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Clinical paper

Sustaining improvement of dispatcher-assisted cardiopulmonary resuscitation for out-of-hospital cardiac arrest patients in Japan: An observational study

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A R T I C L E I N F O

Keywords:
Out-of-hospital cardiac arrest
Cardiopulmonary resuscitation
Dispatcher-assistance
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A B S T R A C T

Objectives: We aimed to estimate the relationship between the promotion of bystander cardiopulmonary resuscitation (CPR) with dispatcher-assistance over time and good cerebral function after out-of-hospital cardiac arrests (OHCAs).

Methods: This was a retrospective observational study, using a nationwide OHCA database in Japan. The eligible 267,193 witnessed cardiogenic OHCA patients between 2005 and 2016 were analysed. Multivariable logistic regression models were performed to estimate the effect of dispatcher-assisted bystander CPR per year. In addition, we calculated the number of patients with good cerebral function, which was attributed to dispatcher-assisted bystander CPR.

Results: Dispatcher-assisted bystander CPR was performed to 84,076 (31.5%), those without dispatcher-assistance were 48,389 (18.1%), and non-bystander CPR were 134,728 (50.4%). The adjusted odds ratio (AOR) of dispatcher-assisted bystander CPR vs. non-bystander CPR was significantly related to good cerebral function, regardless of the year (AOR, 1.47, 1.62; 95%CI, 1.19-1.80, 1.42-1.85, 2005 and 2016, respectively). The association of dispatcher-assisted bystander CPR with good cerebral function tended to increase (AOR, 1.11, 2.97; 95%CI, 0.99-1.24, 2.69-3.28, 2006 and 2016, based on 2005, respectively). Estimating the number of patients with good cerebral function who attributed to dispatcher-assisted bystander CPR was a significant increase from 41 in 2005 to 580 in 2016 ($p < .0001$, $r = 0.98$). Furthermore, chest compression consistently contributed to higher number of patients with good cerebral function than that with a combination of chest compression and shock with public-access-defibrillation.

Conclusion: We found that the increased dispatcher-assisted bystander CPR rate was related to good cerebral function at 1-month post OHCA. Chest compression without public-access-defibrillation was most helpful to that number, explaining the effects of dispatcher-assistance and sustaining improvement.

Background

Out-of-hospital cardiac arrest (OHCA) is a major health concern worldwide.[1–4] The rate of survival in high-income countries has improved, but still remains low.[5]

Early bystander cardiopulmonary resuscitation (CPR) with defibrillation plays a crucial role in the chain of survival after cardiogenic OHCA.[6–11] The time interval from collapse to initiation of bystander CPR by a layperson is an essential determinant of survival.[7,12,13]

In Japan, dispatch centers receive the emergency calls, and promote

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bystander CPR over a telephone. A number of studies have shown that dispatcher-assisted bystander CPR results in similar survival rates to spontaneous bystander CPR.[14–18]

Dispatcher-assisted bystander CPR has been promoted since 1999 in Japan and modified several times. However, the association between sustained dispatcher efforts and the survival rate has not been assessed. The purpose of this study was to estimate the association between promoting dispatcher-assisted bystander CPR over time and survival with good cerebral function.

Methods

Study design

This was a retrospective observational study, using a nationwide OHCA database which collected to assess the local OHCA's medical system in Japan. The Ethics Committee at Kokushikan University approved this study.

Study setting

Japan has an area of 378 000 km^2 and a population of approximately 127 million. Fire departments provide emergency medical service (EMS), and are overseen by the Fire and Disaster Management Agency. The EMS protocol for each region is managed by the local medical control system. An EMS team is comprised of three personnel, and includes at least one emergency life-saving technician, qualified to implement advanced airway management, intravenous lines, and defibrillation with a semi-automated defibrillator. Moreover, emergency life-saving technicians trained in the hospital can insert a tracheal tube and administer adrenaline with direct permission from a medical control physician over the phone. The dispatcher instructs bystander to the first aid over the phone if it needs. The instructor needs to have the license of emergency life-saving technician, emergency medical technician, or first aid instructor.

The validation system, as well as education for dispatchers, was initiated under the supervision of the local medical control system in 2013. The dispatcher-assist protocol, introduced by the Fire and Disaster Management Agency, was altered considering in the region emergency medical system.

Participants

We analysed layperson-witnessed OHCA patients who presumed cardiac etiology registered with the Utstein-style[19] database from January 1, 2005 to December 31, 2016. The data are registered by each EMS and administrated by the Fire and Disaster Management Agency. We excluded cases where: (1) age was null or unrealistic, (2) non-witnessed or status unknown, (3) witnessed by EMS or firefighters, and (4) non-cardiogenic.

Data variables

The variables in the Utstein-style template[19] were as follows: gender, age, etiology of arrest, bystander status, bystander-witnessed category (whether the bystander was a family member, a layperson, other without family, or EMS personnel), treatments by bystander CPR (chest compression, rescue breathing and defibrillation), dispatcher-instruction, initial electrocardiogram rhythm, treatments by EMS personnel (defibrillation, intravenous fluid, adrenaline administration and advanced airway management), time variables (collapse recognition, emergency call, ambulance arrival at the scene, CPR initiation by EMS, advanced life supports, ambulance arrival at the hospital), prehospital field return of spontaneous circulation (ROSC), 1-month survival, and cerebral outcomes a month after cardiac arrest. In this study, patients were divided into three groups:

