Dissemination of Chest Compression-Only Cardiopulmonary Resuscitation and Survival After Out-of-Hospital Cardiac Arrest

Running title: Iwami et al.; Compression-only CPR and Survival from OHCA

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Abstract

**Background**—The best cardiopulmonary resuscitation (CPR) technique for survival after out-of-hospital cardiac arrests (OHCAs) has been intensively discussed in the recent few years. However, most analyses focused on comparison at individual level and how well the dissemination of bystander-initiated chest compression-only CPR (CCCPR) increases survival after OHCAs at the population level remains unclear. We therefore evaluated the impact of nationwide dissemination of bystander-initiated CCCPR on the survival after OHCA.

**Methods and Results**—A nationwide, prospective, population-based observational study covering the whole population of Japan and involving consecutive OHCA patients with resuscitation attempts was conducted from January 2005 through December 2012. The main outcome measure was one-month survival with favorable neurologic outcome. The incidence of survival with favorable neurologic outcome attributed by types of bystander CPR (CCCPR and conventional CPR with rescue breathing) was estimated. Among 816,385 OHCAs before emergency-medical-services arrival, 249,970 (30.6%) received CCCPR, 100,469 (12.3%) conventional CPR, and 465,946 (57.1%) no CPR. The proportion of OHCA patients receiving CCCPR or any CPR (either CCCPR or conventional CPR) by bystanders increased from 17.4% to 39.3% (P for trend <0.001) and 34.6% to 47.3% (P for trend <0.001), respectively. The incidence of survival with favorable neurologic outcome attributed by CCCPR per 10 million population significantly increased from 0.6 to 28.3 (P for trend=0.010), and that by any bystander-initiated CPR significantly increased from 9.0 to 43.6 (P for trend=0.003).

**Conclusions**—Nationwide dissemination of CCCPR for lay-rescuers was associated with the increase in the incidence of survival with favorable neurologic outcome after OHCAs in Japan.

**Key words:** cardiac arrest, cardiopulmonary resuscitation, death, sudden (if surviving, use heart arrest), epidemiology, chest compression resuscitation
Introduction

Sudden cardiac arrest is a major public health problem in the industrialized world.\(^1\text{-}^4\) Survival from out-of-hospital cardiac arrest (OHCA) has been increasing as the chain of survival improves, but is still low.\(^5\text{-}^8\) Cardiopulmonary resuscitation (CPR) by bystanders plays a key role in increasing survival after OHCAs.\(^1\text{-}^4\) However, despite the proven effectiveness of CPR by bystanders and communities’ efforts to increase CPR, the proportion of CPR performed by bystanders is still low in most of the world.\(^5\text{-}^8\)

The combination of chest compressions and rescue breathings has been a standard part of CPR.\(^9\text{-}^{10}\) Recently, many experimental\(^11\text{-}^{12}\) and clinical\(^13\text{-}^{17}\) studies have shown the importance of continuous chest compressions and the effectiveness of chest compression-only CPR (CCCPR). The 2010 CPR guidelines encourage all lay-rescuers to at least perform chest compressions, and recommendations CCCPR for untrained lay-rescuers and dispatcher-assisted CPR.\(^1\text{-}^4\) However, most analyses on the effectiveness of each types of CPR focused on comparison at individual level.

The Japanese 2010 CPR guidelines\(^3\) recommend that communities train citizens in CCCPR to further disseminate CPR, based on a consensus that any CPR would be better than no CPR. However, there is a concern that developing CCCPR training might decrease the survival chance of victims for whom conventional CPR with rescue breathing could be more effective than CCCPR,\(^18\text{-}^{20}\) and whether wider dissemination of bystander-initiated CCCPR increases survival after OHCA in the population level remains unclear.

The Fire and Disaster Management Agency (FDMA) of Japan launched a prospective, nationwide, population-based registry of OHCA victims in January 2005.\(^21\) Based on this registry, we aimed to evaluate whether nationwide dissemination of CCCPR for lay-rescuers contributed to increase the incidence of survival with favorable neurological outcome after OHCAs.
Methods

Study design and settings

The All-Japan Utstein Registry of the FDMA is a prospective, nationwide, population-based registry system of OHCA based on the standardized Utstein-style.\textsuperscript{22,23} This observational study enrolled all patients suffering OHCAs before emergency-medical-services (EMS) arrival, who were resuscitated by bystanders or EMS personnel, and then transported to medical institutions from January 1, 2005 through December 31, 2012. The Ethics Committee of Kyoto University Graduate School of Medicine approved this study. The requirement of written informed consent was waived.

