisted bystander CPR group was associated with a greater compression fraction (69% versus 52%, P<005) and compression rate (101 versus 87 per minute, P<0.05). The proportion where an AED was retrieved or applied was greater in the unassisted versus the TCPR group.

When stratified by the number of bystanders on scene, we observed that the CPR fraction and compression rate increased as the number of bystanders increased (P<0.05 test for trend for fraction and rate, respectively) (Table 3). The proportion of cases where bystanders rotated compressors or retrieved or applied an AED increased as the number of rescuers increased (Table 3).

We observed an interaction with regard to CPR fraction between the type of CPR (TCPR versus unassisted) and the number of rescuers (1 versus ≥2) (P=0.04 for interaction) (Figure 2). The CPR fraction was not different according to the number of bystanders among the TCPR group (CPR fraction 53% for 1 bystander versus 50% for ≥2 bystander). In contrast, we observed that CPR fraction was greater when there was >1 bystander among the unassisted CPR group (CPR fraction 60% for 1 bystander versus 71% for ≥2

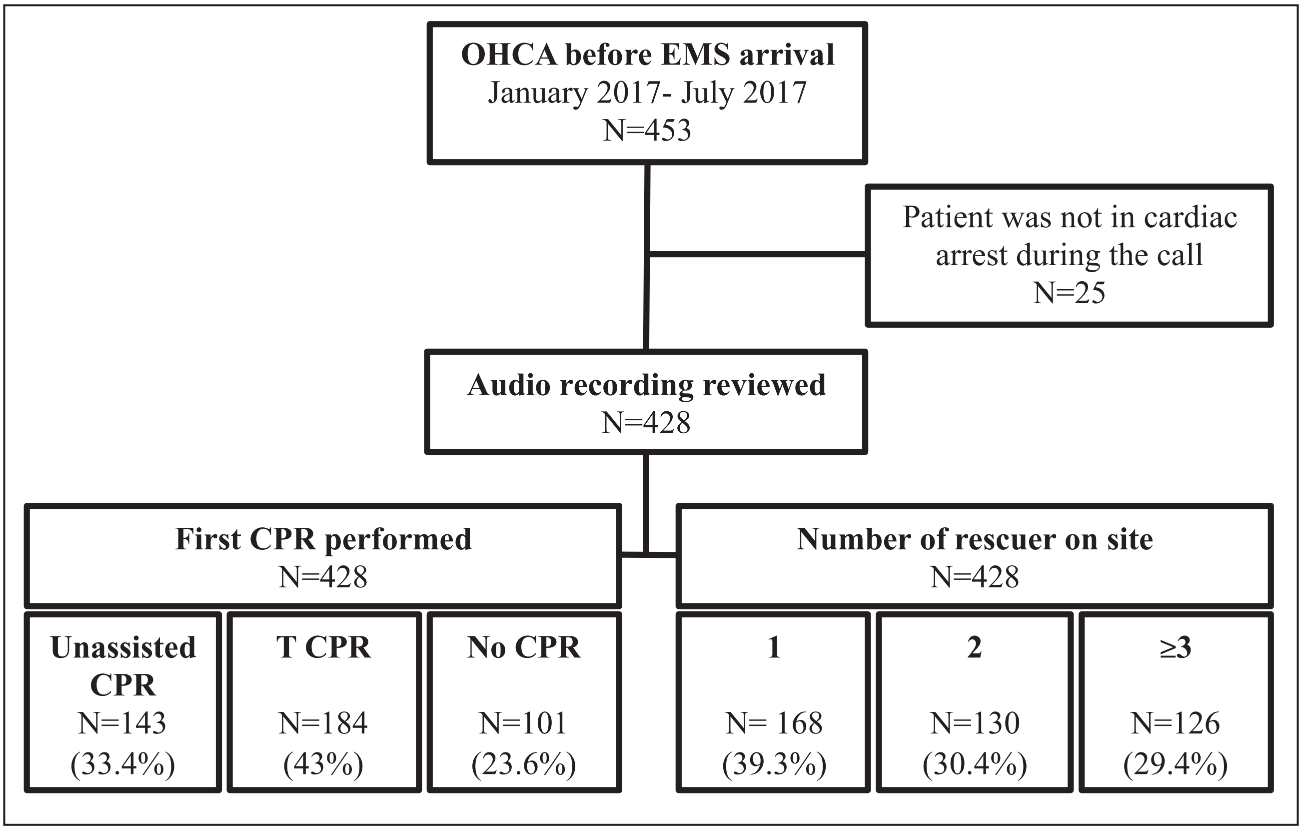

Figure 1. Flow diagram: bystander cardiopulmonary resuscitation according to telephone cardiopulmonary resuscitation and bystander count.
CPR indicates cardiopulmonary resuscitation; EMS, emergency medical service; and OHCA, out-of-hospital cardiac arrest; TCPR, telecommunicator CPR. TCPR instruction for adult arrest consists of chest compressions during which the telecommunicator coaches the rescuer on the compression rate and to count out loud with each compression.

bystander). With regard to compression rate, we observed a similar pattern: 86 for 1 rescuer versus 87 for ≥2 rescuers among the TCPR group and 92 for 1 rescuer versus 105 for ≥2 rescuers among the unassisted group, though the test for interaction was not statistically significant (P=0.07).

DISCUSSION

In this population-based cohort investigation of OHCA, bystander CPR was initiated in three fourths of OHCA before arrival of EMS. Of those receiving CPR, over half involved TCPR and nearly two thirds had ≥2 rescuers. Overall the estimated bystander CPR fraction was 59% and the rate was 88 compressions per minute, and varied according to the need for instruction and the number of bystanders. Additional bystander actions such as rotation of the compressor or AED retrieval/application were uncommon. Collectively, the results describe the quality of bystander CPR and highlight the potential to improve bystander involvement in OHCA resuscitation.