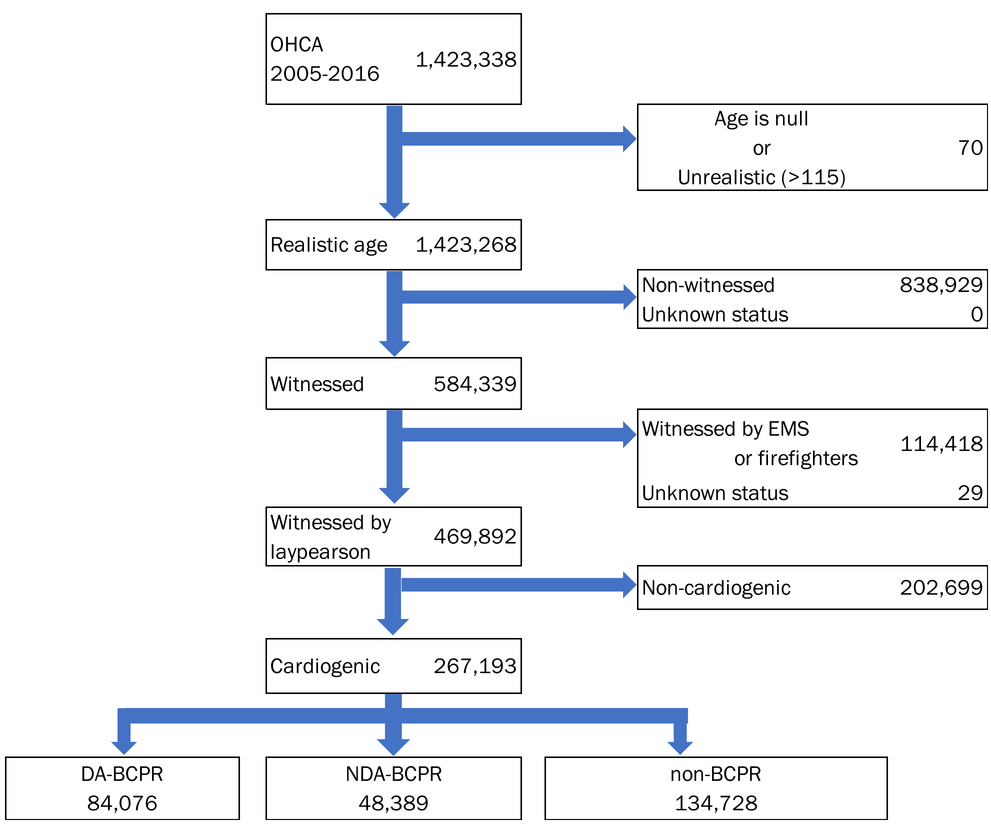


Fig. 1. Study population and subjects.
Abbrevation: OHCA, out-of-hospital cardiac arrest; EMS, emergency medical service; BCPR, bystander cardiopulmonary resuscitation; DA, dispatcher-assisted; NDA, non-dispatcher-assisted.

Table 1
Characteristics of patients with witnessed and cardiogenic out-of-hospital cardiac arrest by occurrence year.

Characteristic	N(%)									
	2005 (n = 17 952)		2006 (n = 18 902)		2007 (n = 19 700)		2008 (n = 20 769)		2009 (n = 21 112)	
Male sex	11352	(63.2)	11976	(63.4)	12341	(62.6)	12968	(62.4)	13164	(62.4)
Age, yr										
<15	115	(0.6)	90	(0.5)	146	(0.7)	194	(0.9)	107	(0.5)
15–44	905	(5.0)	942	(5.0)	1054	(5.4)	969	(4.7)	1009	(4.8)
45–64	3731	(20.8)	3769	(19.9)	3797	(19.3)	3924	(18.9)	3832	(18.2)
65–74	4010	(22.3)	4162	(22.0)	4097	(20.8)	4198	(20.2)	4236	(20.1)
75–84	5092	(28.4)	5558	(29.4)	5751	(29.2)	6197	(29.8)	6376	(30.2)
≥85	4099	(22.8)	4381	(23.2)	4855	(24.6)	5287	(25.5)	5552	(26.3)
Initial rhythm										
VF/VT	3873	(21.6)	4330	(22.9)	4399	(22.3)	4694	(22.6)	4878	(23.1)
PEA	5175	(28.8)	5873	(31.1)	6048	(30.7)	6358	(30.6)	6222	(29.5)
Asystole	8465	(47.2)	8302	(43.9)	8740	(44.4)	9099	(43.8)	9265	(43.9)
Other	439	(2.5)	397	(2.1)	513	(2.6)	618	(3.0)	747	(3.5)
Family bystander	12440	(69.3)	12977	(68.7)	12993	(66.0)	13440	(64.7)	13595	(64.4)
BCPR type										
Non-BCPR	11024	(61.4)	11073	(58.6)	10541	(53.5)	10962	(52.8)	10382	(49.2)
DA-BCPR	3547	(19.8)	4315	(22.8)	5340	(27.1)	5936	(28.6)	6494	(30.8)
NDA-BCPR	3381	(18.8)	3514	(18.6)	3819	(19.4)	3871	(18.6)	4236	(20.1)
Defibrillation	4800	(26.7)	5326	(28.2)	5364	(27.2)	5658	(27.2)	5810	(27.5)
Adrenaline use	61	(0.3)	657	(3.5)	1697	(8.6)	2700	(13.0)	3597	(17.0)
Advanced airway use										
SGA	8549	(47.6)	8748	(46.3)	8432	(42.8)	8146	(39.2)	8219	(38.9)
TI	575	(3.2)	1221	(6.5)	1501	(7.6)	1607	(7.7)	1645	(7.8)
Call-to-contact interval, median (IQR), min	8	(6−10)	8	(6−10)	8	(6−10)	8	(6−10)	8	(6−10)
Contact-to–hospital arrival interval, median (IQR), min	21	(16–27)	21	(21–28)	22	(17–28)	22	(17–28)	22	(17–29)
ROSC before hospital arrival	1534	(8.6)	1876	(9.9)	2326	(11.8)	2659	(12.8)	3082	(14.6)
Cerebral intact survival	723	(4.0)	849	(4.5)	1238	(6.3)	1351	(6.5)	1556	(7.4)
Age-adjusted proportion(95% CI)	8.0	(6.7–9.3)	9.1	(7.8–10.4)	15.9	(14.1–17.7)	16.1	(14.4–17.8)	19.0	(17.3–20.7)
1-mo survival	1355	(7.6)	1586	(8.4)	2029	(10.3)	2174	(10.5)	2438	(11.6)
Age-adjusted proportion(95% CI)	13.5	(11.9–15.1)	15.5	(14.0–17.0)	21.2	(19.3–23.1)	22.4	(20.5–24.3)	24.9	(23.0–26.8)

