Effect of Dispatcher-Assisted Cardiopulmonary Resuscitation Program and Location of Out-of-Hospital Cardiac Arrest on Survival and Neurologic Outcome

Young Sun Ro, MD, DrPH; Sang Do Shin, MD, PhD*; Yu Jin Lee, MD; Seung Chul Lee, MD, PhD; Kyoung Jun Song, MD, PhD; Hyun Wook Ryoo, MD, PhD; Marcus Eng Hock Ong, MD; Bryan McNally, MD, MPH; Bentley Bobrow, MD; Hideharu Tanaka, MD; Helge Myklebust, BEng; Tonje Søraas Birkenes, PhD

*Corresponding Author. E-mail: Shinsangdo@gmail.com.

Study objective: We study the effect of a nationwide dispatcher-assisted cardiopulmonary resuscitation (CPR) program on out-of-hospital cardiac arrest outcomes by arrest location (public and private settings).

Methods: All emergency medical services (EMS)–treated adults in Korea with out-of-hospital cardiac arrests of cardiac cause were enrolled between 2012 and 2013, excluding cases witnessed by EMS providers and those with unknown outcomes. Exposure was bystander CPR categorized into 3 groups: bystander CPR with dispatcher assistance, bystander CPR without dispatcher assistance, and no bystander CPR. The endpoint was good neurologic recovery at discharge. Multivariable logistic regression analysis was performed. The final model with an interaction term was evaluated to compare the effects across settings.

Results: A total of 37,924 patients (31.1% bystander CPR with dispatcher assistance, 14.3% bystander CPR without dispatcher assistance, and 54.6% no bystander CPR) were included in the final analysis. The total bystander CPR rate increased from 30.9% in quarter 1 (2012) to 55.7% in quarter 4 (2014). Bystander CPR with and without dispatcher assistance was more likely to result in higher survival with good neurologic recovery (4.8% and 5.2%, respectively) compared with no bystander CPR (2.1%). The adjusted odds ratios for good neurologic recovery were 1.50 (95% confidence interval [CI] 1.30 to 1.74) in bystander CPR with dispatcher assistance and 1.34 (95% CI 1.12 to 1.60) in bystander CPR without it compared with no bystander CPR. For arrests in private settings, the adjusted odds ratios were 1.58 (95% CI 1.30 to 1.92) in bystander CPR with dispatcher assistance and 1.28 (95% CI 0.98 to 1.67) in bystander CPR without it; in public settings, the adjusted odds ratios were 1.41 (95% CI 1.14 to 1.75) and 1.37 (95% CI 1.08 to 1.72), respectively.

Conclusion: Bystander CPR regardless of dispatcher assistance was associated with improved neurologic recovery after out-of-hospital cardiac arrest. However, for out-of-hospital cardiac arrest cases in private settings, bystander CPR was associated with improved neurologic recovery only when dispatcher assistance was provided. [Ann Emerg Med. 2016;■:1-10.]

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0196-0644/$-see front matter

http://dx.doi.org/10.1016/j.annemergmed.2016.07.028

INTRODUCTION

Background

Out-of-hospital cardiac arrest, with high incidence and low survival rate, is one of the most important public health issues.[1-3] Emergency medical services (EMS) aim to respond to dispatch calls as timely as possible, and despite efforts to improve response times, they cannot respond immediately to all cardiac arrest cases because of high call volumes or traffic congestion.[4] Therefore, there is a need to increase the rate of bystander cardiopulmonary resuscitation (CPR), one of the key components in the chain of survival, to provide early CPR before EMS arrival.[5]

A dispatcher-assisted CPR program enables a layperson to perform CPR; dispatchers instruct untrained bystanders to remove barriers and start CPR and assist trained bystanders in recalling CPR procedure and promote proper chest compression.[6-8] Implementation of dispatcher-assisted CPR programs increases bystander CPR rates and improves outcomes after out-of-hospital cardiac arrest.[5,9-11] For successful implementation, standardized dispatcher

Editor's Capsule Summary

What is already known on this topic

By providing instructions over the telephone, emergency medical dispatchers can facilitate bystander cardiopulmonary resuscitation (CPR) for victims of sudden cardiac arrest.

What question this study addressed

How does dispatcher-assisted bystander CPR affect outcomes when out-of-hospital cardiac arrest occurs in public versus private settings?

What this study adds to our knowledge

Among 37,924 cardiac arrests, dispatcher-assisted CPR was associated with an increase of bystander CPR from 31% to 56%. Bystander CPR in public settings was associated with increased odds of good neurologic recovery, but in private settings only if also associated with dispatcher assistance.

How this is relevant to clinical practice

The study emphasizes the importance of providing instructions to facilitate bystander CPR before emergency medical services arrival, especially when the victim is in a private setting and even when the bystander might have CPR training.

education and quality assurance processes should be included in the programs.[5] Some EMS systems have already adopted these programs and reported increased bystander CPR rates within a relatively short time.[12] However, characteristics of bystanders who provide CPR, such as age, sex, and previous CPR training, may influence outcomes for patients with out-of-hospital cardiac arrest.[13,14] One proxy factor that characterizes bystanders is the arrest location.

Approximately two thirds of out-of-hospital cardiac arrests occur in private settings and have lower survival rates than those in public ones.[2,3] Previous studies show that multiple bystanders are more likely to be present at public places and to be younger, whereas bystanders at home are more likely to be alone, older, and female members of the family.[15-17] Furthermore, strangers in public places are more likely to perform CPR than family members are.[16-19] No studies comparing the effects of dispatcher-assisted CPR on bystander CPR rate and survival outcomes of out-of-hospital cardiac arrests between private and public arrest locations have been reported, to our knowledge.