We observed a high rate of bystander CPR due in part to the assertive efforts of the telecommunicators who were involved in over half of bystander CPR. Overall bystander CPR was more likely to occur when there were multiple rescuers. Over half of rescuers were family members, perhaps expected given that two thirds of OHCA occurred in a personal residence. Consistent with prior investigation, bystander CPR was associated with better functional survival.[17,18] Overall we observed a CPR fraction of 59% and compression rate of 88 per minute. Although these measures fall short of guideline recommendations, they are encouraging. These results approach bystander CPR performance in (mostly) public settings where an AED is deployed sometimes with CPR feedback features.[19–21] The current study includes all cases of bystander CPR regardless of bystander AED application, so likely a much larger and more generalizable OHCA experience. The findings suggest that the messaging to prioritize compressions and emphasize “push hard, push fast, don’t stop” may be an effective strategy.

The study investigated how CPR performance and rescuer action may depend upon the need for TCPR and the number of on-scene bystanders. We observed TCPR achieved guideline benchmarks with regard to timely arrest recognition and compression initiation.[22] TCPR

Table 1. Characteristics and Outcomes According to Bystander CPR Group

	Overall	No CPR	Bystander CPR	
	n=428	n=101	n=327	*P* Value
Type of first CPR, n (%)				
TCPR	184 (43)	…	184 (56.3)	
Unassisted	143 (33.4)	…	143 (43.7)	
No. of rescuers at scene, n (%)				<0.001
0	4 (0.9)	4 (4)	0 (0)	
1	168 (39.3)	53 (52.5)	115 (35.2)	
2	130 (30.4)	21 (20.8)	109 (33.3)	
3+	126 (29.4)	23 (22.8)	103 (31.5)	
Recording measures, mean (SD)*				
Total elapsed sec recorded	323 (148)	298 (147)	332 (147)	0.046
Elapsed sec of CPR done	…	…	191 (113)	…
CPR fraction	…	…	59%(24)	…
CC frequency weighted, CC/min	…	…	90 (22)	…
Rescue breathing, n (%)	…	…	15 (5)	
Clinical characteristics				
Age, mean y (SD)	62.9 (16.6)	63.7 (16.8)	62.6 (16.5)	0.565
Men, n (%)	299 (69.8)	69 (62.4)	230 (70.3)	0.167
Cardiac history, n (%)	155 (36.2)	38 (37.6)	117 (35.8)	0.091
Cancer history, n (%)	32 (7.5)	4 (4)	28 (8.6)	0.046
Diabetes mellitus history, n (%)	103 (24.1)	27 (26.7)	76 (23.2)	0.044
HBP history, n (%)	110 (25.7)	25 (24.8)	85 (26)	0.156
Renal disease history, n (%)	44 (10.3)	6 (5.9)	38 (11.6)	0.042
Respiratory disease history, n (%)	54 (12.6)	16 (15.8)	38 (11.6)	0.033
Stroke history, n (%)	23 (5.4)	4 (4)	19 (5.8)	0.091
Cardiac arrest characteristics and system factors				
Location (detail), n (%)				0.12
Assisted living facility	65 (15.2)	12 (11.9)	43 (13.2)	
Home	285 (66.6)	68 (67.3)	217 (66.4)	
Public location	78 (18.2)	21 (20.8)	57 (17.4)	
Initial shockable rhythm, n (%)	130 (30.4)	24 (23.8)	106 (32.4)	0.02
Witnessed collapse, n (%)	221 (51.6)	55 (54.5)	166 (50.8)	0.526
First pre-EMS CPR provider, n (%)				
Layperson family	165 (38)	…	165 (50.4)	
Layperson other	115 (26.9)	…	115 (35.1)	
Layperson professional†	45 (10.5)	…	45 (13.8)	
Police	2 (0.01)	…	2 (0.6)	
None	101 (23.6)	101 (100)	…	
BLS response time, min (SD)	5.1 (2.3)	5.1 (2.4)	5.0 (2.2)	0.755
ALS response time, min (SD)	8.7 (5)	8.5 (4.6)	8.9 (5.2)	0.524
Outcomes				
Survival at hospital discharge, n (%)	88 (20.6)	18 (17.8)	70 (21.4)	0.04
CPC 1–2 scale, n (%)	83 (19.4)	17 (16.8)	66 (20.1)	0.04