Characteristic	N(%)													
	2010 (n = 22 463)		2011 (n = 23 296)		2012 (n = 23 797)		2013 (n = 25 149)		2014 (n = 24 886)		2015 (n = 24 117)		2016 (n = 25 050)	
Male sex	13740	(61.2)	14318	(61.5)	14348	(60.3)	15314	(60.9)	15272	(61.4)	15262	(61.3)	15262	(60.9)
Age, yr														
<15	138	(0.6)	111	(0.5)	149	(0.6)	134	(0.5)	132	(0.5)	131	(0.5)	147	(0.6)
15–44	1001	(4.5)	1127	(4.8)	997	(4.2)	1098	(4.4)	1048	(4.2)	1026	(4.3)	1008	(4.0)
45–64	3970	(17.7)	4165	(17.9)	3991	(16.8)	4034	(16.0)	3773	(15.2)	3712	(15.4)	3761	(15.0)
65–74	4254	(18.9)	4142	(17.8)	4398	(18.5)	4556	(18.1)	4809	(19.3)	4595	(19.1)	4759	(19.0)
75–84	6774	(30.2)	6890	(29.6)	6957	(29.2)	7456	(29.7)	7260	(29.2)	6854	(28.4)	7207	(28.8)
≥85	6326	(28.2)	6861	(29.5)	7305	(30.7)	7871	(31.3)	7864	(31.6)	7799	(32.3)	8168	(32.6)
Initial rhythm														
VF/VT	4856	(21.6)	4785	(20.5)	4773	(20.1)	5046	(20.1)	4757	(19.1)	4648	(19.3)	4859	(19.4)
PEA	6654	(29.6)	7105	(30.5)	7305	(30.7)	7749	(30.8)	7829	(31.5)	7832	(32.5)	8056	(32.2)
Asystole	10185	(45.3)	10448	(44.9)	10791	(45.4)	11253	(44.8)	11167	(44.9)	10495	(43.5)	10953	(43.7)
Other	768	(3.4)	958	(4.1)	928	(3.9)	1101	(4.4)	1133	(4.6)	1142	(4.7)	1182	(4.7)
Family bystander	14511	(64.6)	14833	(63.7)	14749	(62.0)	15949	(63.4)	15264	(61.3)	14791	(61.3)	15258	(60.9)
BCPR type														
Non-BCPR	11398	(50.7)	11878	(51.0)	11649	(49.0)	12435	(49.5)	11545	(46.4)	10743	(44.6)	11098	(44.6)
DA-BCPR	6843	(30.5)	7254	(31.1)	7812	(32.8)	8463	(33.7)	8952	(36.0)	9249	(38.4)	9871	(39.7)
NDA-BCPR	4222	(18.8)	4164	(17.9)	4336	(18.2)	4251	(16.9)	4389	(17.6)	4125	(17.1)	3923	(15.8)
Defibrillation	5866	(26.1)	5894	(25.3)	5911	(24.8)	5940	(23.6)	5972	(24.0)	5800	(24.1)	6113	(24.4)
Adrenaline use	4477	(19.9)	5330	(22.9)	5790	(24.3)	6487	(25.8)	6762	(27.2)	6928	(28.7)	7576	(30.2)
Advanced airway use														
SGA	8483	(37.8)	8860	(38.0)	8717	(36.6)	9170	(36.5)	8959	(36.0)	8702	(36.1)	8863	(35.4)
TI	1748	(7.8)	1671	(7.2)	1679	(7.1)	1620	(6.4)	1690	(6.8)	1770	(7.3)	1888	(7.5)
Call-to-contact interval, median (IQR), min	8	(7−10)	8	(7−10)	8	(7−11)	8	(7−11)	9	(7−11)	9	(7−11)	9	(7−11)
Contact-to–hospital arrival interval, median (IQR), min	23	(17–29)	23	(18–29)	23	(18–30)	23	(18–30)	23	(18–30)	23	(18–30)	23	(18–30)
ROSC before hospital arrival	3331	(14.8)	3687	(15.8)	3897	(16.4)	4379	(17.4)	4398	(17.7)	4520	(18.7)	4559	(18.2)
Cerebral intact survival	1610	(7.2)	1700	(7.3)	1776	(7.5)	2024	(8.1)	2001	(8.0)	2136	(8.9)	2257	(9.0)
Age-adjusted proportion(95% CI)	17.9	(16.2–19.6)	19.7	(17.7–21.7)	20.7	(18.9–22.5)	23.1	(21.2–25.0)	24.0	(22.1–25.9)	25.0	(23.1–26.9)	25.8	(24.0–27.6)
1-mo survival	2527	(11.3)	2561	(11.0)	2688	(11.3)	2998	(11.9)	3015	(12.1)	3134	(13.0)	3308	(13.2)
Age-adjusted proportion(95% CI)	24.2	(22.4–26.0)	25.4	(23.3–27.5)	27.2	(25.3–29.1)	29.4	(27.4–31.4)	31.0	(29.0–33.0)	32.3	(30.3–34.3)	33.0	(31.1–34.9)

