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Dispatcher-assisted bystander cardiopulmonary resuscitation in a metropolitan city: A before–after population-based study☆,☆☆

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ABSTRACT

Background: The goal of this study was to determine the effects of dispatcher-assisted bystander cardiopulmonary resuscitation (DA-CPR) on outcomes of out-of-hospital cardiac arrest (OHCA).
Methods: All EMS in a metropolitan city with a population of 10 million are dispatched by a single, centralized, and physician-supervised center. Data on patients with adult OHCA with cardiac etiology were collected from the dispatch center registry and from EMS run sheets and hospital medical record review from 2009 to 2011. A standardized DA-CPR protocol (aligned with the 2010 AHA guidelines) we implemented as an intervention in January 2011. The end points were survival to discharge, good neurological outcome, and bystander CPR rate. Multivariate logistic analysis was used to compare between intervention group (2011) and historical control group (2009–2010).
Results: Of 8.144 eligible patients, bystander CPR was performed for the patients in 5.7% (148/2600) of cases in 2009, 6.7% (190/2857) in 2010, and 12.4% (334/2686) in 2011 ($p < 0.001$). The survival to discharge rates was 7.1% (2009), 7.1% (2010), and 9.4% (2011) ($p = 0.001$). Good neurological outcomes occurred in 2.1% (2009), 2.0% (2010), and 3.6% (2011) of cases ($p < 0.001$). The adjusted ORs (95% CIs) for survival to discharge compared with 2009 were 1.33 (1.07–1.66) in 2011 and 1.12 (0.89–1.41) in 2010. The adjusted ORs (95% CIs) for good neurological outcomes were 1.67 (1.13–2.45) in 2011 and 1.13 (0.74–1.72) in 2010.
Conclusions: An EMS intervention using the DA-CPR protocol was associated with a significant increase in bystander CPR and an improved survival and neurologic outcome after OHCA.

1. Introduction

Globally, sudden cardiac deaths have increased each year, although total coronary deaths have decreased.[1,2] The number of OHCA patients in developed countries surviving to hospital discharge remains low.[3–5] While early cardiopulmonary resuscitation (CPR) and early defibrillation play key roles in the chain of survival,[6] it is difficult to reduce the time from a patient's collapse to initiation of resuscitation by trained rescuers. The time interval from collapse to initiation of CPR is an important determinant of survival, yet despite significant mass public training efforts bystander CPR rates remain low (less than 30%) in most developing communities.[4,7–9] The gap between the knowledge and practice of bystander CPR for patients with OHCA originates from multiple barriers.[10] Increasing these low bystander CPR rates requires significant coordination, time, and resources to create an educational program for potential bystanders, as well as extended advocacy.[11] Compression-only CPR

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☆☆ This study was presented at the oral session of the American Heart Association Resuscitation Science Symposium in Nov. 2012 in Los Angeles and received the Young Investigator Award in this conference. This study was presented at the Asian EMS Council meeting collaborating with the Pan-Asian Resuscitation Outcome Study Clinical Research Network in Nov. 2012 in Kyoto, Japan and received the Best Abstract Award.

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(CO-CPR) technique focusing on maximizing coronary and cerebral perfusion may also increase laypersons ability and willingness to perform CPR.[12] CO-CPR ensures that dispatcher-assisted bystander CPR (DA-CPR) is implemented successfully, resulting in increases in bystander CPR rates.[13,14] In order for dispatch CPR to be maximally effective, dispatchers should rapidly identify cardiac arrest with a limited number of questions and deliver clear, concise CPR instructions which help a rescuer begin CPR as quickly as possible.[10,15,16]

Implementing a DA-CPR protocol in evolving EMS systems remains challenging, In Seoul, 4.7% of patients survived to discharge annually, and bystander CPR was performed in approximately 5% of patients (2006–2007).[7] A simplified DA-CPR protocol can be expected to increase the bystander CPR rate within a shortened period of time. We hypothesized that the simplified DA-CPR protocol would be easily implemented by a single unified metropolitan dispatch center and would result in an increase in the bystander CPR rate, followed by improved OHCA outcomes. This study aimed to estimate the effect of DA-CPR on the bystander CPR rate and the outcomes of patients with OHCA in a metropolitan area.

