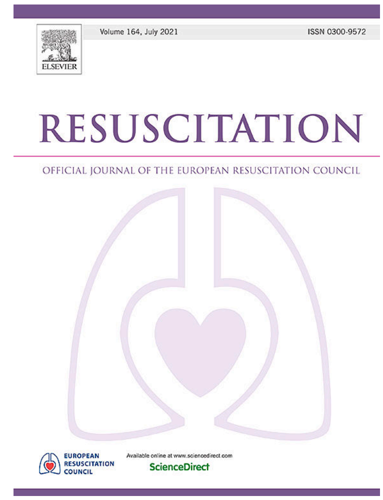
Journal Pre-proofs



Clinical paper

Bystander cardiopulmonary resuscitation for paediatric out-of-hospital cardiac arrest in England: an observational registry cohort study

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PII:	S0300-9572(21)00449-4
DOI:	https://doi.org/10.1016/j.resuscitation.2021.10.042
Reference:	RESUS 9268
To appear in:	*Resuscitation*
Received Date:	14 September 2021
Revised Date:	23 October 2021
Accepted Date:	28 October 2021

Please cite this article as: H. Albargi, S. Mallett, S. Berhane, S. Booth, C. Hawkes, G.D. Perkins, M. Norton, T. Foster, B. Scholefield, Bystander cardiopulmonary resuscitation for paediatric out-of-hospital cardiac arrest in England: an observational registry cohort study, *Resuscitation* (2021), doi: https://doi.org/10.1016/j.resuscitation.2021.10.042

Bystander cardiopulmonary resuscitation for paediatric out-of-hospital cardiac arrest in England: an observational registry cohort study

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Word count: 2969

Abstract word count: 241

Figures and tables: 6

References: 35

Abstract

Introduction: Bystander cardiopulmonary resuscitation (BCPR) is strongly advocated by resuscitation councils for paediatric out-of-hospital cardiac arrests (OHCAs). However, there are limited reports on rates of BCPR in children and its relationship with return of spontaneous circulation (ROSC) or survival outcomes.

Objective: We describe the rate of BCPR and its association with any ROSC and survival- to-hospital-discharge.

Methods: We conducted retrospective analysis of prospectively collected paediatric (<18 years of age) OHCA cases in England; we included specialist registry patients treated by emergency medical services (EMS) with known BCPR status and outcome between January 2014 and November 2018. Data included patient demographics, aetiology, witness status, initial rhythm, EMS, season, time of day and bystander status. Associations between BCPR, and any ROSC and survival-to-hospital-discharge outcomes were explored using multivariable logistic regression.

Results: There were 2363 paediatric OHCAs treated across 11 EMS regions. BCPR was performed in 69.6% (1646/2363) of the cases overall (range 57.7% (206/367) to 83.7% (139/166) across EMS regions). Only 34.9% (550/1572) of BCPR cases were witnessed. Overall, any ROSC was achieved in 22.8% (523/2289) and survival to hospital discharge in 10.8% (225/2066). Adjusted odds ratio (aOR) for any ROSC was significantly improved following BCPR compared to no BCPR (aOR 1.37, 95% CI 1.03-1.81), but adjusted odds ratio for survival-to-hospital-discharge were similar (aOR 1.01, 95% CI 0.66-1.55).

Conclusions: BCPR was associated with improved rates of any ROSC but not survival-to-hospital-discharge. Variations in EMS BCPR rates may indicate opportunities for regional targeted increase in public BCPR education.

Introduction

Four crucial actions form the 'chain of survival' for successful resuscitation following a cardiac arrest consists of four crucial actions: immediate recognition and a call for help; early cardiopulmonary resuscitation (CPR); early defibrillation; and optimal post-resuscitation care.[1] Bystanders play a key role in the first three actions, and the International Liaison Committee on Resuscitation has recommended applying any form of bystander CPR (BCPR) over no bystander CPR (BCPR) for the paediatric population. [2, 3]

Current evidence of the impact of BCPR on survival-to- hospital-discharge in paediatric patients is mixed. In a study by Naim et al (2017), the survival-to-hospital-discharge almost doubled when BCPR was performed compared to no BCPR (14.2 vs 8.6%). [4] However, other studies have not found a significant association between BCPR and survival,[5, 6] with several confounding factors including demographic characteristics (e.g. age), event characteristics (e.g. aetiology, witness status and shockable rhythm) and post-resuscitation care possibly influencing the association.