We hypothesize that providing CPR instructions by telephone is correlated with an increased frequency of bystander CPR for cardiac arrest victims. Bystander CPR with and without dispatcher assistance was associated with improved survival outcomes of out-of-hospital cardiac arrests, and the effect size would be larger if the arrests were to occur in a private rather than public setting.

MATERIALS AND METHODS

This study was approved by the institutional review boards of the Seoul National University Hospital and the Korea Centers for Disease Control and Prevention.

Study Design and Setting

This was a cross-sectional study using a nationwide prospective EMS out-of-hospital cardiac arrest registry in Korea. The EMS level is basic to intermediate, in which the most qualified emergency medical technicians (EMTs) can perform CPR with an automated external defibrillator, evaluate cardiac rhythms on site, manage advanced airway, and administer intravenous fluids. EMS providers cannot stop CPR unless the patient regains a pulse in the field or during transport to an emergency department (ED); all EMS-assessed patients are therefore transported to the nearest hospital. Sixteen provincial fire departments operate a single-tiered and fire-based EMS system. Fifteen provinces operate a single, unified, province-based central dispatch center, whereas 1 province operates agency-based dispatch centers (N=35). Every dispatch center has 2 levels of dispatchers; primary call dispatchers are charged with detecting out-of-hospital cardiac arrests and handing over the call to medical control dispatchers, who provide CPR instructions. Most primary call dispatchers are firefighters, whereas medical control dispatchers are either EMTs or nurses.[20] Medical directors supervise the quality of medical control dispatcher–provided CPR instructions.

A strict, nationwide, quality assurance program for EMS was established in 2011 for 4 major emergency conditions: out-of-hospital cardiac arrest, severe trauma, acute myocardial infarction, and acute stroke. The program now provides feedback to the provincial fire departments, EMS agencies, and individual EMTs. Every year, all EMTs are required to fulfill 20 hours of continuing education to maintain relevant medical skills and knowledge in accordance with the Rescue and Fire EMS Act.

There are approximately 460 EDs in the country, which are designated by the Ministry of Health and Welfare as Levels I through III according to capacity and resource measures, including staffing, equipment, and size of the department. Twenty Level I and 110 Level II EDs provide the highest level of emergency care services in the country.

Every ED is required by the EMS Act to participate in a nationwide performance evaluation program administered by the Ministry of Health and Welfare.[21] Additionally, there are EDs in small hospitals that provide lower levels of service and are not formally designated by the government as EDs.

The public access defibrillator program was approved by the national assembly in 2008, and the first automated external defibrillators were installed in 2010. However, only a small number of them are currently deployed in public places, and bystanders rarely used them in the current study setting.

In 2010, Seoul Fire Department, which is one of the largest provinces in the country, implemented the dispatcher-assisted CPR program and observed improvements in CPR outcomes and in the bystander CPR rate.[14,20] In October 2011, the National Emergency Management Agency (the national fire department) decided to expand the program to all provincial fire departments and implemented a nationwide dispatcher-assisted CPR program. All dispatch centers set up a program for detecting out-of-hospital cardiac arrest, instructing bystander CPR by telephone, and reporting the process. Details of dispatcher education programs and quality assurance processes for the dispatcher-assisted CPR program were developed separately by the provincial fire departments.

The program was based on the 2010 American Heart Association guidelines,[22] which included 2 simplified key questions for detecting out-of-hospital cardiac arrest (altered mental status and abnormal breathing) and structured dialogue for providing high-quality bystander CPR.[5]

Education programs for dispatchers were actively implemented through the dispatcher-assisted CPR course developed in 2011 by the Pan-Asian Resuscitation Outcomes Study Network of the Asian EMS Council, investigators of the Cardiac Arrest Registry to Enhance Survival in the United States, investigators of the Save Hearts in Arizona Registry and Education in Arizona, and Laerdal Medical.[9,23] The education program included didactic sessions for dispatcher-assisted CPR, interactive skill sessions, and direct feedback. More than 90% of dispatchers completed the course by 2011. After the in-class courses were delivered, all dispatchers received refresher training through a Web-based self-learning program that was developed by the Foundation for International Emergency Medicine Education and translated into Korean (see http://www.fiercecert.com/dispatch-cpr-training-module1.html).

An electronic dispatcher CPR registry was developed and implemented in all dispatch centers. All cases identified by primary call dispatchers as potential out-of-hospital cardiac arrest were recorded in the registry by the medical control dispatchers. The registry was also used for quality assurance purposes. Every dispatch center is supervised by a dispatch medical director who is a part-time emergency physician certified as a medical director by the Ministry of Health and Welfare. Medical directors were encouraged to manually review more than 10% of all dispatcher-assisted CPR audio recordings and provide regular feedback to the dispatchers to further improve the quality of the dispatcher-assisted CPR program.[9] Senior medical control dispatchers were encouraged to review the dispatcher CPR registry to increase the detection rate of out-of-hospital cardiac arrest, reduce protocol violations, and maintain the quality of the dispatcher-assisted CPR processes.

Selection of Participants

All adults who were aged 18 years or older and had out-of-hospital cardiac arrests with presumed cardiac cause between January 2012 and December 2014 were included. Patients were excluded from analysis if they did not receive resuscitative attempts and if the arrests were witnessed by EMS providers or occurred at primary care clinics or long-term care facilities. Cases with missing information on bystander CPR, arrest location, or neurologic outcomes at discharge were also excluded.