Cardiopulmonary resuscitation fraction means the proportion of time during bystander phase of the arrest during which cardiopulmonary resuscitation is performed. ALS indicates advanced life support; BLS, basic life support; CA, cardiac arrest; CC, chest compressions; CPC, cerebral performance category; CPR, cardiopulmonary resuscitation; EMS, emergency medical service; HBP, high blood pressure; and TCPR, telecommunicator CPR.

*Duration expressed in seconds (SD).

†Doctor, nurse, registered nurse, off-duty emergency medical service officer.

Table 2. CPR Characteristics According to the Type of Bystander CPR

	TCPR n=184	Unassisted CPR n=143	*P* Value
No. of rescuers at scene, n (%)			<0.01
1	89 (48.3)	26 (18.2)	
2	68 (37)	41 (28.7)	
3+	27 (14.7)	76 (53.1)	
Recording measures, mean (SD)*			
Total elapsed sec recorded	382 (123)	267 (152)	<0.01
Elapsed sec CPR done	203 (116)	174 (107)	0.02
Elapsed sec to CA recognition	77 (63)	…	…
Elapsed sec to give CC instruction	147 (85)	…	…
CPR fraction (%)†	52 (20)	69 (26)	<0.01
CC frequency average	87 (20)	101 (25)	<0.01
Rescuers' actions heard or reported on the recording, n (%)			
Moved the patient	166 (90.2)	49 (34.3)	<0.01
Alternated CC	5 (2.7)	5 (3.5)	0.07
Retrieved an AED	1 (0.5)	7 (4.9)	0.02
Applied an AED	6 (3.3)	20 (14)	0.01

*CPR fraction means the proportion of time during bystander phase of the arrest during which CPR is performed. AED indicates automated external defibrillator; CA, cardiac arrest; CC, chest compressions; CPR, cardiopulmonary resuscitation; and TCPR, telecommunicator CPR.

†Mean (SD) of percentage.

did not on average achieve the same quality metrics as unassisted bystander CPR (fraction of 52% versus 69% and rate of 87 versus 101 per minute). These differences might be expected given the need for telecommunicator OHCA identification, instruction, and coaching. Although the difference in fraction may be challenging to overcome, the telecommunicator may be able to influence bystander compression rate with active coaching or background metronome. The performance differences also support conventional bystander training as a means to prepare bystanders to deliver high quality CPR.

We observed that 60% of OHCA had ≥2 rescuers on scene, similar to prior reports.[23] Multiple rescuers were most common during unassisted CPR (82%), followed by TCPR (52%), and least common when no CPR was performed (44%). Multiple rescuers were associated with higher quality CPR performance in a dose-dependent manner such that average fraction and rate increased as the number of rescuers increased from 1, to 2, to ≥3 bystanders. The dose-dependent relationship appeared to be specific to the unassisted CPR circumstance where fraction and rate increased with rescuer count but not among TCPR group, again suggesting that the telecommunicator may control compression performance (Figure 2).