Cardiac arrest was defined as the cessation of cardiac mechanical activity as confirmed by the absence of signs of circulation.\textsuperscript{22,23} The arrest was presumed to be of cardiac origin unless it was caused by cerebrovascular diseases, respiratory diseases, malignant tumors, external causes including trauma, hanging, drowning, drug overdose, and asphyxia, or any other non-cardiac causes. These diagnoses of cardiac or non-cardiac origin were clinically made by the physicians in charge in collaboration with the EMS personnel, and were fixed by the FDMA.

EMS systems in Japan

Japan has an area of approximately 378,000 km\textsuperscript{2}, and its population was approximately 127 million in 2005. There were 770 fire stations with dispatch centers in 2012, and EMS is provided by municipal governments.\textsuperscript{21} Usually, each ambulance has a crew of three emergency providers including at least one Emergency Life-Saving Technician (ELST), a highly-trained prehospital emergency care provider. ELSTs are allowed to insert an intravenous line and an adjunct airway, and to use semi-automated external defibrillators for OHCA patients. Specially trained ELSTs are permitted to insert tracheal tubes and administer intravenous epinephrine. Citizen use of an
automated external defibrillation (AED) has been legally permitted since July 2004. Details of the EMS system in Japan were described previously.5

**Systemic CPR training for the general public and dispatcher-assisted CPR**

In Japan, CPR training programs have mainly been conducted by local fire departments, and the program has been recommended by the FDMA and the Ministry of Health, Labour and Welfare based on the Japanese CPR guidelines.3 In 2012, local fire departments trained approximately 1.4 million citizens in conventional 3-hour CPR training programs consisting of chest compressions, mouth-to-mouth ventilation, and AED usage.21 The Japanese Red Cross, other organizations like local non-profit organizations, and driver’s license schools have also provided CPR training, and in total, it is expected that about 3 million people will be trained in CPR annually in Japan. The 45-90 minute CCCPR training started to be recommended in September 2013.24 In addition, the Ministry of Education, Culture, Sports, Science and Technology has recommended training in CPR and AED usage in junior high schools and high schools.22 Temporal trends in the number and proportion of people receiving each type of CPR training by local fire departments was shown in Table 1.21

The emergency telephone dispatchers in Japan are basically trained and ordered to give CPR instructions with conventional CPR before EMS arrival. Telephone-assisted CPR by dispatchers was changed from conventional CPR to CCCPR in 2006,26 and dispatchers started to encourage bystanders to provide CCCPR if it is difficult for them to administer rescue breathing.

**Data collection and quality control**

Data were prospectively collected and included origin of arrest, gender, age, type of bystander-witnessed status, first documented cardiac rhythm, time-course of resuscitation, type of bystander-initiated CPR, dispatcher instruction, public-access AED shock, administration of
intravenous fluid and epinephrine, and advanced airway management, as well as prehospital return of spontaneous circulation (ROSC), one-month survival, and neurological status one month after the event. A series of EMS times, including call receipt, vehicle arrival at the scene, contact with patients, initiation of CPR, defibrillation by EMS, and hospital arrival were recorded with the clock used by each EMS system. When laypersons delivered shocks using a public-access AED, the victims’ first documented rhythm was regarded as ventricular fibrillation (VF). Both bystander-initiated CCCPR and conventional CPR with rescue breathing were considered as bystander CPR. Data on initiation and type of bystander CPR was obtained by EMS observation and interview with the bystander before leaving the scene through the use of specific questions on the presence or absence of chest compressions and rescue breathing.

All survivors were followed for up to one month after the event by the EMS providers in charge. Neurological outcome was determined by a follow-up interview one month after successful resuscitation, using the cerebral performance category (CPC) scale: category 1, good cerebral performance; category 2, moderate cerebral disability; category 3, severe cerebral disability; category 4, coma or vegetative state; and category 5, death.22,23

The data form was filled out by the EMS personnel in cooperation with the physicians in charge of the patients transferred to their fire stations, and the data were integrated into the registry system on the FDMA database server. They were logically checked by the computer system and were confirmed by the implementation working group. If the data form was incomplete, the FDMA returned it to the respective fire station and the data were confirmed.

End points

The primary outcome measure was one-month survival with favorable neurologic outcome, which was defined as CPC category 1 or 2.22,23 Secondary outcome measures included ROSC.
before hospital arrival and one-month survival.