2. Methods

2.1. Study design and setting

This was a before- and after-intervention trial. The setting was the capital city of the Republic of Korea, with a population of approximately[10] million people in 605 km^2, consisting mostly of urban area. There are 114 ambulance stations and 23 EMS agencies with a single and unified dispatch center operated by the SMFD.[17] The EMS service level is equivalent to intermediate level of service of North America. EMS providers provide CPR at the scene according to the 2010 AHA CPR guidelines, with a 30:2 compression-to-ventilation ratio and advanced airway or bag-valve-mask ventilation. However, they cannot remain at the scene after one cycle of CPR and rhythm analysis and must transport the patient to an emergency department (ED), performing CPR during ambulance transport.[7,18]

The city has a single centralized dispatch center for the whole population and for ambulance services. The dispatch center receives calls for fire, rescue, and EMS. The average number of call per year is approximately 400.000, including 75% for EMS and 25% for other reasons. The dispatch center has a horizontal dispatch system with two dispatchers responding to every call. All calls are taken by primary call dispatchers (PCDs), who dispatch fire engines, rescue transportation and ambulances if indicated. Therefore, PCDs usually quickly ask for the type of response of vehicle (ambulance, rescue, and fire) and the address where they are needed. The secondary call dispatchers (SCDs) simultaneously track the available ambulances that have been dispatched or that are returning to their stations after transporting patients. The nearest available ambulance is dispatched to the scene by the PCDs without any questions about symptoms or instructions before the arrival of ambulances. The PCDs and SCDs are all firefighters who have finished first responder level of training, and are highly experienced in field firefighting and rescue missions. There are independently operated medical control dispatcher (MCDs) teams composed of one medical doctor and one nurse who provide medical directions to EMS providers 24/7/365 when such directions are requested. MCD nurses are usually highly experienced in providing field care, and these nurses primarily respond to the medical directions requested by EMTs. MCD doctors provide medical supervision for the EMS teams' services, such as ETI, LMA, fluid resuscitation, permission to withdraw CPR, some drug administration, hospital admission, and consulting problems in real time.

2.2. Selection of study participants

The target population was patients with OHCAs that occurred in Seoul, who were assessed treated and transported to 65 participating hospitals by SMFD ambulances from January 1, 2009, to December 31, 2011 (three years). We excluded cases with non-cardiac etiologies, patients less than 15 years of age, and patients with unknown outcomes due to a lack of medical records or due to being transferred to other hospitals from the ED without being admitted.

2.3. Data source

We collected data from two different sources: EMS records and hospital medical records. The EMS record included the following data elements: time for ambulance call and operation, place of event, patient identification, general information about chief complaint, assessment, diagnosis, procedures and care provided by EMTs, and destination hospital information. The hospital medical records were followed up in all cases after at least three months after the event. A medical record review team, operated by the Korea CDC, reviewed the hospital records for Utstein factors[19] and for outcomes such as survival to admission, survival to discharge, and neurological recovery. We also used another source of data, the registry recorded by MCDs in the dispatch center. They recorded all of the medical controls and pre-arrival instructions in a designed registry.

2.4. Intervention and control

The CAREER project decided to implement the 2010 AHA guidelines on DA-CPR and a simplified protocol for DA-CPR.[6,9] The protocol was described with a standard scenario in the Korean language, including two key processes: (1) an identification process using two key questions (altered mental status and abnormal breathing); and (2) a CPR instruction process, using CO-CPR for cardiac etiology and classic CPR with compressions and ventilations for non-cardiac and pediatric victims. The protocol was designed to allow for a simple and easy linkage between PCDs and MCDs in real-time. For example, when a PCD took an ambulance call, the PCD would ask only two key questions.

If the answers to both questions were "yes," the PCD would quickly transfer the call to the MCD to request CPR instructions. While the MCD initiated and continued CPR instructions, the PCDs would dispatch the ambulance and send this information to the ambulance station. No specific training courses or test exams were applied for PCDs or MCDs before implementing the protocol. The PCDs were educated in using the protocol. Most of the MCDs had field experience and were certified basic life support providers, having finished general education and a training program for dispatchers provided by the SMFD. During the before-intervention period, CPR instruction was rarely provided by MCDs because there was no protocol for DA-CPR. However, we held monthly educational meetings, giving feedback from data gathered from the registry. Approximately 100–200 EMTs, including three to six MCDs, attended the monthly educational meetings. The SMFD administrator's or City Mayor's awards were given to excellent EMTs, stations, and agencies to encourage their active participation. However, we did not directly measure quality, although we recorded their instructions for quality monitoring. We started the program on January 1, 2012, and continued it until December 31, 2012. This one-year after-intervention group was defined as the intervention group. The before-intervention group was a historical control group, and consisted of subjects for two years (January 2009 to December 2010).

