ORIGINAL RESEARCH

# Impact of Dispatcher-Assisted Bystander Cardiopulmonary Resuscitation with Out-of-Hospital Cardiac Arrest: A Systemic Review and Meta-Analysis

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**Abbreviations:**
BCPR: bystander cardiopulmonary resuscitation
CA: cardiac arrest
CPC: cerebral performance category
CPR: cardiopulmonary resuscitation
DA-BCPR: dispatcher-assisted bystander cardiopulmonary resuscitation
EMS: Emergency Medical Service
MINORS: Methodological Index for Non-Randomized Studies
OHCA: out-of-hospital cardiac arrest
PRISMA: Preferred Reporting Items for Systemic Reviews and Meta-Analyses
ROSC: return of spontaneous circulation

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## Abstract

**Objective:** This systemic review and meta-analysis was conducted to explore the impact of dispatcher-assisted bystander cardiopulmonary resuscitation (DA-BCPR) on bystander cardiopulmonary resuscitation (BCPR) probability, survival, and neurological outcomes with out-of-hospital cardiac arrest (OHCA).

**Methods:** Electronically searching of PubMed, Embase, and Cochrane Library, along with manual retrieval, were done for clinical trials about the impact of DA-BCPR which were published from the date of inception to December 2018. The literature was screened according to inclusion and exclusion criteria, the baseline information, and interested outcomes were extracted. Two reviewers assessed the methodological quality of the included studies. Pooled odds ratio (OR) and 95% confidence interval (CI) were calculated by STATA version 13.1.

**Results:** In 13 studies, 235,550 patients were enrolled. Compared with no dispatcher instruction, DA-BCPR tended to be effective in improving BCPR rate ($I^2$ = 98.2%; OR = 5.84; 95% CI, 4.58-7.46; P <.01), return of spontaneous circulation (ROSC) before admission ($I^2$ = 36.0%; OR = 1.17; 95% CI, 1.06-1.29; P <.01), discharge or 30-day survival rate ($I^2$ = 47.7%; OR = 1.25; 95% CI, 1.06-1.46; P <.01), and good neurological outcome ($I^2$ = 30.9%; OR = 1.24; 95% CI, 1.04-1.48; P = .01). However, no significant difference in hospital admission was found ($I^2$ = 29.0%; OR = 1.09; 95% CI, 0.91-1.30; P = .36).

**Conclusion:** This review shows DA-BPCR plays a positive role for OHCA as a critical section in the life chain. It is effective in improving the probability of BCPR, survival, ROSC before admission, and neurological outcome.

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## Introduction

Out-of-hospital cardiac arrest (OHCA) is a global public health problem[1] with unfavorable resuscitation outcomes.[2,3] Survival from OHCA largely depends on a set of sequentially coordinated, recursive interventions known as the life chain. Early bystander cardiopulmonary resuscitation (BCPR) provision before Emergency Medical Services (EMS) arrival can increase the opportunity of survival from OHCA.[4-6] However, despite large-scale community training programs, BCPR rates in cases of witnessed arrest have been persistently low.[7]

Dispatcher-assisted bystander cardiopulmonary resuscitation (DA-BCPR), which is implemented to augment the positive effect of BCPR and may improve outcomes of patients with OHCA, refers to emergency medical dispatchers or other emergency medical system staff issuing cardiopulmonary resuscitation (CPR) instructions to a bystander via telephone when OHCA has likely occurred. Simulation studies showed that with instructions from a dispatcher, bystanders without any experience of CPR training acted with comparable CPR quality to previously trained persons.[8] In addition, very few serious adverse consequences of these DA-BCPR programs have been reported to date.[9]

However, previous articles comparing outcomes in systems with DA-BCPR were inconsistent and were limited by several methodological problems, such as small sample size or insufficient control of covariates. Besides, previous systemic reviews revealed that there was limited evidence supporting the survival benefit of DA-BCPR instructions. Studies comparing survival outcomes when CPR was provided with or without the assistance of DA-BCPR instructions lacked the statistical power to draw significant conclusions.[10] However, dispatcher training, continuous quality control, and other DA-BCPR improvement projects were promising in improving operational links of DA-BCPR in recent years.[11-13] It is imperative to summarize the existing studies about the outcome of DA-BCPR again. A systematic review and meta-analysis aimed to summarize current research results on the survival and neurological outcomes of DA-BCPR was conducted.

## Material and Methods

This meta-analysis was performed according to the Cochrane Handbook for Systematic Reviews of Interventions (version 5.1.0) and presented based on Preferred Reporting Items for Systemic Reviews and Meta-Analyses (PRISMA) Guidelines (Appendix 1; available online only).[14] The protocol for this article is available in PROSPERO (CRD42019119277).

### *Data Source and Search Strategy*

PubMed (National Center for Biotechnology Information, National Institutes of Health; Bethesda, Maryland USA), Embase (Elsevier; Amsterdam, Netherlands), and the Cochrane Library (The Cochrane Collaboration; London, United Kingdom) were electronically searched for relevant citations using relevant text words and Medical Subject Headings by two independent researchers (Appendix 2; available online only). Moreover, magazines and meeting abstracts in the hospital library also were manually retrieved. There were no language or geographic restrictions and all searched studies were published from the date of inception to December 2018. No document restrictions and no methodology filters were applied. The search was limited to humans.