The presence of multiple rescuers provides the potential for additional rescuer actions such as rotating compressors or retrieving/applying an AED, actions which could potentially improve CPR performance and OHCA outcome. Overall we observed a low rate of these actions (each <10% overall), though they did increase modestly as the number of bystanders increased. Given that the majority of OHCA had >1 rescuer and low rate of these ancillary actions, one strategy to improve care might be to consider if and how rescuers might rotate compressions or access an AED. The feasibility of such an extended strategy will depend upon the ability for bystanders to rotate compressions efficiently and just-in-time availability of an AED. The latter will require accurate, real-time information about the location and accessibility of AEDs. In many instances, the telecommunicator will be integral to coordinating these additional actions.

Table 3. CPR Characteristics According to Number of Bystanders

	1 115	2 109	3+ 103	*P* for Trend
Recording measures, mean (SD)				
Total elapsed sec recorded	378 (136)	332 (156)	280 (133)	<0.01
Elapsed sec of CPR done	209 (120)	190 (112)	170 (103)	0.04
CPR fraction (%)*	55 (21)	59 (23)	65 (27)	<0.01
CC frequency average	87 (19)	89 (21)	97 (26)	0.02
Rescuers' actions heard or reported during the recording, n (%)				
Moved the patient	93 (80.9)	85 (65.4)	53 (42.1)	<0.01
Alternated CC	0 (0)	2 (1.8)	6 (5.8)	<0.01
Retrieved an AED	1 (0.9)	2 (1.8)	5 (4.9)	0.05
Applied an AED	5 (4.3)	7 (6.4)	14 (13.6)	<0.01

Cardiopulmonary resuscitation fraction means the proportion of time during bystander phase of the arrest during which CPR is performed; ≥3 or <3 rescuers at the scene. AED indicates automated external defibrillator; CC, chest compressions; and CPR, cardiopulmonary resuscitation.

*Mean (SD) of percentage.