Table 1
Demographic findings of study participants in the before- and after-intervention groups.

Variables	Before-intervention				After-intervention		Total		*P* value
	2009		2010		2011				
	n	%	*n*	%	*n*	%	*n*	%	
Total	2599	100.0	2856	100.0	2689	100.0	8144	100.0	
Sex									0.177
Male	1723	66.3	1832	64.1	1727	64.2	5282	64.9	
Female	876	33.7	1024	35.9	962	35.8	2862	35.1	
Age group									0.008
Adult (15< = age<65)	1130	43.5	1124	39.4	1103	41.0	3357	41.2	
Elderly (age> = 65)	1469	56.5	1732	60.6	1586	59.0	4787	58.8	
Average age (mean ± std), years	66.2 ± 16.7		67.8 ± 16.2		67.5 ± 15.7		66.7 ± 16.2		<0.001
Season of event									0.215
Spring (March to May)	667	25.7	737	25.8	719	26.7	2123	26.1	
Summer (June to August)	611	23.5	609	21.3	594	22.1	1814	22.3	
Fall (September to November)	609	23.4	711	24.9	602	22.4	1922	23.6	
Winter (November to February)	712	27.4	799	28.0	774	28.8	2285	28.1	
Weekday of event									0.584
Weekday	1858	71.5	2028	71.0	1943	72.3	5829	71.6	
Weekend	741	28.5	828	29.0	746	27.7	2315	28.4	
Time of event									0.840
00 <hour < = 06	433	16.7	490	17.2	438	16.3	1361	16.7	
06 <hour = 12	798	30.7	881	30.8	867	32.2	2546	31.3	
12 <hour = 18	765	29.4	815	28.5	756	28.1	2336	28.7	
18 <hour = 24	603	23.2	670	23.5	628	23.4	1901	23.3	
Place of event									<0.001
Public	446	17.2	440	15.4	498	18.5	1384	17.0	
Home	1751	67.4	1965	68.8	1746	64.9	5462	67.1	
Other private facilities	203	7.8	278	9.7	297	11.0	778	9.6	
Unknown	199	7.7	173	6.1	148	5.5	520	6.4	
Witness									0.636
Witnessed	1032	39.7	1144	40.1	1047	38.9	3223	39.6	
Unwitnessed	1329	51.1	1443	50.5	1365	50.8	4137	50.8	
Unknown	238	9.2	269	9.4	277	10.3	784	9.6	
Elapsed time intervals									
Response time[a] (mean ± std), min.	6.9 ± 3.2		7.2 ± 3.6		6.6 ± 3.0		6.9 ± 3.3		<0.001
Prehospital time[b] (mean ± std), min.	21.7 ± 8.3		22.2 ± 8.5		21.5 ± 8.4		21.8 ± 8.4		0.004
Defibrillation at EMS									<0.001
Yes	252	9.7	308	10.8	415	15.4	975	12.0	
No	2347	90.3	2548	89.2	2274	84.6	7169	88.0	
Primary ECG rhythm									<0.001
VF/VT	147	5.7	143	5.0	167	6.2	457	5.6	
PEA	162	6.2	231	8.1	293	10.9	686	8.4	
Asystole	1818	69.9	2041	71.5	1871	69.6	5730	70.4	
Unknown	472	18.2	441	15.4	358	13.3	1271	15.6	
Endotracheal intubation									0.001
Yes	68	2.6	38	1.3	68	2.5	174	2.1	
No	2531	97.4	2818	98.7	2621	97.5	7970	97.9	
Laryngeal mask airway									<0.001
Yes	99	3.8	80	2.8	152	5.7	331	4.1	
No	2500	96.2	2776	97.2	2537	94.3	7813	95.9	
CPR attempted									<0.001
Yes	2268	87.3	2526	88.4	2535	94.3	7329	90.0	
No	331	12.7	330	11.6	154	5.7	815	10.0	
Level of ED								0.017	<0.017
Level 1	237	9.1	268	9.4	270	10.0	775	9.5	
Level 2	1814	69.8	1956	68.5	1920	71.4	5690	69.9	
Level 3	447	17.2	540	18.9	422	15.7	1409	17.3	
Level 4	101	3.9	92	3.2	77	2.9	270	3.3	
Outcomes									
Bystander CPR	148	5.7	190	6.7	334	12.4	672	8.3	<0.001
Any ROSC	827	31.8	889	31.1	978	36.4	2694	33.1	<0.001
Survival to admission	503	19.4	539	18.9	599	22.3	1641	20.1	0.003
Survival to discharge	185	7.1	204	7.1	254	9.4	643	7.9	0.001
Good neurological outcome	55	2.1	56	2.0	95	3.5	206	2.5	<0.001