Abbreviation: VF, ventricular fibrillation; VT, ventricular tachycardia; PEA, pulseless electrical activity; BCPR, bystander cardiopulmonary resuscitation; DA, dispatcher-assisted; NDA, non-dispatcher-assisted; EMS, emergency medical service; SGA, supraglottic airway; TI, Tracheal intubation; IQR, interquartile range; ROSC, return of spontaneous circulation; CI, confidence interval.

Table 2
Outcomes among treatment groups by occurrence year.

	N(%)																							
	2005 (n = 17 952)		2006 (n = 18 902)		2007 (n = 19 700)		2008 (n = 20 769)		2009 (n = 21 112)		2010 (n = 22 463)		2011 (n = 23 296)		2012 (n = 23 797)		2013 (n = 25 149)		2014 (n = 24 886)		2015 (n = 24 117)		2016 (n = 25 050)	
Good cerebral function																								
DA-BCPR	154	(4.3)	207	(4.8)	367	(6.9)	432	(7.3)	518	(8.0)	542	(7.9)	627	(8.6)	667	(8.5)	794	(9.4)	887	(9.9)	997	(10.8)	1080	(10.9)
NDA-BCPR	220	(6.5)	269	(7.7)	386	(10.1)	453	(11.7)	508	(12.0)	552	(13.1)	520	(12.5)	561	(12.9)	604	(14.2)	602	(13.7)	615	(14.9)	615	(15.1)
Non-BCPR	349	(3.2)	373	(3.4)	485	(4.6)	466	(4.3)	530	(4.4)	516	(4.5)	553	(4.7)	548	(4.7)	626	(5.0)	512	(4.4)	524	(4.9)	562	(5.1)
Survival																								
DA-BCPR	279	(7.9)	373	(8.6)	576	(10.8)	661	(11.1)	796	(12.3)	839	(12.3)	901	(12.4)	997	(12.8)	1150	(13.6)	1241	(13.9)	1362	(14.7)	1505	(15.3)
NDA-BCPR	341	(10.1)	415	(11.8)	538	(14.1)	615	(15.9)	699	(16.5)	703	(16.7)	674	(16.2)	711	(16.4)	766	(18.0)	817	(18.6)	800	(19.4)	788	(19.3)
Non-BCPR	735	(6.7)	798	(7.2)	915	(8.7)	898	(8.2)	943	(9.1)	985	(8.6)	986	(8.3)	980	(8.4)	1082	(8.7)	957	(8.3)	972	(9.1)	1015	(9.2)

Abbreviation: BCPR, bystander cardiopulmonary resuscitation; DA, dispatcher-assisted; NDA, non-dispatcher-assisted.

Table 3
Association between bystander cardiopulmonary resusctation with dispatcher-assistance and good cerebral function by occurrence year.[a].