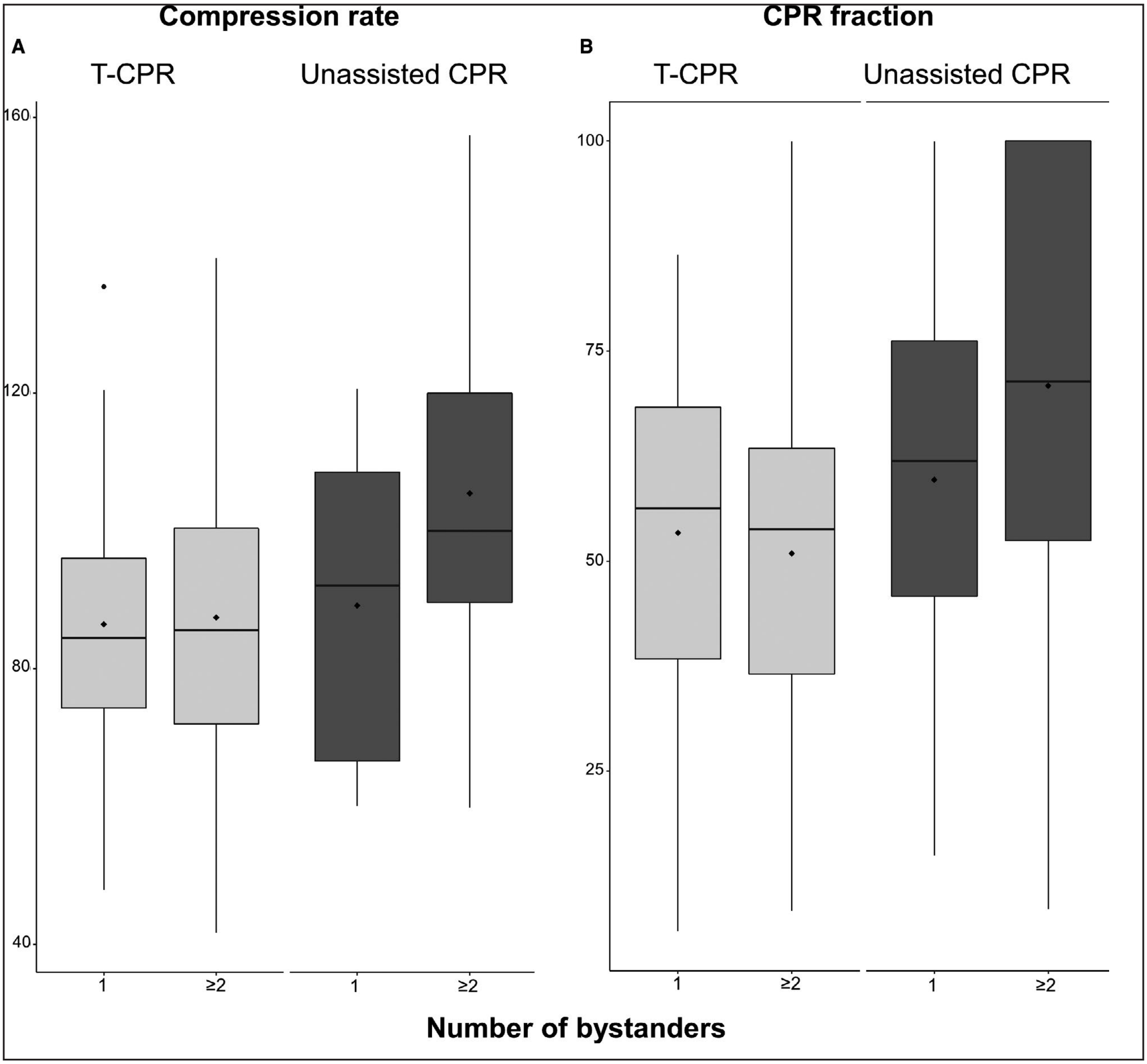

Figure 2. Cardiopulmonary resuscitation fraction and compression rate by the type of bystander cardiopulmonary resuscitation and the number of rescuers at the scene.

Inside each box plot the dot represents the mean and the line represent the median. Cardiopulmonary resuscitation fraction means the proportion of time during bystander phase of the arrest during which cardiopulmonary resuscitation is performed. CPR indicates cardiopulmonary resuscitation; EMS, emergency medical system; OHCA, out-of-hospital cardiac arrest; and TCPR, telecommunicator CPR.

Limitations

The study has limitations. Audio recordings provide incomplete information, potentially producing inaccurate or missing data. For instance, ascertainment of the number of rescuers relied on listening to the call to understand who was involved in the resuscitation. There is potential that the study may have underestimated the number of rescuers given the modality to ascertain bystander count. The resulting misclassification would likely attenuate the true relationships such that the dose-relationship may be even stronger than what was observed. We were only able to assess CPR fraction and compression rate but not compression depth and release using audio, appreciating that these metrics were an imperfect calculation that relied on audio recording. The audio approach, however, is not restricted to the modest proportion of OHCA that capture bystander CPR via AED recording that can occur with a public access AED. Thus the current investigation enables comprehensive case inclusion and hence is likely more generalizable. There was a low prevalence of rescue breathing highlighting the emphasis on chest compressions in current training programs. An experience with higher proportion of rescue breathing could observe different results about CPR performance. The study did not undertake a comprehensive assessment of predictors of bystander CPR performance but rather focused on a-priori exposures of type-specific bystander CPR and rescuer count. We cannot comment for example on whether the age or sex profiles of the rescuer(s) or patients influenced CPR performance. The study took place in a large metropolitan system with a longstanding OHCA registry and program of evaluation so it may differ from other communities, though many of the patient and treatment characteristics are similar to other reports.

CONCLUSIONS

In this population-based investigation of bystander CPR, CPR quality as gauged by compression fraction and compression rate indicated measurable performance that overall approached guideline benchmarks. Bystander CPR performance was associated with the type of CPR—TCPR or unassisted—and the number of bystanders. Additional bystander actions to rotate compressors or deliver an AED were uncommon, even when there were multiple rescuers. The findings help characterize the status of the essential link of early CPR and suggest opportunities for how CPR quality and early defibrillation may be improved.