EMS: emergency medical services; VF/VT: ventricular fibrillation/ventricular tachycardia; PEA: pulseless electrical activity; CPR: cardiopulmonary resuscitation; ED: emergency department; ROSC: return of spontaneous circulation.

[a] Response time: defined as time interval from call to ambulance arrival at the scene.

[b] Prehospital time: defined as time interval from call to ambulance arrival at emergency department.

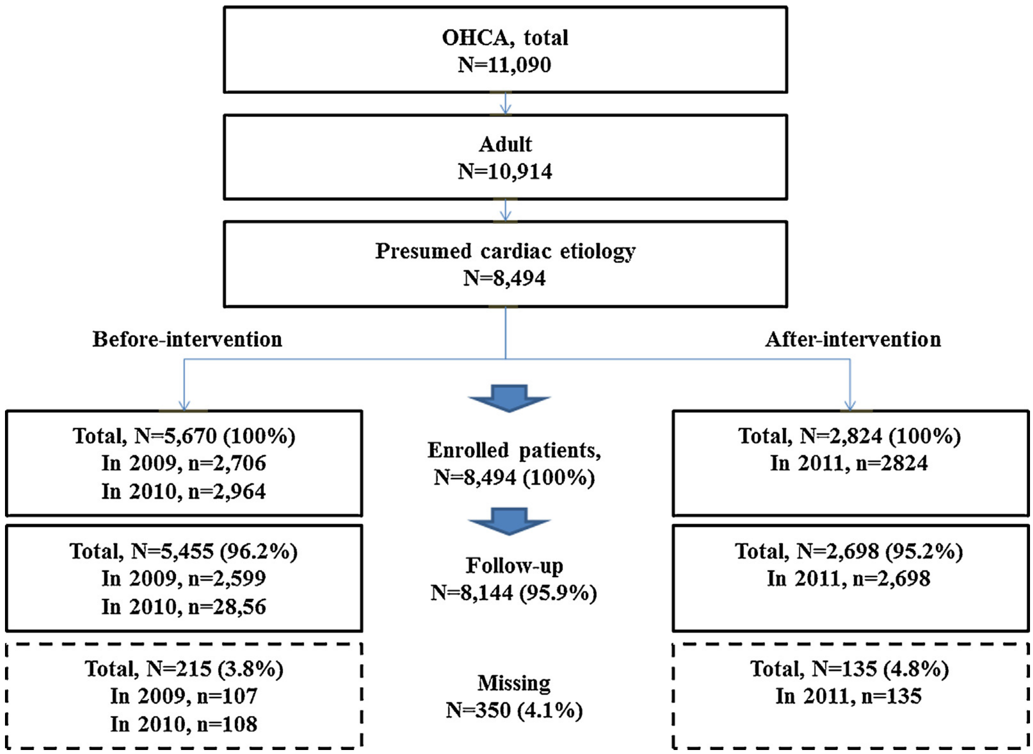

Fig. 1. Patient enrollment flow. OHCA: out-of-hospital cardiac arrest; Adults: fifteen years old and older; and Missing: cases without available outcome variables.

2.5. Outcome measurements

The primary outcome was survival to discharge. The secondary outcome was survival to discharge with a good neurological outcome, defined as cerebral performance category (CPC) 1 or 2. The tertiary outcome was the bystander CPR rate.

2.6. Statistical analysis

We tested the trends of rates of detection of OHCA identified by PCDs by month in 2011, as well as pre-arrival CPR instructions provided by MCDs, total bystander CPR and DA-CPR rate by bystanders using the Cochran–Armitage trend test or the Mantel–Haenszel chi-square test.