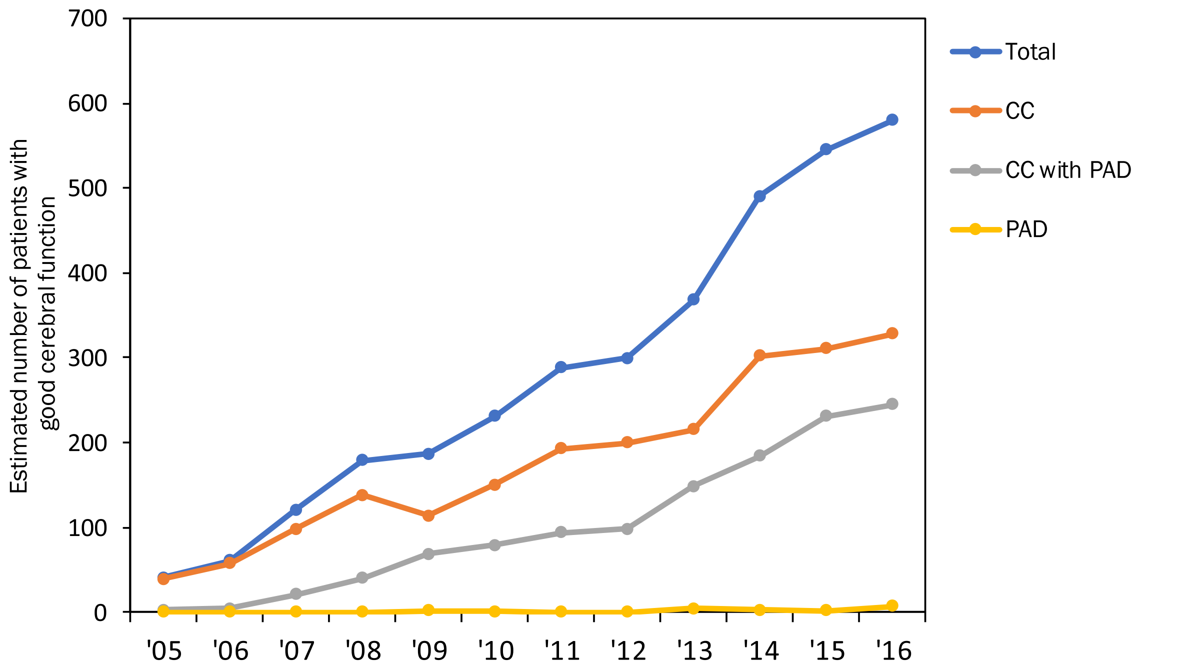
	Adjusted odds ratio (95% confidence interval)[b]											
	2005[c]	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Reference of Non-BCPR												
DA-BCPR	1.47 (1.19–1.80)	1.46 (1.20–1.77)	1.43 (1.21–1.68)	1.65 (1.41–1.94)	1.50 (1.29–1.74)	1.57 (1.35–1.82)	1.78 (1.55–2.05)	1.45 (1.25–1.67)	1.41 (1.23–1.61)	1.75 (1.52–2.00)	1.76 (1.53–2.01)	1.62 (1.42–1.85)
NDA-BCPR	1.58 (1.30–1.92)	1.57 (1.30–1.90)	1.65 (1.40–1.96)	1.98 (1.68–2.35)	1.8 (1.53–2.12)	1.93 (1.65–2.25)	1.91 (1.62–2.24)	1.69 (1.44–1.99)	1.82 (1.56–2.13)	1.74 (1.48–2.05)	1.93 (1.64–2.28)	1.72 (1.46–2.03)
Reference of NDA-BCPR												
DA-BCPR	0.93 (0.73–1.17)	0.93 (0.75–1.16)	0.86 (0.72–1.04)	0.83 (0.70–0.99)	0.83 (0.70–0.99)	0.81 (0.69–0.96)	0.93 (0.79–1.10)	0.86 (0.73–1.01)	0.77 (0.66–0.90)	1.00 (0.86–1.17)	0.91 (0.78–1.06)	0.94 (0.81–1.10)
Non-BCPR	0.63 (0.52–0.77)	0.64 (0.53–0.77)	0.6 (0.51–0.72)	0.5 (0.43–0.60)	0.56 (0.47–0.65)	0.52 (0.44–0.61)	0.52 (0.45–0.62)	0.59 (0.50–0.70)	0.55 (0.47–0.64)	0.57 (0.49–0.67)	0.52 (0.44–0.61)	0.58 (0.49–0.68)

Abbreviation: DA, dispatcher-assisted; BCPR, bystander cardiopulmonary resuscitation; NDA, non-dispacher-assisted.

[a] We excluded patients with impossible time variables(each of interval variable<0 minute) or outlying (emergency call-to-contact interval >30 minutes or contact-to–hospital arrival interval >90 minutes) data (n = 2458 [0.92%]).

[b] Adjusted by age(for one year increment), sex, prefecture, bystander type(family or nonfamily), initial electrocardiogram rhythm(ventricular fibrillation/ventricular tachycardia, pulseless electrical activity, asystole, or other), defibrillated by emergency medical service, adrenaline administration, advanced airway type(bag valve mask, supraglottic airway device or endotracheal intubation), call-to-contact interval(for 1 min increment),contact-to–hospital arrival(for 1 min increment).

[c] For the 2005 analysis, the variable of prefecture was excluded because the variable made regression models unstable. For each year analysis, good-of-fit tests were P = 1.0. All variables have no multicollinearity(VIF < 10). Area under receiver operating characteristics curve were 0.82, 0.87, 0.89, 0.91, 0.91, 0.91, 0.92, 0.92, 0.93, 0.93, 0.92, 2005 to 2016, respectively. R^2 were 0.18, 0.26, 0.32, 0.35, 0.37, 0.36, 0.38, 0.40, 0.40, 0.42, 0.44, 0.42, 2005 to 2016, respectively.



	Estimated number												p-value	Pearson's r
Total[a]	41	61	121	179	187	231	288	299	368	490	545	580	<.0001	0.98
CC	39	57	98	138	114	150	193	200	215	302	311	328	<.0001	0.98
CC+PAD	3	4	21	40	69	79	94	98	148	184	231	245	<.0001	0.97
PAD	0	0	0	0	2	1	0	0	4	3	2	7	0.005	0.74

Fig. 2. Estimating the number of good cerebral function patients who attributed to dispatcher-assisted cardiopulmonary resuscitation.
Abbreviation: CC, chest compression, PAD; public-access-defibrillation.
[a]Since the estimated number of patients was calculated by rounding down the decimals, the total number may be deviated.

DA-BCPR, performed bystander CPR with dispatcher-assistance; NDA-BCPR, performed bystander CPR without dispatcher-assistance; non-BCPR, did not perform bystander CPR. Bystander CPR was defined as chest compressions or defibrillation done by a layperson.

Cerebral outcomes were defined with the Glasgow-Pittsburgh Cerebral Performance Category (CPC) scale[19] from 1 to 5: (1): good cerebral performance, (2): moderate cerebral disability, (3): severe cerebral disability, (4): coma or vegetative state, and (5): death. The CPC categorisation was determined by the in-hospital physician in charge, as well as 1-month survival. When the patient discharged from the hospital before one month, the CPC score was recorded at the time of discharge. However, there is not an item about when the patients were discharged from the hospital in the database. CPR duration was defined as the time from initiation by EMS providers to prehospital ROSC.

Primary outcome

The primary endpoint was survival with good cerebral function at 1-month post-arrest, defined as CPC 1 or 2.