### *Inclusion and Exclusion Criteria*

Trials were selected based on the following inclusion criteria: (1) trials enrolling adults or children suffering OHCA; (2) the intervention was DA-BCPR; (3) bystanders in comparison group did not receive dispatcher CPR instructions; (4) studies providing BCPR rate, survival rate, or neurological outcomes of patients; and (5) randomized controlled trials or observational trials. Exclusion criteria were: (1) enrolled samples were all OHCA patients with BCPR; (2) the intervention was a bundle of CPR programs, including DA-BCPR; and (3) simulated patients and humans.

### *Assessment of Methodological Quality*

Although preferable, a randomized controlled trial could not have been possible, because withholding a potentially life-saving intervention would be considered unethical. In this review, all included articles were non-randomized. As a result, the Methodological Index for Non-Randomized Studies (MINORS)[15] was applied to further access the quality of each study by two reviewers independently. This validated index involves 12 items, the first eight items specifically designed for non-comparative studies and the remaining four items applied to comparative studies. Items are scored as zero (not reported), one (reported but inadequate), and two (reported and adequate). The maximum ideal score for non-comparative studies is 16, and for comparative studies, it is 24.

### *Data Extraction*

Included articles were examined in-depth and key data were extracted using a standardized electronic form: first author's last name, year of publication, site of origin, enrolment period, witnessed cardiac arrest (CA), number of institution, patients' age, the number of cases and controls, female rate, mean age, study design, etiology of CA, and follow-up duration. Survival to discharge was the primary outcome variable; if data of survival to hospital discharge were not available, 30-day survival was used as the primary outcome. Secondary outcomes were BCPR rate, return of spontaneous circulation (ROSC) before admission, hospital admission, and cerebral performance category (CPC) at discharge (if not available, 30-day CPC applied). Once chest compression was operated, CPR initiated. The odds ratios (OR) of preceding outcomes and 95% confidence intervals (CI) were extracted, and if not available, numbers of dichotomous outcomes were extracted. Any disagreement in extracted data was settled by consultation, and a final consensus was reached on all items. For CPC categories, CPC 1 was defined as good cerebral performance and CPC 2 was defined as moderate cerebral disability; CPC 1-2 was deemed as good neurological recovery while CPC 3-5 was regarded as bad neurological recovery.

### *Statistical Synthesis and Analysis*

Factors documented in at least three studies were entered into a meta-analysis. Odds ratio (OR) and 95% CI were calculated through the chi-square test by SPSS version 24.0 (IBM Corp.; Armonk, New York USA) for primary studies not reporting OR and 95% CI calculated by multivariate analysis. The adjusted data and unadjusted data were all included in the meta-analysis. Random-effect model was used to pool the data given the observational nature and the differences in settings and population of included studies, and the percentage of variability across the pooled estimates attributable to heterogeneity beyond chance was estimated using the $I^2$ statistic and the P value (a P value of less than or equal to 0.1 for heterogeneity). If no adjusted OR and 95% CI were reported in the included studies, the pooled OR was calculated according to dichotomous data. Sensitivity analysis was performed by shearing-patching methods. Another sensitivity analysis was performed by synthesized only adjusted data. Publication bias was assessed by funnel plot when the number of trials reporting the outcomes was 10 or more. All meta-analyses were performed using STATA version 13.1 (Stata Corporation; College Station, Texas USA). All tests were two-tailed, and $P < .05$ was considered statistically significant.

## Results

### *Studies Retrieved and Characteristics*

The literature search yielded 1,126 articles, of which 58 were reviewed in full text. Of these, 45 studies were excluded because they did not fulfil inclusion criteria. The flowchart of systemic review was displayed in PRISMA Flow Diagram. These studies and reasons for their exclusion are listed in the Supplemental Material 1 (available online only). At last, 13 studies (235,550 patients [DA-BCPR group 97,925 and non-DA-BCPR group 137,625]) met inclusion criteria.[16-28] The flow chart of this systemic review is shown in Figure 1. However, no randomized controlled studies were identified. These observational studies included three before-after studies, nine retrospective studies,