Data Collection and Processing

Data were retrieved from the following sources: EMS run sheets for basic ambulance operation information, EMS cardiac arrest registry and dispatcher CPR registry for the Utstein factors,[24,25] and the national out-of-hospital cardiac arrest registry for hospital care and outcomes, which is extracted from hospital medical records by the Korea Centers for Disease Control and Prevention.[20]

EMS run sheets are electronically stored in individual provincial EMS headquarters operated by the national fire department.[3] EMTs enter data in the EMS cardiac arrest registry for all EMS-transported out-of-hospital cardiac arrests, and medical control dispatchers enter data in the dispatcher CPR registry for all potential out-of-hospital cardiac arrest cases identified by the primary call dispatchers. All EMS registries for each patient are linked with ambulance dispatch numbers in the national fire department's electronic database server and are integrated as a single episode.

The Korea Centers for Disease Control and Prevention performed medical record review of all out-of-hospital cardiac arrest patients transported by EMS to hospitals (460 EDs and 140 undesignated EDs) using the abovementioned EMS registries. Thirteen medical record review experts were trained on conducting medical record

review of variables related to the risks and outcomes of out-of-hospital cardiac arrest, using the Utstein guidelines. To ensure the quality of the medical record review process, a quality management committee of emergency physicians, epidemiologists, statistical experts, and medical record review experts analyzed the data every month while providing feedback to each medical record reviewer.[26]

Outcome Measures

The primary endpoint was good neurologic recovery at discharge from the hospital, which was defined as a Cerebral Performance Category score of 1 (good cerebral performance; able to work) or 2 (moderate cerebral disability; able to perform daily activities independently). The secondary endpoints were survival to discharge and out-of-hospital return of spontaneous circulation. Out-of-hospital return of spontaneous circulation was defined as ED arrival with sustained spontaneous circulation, which was identified by medical record review.

Methods of Measurement

The main exposure of interest was bystander CPR in 3 categories: bystander CPR with dispatcher assistance group, composed of out-of-hospital cardiac arrest patients who received bystander CPR under dispatcher-provided CPR instructions; bystander CPR without dispatcher assistance group, composed of out-of-hospital cardiac arrest patients who received bystander CPR without any dispatcher assistance; and no bystander CPR group, who did not receive any bystander CPR regardless of dispatcher-provided CPR instructions. Medical control dispatchers provided CPR instructions to all out-of-hospital cardiac arrest cases identified by the primary call dispatchers unless the caller refused to perform CPR or there already was a self-reported competent bystander performing it who declined dispatcher assistance. For bystanders performing CPR and not declining assistance, medical control dispatchers provided supportive CPR instructions. Provision of dispatcher assistance was confirmed with the dispatcher CPR registry and the EMS cardiac arrest registry, which includes bystander CPR information identified at the scene by EMTs.

Arrest locations were categorized into public and private settings. Public settings included streets, train or subway stations, business and commercial office buildings, sports and leisure spaces, factories, and schools and academies, whereas private settings included homes and mass residential facilities such as dormitories and orphanages.

We collected information on demographic factors, provision of bystander CPR, provision of dispatcher assistance, type of cardiac rhythm at the scene, out-of-hospital defibrillation by EMTs, response interval from call for ambulance to arrival at the scene, scene interval from arrival at and departure from the scene, transport interval from departure from the scene to arrival at the ED, and level of ED. Metropolitan area was defined as an administrative district with a population of 1,000,000 or more (eg, Seoul). To calculate the interval from collapse to initial compression, we collected information from bystanders on the estimated onset time of arrest and the time of initial chest compression from bystanders or EMTs.

Primary Data Analysis

To determine the associations of bystander CPR with and without dispatcher assistance with the study outcomes, adjusted odds ratios (ORs) with 95% confidence intervals (CIs) of the study endpoints were calculated, using multivariable logistic regression analysis with the no bystander CPR group as reference. We adjusted for age (by decade), sex, metropolitan area (versus nonmetropolitan), arrest location (private versus public settings), witnessed arrest, type of primary cardiac rhythm at the scene, and EMS response times as potential confounders in the model. All variables included in the final model were assessed for multicollinearity, which was not detected in this analysis. Furthermore, to determine the effectiveness of bystander CPR with dispatcher assistance compared with that performed by a willing or competent bystander without dispatcher assistance, adjusted ORs with 95% CIs were recalculated with the abovementioned model, with the bystander CPR without dispatcher assistance group as reference.

To calculate adjusted ORs according to the arrest location (public and private settings), we used a multivariable logistic regression model with an interaction term (bystander group × arrest location) as the final model for the outcomes.

For sensitivity analysis, the final model and interaction model were assessed for adult patients with out-of-hospital cardiac arrest of presumed cardiac cause whose arrests were witnessed by laypersons and those who had shockable rhythm at the scene.

RESULTS

Among 79,832 EMS-assessed out-of-hospital cardiac arrests (21.5% and 11.7% receiving bystander CPR with and without dispatcher assistance, respectively), 37,924 patients (31.1% and 14.3% of whom received bystander CPR with and without dispatcher assistance, respectively) were included in the final analysis (Figure 1).