Statistical analysis

Patients' characteristics

We described patients' characteristics, demographics, treatments received, and outcomes. The number and percentage of qualitative data, as well as the median and interquartile range for quantitative data, was calculated. We showed age-adjusted proportions with 95% confidence intervals (CIs) for 1-month survival and survival with good cerebral function at 1-month post-arrest, calculated using the direct method, and based on the population in 2005.

Logistic regression analysis

The logistic regression models were applied to estimate the association between dispatcher-assisted bystander CPR and CPC 1-2 at 1 month by year with calculating the adjusted odds ratios (AORs) and 95%CIs. As potential confounders, adjusting for calendar year, prefecture, age, sex, initial electrocardiogram rhythms, emergency call-to-contact interval, contact-to-hospital arrival interval, adrenaline administration, and advanced airway management type (bag valve mask, supraglottic airway device, or tracheal tube) were adjusted in the multivariable models. .

The interannual effects of DA-BCPR were evaluated for DA-BCPR cases, with previous adjusting variables. We excluded patients with impossible time variables (each interval variable < 0 minutes) or outlying (emergency call-to-contact interval > 30 minutes, or contact-to-hospital arrival interval > 90 minutes) in this analysis ($n = 2458$ [0.92%]). Adrenaline administration and advanced airway management were related to patient severity. These factors were used in models as indicators of patient severity. Continuous variables that satisfied linearity were incorporated. It was confirmed that multicollinearity does not exist between variables. The area under the receiver operating characteristic curve (AUROC) was used to check the model's capability and specification. The goodness-of-fit test and coefficient of determination (R^2) were used for model fit evaluation.

Estimation of dispatcher-assisted bystander CPR attribution

In order to evaluate the effect of DA-BCPR on the actual number of patients, we calculated the number with good cerebral function, attributed to DA-BCPR. They represent an estimated number of treatment effects, based on attributable risk. The formula is: the number of patients receiving DA-BCPR each year × (the percentage of patients surviving with a favourable neurologic outcome among those receiving DA-BCPR each year − the percent surviving with a favourable neurologic outcome among not those receiving DA-BCPR each year). As a subanalysis, we calculated those attributable to good cerebral function for each type of bystander CPR (only chest compressions, only shock with AED, a combination of chest compressions and shock with AED). To evaluate the trend, we used a *t*-test (H_0: $\beta = 0$) for slopes by linear regression and effect size of Pearson's correlation coefficient.

All statistics were performed using JMP pro-version 13.2.1 (SAS Institute Inc., Cary, NC, USA). The value $p < .05$ (2-tailed) was considered to be statistically significant.

Results

A total of 1,423,338 patients was registered in the Utstein-style database from January 1, 2005 to December 31, 2016. Among them, 267 193 patients matching the extraction strategy were subjects in this study (Fig. 1). In all target years, DA-BCPRs were 84 076 (31.5%), NDA-BCPRs were 48 389 (18.1%), and non-BCPRs were 134 728 (50.4%).

Table 1 shows demographics and treatment trends. The proportion of people over age 85 increased. In the study period, DA-BCPR increased from 19.8% to 39.7%, and non-BCPR decreased from 61.4% to 44.6%. The age-adjusted proportion with good cerebral function increased from 8.0 per 100 000 persons to 25.8 per 100 000 persons. The percent of good cerebral function with DA-BCPR increased from 4.3% to 10.9%, NDA-BCPR increased from 6.5% to 15.1%, non-BCPR increased from 3.2% to 5.1%, with all groups improving (Table 2).

Table 3 shows an association between DA-BCPR and good cerebral function. The DA-BCPR was significantly related to good cerebral function compared with non-BCPR, regardless of year (AOR, 1.47, 1.62; 95% CI, 1.19–1.80, 1.42–1.85, 2005 and 2016, respectively). In the case of compared with NDA-BCPR, DA-BCPR indicated different associations (equivalent or inferior) for good cerebral function by years (AOR, 0.93, 0.94; 95%CI, 0.73–1.17, 0.81–1.10, 2005 and 2016, respectively).

In addition, DA-BCPR for good cerebral function tended to increase each year (AOR, 1.11, 2.97; 95%CI, 0.99–1.24, 2.69–3.28, 2006 and 2016 based on 2005, respectively). (eTable 1 in the Supplement).

Estimating the number of patients with good cerebral function contributed by DA-BCPR, there was a significant increase in the total number of patients receiving DA-BCPR from 41 in 2005 to 580 in 2016 ($p < .0001$, $r = 0.98$). Furthermore, in a subanalysis, chest compressions ($p < .0001$, $r = 0.98$) consistently contributed to a higher number of patients with good cerebral function than those with a combination of chest compressions and shock with public-access-defibrillator ($p < .0001$, $r = 0.97$) (Fig. 2).

Discussion

In this nationwide observational study, we evaluated the relationship between dispatcher-assisted bystander CPR and good cerebral function. From 2005 to 2016, patients with good cerebral function by dispatcher-assisted bystander CPR increased from 4.3% to 10.9% in study period, and we found that promotion of dispatcher-assisted bystander CPR was a factor in increasing good cerebral function. These results are evidence of the continuous improvement of a nationwide dispatcher-assistance system, along with dissemination and stepwise implementation.

The essential role of the dispatcher is assisting with cardiopulmonary resuscitation recognition for a bystander, reducing hesitation of starting bystander CPR, and shortening non-flow time. Given the effects of dissemination and efforts of dispatcher-assistance, the principal purpose of this study (i.e., promoting bystander CPR as the focus), we demonstrated how the relationship between increasing dispatcher-assistance and good cerebral function has become stronger each year.