**Statistical analysis**

Analyses were conducted for patients with OHCAs before EMS arrival. Patient and EMS characteristics and outcomes by the type of bystander-initiated CPR were evaluated with analysis of variance for numeric variables and chi-square test for categorical variables. Trends in categorical values were tested with univariable regression models. Multivariable analysis with the use of logistic regression models was used to assess the contribution of bystander-initiated CPR to one-month survival with favorable neurologic outcome; odds ratios (ORs) and their 95% confidence intervals (CIs) were calculated. Factors that were biologically essential and considered to be associated with clinical outcomes were taken in the multivariable analyses as potential confounders. These variables included origin of arrest (cardiac, non-cardiac), gender (male, female), age (0-17, 18-74, >=75), type of bystander-witnessed status (yes, no), first documented rhythm (VF, non-VF), public-access AED shock (yes, no), dispatcher instruction (yes, no), intravenous fluid (yes, no), epinephrine (yes, no), advanced airway management (yes, no), and EMS response time (time interval from call to contact with a patient). The incidence of survival with favorable neurologic outcome per 10 million population attributed by bystander-initiated CPR was estimated annually as follows: the number of OHCA patients receiving CPR × (the proportion of favorable neurologic outcome among OHCA patients receiving CPR – the proportion among those without CPR)/10 million people from the 2005 Japanese census population. These trends were also tested with Poisson regression models. Subgroup analyses for respiratory etiology or children for potential harm of CCCPR were also conducted. All statistical analyses were performed using SPSS statistical package ver21.0J (IBM Corp. Armonk, NY). All tests were 2-tailed, and P values of <0.05 were considered statistically significant.
The authors had full access to the data and take responsibility for its integrity. All authors have read and agree to the manuscript as written.

Results

A total of 925,223 OHCA patients were documented during eight years (Fig. 1). Of 911,596 OHCA patients with resuscitation attempts, 835,402 had arrests before EMS arrival. Excluding patients without information on bystander-initiated CPR and first documented rhythm, and those with bystander-initiated rescue breathing-only CPR, 816,385 were eligible for our analyses. Among them, 249,970 (30.6%) received CCCPR, 100,469 (12.3%) conventional CPR, and 465,946 (57.1%) no CPR.

Trends in the proportion of bystander-initiated CPR are shown in Figure 2. The proportion of OHCA patients receiving any bystander-initiated CPR (CCCPR or conventional CPR) increased from 34.6% in 2005 to 47.3% in 2012 (P for trend <0.001), and the proportion of those receiving CCCPR increased from 17.4% to 39.3% during this period (P for trend <0.001).

<table>
<thead>
<tr>
<th>Patient and EMS characteristics and outcomes of OHCA patients by the type of CPR</th>
<th>Patient and EMS characteristics and outcomes of OHCA patients by the type of CPR</th>
</tr>
</thead>
</table>

bystander-initiated CPR are noted in Table 2. The etiology of cardiac arrests was similar among the groups. The conventional CPR group was more likely to be female, children aged 0-17 years, and be witnessed by bystanders, have VF as the first documented rhythm, and receive shocks with public-access AEDs than the CCCPR and no CPR groups. The proportion of those who received dispatcher CPR instruction was significantly greater in the CCCPR group than in the other groups. EMS resuscitation times were similar among the groups. The proportion of one-month survival with favorable neurologic outcome after OHCA was 1.9% in the CCCPR group, 2.7% conventional CPR, and 1.2% no CPR. In a multivariate analysis, both CCCPR (1.38; 95%
CI, 1.31 to 1.44) and conventional CPR (1.49; 95% CI, 1.40 to 1.57) were similarly more effective than no CPR after adjusting for prehospital confounding factors.

Table 3 shows trends in one-month survival with favorable neurologic outcome after OHCA by types of bystander-initiated CPR. Better neurological outcome gradually increased irrespective of the type of bystander-initiated CPR during the study period. In 2005, the conventional CPR group (1.68; 95% CI, 1.41 to 2.00) had a significantly higher OR for one-month survival with favorable neurologic outcome after OHCA than the no CPR group, while the CCCPR group did not (1.08; 95% CI, 0.88 to 1.33). In the last few years, both CCCPR and conventional CPR groups had similar ORs referring to the no CPR group.