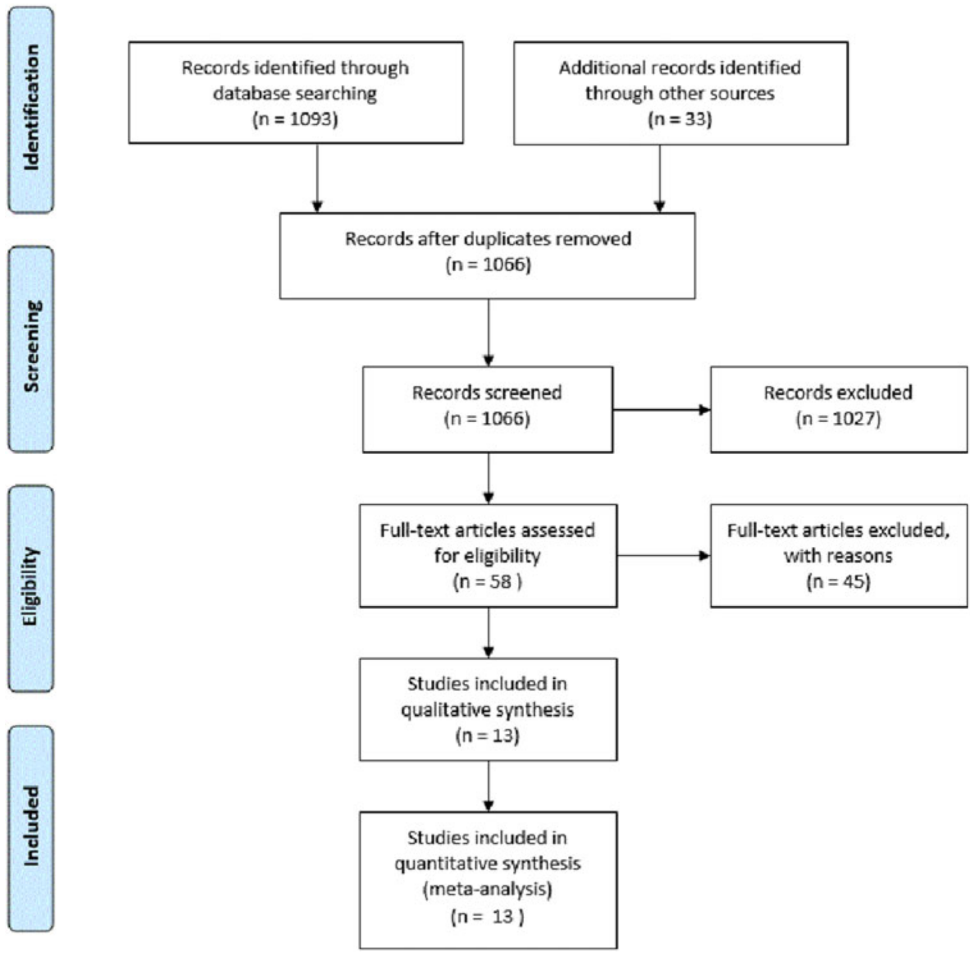




**Figure 1.** Flowchart of Systemic Review.

and one prospective cohort study. These studies were conducted in Japan (6; 46.2%), American (2; 15.4%), Finland (2; 15.4%), Sweden (1; 7.7%), Canada (1; 7.7%), and Korea (1; 7.7%). The duration of follow-up ranged from the process of DA-BCPR to one year following CA. Two studies[27,28] explored the impact of DA-BCPR on outcomes in children, while the rest invested the impact of DA-BCPR on outcomes in adults (or mostly adults). All trial results were published from 1976 through 2012. Sample size ranged from 135 to 173,565. Patients in seven studies were all witnessed OHCA. These study characteristics are shown in Table 1a and Table 1b. Their MINORS ranged 13-20 (Supplemental Material 2; available online only).

*BCPR Rate and DA-BCPR*

A significant difference in BCPR rate was found (OR = 5.84; 95% CI, 4.58-7.46; P <.01) favoring 97,561 DA-BCPR to 137,217 non-DA-BCPR enrolled in 11 articles with substantial heterogeneity ($I^2$ = 98.2%; P <.01; Figure 2). Sensitivity analysis including both shearing-patching methods and adjusted data were taken and indicated that this outcome was robust (Supplemental Material 3; available online only). Funnel plots showed that there was publication bias, and the publication bias was mostly due to substantial between-study heterogeneity (Supplemental Material 3).

*Survival Rate and DA-BCPR*

A significant difference in ROSC before hospital admission was found (OR = 1.17; 95% CI, 1.06-1.29; P <.01) favoring 18,955 DA-BCPR to 29,254 non-DA-BCPR enrolled in seven articles with mild heterogeneity ($I^2$ = 36.0%; P = .15; Figure 3). Sensitivity analysis of shearing-patching methods was taken and indicated that this outcome was robust (Supplemental Material 3).

No significant difference in hospital admission was found (OR = 1.09; 95% CI, 0.91-1.30; P = .36) between 2,830 DA-BCPR and 6,355 non-DA-BCPR enrolled in five articles with mild heterogeneity ($I^2$ = 29.0%; P = .23; Figure 4). Sensitivity analysis of shearing-patching methods was taken and indicated that this outcome was not robust (Supplemental Material 3).

Overall discharge or 30-day survival rate tended to be higher in 11,298 DA-BCPR than 11,702 non-DA-BCPR (OR = 1.25; 95% CI, 1.06-1.46; P <.01), and moderate between-study heterogeneity was observed for this analysis ($I^2$ = 47.7%; P = .05; Figure 5). Sensitivity analysis including both shearing-patching methods and adjusted data were taken and indicated that this outcome was robust (Supplemental Material 3).

*Neurological Outcomes and DA-BCPR*

A significant difference in neurological outcome was found (OR = 1.24; 95% CI, 1.04-1.48; P = .01) favoring 21,551 DA-BCPR to