Approximately 44.8% of bystanders received CPR instructions from dispatchers (bystander CPR with

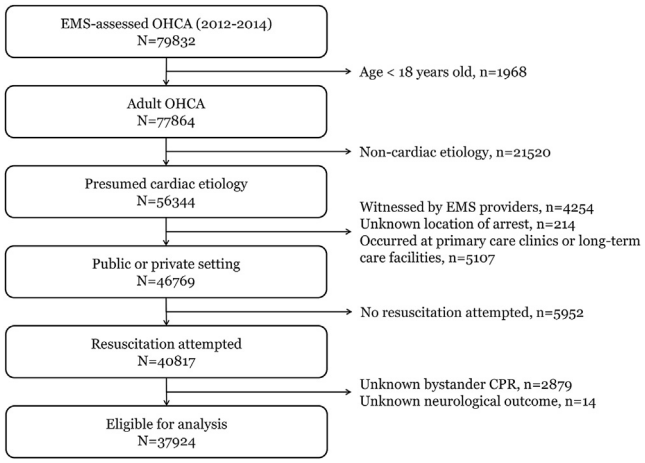

Figure 1. Study population. *OHCA*, Out-of-hospital cardiac arrest.

dispatcher assistance group and 30.7% of no bystander CPR group). The bystander CPR rate increased from 30.9% (11.6% with dispatcher assistance and 19.3% without it) in the first quarter of 2012 to 55.7% (44.4% with dispatcher assistance and 11.3% without it) in the last quarter of 2014 (Figure 2).

More patients with an interval from collapse to initial compression of 4 minutes or less and more cases of shockable rhythm were observed in both bystander CPR groups compared with the no bystander CPR group. Good neurologic recovery and survival to discharge were more frequent in the bystander CPR groups (4.8% [95% CI 4.5 to 5.2] and 7.3% [95% CI 6.8% to 7.8%] with dispatcher assistance; 5.2% [95% CI 4.6 to 5.8] and 8.4% [95% CI 7.7 to 9.6] without dispatcher assistance) than in the no bystander CPR group (2.1% [95% CI 1.9 to 2.3] and 4.8% [95% CI 4.6 to 5.1]) (Table 1).

Multivariable analysis showed that out-of-hospital cardiac arrest patients who received bystander CPR were more likely to have good neurologic recovery than patients

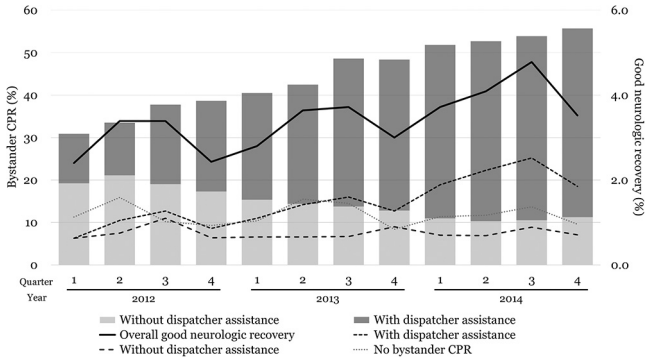

Figure 2. Trends of bystander CPR with and without dispatcher assistance and good neurologic outcome.

who did not (adjusted OR 1.50 [95% CI 1.30 to 1.74] with dispatcher assistance; 1.34 [1.12 to 1.60] without it) and that there was no difference in survival to hospital discharge between the groups (adjusted OR 1.03 [95% CI 0.92 to 1.15] with dispatcher assistance; OR 1.08 [95% CI 0.94 to 1.23] without it) (Table 2).

The bystander CPR rates (with and without dispatcher assistance) at the start of the study period were higher in public settings than in private ones (36.5% versus 29.2%), and the difference in rates decreased at the end of the study period (56.3% versus 55.6%) (Figure 3, Table E1, available online at http://www.annemergmed.com).

In the interaction model, although there was no difference in survival to hospital discharge between the bystander CPR and no bystander CPR groups, good neurologic recovery was more frequent in the bystander CPR groups when out-of-hospital cardiac arrest occurred in a public setting (adjusted OR 1.41 [95% CI 1.14 to 1.75] with dispatcher assistance; 1.37 [1.08 to 1.72] without it). However, when out-of-hospital cardiac arrest occurred in a private setting, good neurologic recovery was improved only when bystander CPR was provided with dispatcher assistance (adjusted OR 1.58 [95% CI 1.30 to 1.92] with dispatcher assistance; 1.28 [0.98 to 1.67] without it) (Table 3).

Sensitivity Analyses

In adult out-of-hospital cardiac arrests of presumed cardiac cause that were witnessed by laypersons, patients who received bystander CPR were more likely to have good neurologic recovery (adjusted OR 1.84 [95% CI 1.55 to 2.19] with dispatcher assistance; 1.50 [95% CI 1.22 to 1.84] without it); the effect was similar among adult out-of-hospital cardiac arrests of presumed cardiac cause that were witnessed by laypersons and had shockable rhythm at the scene (adjusted OR 1.95 [95% CI 1.61 to 2.37] with dispatcher assistance; 1.50 [95% CI 1.20 to 1.88] without it). In the interaction model, the effects of the dispatcher-assisted CPR program were more apparent in out-of-hospital cardiac arrests that occurred in private settings than in public ones for both populations (Table 4).

LIMITATIONS

This study has several limitations. First, bystander CPR groups were classified according to the information EMTs obtained from bystanders at the scene. It is possible that bystander CPR rates were under- or overestimated. Second, this study was an observational one, not a randomized controlled trial. There is significant potential that a confounding issue exerted an influence. Last, this study was

Table 1. Demographic findings of study population by bystander CPR groups.