Figure 3 shows the incidence of attributable survival with favorable neurologic outcome per 10 million population after OHCA by bystander-initiated CPR. The incidence of survival with favorable neurologic outcome attributed by any bystander-initiated CPR (either CCCPR or conventional CPR) significantly increased from 9.0 in 2005 to 43.6 in 2012 (P for trend=0.003), and survivors from CCCPR sharply increased from 0.6 to 28.3 (P for trend=0.010). Temporal trend in the incidence of attributable survival with favorable neurologic outcome per 10 million population after OHCA by bystander-initiated CPR of adult OHCAs with cardiac etiology (Appendix Figure 1) was almost same with those of whole OHCAs (Figure 3). The incidence of survival with favorable neurologic outcome attributed by bystander-initiated CPR was around zero irrespective of type of CPR among adult OHCAs of non-cardiac etiology or pediatric OHCAs (Appendix Figures 2, 3, and 4).

Discussion

From the nationwide registry of OHCA, we successfully demonstrated that wider dissemination
of CCCPR was associated with the increase in bystander-initiated CPR and the incidence of OHCA survival with favorable neurologic outcome in the population level. The challenge of the Japanese CPR guideline to increase bystander CPR and survival after OHCA by use of CCCPR\(^3\) and the continuous national registry enabled to elucidate the effectiveness of wider dissemination of CCCPR to increase survival incidence from OHCA in the whole Japan.

By recommending CCCPR and implementing CCCPR training for citizens, the proportion of CPR (either CCCPR or conventional CPR) performed by bystanders increased. CCCPR, which is simpler and easier to learn and perform\(^{27,28}\) would make it possible for many lay-rescuers to learn and provide CPR. An Arizona group launched a statewide effort to encourage bystanders to perform CCCPR, and led to a significant increase in the proportion of bystander CPR.\(^{16}\) The AHA is now leading the Hands-Only CPR campaign across the United States to increase CPR by bystanders.\(^{20}\) This study exhibiting the success of a nationwide dissemination of CCCPR will reinforce this strategy and help other communities promote these programs.

Most analyses on the effectiveness of each types of CPR focused on comparison between CCCPR and conventional CPR at individual level and how well the dissemination of bystander-initiated CCCPR increases survival after OHCAs at the population level remains unclear. The effectiveness of CPR for individual OHCA cases would differ by many factors including etiology of cardiac arrests, age of the victims, timing, and duration of cardiac arrests.\(^{13-20}\) Different from the comparison at individual level, for communities, the best CPR technique should be discussed as a total balance of clinical effectiveness to increase chance of survival at individual level and educational and implemented effectiveness to increase provision of CPR by bystanders in the community, and an increment in survival incidence in the population level is
important. The most important result from this nationwide registry of OHCA are not the comparison of ORs between CCCPR and conventional CPR, but the increase in the total incidence of survival with favorable neurologic outcome attributed by either type of bystander CPR.

Notably, although the proportion of conventional CPR by bystanders decreased as that of CCCPR increased, the incidence of survival attributed by conventional bystander-initiated CPR remained about the same. These data are important to lull the concern that developing CCCPR training might lose the chance of survival for victims among whom conventional CPR would be more effective than CCCPR. Well-trained rescuers such as off-duty medical professionals who can perform rescue breathing might successfully provide conventional CPR for those who need it, as the public endorsement of CCCPR in the State of Arizona successfully demonstrated. In addition, in adults, survival after OHCA of non-cardiac etiology and long duration cardiac arrests are similarly low regardless of the type of CPR. Conventional CPR would be more effective than CCCPR for pediatric cardiac arrests of non-cardiac origin, but their incidence is relatively small. Our subgroup analyses demonstrated that the incidence of survival with favorable neurologic outcome attributed by bystander-initiated CPR was around zero irrespective of type of CPR among adult OHCA of non-cardiac etiology or pediatric OHCA which might be harmed by CCCPR dissemination (Appendix Figure 2, 3, and 4). These data suggests even though there are some kinds of OHCA victims who need rescue breathing, the number is probably small.

The effectiveness of a wider dissemination of CCCPR in the community would depend on some conditions including the proportion of bystander CPR, the level of the EMS system and hospital care, the development of a public-access defibrillation (PAD) program, and survival
from OHCA in the region. Today, Japan has a well-organized and trained EMS system, and has one of the most developed PAD programs.\textsuperscript{21,32} We previously reported, based on this Japanese OHCA registry, that CCCPR was more effective than conventional CPR for OHCA patients who were witnessed and shocked with public-access AEDs, and suggested that CCCPR can be more useful in areas where there is a greater chance of receiving shocks with public-access AEDs.\textsuperscript{33} In Japan, the proportion of bystander CPR has been increasing in the last decade, but has levelled off to around 40\%\textsuperscript{5,6,21} In advanced areas where the proportion of bystander CPR is relatively high, the benefit of wider dissemination of CCCPR might be relatively small. However, the proportion of bystander CPR is insufficient in most areas of the world.\textsuperscript{1-4,27} Considering the recent data showing the benefit of wider dissemination of CCCPR in the community, we consider that CCCPR should be the standard for the lay-rescuer CPR program in most areas worldwide.