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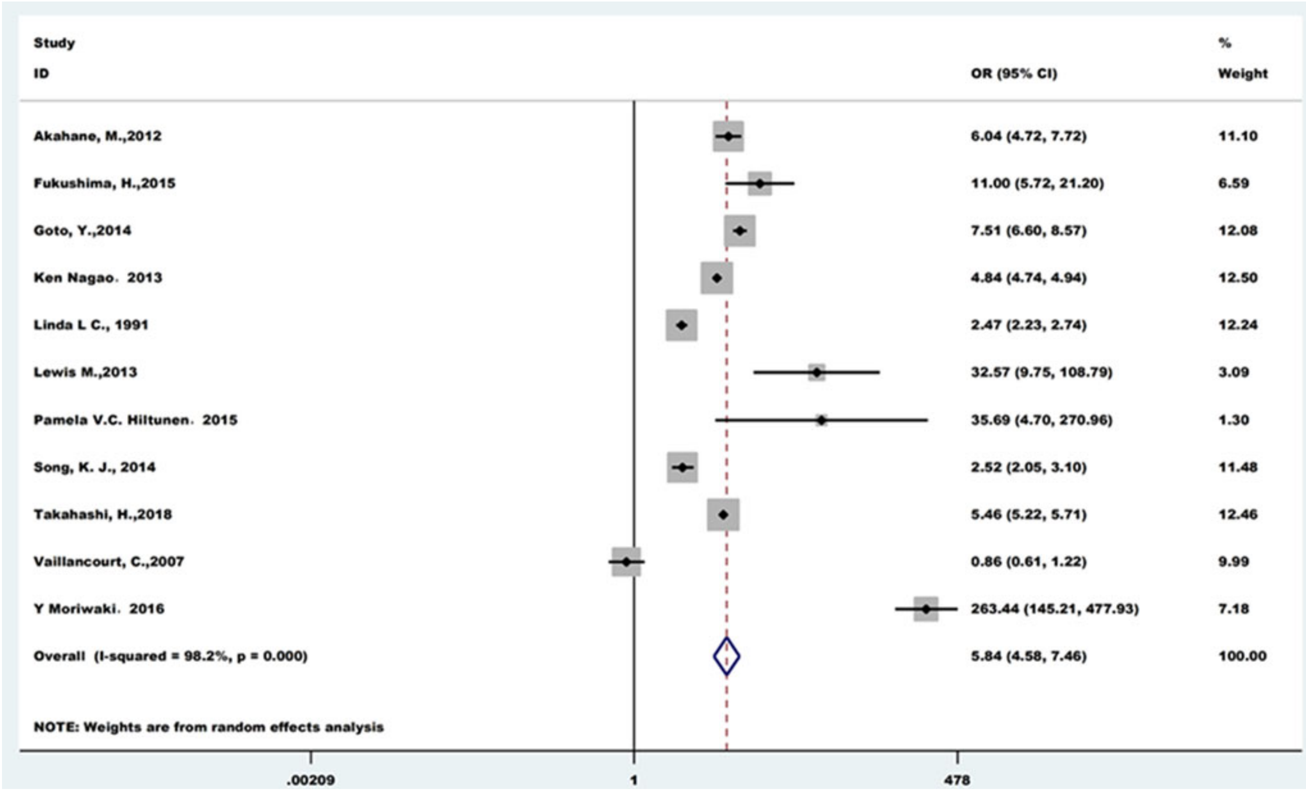




**Figure 2.** Forest Plot of Studies Reporting BCPR Rate.
Abbreviation: BCPR, bystander cardiopulmonary resuscitation.

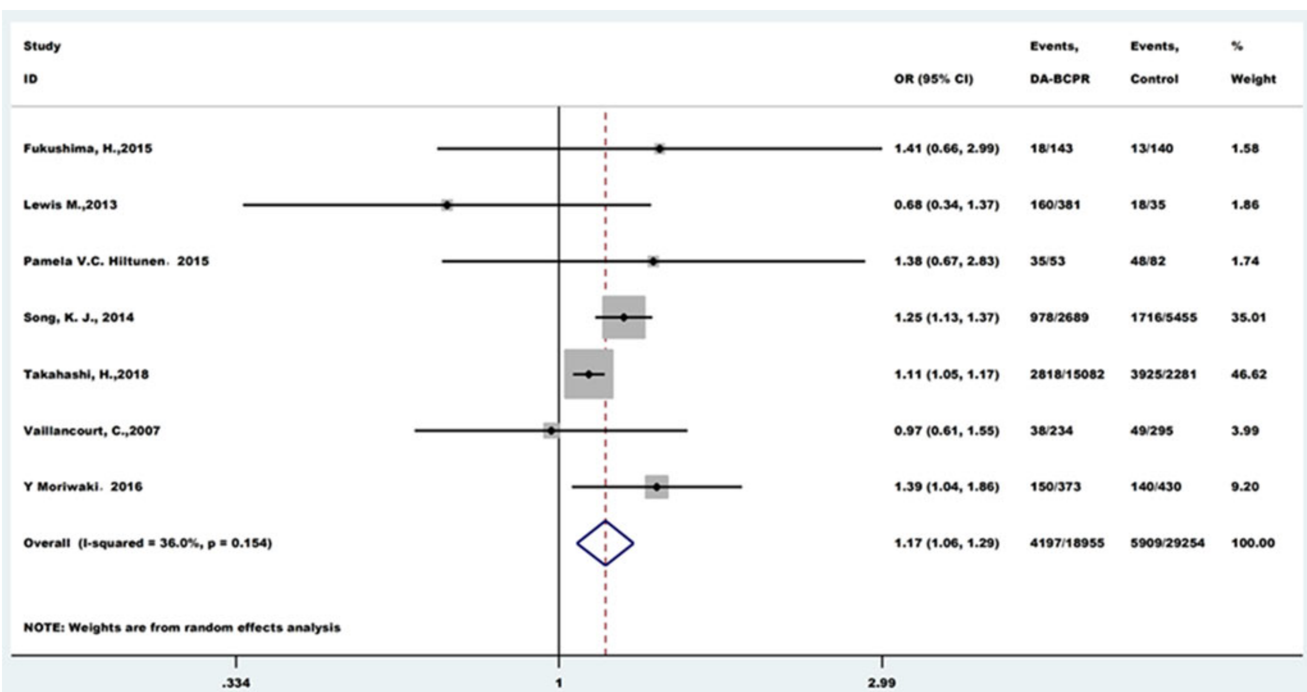




**Figure 3.** Forest Plot of Studies Reporting ROSC before Hospital Admission.
Abbreviations: DA-BCPR, dispatcher-assisted bystander cardiopulmonary resuscitation; ROSC, return of spontaneous circulation.