Multivariate logistic regression analysis was used to compare the outcomes between the before- and after-intervention groups to calculate the adjusted ORs and 95% confidence intervals (95% CI). The main exposure (intervention in this study) was whether the patients were enrolled before (2009 and 2010) and after the intervention (2011). Potential factors for primary (survival to discharge) and secondary outcomes (good neurological recovery) were adjusted in the final model.[20] The goodness of fit of the model was tested using the Hosmer–Lemeshow test with chi-square analysis for calibration performance, and *c* statistics were measured to assess the discrimination performance of the final models. Subgroup analysis was performed to compare the effect on DA-CPR intervention on outcome using multivariable logistic regression models, between patients group who received non-DA bystander CPR and patients group who received DA bystander CPR or not.

3. Results

3.1. Demographic findings

The total number of adult OHCAs with presumed cardiac etiologies was 8494, excluding 185 pediatric cases (1.7%) and 2420 non-cardiac causes (21.8%) among 11,099 target patients. Of these, follow-up for outcomes was successful in 8144 (95.9%) cases: 6455 (96.2%) in the before-intervention period and 2698 (95.2%) in the after-intervention period (Fig. 1). Gender, time of event (season, weekday, time of occurrence), and witnesses were not significantly different. The proportions of CPR attempted, bystander CPR rate, ROSC, survival to discharge, and good neurological outcomes were significantly different between 2009/210 and 2011, respectively. ($p < 0.001$) (Table 1). A total of 25.4% of OHCAs were detected by dispatchers, and 24.2% received pre-arrival CPR instructions. Among the 12.4% of cases in which bystander CPR was administered, 5.2% were instructed by dispatchers, and 7.2% performed it without dispatch assistance in 2011 while 5.7% in 2009 and 6.7% in 2010, respectively (Table 2).

We compared and tested the monthly rates of detection of OHCA by PCDs, pre-arrival CPR instructions provided by MCDs, total bystander CPR and DA-CPR performed by bystanders. All of the rates showed significant trends and increased by month (all p-values for trend < 0.01) (Fig. 2).

3.2. Main outcomes and subgroup analysis

For survival to discharge, the adjusted OR (95% CI) was significantly higher in 2011 (OR = 1.33, 95% CI: 1.07–1.66) and was not significant in 2010 (OR = 1.12, 95% CI: 0.89–1.41) compared with 2009. For good neurological recovery, the adjusted OR (95% CI) was also significantly higher in 2011 (OR = 1.67, 95% CI: 1.13–2.45) and was not significant in 2010 (OR = 1.13, 95% CI: 0.74–1.72). The adjusted ORs (95% CI) in 2011 and 2010 for bystander CPR were 2.52 (2.05–3.10) and 1.25 (1.00–1.57), respectively (Table 3).

For the patients group receiving non-DA bystander CPR, the adjusted ORs (95% CIs) were 0.45 (0.21–0.95) for survival to discharge and 0.96 (0.34–2.68) in good neurological recovery in 2011, respectively. For the patients group who received DA-CPR or not, the adjusted ORs (95% CIs) were 1.51 (1.19–1.91) for survival to discharge and 1.89 (1.23–2.91) for good neurological recovery in

Table 2
Detection rate, pre-arrival CPR instruction rate, and bystander CPR rate by year and month.

Variables	Before-intervention				After-intervention	
	2009		2010		2011	
	n	%	*n*	%	*n*	%
Total	2599		2856		2689	
Detection of OHCA						
Yes	0	0.0	0	0.0	682	25.4
Pre-arrival CPR instruction						
Yes	0	0.0	0	0.0	651	24.2
Bystander CPR						
No	2451	94.3	2666	93.3	2355	87.6
B-CPR with DA	0	0.0	0	0.0	141	5.2
B-CPR without DA	148	5.7	190	6.7	193	7.2
Subtotal	148	5.7	190	6.7	334	12.4
Bystander CPR rate by month[a]						
January	9	3.5	13	5.1	27	9.4
February	7	3.5	17	6.7	26	10.2
March	11	4.7	11	4.3	29	11.6
April	12	5.3	17	6.6	22	9.3
May	8	3.9	21	9.3	25	10.8
June	13	6.7	14	6.6	25	12.7
July	15	6.8	15	7.1	36	18.3
August	10	5.1	15	8.0	23	11.5
September	16	8.4	12	5.7	32	17.7
October	15	7.6	15	5.9	28	12.5
November	17	7.7	21	8.5	21	10.7
December	15	5.8	19	6.5	40	17.1

OHCA: out-of-hospital cardiac arrest; CPR: cardiopulmonary resuscitation; B-CPR: bystander CPR; DA: dispatch assistance.
[a] The rate was calculated using the number of monthly based OHCA patients for each year as a denominator.