Although the Japanese CPR Guidelines started to recommend CCCPR for dispatcher-assisted CPR, our data showed that many bystanders assisted by dispatchers provided traditional CPR with rescue breathing. This high prevalence of traditional CPR in dispatcher-assisted CPR does not mean high prevalence of cardiac arrests which need rescue breathing such as pediatric cardiac arrests or obvious respiratory arrests, but difficulty to implement new guidelines or new strategies in an EMS system as reported.\textsuperscript{34,35} Most dispatch systems do not have detailed protocol for dispatcher-assisted CPR and just recommend dispatchers to encourage bystanders to provide CCCPR if they are not trained CPR or it is difficult for them to administer rescue breathing. Systematic training and detailed protocol for dispatchers are needed to improve dispatcher-assisted CPR and increase CPR by bystanders.

This nationwide registry shows that the proportion of bystander CPR and survival after OHCA is improving in Japan. However, survival with favorable neurologic outcome was still
3.3% and the proportion of those who received shocks with public-access AEDs was only 1.0% among witnessed OHCAs. Although public-access AEDs were delivered to over 40% of bystander-witnessed OHCA victims in some kinds of public places, it was still insufficient. Even in an interventional trial, on-site AED was used for only one third of the victims who had an arrest at locations with public-access AEDs. More strategies and efforts to increase the number of lay-rescuers who can at least perform CPR and use an AED are needed.

Limitations

The important limitations of this study are the lack of data on the quality of bystander CPR and the potential biases involved in providing CCCPR or conventional CPR. Previous study from Japan reported that unwillingness to perform conventional CPR was not due to fear or reluctance to provide mouth to mouth ventilation, but the lack of confidence in their ability to perform CPR properly. Because only conventional CPR with rescue breathing has been taught for a long time, rescuers who provide CCCPR may be less trained and thus provide less effective chest compressions, especially in earlier times. Temporal improvements in the OR of CCCPR referred to no CPR might be due to this bias. The insufficiency of detailed information on the type of CPR training is another limitation. As with all multisite epidemiological studies, data integrity, validity, and ascertainment bias are potential limitations.

Conclusions

Nationwide dissemination of CCCPR for lay-rescuers was associated with the increase in the incidence of survival with favorable neurologic outcome after OHCA in Japan.
**Acknowledgments:** We are greatly indebted to all of the EMS personnel and concerned physicians in Japan, and to the Fire and Disaster Management Agency and Institute for Fire Safety and Disaster Preparedness of Japan for their generous cooperation in establishing and following the Utstein database. We also thank Dr. Tomohiko Sakai for supporting the interpretation of results and writing the report.

**Conflict of Interest Disclosures:** None.

**References:**


Table 1. Trends in the Number and Proportion of Each Type of CPR Training During the Study Period in Japan.

<table>
<thead>
<tr>
<th></th>
<th>2005</th>
<th>2006</th>
<th>2007</th>
<th>2008</th>
<th>2009</th>
<th>2010</th>
<th>2011</th>
<th>2012</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N=127768000</td>
<td>N=127990000</td>
<td>N=128033000</td>
<td>N=128084000</td>
<td>N=128032000</td>
<td>N=128057000</td>
<td>N=127799000</td>
<td>N=127515000</td>
</tr>
<tr>
<td>Conventional 3-hour CPR training programs, n (%=n/N)</td>
<td>1147904 (0.9%)</td>
<td>1388212 (1.1%)</td>
<td>1499485 (1.2%)</td>
<td>1541459 (1.2%)</td>
<td>1490246 (1.2%)</td>
<td>1408864 (1.1%)</td>
<td>1345591 (1.1%)</td>
<td>1410981 (1.1%)</td>
</tr>
<tr>
<td>Conventional 8-hour CPR training programs, n (%=n/N)</td>
<td>68081 (0.1%)</td>
<td>78922 (0.1%)</td>
<td>72843 (0.1%)</td>
<td>77660 (0.1%)</td>
<td>75926 (0.1%)</td>
<td>76999 (0.1%)</td>
<td>79959 (0.1%)</td>
<td>84898 (0.1%)</td>
</tr>
<tr>
<td>45-90 minutes CCCPR training programs, n (%=n/N)</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>—</td>
<td>3402 (0.003%)</td>
<td>224230 (0.2%)</td>
<td>—</td>
</tr>
<tr>
<td>Other CPR training programs, n (%=n/N)</td>
<td>2095146 (1.6%)</td>
<td>2192795 (1.7%)</td>
<td>2427543 (1.9%)</td>
<td>2611750 (2.0%)</td>
<td>2528730 (2.0%)</td>
<td>2270840 (1.8%)</td>
<td>2270840 (1.8%)</td>
<td>2318930 (1.8%)</td>
</tr>
<tr>
<td>Total, n (%=n/N)</td>
<td>3311131 (2.6%)</td>
<td>3659929 (2.9%)</td>
<td>3999871 (3.1%)</td>
<td>4230869 (3.3%)</td>
<td>4094902 (3.2%)</td>
<td>3756703 (2.9%)</td>
<td>3699792 (2.9%)</td>
<td>4039039 (3.2%)</td>
</tr>
</tbody>
</table>