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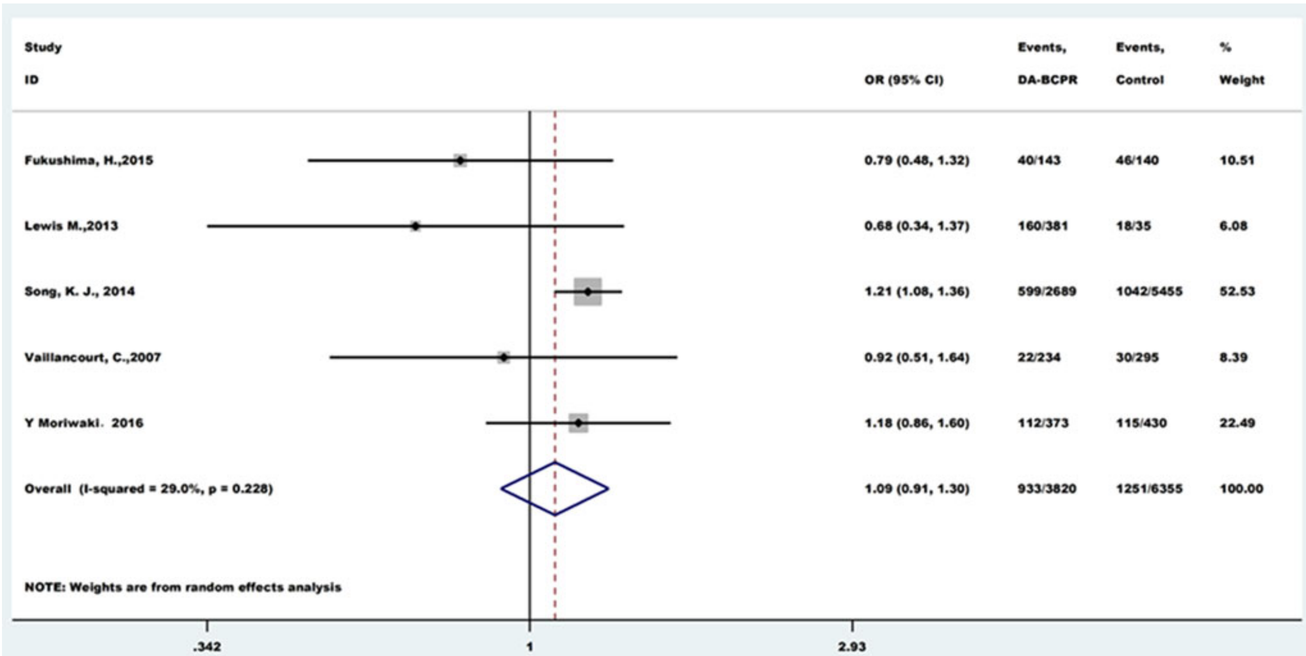

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**Figure 4.** Forest Plot of Studies Reporting Hospital Admission.
Abbreviation: DA-BCPR, dispatcher-assisted bystander cardiopulmonary resuscitation.

31,412 non-DA-BCPR enrolled in six articles with mild heterogeneity ($I^2 = 30.9\%$; P = .19; Figure 6). Sensitivity analysis including both shearing-patching methods and adjusted data were taken and indicated that this outcome was robust (Supplemental Material 3).

## Discussion

In view of the previous studies, the impact of DA-BCPR on survival and neurological outcomes with OHCA may be inconsistent. This systemic review and meta-analysis found DA-BCPR enhanced the provision of BCPR and improved the survival and neurological outcomes in pediatric and adult OHCAs. Survival to hospital admissions have shown trends of improvement but have yet to achieve statistical significance. European Resuscitation Council Guidelines for Resuscitation noted that dispatchers should provide telephone-CPR instructions in all cases of suspected CA, unless a trained provider is already delivering CPR.[29]