Chest compressions without public-access-defibrillator contributed to the number of those surviving with good cerebral function. This may be due to the diffusion of compression-only CPR[20] instructions, which is simpler than conventional CPR (with ventilation) instruction.[21,22] Yet, the effect of chest compressions with public-access-defibrillator, potentially effective against shockable patients,[23,24] was lower. Many OHCAs occurred at home[25–27] where there may be only one bystander. The dispatcher rarely instructs them to get an AED. To deal with AED location and use, we must establish a system linking the dispatcher and first responder, such as going to get an AED using ICT.[28]

The dispatcher-assisted bystander CPR effect has been shown in previous research results.[14–18] However, we suspect that this was not only about dispatcher's efforts. A report of a simulation study on the quality of chest compressions with dispatcher-assistance showed that the depth of chest compressions did not reach an effective depth of 5 cm.[29–31] That is, the improvement and popularization of the dispatcher-assist system alone cannot explain this study's results. We consider that the spread of the basic life support (BLS) course increased awareness of bystander's resuscitation impact, and that the response to dispatcher-assistance improved. In dispatcher-assistance by phone, it can accurately instruct only auditory information. The rate conveyed is a rhythm, using a metronome, can be accurately instructed via telephone, but depth of compression, position, or recoil can not be instructed if using the guideline recommendations.[29–33]

Limitations

This study has several limitations. First, it may not address unmeasured confounders. In-hospital care, considered to be associated with cerebral function after OHCA, was not collected.[34,35] Second, in Japan's OHCA database, it is not recorded an application of AED (a shock by AED is recorded). So, it is not clear if the results of the subanalysis were influenced by fewer dispatcher instructions or less shockable rhythms. It was, however, speculated that fewer instructions because the shockable rhythm appeared about 20% of subjects. Third, the result of increasing cerebral function year by year might be influenced by the spread of AED, the increase of BLS activities, the improving of EMS treatment, and intensive care in-hospital in addition to dispatcher-assistance. Since this study was directed to witnessed cardiogenic cardiac arrest, it cannot be generalized for non-cardiogenic and non-witnessed cases.

Conclusion

We found that the rate of dispatcher-assisted bystander cardiopulmonary resuscitation has increased since 2005, and is related to good cerebral function at 1-month post-out-of-hospital cardiac arrest. Chest compressions without public-access-defibrillation were most helpful to that number, explaining effects of dispatcher-assistance and continuous improvement.

Measures to increase automated external defibrillator use, potentially effective against shockable patients, with dispatcher-assistance may more increase bystander cardiopulmonary resuscitation effectiveness.

Authors' contributions

RS conducted the studies, the statistical analysis, participated in sequence alignment, and drafted the manuscript. RS, KN, and HT participated in study design and performed statistical analyses. RS and KN drew the figures and tables. RS, HT, and HT conceived the study and participated in its design and implementation. MK assisted in planning this paper. ST and TK revised the manuscript for content. All authors read and approved the final version.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.resplu.2020.100013.