Globally, the reported BCPR rate varies widely across paediatric studies and ranges from 20% to 86%.[5, 7-13] Potential explanations for this variation include differences in (or a lack of) emergency medical services (EMS) dispatcher systems, variable community education programs, bystanders' fear of responsibility, infection concerns, as well as variations in study sample sizes. Therefore, the estimated paediatric BCPR rate remains uncertain.

In 2012, the University of Warwick established the Out-of-Hospital Cardiac Arrest Outcomes registry [14], which collects prospective data from the national ambulance services. There have been previous published reports of the larger cohort of adult out-of-hospital cardiac arrests patients which included some paediatric patients. However, there has been no in-depth analysis of the BCPR rate or its association with clinical outcomes in the paediatric population. [14]

Therefore, the aim of this study was to examine rates of BCPR in children <18 years of age across EMS regions in England, investigate potentially modifiable factors associated with BCPR and assess the relationship between BCPR with return of spontaneous circulation (ROSC) and survival-to-hospital-discharge outcomes.

Methods

Settings and Participants

This is a retrospective analysis of a prospective cohort within the OHCAO registry. This registry collects data from all 11 English ambulance service (Emergency Medical Services (EMS)) regions. We included paediatric OHCA patients identified from January 2014 to November 2018 who were under 18 years of age and had resuscitation attempted by EMS providers. We excluded EMS witnessed OHCA and patients whose bystander CPR status and outcome were missing.

Ethical Approval

The University of Warwick hosts the OHCAO project which has approval from the National Research Ethics Service (13/SC/0361). Details of the registry have been previously summarised. [(15)] This study was additionally approved by the University of Birmingham Internal Review Board (RG 17-246. 14.11.2018).

Description of the EMS

Eleven National Health Service ambulance trusts provide emergency care to different regions of England. The services respond to emergency calls made to 999 or 112. Calls are assessed by a dispatcher centre, which sends the appropriate team to manage the case with cardiac arrests categorised as a high priority. As one of the quality indicators of an ambulance services system, the target response time for life-threatening cases, such as cardiac arrest, was initially 8 minutes, and reduced to 7 minutes in 2017. [(16)] The dispatch system assigns the nearest available resources, including community responders, ambulance vehicles, or a helicopter to the scene. Emergency medical technicians and community responders may provide basic life support, which includes CPR, defibrillation and the use of supraglottic airway devices, if trained. Paramedics can then perform advanced life support including advanced airway management and intravenous medications. The dispatch may assign paramedics, technicians, or physicians to cardiac arrest cases.

The EMS provider must attempt resuscitation whenever there is chance of survival for the patient. However, if a patient shows signs of death, including hypostasis, rigour mortis, putrefaction etc., resuscitation is not pursued or continued and the case is recorded as a Recognition of Life Extinct (ROLE). [(17)]

Data Collection

Participating EMS clinical audit teams identify cases and extract data from routinely collected data recorded on Patient Report Forms and survival outcomes from admitting hospitals or from SPINE (https://digital.nhs.uk/services/spine), a secure national health and social care record sharing platform. The EMS clinical audit teams clean and verify their data before uploading it to the OHCAO registry servers. At this point, due to different terms used by each EMS region and to ensure data is mapped to the variables used in the registry, the data is transformed using service-specific rules. The OHCAO team verify and clean the data before it is analysed. [(14)]