Early detection, call for help, early access to emergency services, and promptly initiated CPR were very important and known as elements of the "chains of survival."[29-32] Previous studies showed that the survival rate decreased as CPR was delayed.[33] Speedy BCPR is a key factor in improving survival from OHCA, offering a potential 50% decrease in mortality.[34] Fifty-three percent of CAs were witnessed by a bystander; however, only 32% of victims actually received BCPR before arrival of EMS.[35] Because most OHCA events were witnessed, efforts to improve survival should focus on prompt delivery of interventions of known effectiveness by bystanders. This research demonstrated that DA-BCPR could improve the probability of BCPR. As the effectiveness of BCPR is time-dependent, DA-BCPR before EMS arrival should be encouraged. Though, 56% of CA patients in included studies still did not receive BCPR. Recognition of CA and prompt activation time on the part of emergency medical dispatch are key measures that have been associated with improved survival rates after OHCA.[36]. Vaillancourt, et al found that dispatchers had 65.9% sensitivity and 32.3% specificity for the recognition of OHCA.[37] An optimized protocol, which includes a dispatcher education and training program, monthly debriefing meetings, and continuous quality control, is promising as it improved the successful recognition of CA.[13] The sensitivity of medical priority dispatch systems in detecting CA was 76.7% and the specificity was 99.2%.[38] A longer detection time interval from the call for ambulance to the detection of OHCA by the dispatcher in DA-BCPR showed significantly lower good neurological recovery in adult patients with witnessed OHCA. A 30 second delay in detection time interval was associated with a three percent decrease of a good CPC score.[39] Given this situation, simplified DA-BCPR instructions have resulted in time reduction and greater compression depth, even though the hand position might be corrected frequently in the conventional instruction group.[40] Delays in the delivery of dispatcher-assisted CPR chest compressions are common and are attributable to a mixture of dispatcher behavior and factors beyond the control of the dispatcher.[41] Inability to move patients to a hard, flat surface is associated with a reduced rate of DA-BCPR and increased time to first compression.[42] Even trained bystanders sometimes hesitate to start CPR and the dispatcher can also in these cases play an important role.[43] Some standardized protocols have the potential to help bystanders initiate CPR.[44] Instruction on chest-compression-only CPR; education on how to recognize OHCA with agonal breathing, emesis, and convulsion; recommendations for on-line or re-dialing instructions; and feedback from emergency physicians increased the incidence of telephone CPR and BCPR, and also decreased the incidence of failed DA-BCPR.[12] On-going training of medical dispatchers to ensure recognition of OHCA during emergency calls and provision of DA-BCPR instructions to the bystander


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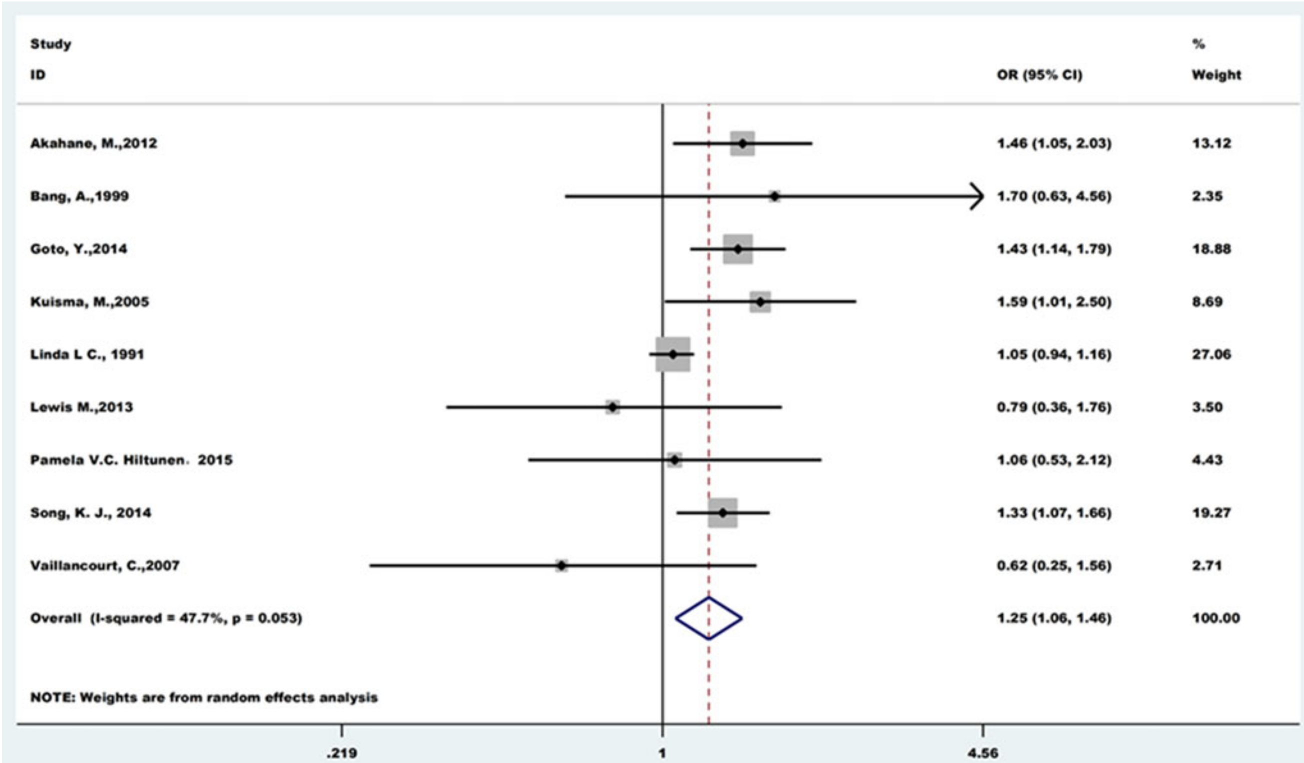