2011, respectively. No significant differences were there in 2010 (Table 4).

4. Discussion

We found a positive effect of a DA-CPR protocol in the after-intervention period in a metropolitan area on survival to discharge, from 7.1% in 2009 to 9.4% in 2011, and on good neurological outcome, from 2.1% (2009) to 3.5% (2011). The bystander CPR rate also significantly increased from 5.7% in 2009 and 6.7% in 2010 to 12.4% in 2011. The bystander CPR rate in 2011 was significantly increased by DA-CPR. These findings favor the hypothesis that the bystander CPR rate would increase by more than 30%.

Effective pre-arrival CPR instruction programs have reported that they were able to increase the rate of bystander CPR performed.[21–23] In a Swedish study, the absolute difference in receiving bystander CPR using DA-CPR was 9.7%.[22] In the other cohorts, 44.1% received no bystander CPR before EMS arrival, 25.7% received dispatcher-assisted bystander CPR, and 30.2% received bystander CPR without dispatcher assistance.[24] Our study showed

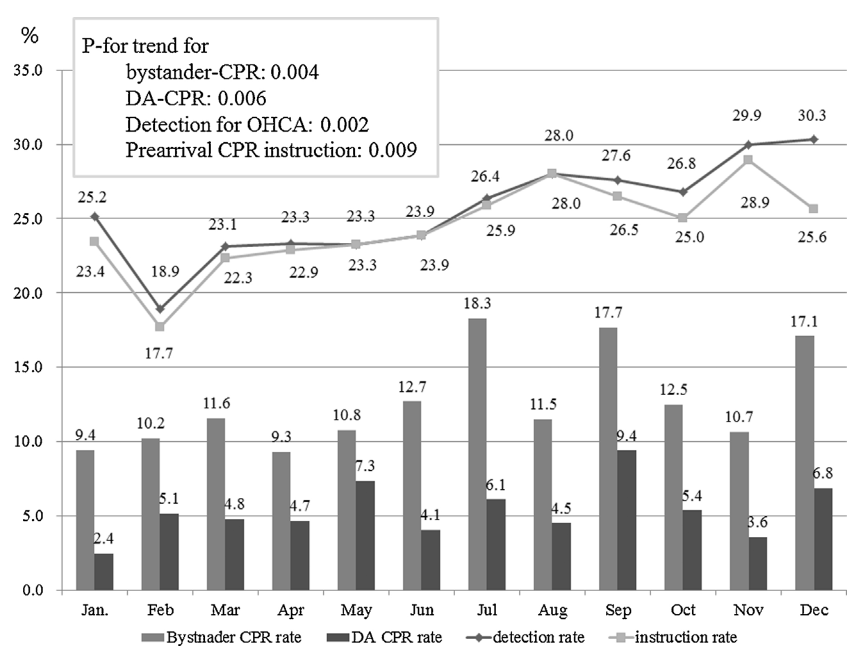

Fig. 2. Monthly trends in the detection rate of OHCA, pre-arrival CPR instructions, and dispatcher-assisted CPR. CPR, cardiopulmonary resuscitation; DA-CPR, dispatcher-assisted CPR; and OHCA, out-of-hospital cardiac arrest. *The Cochran–Armitage test and Mantel–Haenszel chi-square test were performed for the trend in each rate by month.

Table 3
Associations between intervention (dispatch-assisted cardiopulmonary resuscitation) and outcomes using a multivariable logistic regression model for 8144 adult out-of-hospital cardiac arrest with presumed cardiac etiologies.

Outcome	Total	Positive		Unadjusted			Adjusted[a]			HL chi-square	*p*-value	*c*-statistic
		N	%	OR	95%*CI*		OR	95%*CI*				
Survival to discharge										9.4	0.311	0.836
Total	8144	643	7.9									
2009 (control and reference)	2599	185	7.1	1.00			1.00					
2010 (control)	2856	204	7.1	1.00	0.82	1.23	1.12	0.89	1.41			
2011 (intervention)	2689	254	9.4	1.36	1.12	1.66	1.33	1.07	1.66			
Good neurological recovery										10.4	0.241	0.927
Total	8144	206	2.5									
2009 (control and reference)	2599	55	2.1	1.00			1.00					
2010 (control)	2856	56	2.0	0.93	0.64	1.35	1.13	0.74	1.72			
2011 (intervention)	2689	95	3.5	1.69	1.21	2.37	1.67	1.13	2.45			
Bystander cardiopulmonary resuscitation										6.2	0.630	0.702
Total	8144	672	8.3									
2009 (control and reference)	2599	148	5.7	1.00			1.00					
2010 (control)	2856	190	6.7	1.18	0.95	1.47	1.25	1.00	1.57			
2011 (intervention)	2689	334	12.4	2.35	1.92	2.87	2.52	2.05	3.10			