References

1. Nolan JP, Hazinski MF, Aickin R, et al. Part 1: executive summary: 2015 international consensus on cardiopulmonary resuscitation and emergency cardiovascular care science with treatment recommendations. *Resuscitation*. 2015;95: e1–e31.
2. Monsieurs KG, Nolan JP, Bossaert LL, et al. *European Resuscitation Council Guidelines for Resuscitation 2015 Section 1. Executive Summary*. vol. 95. Resuscitation-Limerick; 1972:1–80. currens. 2015.
3. Neumar RW, Shuster M, Callaway CW, et al. Part 1: executive summary: 2015 American Heart Association guidelines update for cardiopulmonary resuscitation and emergency cardiovascular care. *Circulation*. 2015;132(18_suppl_2):S315–S367.
4. Chung SP, Sakamoto T, Lim SH, et al. The 2015 Resuscitation Council of Asia (RCA) guidelines on adult basic life support for lay rescuers. *Resuscitation*. 2016;105: 145–148.
5. Yan S, Gan Y, Jiang N, et al. The global survival rate among adult out-of-hospital cardiac arrest patients who received cardiopulmonary resuscitation: a systematic review and meta-analysis. *Crit Care*. 2020;24(1):61.
6. Wissenberg M, Lippert FK, Folke F, et al. Association of national initiatives to improve cardiac arrest management with rates of bystander intervention and patient survival after out-of-hospital cardiac arrest. *Jama*. 2013;310(13):1377–1384.
7. Hasselqvist-Ax I, Riva G, Herlitz J, et al. Early cardiopulmonary resuscitation in out-of-hospital cardiac arrest. *N Engl J Med*. 2015;372(24):2307–2315.
8. Hansen CM, Kragholm K, Pearson DA, et al. Association of bystander and first-responder intervention with survival after out-of-hospital cardiac arrest in North Carolina, 2010-2013. *Jama*. 2015;314(3):255–264.
9. Nakahara S, Tomio J, Ichikawa M, et al. Association of bystander interventions with neurologically intact survival among patients with bystander-witnessed out-of-hospital cardiac arrest in Japan. *J Am Med Assoc*. 2015;314(3):247–254.
10. Kleinman ME, Brennan EE, Goldberger ZD, et al. Part 5: adult basic life support and cardiopulmonary resuscitation quality: 2015 American Heart Association guidelines update for cardiopulmonary resuscitation and emergency cardiovascular care. *Circulation*. 2015;132(18_suppl_2):S414–S435.
11. Japan Resuscitation Council. JRC Resuscitation Guidelines 2015 for online: Chaper 1 basic life support(BLS). https://www.japanresuscitationcouncil.org/wp-content/uploads/2016/04/1327fc7d4e9a5dcd73732eb04c159a7b.pdf.
12. Ono Y, Hayakawa M, Iijima H, et al. The response time threshold for predicting favourable neurological outcomes in patients with bystander-witnessed out-of-hospital cardiac arrest. *Resuscitation*. 2016;107:65–70.
13. Rajan S, Wissenberg M, Folke F, et al. Association of bystander cardiopulmonary resuscitation and survival according to ambulance response times after out-of-hospital cardiac arrest. *Circulation*. 2016;134(25):2095–2104.
14. Rea TD, Eisenberg MS, Culley LL, Becker L. Dispatcher-assisted cardiopulmonary resuscitation and survival in cardiac arrest. *Circulation*. 2001;104(21):2513–2516.
15. Bobrow BJ, Spaite DW, Vadeboncoeur TF, et al. Implementation of a regional telephone cardiopulmonary resuscitation program and outcomes after out-of-hospital cardiac arrest. *JAMA Cardiol*. 2016;1(3):294–302.
16. Ro YS, Shin SD, Lee YJ, et al. Effect of dispatcher-assisted cardiopulmonary resuscitation program and location of out-of-hospital cardiac arrest on survival and neurologic outcome. *Ann Emerg Med*. 2017;69(1):52–61 e1.
17. Takahashi H, Sagisaka R, Natsume Y, Tanaka S, Takyu H, Tanaka H. Does dispatcher-assisted CPR generate the same outcomes as spontaneously delivered bystander CPR in Japan? *Am J Emerg Med*. 2018;36(3):384–391.
18. Noel L, Jaeger D, Baert V, 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.
19. Perkins GD, Jacobs IG, Nadkarni VM, 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(13):1286–1300.
20. Hüpfl M, Selig HF, Nagele P. Chest-compression-only versus standard cardiopulmonary resuscitation: a meta-analysis. *Lancet*. 2010;376(9752):1552–1557.
21. Hallstrom AP. Dispatcher-assisted "phone" cardiopulmonary resuscitation by chest compression alone or with mouth-to-mouth ventilation. *Crit Care Med*. 2000;28(11 Suppl):N190–N192.
22. Cho GC, Sohn YD, Kang KH, et al. The effect of basic life support education on laypersons' willingness in performing bystander hands only cardiopulmonary resuscitation. *Resuscitation*. 2010;81(6):691–694.
23. Holmberg MJ, Vognsen M, Andersen MS, Donnino MW, Andersen LW. Bystander automated external defibrillator use and clinical outcomes after out-of-hospital cardiac arrest: a systematic review and meta-analysis. *Resuscitation*. 2017;120:77–87.
24. 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(10):954–965.
25. Kiguchi T, Kiyohara K, Kitamura T, et al. Public-access defibrillation and survival of out-of-hospital cardiac arrest in public vs. Residential locations in Japan. *Circ J : Off J Jpn Circ Soc*. 2019;83(8):1682–1688.
26. Kiyohara K, Nishiyama C, Matsuyama T, et al. Out-of-Hospital cardiac arrest at home in Japan. *Am J Cardiol*. 2019;123(7):1060–1068.
27. Kobayashi D, Sado J, Kiyohara K, et al. Public location and survival from out-of-hospital cardiac arrest in the public-access defibrillation era in Japan. *J Cardiol*. 2020;75(1):97–104.
28. Ringh M, Rosenqvist M, Hollenberg J, et al. Mobile-phone dispatch of laypersons for CPR in out-of-hospital cardiac arrest. *N Engl J Med*. 2015;372(24):2316–2325.
29. Mirza M, Brown TB, Saini D, et al. Instructions to "push as hard as you can" improve average chest compression depth in dispatcher-assisted cardiopulmonary resuscitation. *Resuscitation*. 2008;79(1):97–102.
30. Asai H, Fukushima H, Bolstad F, Okuchi K. Quality of dispatch-assisted cardiopulmonary resuscitation by lay rescuers following a standard protocol in Japan: an observational simulation study. *Acute Med. Surg.* 2018;5(2):133–139.
31. Trethewey SP, Vyas H, Evans S, et al. The impact of resuscitation guideline terminology on quality of dispatcher-assisted cardiopulmonary resuscitation: a randomised controlled manikin study. *Resuscitation*. 2019;142:91–96.
32. Lin YY, Chiang WC, Hsieh MJ, Sun JT, Chang YC, Ma MH. Quality of audio-assisted versus video-assisted dispatcher-instructed bystander cardiopulmonary resuscitation: a systematic review and meta-analysis. *Resuscitation*. 2018;123:77–85.
33. Park SO, Hong CK, Shin DH, Lee JH, Hwang SY. Efficacy of metronome sound guidance via a phone speaker during dispatcher-assisted compression-only cardiopulmonary resuscitation by an untrained layperson: a randomised controlled simulation study using a manikin. *Emerg Med J*. 2013;30(8):657–661.
34. Schenone AL, Cohen A, Patarroyo G, et al. Therapeutic hypothermia after cardiac arrest: a systematic review/meta-analysis exploring the impact of expanded criteria and targeted temperature. *Resuscitation*. 2016;108:102–110.
35. Beyea MM, Tillmann BW, Iansavichene AE, Randhawa VK, Van Aarsen K, Nagpal AD. Neurologic outcomes after extracorporeal membrane oxygenation assisted CPR for resuscitation of out-of-hospital cardiac arrest patients: a systematic review. *Resuscitation*. 2018;130:146–158.