	Total		Bystander CPR With DA		Bystander CPR Without DA		No Bystander CPR	
Characteristic	**No.**	**%**	**No.**	**%**	**No.**	**%**	**No.**	**%**
All	37,924		11,791	31.1	5,418	14.3	20,715	54.6
Sex								
Female	12,855	33.9	4,202	35.6	1,720	31.7	6,933	33.5
Age, y								
19–39	1,747	4.6	643	5.5	309	5.7	795	3.8
40–49	3,550	9.4	1,179	10.0	599	11.1	1,772	8.6
50–59	6,491	17.1	2,199	18.6	1,079	19.9	3,213	15.5
60–69	6,749	17.8	2,135	18.1	988	18.2	3,626	17.5
70–79	10,970	28.9	3,085	26.2	1,462	27.0	6,423	31.0
80–89	7,078	18.7	2,135	18.1	838	15.5	4,105	19.8
≥90	1,339	3.5	415	3.5	143	2.6	781	3.8
Median (IQR)	70 (57–79)		69 (55–79)		67 (54–77)		72 (58–80)	
Metropolitan	16,931	44.6	6,540	55.5	1,624	30.0	8,767	42.3
Arrest location								
Private	29,995	79.1	9,684	82.1	3,648	67.3	16,663	80.4
Public	7,929	20.9	2,107	17.9	1,770	32.7	4,052	19.6
Witnessed arrest	16,662	43.9	5,821	49.4	3,083	56.9	7,758	37.5
Interval from arrest to initial chest compression, min								
Median (IQR)	8 (3–18)		3 (0–11)		2 (0–9)		12 (7–22)	
≤4	7,639	20.1	4,387	37.2	2,229	41.1	1,023	4.9
>4	20,859	55.0	4,134	35.1	1,788	33.0	14,937	72.1
Unknown	9,426	24.9	3,270	27.7	1,401	25.9	4,755	23.0
Primary cardiac rhythm at the scene								
Shockable	6,084	16.0	2,221	18.8	1,215	22.4	2,648	12.8
Out-of-hospital defibrillation	4,731	12.5	1,777	15.1	911	16.8	2,043	9.9
EMS response interval, min								
Median (IQR)	7 (5–10)		7 (5–10)		8 (6–11)		7 (5–10)	
EMS scene interval, min								
Median (IQR)	8 (5–11)		8 (5–11)		8 (5–11)		8 (5–11)	
EMS transport interval, min								
Median (IQR)	7 (5–11)		7 (5–10)		7 (5–11)		7 (4–11)	
ED level								
I	4,338	11.4	1,394	11.8	685	12.6	2,259	10.9
II	19,039	50.2	6,239	52.9	2,631	48.6	10,169	49.1
III	14,547	38.4	4,158	35.3	2,102	38.8	8,287	40.0
Outcomes								
Out-of-hospital ROSC	1,447	3.8	622	5.3	317	5.9	508	2.5
Survival to discharge	2,320	6.1	861	7.3	456	8.4	1,003	4.8
Good neurologic recovery	1,294	3.4	570	4.8	282	5.2	442	2.1

DA, Dispatcher assistance; *IQR*, interquartile range; *ROSC*, return of spontaneous circulation.

conducted in an EMS system with an intermediate service level, which is different from the North American or European models with advanced service levels. Generalization of the study findings should be made with caution.

DISCUSSION

This study evaluated the effect of a nationwide dispatcher-assisted CPR program on bystander CPR rate improvement and identified the associations of dispatcher-assisted bystander CPR with survival outcomes after out-of-hospital cardiac arrest by arrest locations. Provision of CPR instructions by a dispatcher over the telephone increased frequency of bystander CPR for cardiac arrest victims, and bystander CPR was more likely to improve neurologic recovery after out-of-hospital cardiac arrest. Although bystander CPR with or without dispatcher assistance was associated with improved neurologic recovery in a public setting, in private settings, it was associated with improved neurologic recovery only when dispatcher assistance was provided.

Because the study setting had a single, unified EMS system operated by the fire department, all provincial fire departments successfully implemented the dispatcher-assisted CPR program with a quality management process within a few months as part of the nationwide program. An ideal dispatcher-assisted CPR protocol increases the bystander CPR rate through simple and discriminative

Table 2. Logistic regression analysis on survival outcomes by bystander CPR groups.

	Total	Outcome		Unadjusted	Adjusted*†	Adjusted*†
Characteristic	**N**	**n**	**%**	**OR (95% CI)**	**OR (95% CI)**	**OR (95% CI)**
Good neurologic recovery						
Total	37,924	1,294	3.4			
Bystander CPR with DA	11,791	570	4.8	2.33 (2.05–2.64)	1.50 (1.30–1.74)	1.12 (0.95–1.34)
Bystander CPR without DA	5,418	282	5.2	2.52 (2.16–2.93)	1.34 (1.12–1.60)	1.00
No bystander CPR	20,715	442	2.1	1.00	1.00	0.75 (0.63–0.89)
Survival to discharge						
Total	37,924	2,320	6.1			
Bystander CPR with DA	11,791	861	7.3	1.55 (1.41–1.70)	1.03 (0.92–1.15)	0.95 (0.83–1.09)
Bystander CPR without DA	5,418	456	8.4	1.81 (1.61–2.03)	1.08 (0.94–1.23)	1.00
No bystander CPR	20,715	1,003	4.8	1.00	1.00	0.93 (0.81–1.06)
Out-of-hospital ROSC						
Total	37,924	1,447	3.8			
Bystander CPR with DA	11,791	622	5.3	2.22 (1.97–2.50)	1.51 (1.32–1.72)	1.06 (0.90–1.24)
Bystander CPR without DA	5,418	317	5.9	2.47 (2.14–2.85)	1.42 (1.21–1.67)	1.00
No bystander CPR	20,715	508	2.5	1.00	1.00	0.70 (0.60–0.82)