**Figure 5.** Forest Plot of Studies Reporting Survival Rate.

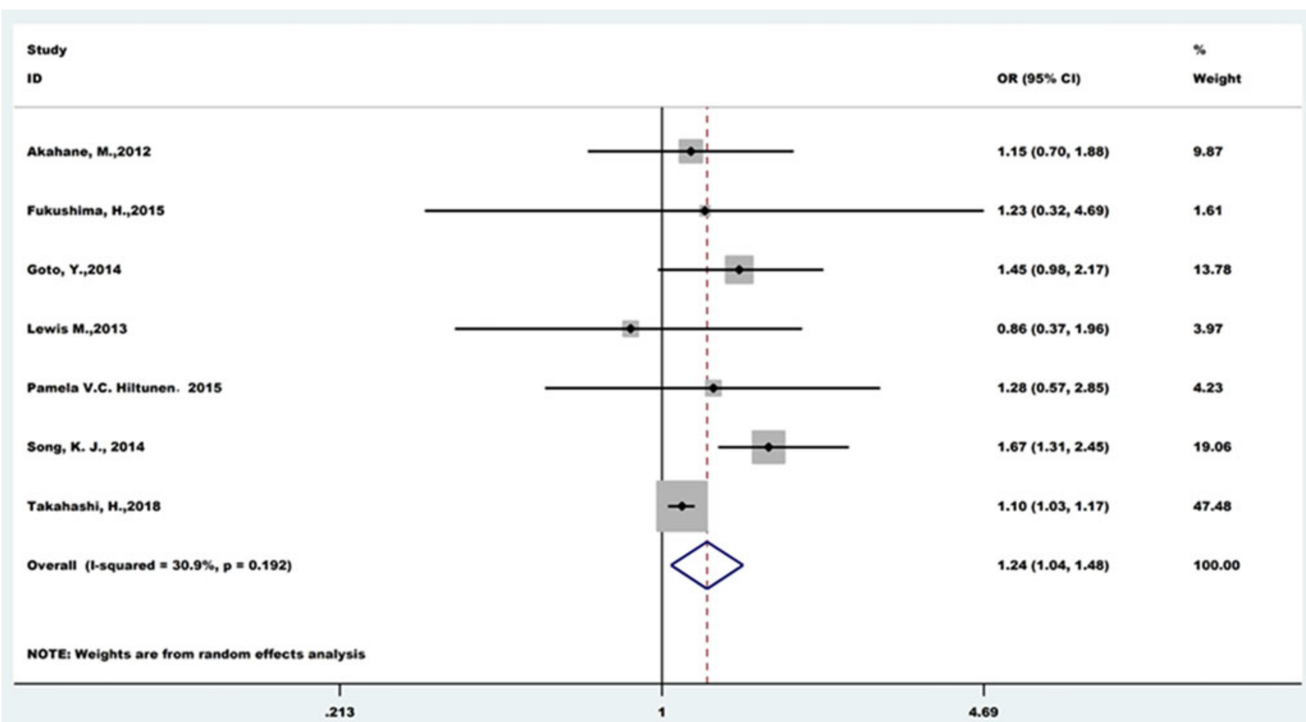




**Figure 6.** Forest Plot of Studies Reporting CPC1-2 Rate.
Abbreviation: CPC, cerebral performance category.



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was encouraged in the 2015 European Resuscitation Council Guidelines as a strategy for improving OHCA recognition and performance of high-quality BCPR.[45]

As was shown in this study, DA-BCPR was able to improve the probability of ROSC before hospital admission and discharge or 30-day survival, as well as the neurological outcomes. The CPR performed before EMS arrival was associated with a 30-day survival rate after an OHCA that was more than twice as high as that associated with no CPR before EMS arrival.[46] The quality of CPR and prolonged time interval from collapse to CPR have been suggested as possible causes for the limited survival effect of DA-BCPR, but the cause has not been determined.[10,47,48] Although a shorter delay from collapse to CPR,[17] the initiation of BCPR prior to the emergency call was not associated with an increase of ROSC or 30-day survival compared with DA-BCPR.[49] Conventional CPR is a complex behavior; skill acquisition is difficult and skill retention has been shown to deteriorate rapidly with time following community resuscitation training programs for the lay public.[50,51] Thus, DA-BCPR was originally intended to initiate CPR by bystanders with little or no training, but may be equally important for the large group of trained who panic and failed to start CPR.[43] Simulation studies suggest that bystanders without former CPR training who receive dispatcher-assisted instructions show comparable CPR skills to previously trained persons, although more time elapses before initiation of CPR for the untrained group.[52] The pre-arrival CPR instructions have been shown to increase the rate and depth of chest compression and improve the quality of BCPR, even in laypersons with previous CPR training.[53] It has been established that dispatcher assistance improves BCPR rates,[10,47] which leads to better outcomes.[54] Implementation of a standardized DA-BCPR protocol (such as medical priority dispatch and criteria-based dispatch) resulted in faster identification of CA, response team dispatching, and arrival at scene. These factors were associated with a trend to better survival.[55] Some measures were taken to improve the efficiency of DA-BCPR. Real-time smart-phone video conferencing calls between EMS personnel and physicians is feasible for patients with OHCA, and effective to improve the survival rate and cerebral function recovery rate.[56] A feedback CPR program with professional recording and feedback of CPR process was associated with good neurological recovery and survival to discharge.[57]