ARTICLE INFORMATION

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Disclosures

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REFERENCES

1. Benjamin EJ, Muntner P, Alonso A, Bittencourt MS, Callaway CW, Carson AP, Chamberlain AM, Chang AR, Cheng S, Das SR, et al. Heart disease and stroke statistics—2019 update: a report from the American Heart Association. *Circulation*. 2019;139:e56–e528. DOI: 10.1161/CIR.0000000000000659.
2. Nakashima T, Noguchi T, Tahara Y, Nishimura K, Yasuda S, Onozuka D, Iwami T, Yonemoto N, Nagao K, Nonogi H, et al. Public-access defibrillation and neurological outcomes in patients with out-of-hospital cardiac arrest in Japan: a population-based cohort study. *Lancet*. 2020;394:2255–2262. DOI: 10.1016/S0140-6736(19)32488-2.
3. Kobayashi D, Kitamura T, Kiyohara K, Nishiyama C, Hayashida S, Matsuyama T, Katayama Y, Shimamoto T, Kiguchi T, Okabayashi S, et al. Cardiopulmonary resuscitation performed by off-duty medical professionals versus laypersons and survival from out-of-hospital cardiac arrest among adult patients. *Resuscitation*. 2019;135:66–72. DOI: 10.1016/j.resuscitation.2019.01.005.
4. Bækgaard JS, Viereck S, Møller TP, Ersbøll AK, Lippert F, Folke F. The effects of public access defibrillation on survival after out-of-hospital cardiac arrest: a systematic review of observational studies. *Circulation*. 2017;136:954–965. DOI: 10.1161/CIRCULATIONAHA.117.029067.
5. Derkenne C, Jost D, Thabouillot O, Briche F, Travers S, Frattini B, Lesaffre X, Kedzierewicz R, Roquet F, de Charry F, et al. Improving emergency call detection of Out-of-Hospital Cardiac Arrests in the Greater Paris area: efficiency of a global system with a new method of detection. *Resuscitation*. 2020;146:34–42. DOI: 10.1016/j.resuscitation.2019.10.038.
6. Seyed Bagheri SM, Sadeghi T, Kazemi M, Esmaeili NA. Dispatcher-assisted bystander cardiopulmonary resuscitation (telephone-CPR) and outcomes after out of hospital cardiac arrest. *Bull Emerg Trauma*. 2019;7:307–313. DOI: 10.29252/beat-070315.
7. Hatakeyama T, Kiguchi T, Kobayashi D, Nakamura N, Nishiyama C, Hayashida S, Kiyohara K, Kitamura T, Kawamura T, Iwami T. Effectiveness of dispatcher instructions-dependent or independent bystander cardiopulmonary resuscitation on neurological survival among patients with out-of-hospital cardiac arrest. *J Cardiol*. 2020;75:315–322. DOI: 10.1016/j.jjcc.2019.08.007.
8. Shibahashi K, Ishida T, Kuwahara Y, Sugiyama K, Hamabe Y. Effects of dispatcher-initiated telephone cardiopulmonary resuscitation after out-of-hospital cardiac arrest: a nationwide, population-based, cohort study. *Resuscitation*. 2019;144:6–14. DOI: 10.1016/j.resuscitation.2019.08.031.
9. Hagihara A, Onozuka D, Shibuta H, Hasegawa M, Nagata T. Dispatcher-assisted bystander cardiopulmonary resuscitation and survival in out-of-hospital cardiac arrest. *Int J Cardiol*. 2018;265:240–245. DOI: 10.1016/j.ijcard.2018.04.067.
10. Rea TD, Eisenberg MS, Culley LL, Becker L. Dispatcher-assisted cardiopulmonary resuscitation and survival in cardiac arrest. *Circulation*. 2001;104:2513–2516. DOI: 10.1161/hc4601.099468.
11. Lewis M, Stubbs BA, Eisenberg MS. Dispatcher-assisted cardiopulmonary resuscitation: time to identify cardiac arrest and deliver chest compression instructions. *Circulation*. 2013;128:1522–1530. DOI: 10.1161/CIRCULATIONAHA.113.002627.
12. Dameff C, Vadeboncoeur T, Tully J, Panczyk M, Dunham A, Murphy R, Stolz U, Chikani V, Spaite D, Bobrow B. A standardized template for measuring and reporting telephone pre-arrival cardiopulmonary resuscitation instructions. *Resuscitation*. 2014;85:869–873. DOI: 10.1016/j.resuscitation.2014.02.023.
13. Panchal AR, Berg KM, Cabañas JG, Kurz MC, Link MS, Del Rios M, Hirsch KG, Chan PS, Hazinski MF, Morley PT, et al. 2019 American Heart Association focused update on systems of care: dispatcher-assisted cardiopulmonary resuscitation and cardiac arrest centers: an update to the American Heart Association Guidelines for Cardiopulmonary Resuscitation and Emergency Cardiovascular Care. *Circulation*. 2019;140:e895–e903. DOI: 10.1161/CIR.0000000000000733.
14. Debaty G, Labarere J, Frascone RJ, Wayne MA, Swor RA, Mahoney BD, Domeier RM, Olinger ML, O'Neil BJ, Yannopoulos D, et al. Long-term prognostic value of gasping during out-of-hospital cardiac arrest. *J Am Coll Cardiol*. 2017;70:1467–1476. DOI: 10.1016/j.jacc.2017.07.782.
15. Noel L, Jaeger D, Baert V, Debaty G, Genin M, Sadoune S, Bassand A, Tazarourte K, Gueugniaud P-Y, El Khoury C, et al. Effect of bystander CPR initiated by a dispatch centre following out-of-hospital cardiac arrest on 30-day survival: adjusted results from the French National Cardiac Arrest Registry. *Resuscitation*. 2019;144:91–98. DOI: 10.1016/j.resuscitation.2019.08.032.
16. Perkins GD, Jacobs IG, Nadkarni VM, Berg RA, Bhanji F, Biarent D, Bossaert LL, Brett SJ, Chamberlain D, de Caen AR, et al. Cardiac arrest and cardiopulmonary resuscitation outcome reports: update of the Utstein Resuscitation Registry Templates for Out-of-Hospital Cardiac Arrest: a statement for healthcare professionals from a Task Force of the International Liaison Committee on Resuscitation (American Heart Association, European Resuscitation Council, Australian and