*Adjusted for sex, age (by decade), metropolitan area, arrest location, witness, primary cardiac rhythm at the scene, and EMS response interval.
†Same models with different references.

questions to maximize the sensitivity for detecting cardiac arrests and a feedback system for identifying undetected out-of-hospital cardiac arrest cases. The quality control program and feedback system increased the out-of-hospital cardiac arrest detection rate of the primary call dispatchers and the CPR instruction provision rate of the medical control dispatchers, leading to an increased rate of bystander CPR with dispatcher assistance, from 11.6% in the first quarter of 2012 to 44.4% in the last quarter of 2014, and the increase was greater for arrests in private settings than those in public ones. We believe that there are more opportunities to further increase the bystander CPR rate. Public bystander CPR training could augment the effect of a dispatcher-assisted CPR program by reducing out-of-hospital cardiac arrest cases in which untrained bystanders fail to perform CPR even with dispatcher assistance. Furthermore, providing instructions for locating the nearest public access defibrillator may enhance survival outcomes by increasing bystanders' automated external defibrillator use and reducing the time to first shock.

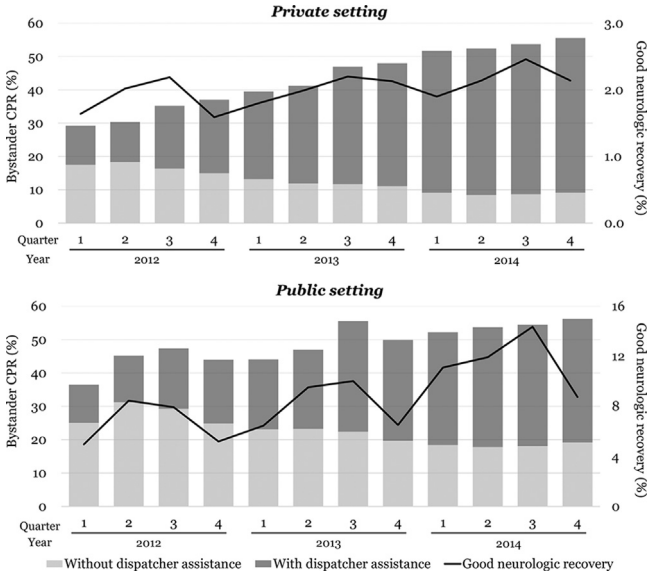

Figure 3. Trends of bystander CPR rate with and without dispatcher assistance and good neurologic outcome by arrest location.

A previous systematic review on the effects of dispatcher-assisted CPR on survival outcomes[27] reported that an increase in the bystander CPR rates after implementation of a dispatcher-assisted CPR program does not always confer improvement in survival outcomes. Bystander CPR in this study demonstrated no effect on the survival to hospital discharge, but it did improve neurologic recovery after out-of-hospital cardiac arrest. Although survival from out-of-hospital cardiac arrest was still low, good neurologic recovery rate increased from 2.8% (309/10,870) in 2012 to 4.0% (569/14,287) in 2014. Dispatcher-assisted bystander CPR was associated with an increased frequency of neurologic recovery compared with no bystander CPR, and the dispatcher-assisted CPR was as effective as CPR performed by a willing or presumably competent bystander (Table 2).

The interaction model was evaluated to identify out-of-hospital cardiac arrest patients who would benefit most from the dispatcher-assisted CPR program. The observed effect on survival outcomes was different across the bystander CPR groups by arrest locations. When an out-of-hospital cardiac arrest occurred in a public setting, both

Table 3. Effects of bystander CPR in an interaction model with the place of cardiac arrest.

	Arrest Location, Setting			
	Private		Public	
Characteristic	**Outcome, n/N (%)**	**AOR* (95% CI)**	**Outcome, n/N (%)**	**AOR* (95% CI)**
Good neurologic recovery				
Bystander CPR with DA	305/9,684 (3.1)	1.58 (1.30–1.92)	265/2,107 (12.6)	1.41 (1.14–1.75)
Bystander CPR without DA	94/3,648 (2.6)	1.28 (0.98–1.67)	188/1,770 (10.6)	1.37 (1.08–1.72)
No bystander CPR	206/16,663 (1.2)	1.00	236/4,052 (5.8)	1.00
Survival to discharge				
Bystander CPR with DA	514/9,684 (5.3)	1.08 (0.95–1.24)	347/2,107 (16.5)	1.02 (0.85–1.22)
Bystander CPR without DA	179/3,648 (4.9)	1.05 (0.87–1.27)	277/1,770 (15.6)	1.16 (0.96–1.40)
No bystander CPR	554/16,663 (3.3)	1.00	449/4,052 (11.1)	1.00
Out-of-hospital ROSC				
Bystander CPR with DA	369/9,684 (3.8)	1.49 (1.26–1.76)	253/2,107 (12.0)	1.52 (1.24–1.88)
Bystander CPR without DA	123/3,648 (3.4)	1.28 (1.02–1.61)	194/1,770 (11.0)	1.57 (1.25–1.96)
No bystander CPR	290/16,663 (1.7)	1.00	218/4,052 (5.4)	1.00

AOR, Adjusted OR.

*Adjusted for sex, age (by decade), metropolitan area, arrest location, witness, primary cardiac rhythm at the scene, EMS response interval, and interaction term (bystander CPR × arrest location).

bystander CPR performed by a presumably competent person and bystander CPR performed by one who received CPR instruction by a dispatcher showed significant improvement in good neurologic recovery. In contrast, in a private setting, only bystander CPR with dispatcher assistance showed significant improvement. Previous studies have shown that in private settings, even when a trained layperson performed CPR, without dispatcher assistance the quality of bystander CPR was generally suboptimal.[16,18,19] Audio CPR instruction has been shown

Table 4. Sensitivity analysis for effects of bystander CPR on survival outcomes.