## Limitations

However, several limitations should be acknowledged. Firstly, there is substantial heterogeneity among included articles for some outcomes. Although 2015 international consensus recommend that dispatchers provide chest-compression-only CPR instructions to callers for adults with suspected OHCA,[58] the EMS of each country is different, and there were no uniform standardized dispatch tools, so the instructions provided by dispatchers are various. Besides, the quality of BCPR and arrest-to-CPR duration was not reported in most included articles, and it may be uneven. In all of the studies in this meta-analysis, no data were available whether the bystander had been trained in CPR or not, and it was unable to measure the quality of the BCPR. Secondly, the cases included in this article covered a long span of 35 years from 1976 through 2011. The protocol of DA-BCPR may have changed during this period. This may be another source of heterogeneity. Thirdly, all the articles included in this meta-analysis were not randomized controlled trials, which downgraded the quality of evidence. Fourthly, most included articles did not report the adjusted ORs of outcomes, so the ORs calculated by cross-tabs did not considered the confounding factors; for example, patients' age and gender, chest-compression-only or chest compression and mouth-to-mouth ventilation, attempted defibrillation, and collapse-to-initiation time.

## Conclusions

This systemic review and meta-analysis provide evidence suggesting that DA-BCPR plays an important role for OHCA as a critical section in the life chain. It is effective in improving the BCPR rate, ROSC before hospital admission, discharge or 30-day survival, and neurological outcome. Optimized standardized dispatch tools and DA-BCPR quality improvement should be amended to achieve better outcomes.

## Supplementary Material

To view supplementary material for this article, please visit https://doi.org/10.1017/S1049023X20000588


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| Author, Year | Akahane, 2012 | Bang, 1999 | Fukushima, 2015 | Goto, 2014 | Group JCSRSS, 2013 | Kuisma, 2005 | Culley, 1991 |
|---|---|---|---|---|---|---|---|
| **Country** | **Japan** | **Sweden** | **Japan** | **Japan** | **Japan** | **Finland** | **American** |
| Enrolment Period | 2005.1-2008.12 | 1994.1-1996.3 | 2007.1.1-2009.12 | 2008.1-2010.12 | 2006.1-2010.12 | 1997.1-2002.12 | 1976-1988 |
| MINORS Score | 15 | 15 | 17 | 17 | 17 | 17 | 13 |
| No. of Institution | 807 | 28 | 13 | Approx. 800 | Approx. 800 | 1 | 9 |
| Children/Adults (age) | Children | ≥15 | ≥18 | Children | ≥18 | NR | NR |
| Samples[a] | 1,780 | 426 | 283 | 4,306 | 173,565 | 346 | 6,918 |
| Witnessed CA | All | NR | All | 22% | All | All | All |
| Female | 570 (32.0%) | 136 (31.9%) | NR | 1679 (39.0%) | 67,690 (39.0%) | NR | NR |
| Age (year) | NR | 69 (15)[b] | NR | NR | 73.6 (15.9)[b] | NR | NR |
| Study Design | Before-After Study | Observational Study | Retrospective Analysis of Prospective Cohort Data | Retrospective Cohort Study | Observational Study | Retrospective Cohort Study | Before-After Study |
| Etiology of CA | Various | Various | NR | Various | Various | Cardiac Origin | Non-Traumatic |
| Follow-Up Time | 1-month | Discharge | Discharge | 1-month | 30-day | Discharge | TCPR Process |



**Table 1a.** Characteristics of Included Studies
Abbreviations: CA, cardiac arrest; MINORS, Methodological Index for Non-Randomized Studies; NR, not reported.

[a] Samples included in meta-analysis.

[b] Mean (standard deviation).

| Author, Year | Lewis, 2013 | Hiltunen, 2015 | Song, 2014 | Takahashi, 2018 | Vaillancourt, 2007 | Moriwaki, 2016 |
|---|---|---|---|---|---|---|
| **Country** | **American** | **Finland** | **Korea** | **Japan** | **Canada** | **Japan** |
| Enrolment Period | 2011.1-2011.12 | 2010.3-2010.8 | 2009.1-2011.12 | 2005.1-2012.12 | 2003.7-2004.12 | 2007.9-2010.2 |
| MINORS Score | 18 | 20 | 16 | 19 | 17 | 18 |
| No. of Institution | 1 | NR | 65 | NR | 1 | 12 |
| Children/Adults (age) | >17 | NR | ≥15 | 15-64 | Adults | NR |
| Samples[a] | 416 | 135 | 8,144 | 37,899 | 529 | 803 |
| Witnessed CA | 198 (47.6%) | All | 3,258 (40.0%) | All | 265 (50.1%) | Partly |
| Female | NR | NR | 2,850 (35.0%) | NR | 185 (35.0%) | NR |
| Age (year) | NR | NR | 66.7 (16.2)[b] | NR | 76 (65.8)[c] | NR |
| Study Design | Retrospective Cohort Study | Prospective Observational Cohort Study | Before-After Study | Retrospective Study | Retrospective Cohort Study | Retrospective Study |
| Etiology of CA | Non-Traumatic | NR | Cardiac Origin | Cardiac Origin | Non-Traumatic | NR |
| Follow-Up Time | Discharge | 1-year | Discharge | 1-month | 1-month | 7-day |



**Table 1b.** Characteristics of Included Studies
Abbreviations: CA, cardiac arrest; MINORS, Methodological Index for Non-Randomized Studies; NR, not reported.

[a] Samples included in meta-analysis.

[b] Mean (standard deviation).

[c] Median (interquartile range).