CPR indicates cardiopulmonary resuscitation, CCCPR chest compression-only CPR.
Table 2. Patient and EMS Characteristics and Outcomes From Out-of-hospital Cardiac Arrest By the Type of Bystander CPR.

<table>
<thead>
<tr>
<th>Etiology, no. (%)</th>
<th>Chest compression-only CPR (N=249970)</th>
<th>Conventional CPR (N=100469)</th>
<th>No CPR (N=465946)</th>
<th>P value‡</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac</td>
<td>146255 (58.5)</td>
<td>59407 (59.1)</td>
<td>252187 (54.1)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Non-cardiac</td>
<td>103715 (41.5)</td>
<td>41062 (40.9)</td>
<td>213759 (45.9)</td>
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<tr>
<td>External cause</td>
<td>10864 (4.3)</td>
<td>4451 (4.4)</td>
<td>19120 (4.1)</td>
<td></td>
</tr>
<tr>
<td>Respiratory disease</td>
<td>15428 (6.2)</td>
<td>6398 (6.4)</td>
<td>24036 (5.2)</td>
<td></td>
</tr>
<tr>
<td>Cerebrovascular disease</td>
<td>7805 (3.1)</td>
<td>1926 (1.9)</td>
<td>17091 (3.7)</td>
<td></td>
</tr>
<tr>
<td>Malignant tumor</td>
<td>39248 (15.7)</td>
<td>15825 (15.8)</td>
<td>93520 (20.1)</td>
<td></td>
</tr>
<tr>
<td>Other</td>
<td>30370 (12.1)</td>
<td>12462 (12.4)</td>
<td>59992 (12.9)</td>
<td></td>
</tr>
<tr>
<td>Male, no. (%)</td>
<td>139047 (55.6)</td>
<td>50992 (50.8)</td>
<td>283267 (60.8)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Age, year, median (Q1 - Q3)</td>
<td>79 (67 - 86)</td>
<td>79 (65 - 87)</td>
<td>76 (63 - 84)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Age group, no. (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Age 0-17 years</td>
<td>3298 (1.3)</td>
<td>3186 (3.2)</td>
<td>5851 (1.3)</td>
<td></td>
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<tr>
<td>Age 18-74 years</td>
<td>94124 (37.7)</td>
<td>36216 (36.0)</td>
<td>211398 (45.4)</td>
<td></td>
</tr>
<tr>
<td>Age &gt;=75 years</td>
<td>152548 (61.0)</td>
<td>61067 (60.8)</td>
<td>248697 (53.4)</td>
<td></td>
</tr>
<tr>
<td>Type of bystander witness status, no. (%)</td>
<td></td>
<td></td>
<td></td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>None</td>
<td>162432 (65.0)</td>
<td>58286 (58.0)</td>
<td>309298 (66.4)</td>
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<td>Yes</td>
<td>87538 (35.0)</td>
<td>42183 (42.0)</td>
<td>156648 (33.6)</td>
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<tr>
<td>Family member</td>
<td>52797 (21.1)</td>
<td>16941 (16.9)</td>
<td>111413 (23.9)</td>
<td></td>
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<tr>
<td>Friend</td>
<td>3224 (1.3)</td>
<td>1815 (1.8)</td>
<td>6187 (1.3)</td>
<td></td>
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<tr>
<td>Colleague</td>
<td>3042 (1.2)</td>
<td>1420 (1.4)</td>
<td>5277 (1.1)</td>
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<tr>
<td>Passer-by</td>
<td>3477 (1.4)</td>
<td>1416 (1.4)</td>
<td>10207 (2.2)</td>
<td></td>
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<tr>
<td>Other</td>
<td>24998 (10.0)</td>
<td>20591 (20.5)</td>
<td>23564 (5.1)</td>
<td></td>
</tr>
<tr>
<td>First documented rhythm, no. (%)</td>
<td></td>
<td></td>
<td></td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>VF</td>
<td>21853 (8.7)</td>
<td>12160 (12.1)</td>
<td>30194 (6.5)</td>
<td></td>
</tr>
<tr>
<td>PEA</td>
<td>42665 (17.1)</td>
<td>20823 (20.7)</td>
<td>97629 (21.0)</td>
<td></td>
</tr>
<tr>
<td>Asystole</td>
<td>185452 (74.2)</td>
<td>67486 (67.2)</td>
<td>338123 (72.6)</td>
<td></td>
</tr>
<tr>
<td>Shock by public-access AEDs, no. (%)</td>
<td></td>
<td></td>
<td></td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Dispatcher instruction, no. (%)</td>
<td></td>
<td></td>
<td></td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Intravenous fluid, no. (%)</td>
<td></td>
<td></td>
<td></td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Epinephrine, no. (%)</td>
<td></td>
<td></td>
<td></td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Advanced airway management, no. (%)</td>
<td></td>
<td></td>
<td></td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>EMS resuscitation times, min, median (Q1 - Q3)†</td>
<td></td>
<td></td>
<td></td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>EMS response time (call to contact with a patient)</td>
<td>8 (7 - 10)</td>
<td>8 (7 - 11)</td>
<td>8 (6 - 10)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Hospital arrival time (call to hospital arrival)</td>
<td>30 (24 - 37)</td>
<td>30 (24 - 37)</td>
<td>30 (24 - 38)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Outcomes, no. (%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Prehospital ROSC</td>
<td>15818 (6.3)</td>
<td>7982 (7.9)</td>
<td>24163 (5.2)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>One-month survival</td>
<td>10685 (4.3)</td>
<td>5717 (5.7)</td>
<td>16636 (3.6)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>CPC 1 or 2</td>
<td>4846 (1.9)</td>
<td>2690 (2.7)</td>
<td>5762 (1.2)</td>
<td>&lt; 0.001</td>
</tr>
</tbody>
</table>
Table 3. Trends in One-Month Survival with Favorable Neurologic Outcome from OHCA by Type of Bystander-Initiated CPR during the Study Period.