	Logistic Regression Model		Interaction Analysis			
	Total		Private		Public	
Characteristic	**Outcome, n/N (%)**	**AOR* (95% CI)**	**Outcome, n/N (%)**	**AOR† (95% CI)**	**Outcome, n/N (%)**	**AOR† (95% CI)**
Witnessed OHCAs by laypersons						
Good neurologic recovery						
Total	1,016/16,662 (6.1)		450/12,682 (3.5)		566/3,980 (14.2)	
Bystander CPR with DA	497/5,821 (8.5)	1.84 (1.55–2.19)	252/4,507 (5.6)	2.06 (1.62–2.63)	245/1,314 (18.7)	1.63 (1.27–2.09)
Bystander CPR without DA	243/3,083 (7.9)	1.50 (1.22–1.84)	80/1,949 (4.1)	1.61 (1.17–2.20)	163/1,134 (14.4)	1.39 (1.07–1.82)
No bystander CPR	276/7,758 (3.6)	1.00	118/6,226 (1.9)	1.00	158/1,532 (10.3)	1.00
Survival to discharge						
Total	1,669/16,662 (10.0)		861/12,682 (6.8)		808/3,980 (20.3)	
Bystander CPR with DA	728/5,821 (12.5)	1.29 (1.13–1.47)	412/4,507 (9.1)	1.33 (1.12–1.57)	316/1,314 (24.1)	1.23 (1.00–1.53)
Bystander CPR without DA	369/3,083 (12.0)	1.17 (1.00–1.38)	136/1,949 (7.0)	1.11 (0.88–1.39)	233/1,134 (20.6)	1.22 (0.97–1.53)
No bystander CPR	572/7,758 (7.4)	1.00	313/6,226 (5.0)	1.00	259/1,532 (16.9)	1.00
Witnessed OHCAs with shockable rhythm at the scene						
Good neurologic recovery						
Total	890/3,982 (22.4)		380/2,272 (16.7)		510/1,710 (29.8)	
Bystander CPR with DA	448/1,630 (27.5)	1.95 (1.61–2.37)	223/996 (22.4)	2.35 (1.78–3.12)	225/634 (35.5)	1.64 (1.26–2.14)
Bystander CPR without DA	215/931 (23.1)	1.50 (1.20–1.88)	71/429 (16.6)	1.77 (1.24–2.52)	144/502 (28.7)	1.32 (0.99–1.76)
No bystander CPR	227/1,421 (16.0)	1.00	86/847 (10.2)	1.00	141/574 (24.6)	1.00
Survival to discharge						
Total	1,238/3,982 (31.1)		569/2,272 (25.0)		669/1,710 (39.1)	
Bystander CPR with DA	586/1,630 (36.0)	1.52 (1.29–1.81)	307/996 (30.8)	1.63 (1.29–2.05)	279/634 (44.0)	1.40 (1.10–1.80)
Bystander CPR without DA	282/931 (30.3)	1.17 (0.96–1.43)	94/429 (21.9)	1.13 (0.84–1.53)	188/502 (37.5)	1.19 (0.91–1.55)
No bystander CPR	370/1,421 (26.0)	1.00	168/847 (19.8)	1.00	202/574 (35.2)	1.00

*Adjusted for sex, age (by decade), metropolitan area, arrest location, primary cardiac rhythm at the scene, and EMS response interval.

†Adjusted for sex, age (by decade), metropolitan area, arrest location, primary cardiac rhythm at the scene, EMS response interval, and interaction term (bystander CPR × arrest location).

to increase the rate and depth of chest compression even when it is performed by laypersons with previous CPR training,[28] and prearrival instructions could have improved the quality of bystander CPR. Bystanders at home are also more likely to be older, possibly having more difficulties with skill retention, and alone,[16,17] leading to more interruptions during CPR. By following the CPR instructions of the dispatcher, bystanders at home would probably perform better CPR and show significant improvement.

The current dispatcher-assisted CPR program targets the general population and does not differentiate between different bystander groups. However, considering the characteristics of the bystander in the dispatcher-bystander interaction may be a key component to delivering high-quality bystander CPR with dispatcher assistance.[29] In simulation studies, a dispatcher-assisted CPR protocol with detailed CPR instructions including guidelines for removing obstacles, as well as optimal compression rate, depth, and position, resulted in significant improvement of the CPR quality during the first 10 minutes.[23,30] Such findings in simulation settings indicate that the dispatcher-assisted CPR protocol needs to be more customized to different bystanders' characteristics. In addition, public CPR training programs designed to emphasize calling EMS and following dispatchers' CPR instructions by telephone could further reduce barriers and encourage bystander CPR.

In conclusion, a nationwide dispatcher-assisted CPR program was implemented in Korea, and the subsequent bystander CPR rate for out-of-hospital cardiac arrest with cardiac cause nearly doubled. Bystander CPR was more likely to improve survival with good neurologic recovery after out-of-hospital cardiac arrest. The effect of bystander CPR on neurologic outcomes was similar whether bystander CPR was performed with dispatcher assistance or performed by a competent person without dispatcher assistance. However, for out-of-hospital cardiac arrest cases occurring in private settings, only bystander CPR with dispatcher assistance showed improvement in patients' neurologic outcomes.