New Zealand Council on Resuscitation, Heart and Stroke Foundation of Canada, InterAmerican Heart Foundation, Resuscitation Council of Southern Africa, Resuscitation Council of Asia); and the American Heart Association Emergency Cardiovascular Care Committee and the Council on Cardiopulmonary, Critical Care, Perioperative and Resuscitation. *Circulation*. 2015;132:1286–1300. DOI: 10.1161/CIR.0000000000000144.
17. Pollack RA, Brown SP, Rea T, Aufderheide T, Barbic D, Buick JE, Christenson J, Idris AH, Jasti J, Kampp M, et al. Impact of bystander automated external defibrillator use on survival and functional outcomes in shockable observed public cardiac arrests. *Circulation*. 2018;137:2104–2113. DOI: 10.1161/CIRCULATIONAHA.117.030700.
18. 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;3:63–81. DOI: 10.1161/CIRCOUTCOMES.109.889576.
19. Rea TD, Stickney RE, Doherty A, Lank P. Performance of chest compressions by laypersons during the Public Access Defibrillation Trial. *Resuscitation*. 2010;81:293–296. DOI: 10.1016/j.resuscitation.2009.12.002.
20. Fernando SM, Vaillancourt C, Morrow S, Stiell IG. Analysis of bystander CPR quality during out-of-hospital cardiac arrest using data derived from automated external defibrillators. *Resuscitation*. 2018;128:138–143. DOI: 10.1016/j.resuscitation.2018.05.012.
21. Gyllenborg T, Granfeldt A, Lippert F, Riddervold IS, Folke F. Quality of bystander cardiopulmonary resuscitation during real-life out-of-hospital cardiac arrest. *Resuscitation*. 2017;120:63–70. DOI: 10.1016/j.resuscitation.2017.09.006.
22. Kurz MC, Bobrow BJ, Buckingham J, Cabanas JG, Eisenberg M, Fromm P, Panczyk MJ, Rea T, Seaman K, Vaillancourt C; American Heart Association Advocacy Coordinating Committee. Telecommunicator cardiopulmonary resuscitation: a policy statement from the American Heart Association. *Circulation*. 2020;141:e686–e700. DOI: 10.1161/CIR.0000000000000744.
23. Takei Y, Nishi T, Matsubara H, Hashimoto M, Inaba H. Factors associated with quality of bystander CPR: the presence of multiple rescuers and bystander-initiated CPR without instruction. *Resuscitation*. 2014;85:492–498. DOI: 10.1016/j.resuscitation.2013.12.019.