<table>
<thead>
<tr>
<th>Year</th>
<th>Conventional CPR</th>
<th>Chest compression-only CPR</th>
<th>No CPR</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n/N, % (95% CI)</td>
<td>n/N, % (95% CI)</td>
<td>n/N, % (95% CI)</td>
</tr>
<tr>
<td>2005</td>
<td>238/ (1.6%, 15226 1.4% - 1.8%)</td>
<td>141/ (0.9%, 15511 0.8% - 1.1%)</td>
<td>499/ (0.9%, 15219 0.8% - 0.9%)</td>
</tr>
<tr>
<td>2006</td>
<td>294/ (1.9%, 15602 1.7% - 2.1%)</td>
<td>233/ (1.2%, 19144 1.1% - 1.4%)</td>
<td>536/ (0.9%, 58835 0.8% - 1.0%)</td>
</tr>
<tr>
<td>2007</td>
<td>346/ (2.5%, 14028 2.2% - 2.7%)</td>
<td>445/ (1.8%, 25381 1.6% - 1.9%)</td>
<td>730/ (1.3%, 55992 1.2% - 1.4%)</td>
</tr>
<tr>
<td>2008</td>
<td>362/ (2.8%, 13033 2.5% - 3.1%)</td>
<td>601/ (2.0%, 30262 1.8% - 2.1%)</td>
<td>701/ (1.2%, 57472 1.1% - 1.3%)</td>
</tr>
<tr>
<td>2009</td>
<td>367/ (3.0%, 12064 2.7% - 3.3%)</td>
<td>740/ (2.1%, 34853 2.0% - 2.3%)</td>
<td>818/ (1.5%, 55663 1.4% - 1.6%)</td>
</tr>
<tr>
<td>2010</td>
<td>376/ (3.4%, 11098 3.1% - 3.7%)</td>
<td>830/ (2.1%, 38715 2.0% - 2.3%)</td>
<td>807/ (1.4%, 59109 1.3% - 1.5%)</td>
</tr>
<tr>
<td>2011</td>
<td>386/ (3.8%, 10238 3.4% - 4.1%)</td>
<td>885/ (2.1%, 41549 2.0% - 2.3%)</td>
<td>854/ (1.4%, 60877 1.3% - 1.5%)</td>
</tr>
<tr>
<td>2012</td>
<td>321/ (3.5%, 9168 3.1% - 3.9%)</td>
<td>971/ (2.2%, 44524 2.0% - 2.3%)</td>
<td>818/ (1.4%, 59740 1.3% - 1.5%)</td>
</tr>
</tbody>
</table>