OR: odds ratio; 95% CI: 95% confidence interval; HL chi-square: Hosmer–Lemeshow chi-square test.
[a] Adjusted for age, gender, time of event (season, weekend, hour), witnessed, place, response time, prehospital transport time, defibrillation by emergency medical services, primary ECG, endotracheal intubation, laryngeal mask airway, and level of destination emergency department.

that 42.2% received DA-CPR, when using a more simplified protocol based on CO-CPR. The pre-arrival CPR instructions for adults who suddenly collapse were based on CO-CPR, rather than classic CPR. The caller had an opportunity to be instructed to provide rapid, forceful chest compressions with minimal interruptions.[9] A randomized, controlled trial comparing CO-CPR to classic CPR showed no difference in survival (14.6% vs. 10.4%, $p = 0.18$).[25] A recent randomized, controlled, multicenter study also observed no significant difference between the two groups for survival to hospital discharge (12.5% with chest compression alone and 11.0% with chest compression plus rescue breathing, $p = 0.31$) or for favorable neurological recovery (14.4% and 11.5%, respectively; $p = 0.13$).[26] Another randomized, controlled trial found no difference between CO-CPR and CPR with ventilations regarding 30-day survival rate: 8.7% for CO-CPR and 7.0% for classic CPR ($p = 0.29$).[27] These findings indicate that the CO-CPR can be suggested as a core element of dispatcher-assistant CPR programs. Although CO-CPR has no benefit on survival, compared to classic CPR, when it is used in a DA-CPR protocol, more callers can follow the protocol easily, and the CPR rate will increase. In our study, dispatcher-assisted CO-CPR resulted in a 42.2% increase in the bystander CPR rate. As a result, significant increases in survival and neurologic recovery were observed.

Most MCDs in this study could understand the protocol and performed the instructions without any extensive training. A total of 25.4% of cases with OHCA were detected by PCDs and were forwarded to MCDs. Approximately 24.2% received pre-arrival CPR instructions. Many studies have shown various detection rates/instruction rates or sensitivity/specificity in detecting cases. One study reported an instruction rate of 69% for eligible patients.[28] The sensitivity of MPDS in detecting cardiac arrest was 76.7% (95% confidence interval [CI]: 73.6%-79.8%), and the specificity was 99.2% (95% CI: 99.1–99.3%).[29] Previous studies have suggested that CO-CPR for cases without OHCA is either minimally or negligibly harmful. A study observed that 12% of the 247 patients not in arrest who received chest compressions experienced minimal discomfort, and 2% (6 of 247) sustained injuries likely or possibly caused by bystander CPR. Only 2% (5 of 247) suffered a fracture, and no patients suffered visceral organ injury.[30]

Table 4
Subgroup analysis using multivariable logistic regression analysis.

Outcome/subgroup	Exposure	Total	Positive		Crude			Adjusted*			HL Chi-square	*p*-value	c-statistic
		N	*n*	%	OR	95% CI		OR	95% CI				
Survival to discharge													
Patients receiving non-DA bystander CPR	Total	531	99	18.6									
	2009	148	33	22.3	1.00			1.00			3.4	0.902	0.868
	2010	190	39	20.5	0.90	0.53	1.52	1.00	0.50	1.97			
	2011	193	27	14.0	0.57	0.32	0.99	0.45	0.21	0.95			
Patients receiving DA bystander CPR or not	Total	7613	544	7.1									
	2009	2451	152	6.2	1.00			1.00			5.4	0.714	0.830
	2010	2666	165	6.2	1.00	0.80	1.25	1.11	0.86	1.42			
	2011	2496	227	9.1	1.51	1.22	1.87	1.51	1.19	1.91			
Good neurological recovery													
Patients receiving non-DA bystander CPR	Total	8144	643	7.9									
	2009	148	14	9.5	1.00			1.00			4.0	0.854	0.920
	2010	190	18	9.5	1.00	0.48	2.09	1.25	0.46	3.39			
	2011	193	16	8.3	0.87	0.41	1.84	0.96	0.34	2.68			
Patients receiving DA bystander CPR or not	Total	7613	158	2.1									
	2009	2451	41	1.7	1.00			1.00			10.3	0.247	0.928
	2010	2666	38	1.4	0.85	0.55	1.33	1.02	0.63	1.67			
	2011	2496	79	3.2	1.92	1.31	2.81	1.89	1.23	2.91			