Supervising editor: Theodore R. Delbridge, MD, MPH

Author affiliations: From the Laboratory of Emergency Medical Services, Seoul National University Hospital Biomedical Research Institute, Seoul, South Korea (Ro, Shin, Y. J. Lee, S. C. Lee, Song, Ryoo); the Department of Emergency Medicine, Seoul National University College of Medicine, Seoul, South Korea (Shin, Y. J. Lee, Song); the Department of Emergency Medicine, Dongkuk University Ilsan Hospital (S. C. Lee); the Department of Emergency Medicine, Kyoungpook National University Hospital (Ryoo); the Department of Emergency Medicine, Singapore General Hospital, and Health Services and Systems Research, Duke-NUS Graduate Medical School, Singapore (Ong); the Department of Emergency Medicine, Emory University School of Medicine, Atlanta, GA (McNally); the Bureau of EMS and Trauma System, Arizona State Department of Health Service, Phoenix, AZ (Bobrow); the Department of Emergency Medical System, Kokushikan University, Tokyo, Japan (Tanaka); and Laerdal Medical, Stavanger, Norway (Myklebust, Birkenes).

Author contributions: YSR and SDS drafted the article, were responsible for statistical analysis, had full access to all of the data in the study, and take responsibility for the integrity of the data and the accuracy of the data analysis. YSR, SDS, YJL, SCL, and KJS were responsible for study concept and design. YSR, SDS, KJS, and HWR were responsible for acquisition, analysis, and interpretation of data. SDS, KJS, MEHO, BM, BB, HT, HM, and TSB were responsible for critical revision of the manuscript for important intellectual content. SDS obtained funding. YJL, SCL, HWR, HM, and TSB were responsible for administrative, technical, and material support. SDS, MEHO, BM, BB, and HT were responsible for study supervision. All authors approved the article. SDS takes responsibility for the paper as a whole.

Funding and support: By *Annals* policy, all authors are required to disclose any and all commercial, financial, and other relationships in any way related to the subject of this article as per ICMJE conflict of interest guidelines (see www.icmje.org). The authors have stated that no such relationships exist and provided the following details: This study was supported by the National Emergency Management Agency of Korea and the Korea Centers for Disease Control and Prevention. The study was funded by the Korea Centers for Disease Control and Prevention (2012 to 2014) (grants 2012-E33010-00, 2013-E33015-00, and 2014-E33011-00).

Publication dates: Received for publication November 17, 2015. Revisions received April 7, 2016; May 27, 2016, and June 21, 2016. Accepted for publication July 19, 2016.

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Table E1. Trends of bystander CPR rate with and without dispatcher assistance and good neurologic outcome by arrest location.

	2012				2013				2014			
Year	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**	**Q1**	**Q2**	**Q3**	**Q4**
Total												
OHCA, n	2,997	2,386	2,362	3,125	3,460	3,025	2,820	3,462	3,871	3,325	3,138	3,953
Bystander CPR with DA, No. (%)	349	296	442	667	869	849	982	1,231	1,581	1,409	1,360	1,756
	(11.6)	(12.4)	(18.7)	(21.3)	(25.1)	(28.1)	(34.8)	(35.6)	(40.8)	(42.4)	(43.3)	(44.4)
Bystander CPR without DA, No. (%)	577	504	450	541	532	436	389	444	425	343	331	446
	(19.3)	(21.1)	(19.1)	(17.3)	(15.4)	(14.4)	(13.8)	(12.8)	(11.0)	(10.3)	(10.6)	(11.3)
Good neurologic recovery, No. (%)	72	81	80	76	97	110	105	104	144	136	150	139
	(2.4)	(3.4)	(3.4)	(2.4)	(2.8)	(3.6)	(3.7)	(3.0)	(3.7)	(4.1)	(4.8)	(3.5)
Private												
OHCA, n	2,312	1,877	1,870	2,393	2,716	2,363	2,271	2,771	3,105	2,662	2,525	3,130
Bystander CPR with DA, No. (%)	271	225	353	527	713	692	800	1,022	1,322	1,171	1,137	1,451
	(11.7)	(12.0)	(18.9)	(22.0)	(26.3)	(29.3)	(35.2)	(36.9)	(42.6)	(44.0)	(45.0)	(46.4)
Bystander CPR without DA, No. (%)	405	345	306	359	360	282	266	308	284	225	220	288
	(17.5)	(18.4)	(16.4)	(15.0)	(13.3)	(11.9)	(11.7)	(11.1)	(9.2)	(8.5)	(8.7)	(9.2)
Good neurologic recovery, No. (%)	38	38	41	38	49	47	50	59	59	57	62	67
	(1.6)	(2.0)	(2.2)	(1.6)	(1.8)	(2.0)	(2.2)	(2.1)	(1.9)	(2.1)	(2.5)	(2.1)
Public												
OHCA, n	685	509	492	732	744	662	549	691	766	663	613	823
Bystander CPR with DA, No. (%)	78	71	89	140	156	157	182	209	259	238	223	305
	(11.4)	(14.0)	(18.1)	(19.1)	(21.0)	(23.7)	(33.2)	(30.3)	(33.8)	(35.9)	(36.4)	(37.1)
Bystander CPR without DA, No. (%)	172	159	144	182	172	154	123	136	141	118	111	158
	(25.1)	(31.2)	(29.3)	(24.9)	(23.1)	(23.3)	(22.4)	(19.7)	(18.4)	(17.8)	(18.1)	(19.2)
Good neurologic recovery, No. (%)	34	43	39	38	48	63	55	45	85	79	88	72
	(5.0)	(8.5)	(7.9)	(5.2)	(6.5)	(9.5)	(10.0)	(6.5)	(11.1)	(11.9)	(14.4)	(8.8)

Q, Quarter.