OHCA indicates out-of-hospital cardiac arrest, CPR cardiopulmonary resuscitation, OR odds ratio, CI confidence interval.

Adjusted ORs (95% CI) of bystander-initiated conventional CPR and chest compression-only CPR referring to no CPR. ORs are adjusted for origin of arrest, gender, age, type of bystander-witnessed status, first documented rhythm, public-access AED shock, dispatcher instruction, intravenous fluid, epinephrine, advanced airway management, and EMS response time.
Figure Legends:

Figure 1. Flowchart of the Study. EMS denotes emergency medical service, CPR denotes cardiopulmonary resuscitation.

Figure 2. Trends in the Proportion of Compression-only CPR and Conventional CPR during the Study Period. CPR denotes cardiopulmonary resuscitation.

Figure 3. Trends in the Incidence of Survival with Favorable Neurologic Outcome per 10 Million Population, Attributed by the Type of Bystander-Initiated CPR. The trends were tested with Poisson regression models. CPR denotes cardiopulmonary resuscitation.
All out-of-hospital cardiac arrests from 2005 to 2012 in Japan
n = 925,288

- Age unknown n = 65

Confirmed cardiac arrests
n = 925,223

- No resuscitation n = 13,627

Resuscitation attempted
n = 911,596

- Arrests witnessed by EMS n = 73,827
  - Witness status unknown n = 2,367

Arrests before EMS arrival n = 835,402
  - Arrests witnessed by bystanders n = 296,652
  - Not witnessed arrests n = 538,750

- Rescue breathing only n = 5,764
  - Bystander CPR unknown n = 1,095
  - First documented rhythm unknown n = 12,388

Eligible patients
n = 816,385

- Chest compression-only CPR n = 249,970
- Conventional CPR n = 100,469
- No CPR n = 465,946

Figure 1
Figure 2

Chest compression-only CPR

Conventional CPR

Year

2005 2006 2007 2008 2009 2010 2011 2012

34.5 37.2 41.3 42.9 45.8 45.5 45.9 47.4

17.1 16.7 14.7 12.9 11.8 10.0 9.0 8.1

0 10 20 30 40 50

(%)
Incidence of Survival with Favorable Neurologic Outcome

- Any CPR (Trend P=0.003)
- Chest compression-only CPR (Trend P=0.010)
- Conventional CPR (Trend P=0.015)

Figure 3
SUPPLEMENTAL MATERIAL

Appendix Figure 1: Age ≥18, Cardiac cause

Incidence of Survival with Favorable Neurologic Outcome

- Any CPR (Trend P<0.001)
- Chest compression-only CPR (Trend P<0.001)
- Conventional CPR (Trend P=0.020)

Year

- Any CPR: 1.6, 7.1, 8.6, 14.2, 18.6, 30.8, 29.1, 38.0, 36.4, 38.3
- Chest compression-only CPR: 1.6, 4.6, 7.7, 11.0, 14.3, 16.4, 17.4, 23.3, 20.8, 25.7
- Conventional CPR: 1.6, 4.6, 7.7, 11.0, 14.3, 16.4, 17.4, 23.3, 20.8, 25.7

2005 2006 2007 2008 2009 2010 2011 2012
Appendix Figure 2: Age ≥18, Non-cardiac cause

Incidence of Survival with Favorable Neurologic Outcome

- Any CPR (Trend P=0.077)
- Chest compression-only CPR (Trend P=0.331)
- Conventional CPR (Trend P=0.162)
Appendix Figure 3: Age 0-17, Cardiac cause

- Any CPR (Trend P=0.220)
- Chest compression-only CPR (Trend P=0.312)
- Conventional CPR (Trend P=0.261)
Appendix Figure 4: Age 0-17, Non-cardiac cause

- Any CPR (Trend P=0.583)
- Chest compression-only CPR (Trend P=0.377)
- Conventional CPR (Trend P=0.607)