OR, odds ratio; 95% CI, 95% confidence interval, HL chi-square: Hosmer–Lemeshow chi-square test: DA, dispatcher-assisted; CPR, cardiopulmonary resuscitation.
* Adjusted for age, gender, time of event (season, weekend, hour), witnessed, place, response time, prehospital transport time, defibrillation by emergency medical services, primary ECG, endotracheal intubation, laryngeal mask airway, and level of destination emergency department.

To increase the rate of detection of OHCA and pre-arrival CPR instructions, we held regular monthly educational meetings and gave providers some awards. This process might not be perfect for measuring quality and maintaining the skill and knowledge for performing DA-CPR. However, the detection rate, instruction rate, bystander and DA-CPR rates increased monthly during the intervention period. Regular and continuing monthly education might be effective to maintain quality. However, we also found fluctuations in rates, for example 12–18% for bystander CPR, in the latter six months. These findings favor the hypothesis that DA-CPR using CO-CPR is associated with increased bystander performance of CPR, but the protocol also requires a continuous quality management process. The low detection rate might be due to lower level of skill and knowledge of PCDs and absence of strong quality assurance program for maintaining their performance. But MCDs could provide prearrival CPR instruction with most cases which were detected by PCDs. High compliance rate might be due to higher level of skill and knowledge of MCDs who had fully experienced in EMS and were supervised by medical director. A quality assurance program for PCDs will increase the detection rate of OHCA and provide prearrival CPR instruction with more patients.

Subgroup analysis showed significant improvement in survival to discharge and good neurological recovery by intervention year excluding patients group who received bystander CPR without dispatcher assistance. The DA CPR has still a significant association with better outcome even when the natural increase in bystander CPR is removed. DA bystander CPR in 2011, in contrast, had poorer outcome than 2009/2010. The poor outcome in patients group receiving non-DA bystander CPR might be due to a trade-off from non-DA bystander CPR with low quality to DA bystander CPR with relatively high quality of bystanders with previous training experience.

We could not analyze the association between DA CPR protocol implementation and performance improvement in EMTs' CPR during ambulance transport; higher resuscitation attempt rate, higher advanced airway management (LMA) rate, defibrillation attempt rate, and more patients transported to higher level of EDs. These changes were not direct results of DA CPR protocol. But if EMTs heard a prearrival CPR instruction during driving to the scene and found patients receiving a bystander CPR, they would be likely to give more efforts to save life after taking patients. The positive but unexpected effect followed by DA CPR intervention might contribute to better outcomes (9.4% of survival to discharge) in the ambulance CPR setting.

5. Limitations

This study has several limitations. First, this study was not a controlled trial but a before- and after-intervention trial, in which longitudinal changes were not controlled for unmeasured confounders. The natural increase in non-DA bystander CPR from 5.7% to 7.2% was not controlled in the final analysis and therefore we performed subgroup analysis to minimize the overestimation. Second, although we tried to adjust for many potential risks, including ED service levels, we might not have controlled all of the confounders, post-resuscitation care. The study setting was different from that of EMS systems with paramedic/physician providers, such as in most North American or European communities. The quality of bystander CPR and of EMS providers was not fully measured, which could have biased the results. We also did not measure dispatcher quality, which could have resulted in unmeasured bias for bystander CPR and its quality. The use of retrospectively collected data caused important variables to be categorized as unknown or missing, which might have caused some misclassification bias. Patients with unknown outcomes were excluded, which could have resulted in selection bias.

6. Conclusion

Simplified DA-CPR, using CO-CPR, was associated with an increase in survival to discharge with good neurological outcomes, as well as an increase in the bystander CPR rate, in adult patients with presumed cardiac etiologies in a metropolitan area.

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Conflict of interest statement

There are no additional conflicts of interest related to this study for any of the authors.

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