Definitions

Age was divided into five groups based on the Utstein style[(18)]: infants (≤1 year); pre-school children (1-4 years); school children (>4-8 years); older school children (>8-12); and adolescents (>12-<18 years). Resuscitation characteristics included whether the OHCA case was witnessed by a member of the public. The initial cardiac rhythm was defined as shockable (ventricular fibrillation and pulseless ventricular tachycardia) or non-shockable (asystole and pulseless electrical activity). Bystander interventions included CPR and the use of an automated external defibrillator. Aetiology was categorised as medical (which included cardiac causes and non-cardiac causes), trauma, drowning, drug overdose and asphyxia. Daytime was defined as the period from 9.00 am to 4.59 pm, and nighttime was defined as the period from 5.00 pm to 8.59 am. The seasons (spring, summer, autumn and winter) were categorised based on the meteorological seasons.

The primary outcome was survival-to-hospital-discharge and the secondary outcome was any ROSC which included both pre-hospital arrival and ROSC achieved at transfer between EMS and emergency department teams.

Statistical Analysis

The primary exposure of interest was BCPR. We examined the association between demographic and pre-hospital factors with both BCPR, ROSC and survival outcomes. A statistical analysis plan was prepared prior to data analysis, including outcomes and adjusted variables chosen based on prior literature and clinical expertise (EMS and paediatric resuscitation). Descriptive statistics included means and standard deviations for normally distributed data and medians with interquartile ranges (IQRs) for non-parametric data. Comparison of BCPR and no-BCPR and outcomes were conducted using Chi-square tests for categorical variables, and the Mann-Whitney test was used for continuous data. We used univariate logistic regression analysis to calculate unadjusted odds ratio (OR) with a 95% confidence interval (CI) to examine the association between BCPR, age, sex, initial cardiac rhythm, arrest cause, status of the witness, the time of day and the season, EMS characteristics with ROSC and survival. A multivariable logistic regression analysis of complete case data was created using the same factors to identify adjusted odds ratio (aOR). Statistical analyses were performed using STATA 16.0 (STATA Corp., College Station TX, USA).

Results

A total of 3173 paediatric OHCA cases were identified from the OHCAO registry over a period of 4 years and 11 months. We excluded 308 (18 years or older), 258 (missing BCPR status), 215 (EMS witnessed) and 29 (missing both ROSC and survival outcome) cases. A total of 2363 cases were included (Supplemental Fig 1)

Demographics

The characteristics of included patients are detailed in Table 1. Median age of the cases was 3.1 years (IQR 0.5-11.5) and a third (33.4%) were less than 1 year of age (Supplemental Table 1). There were more males than females (58.7% vs. 41.3%). Medical causes accounted for 82.8% of all cardiac arrests and 34.1% were witnessed. An initial shockable rhythm was recorded in 6.87% of cases and an automated external defibrillator was used in 2.4% of cases (Table 1). An OHCA occurred most frequently between 05:00 pm and 08:59 am, with the highest frequency reported between 07:00 am and 07:59 am (Supplemental Fig 2). Overall, any ROSC was achieved in 22.8% of the cases, with 10.8% survival-to-hospital-discharge

BCPR was performed in 69.6% of all OHCA cases, of which 34.9% were witnessed. The number of cases per EMS region per year are outlined in Supplemental Table 2. The rate of BCPR varied across EMS regions and ranged from 57.7 to 83.7%. The highest BCPR rate was recorded in 2018 at 74.3% (Figure 1).

BCPR was less common for trauma-related OHCAs (62.5%). However, 79.1% of cases presenting with a shockable rhythm had undergone BCPR. After adjusting for age, sex, aetiology, EMS regions, status of witness, initial rhythm, time of the day and season there was a significantly reduced odds of receiving BCPR in patients experiencing a traumatic OHCA compared to other causes (aOR 0.64, 95% CI 0.42-0.97). There was variation across EMS in adjusted odds of receiving BCPR, ranging from a 3-fold increase to a reduction of a third compared to the EMS region with the largest number of patients. In the unadjusted analysis, a shockable rhythm was associated with increased odds of BCPR (OR 1.62, 95% CI 1.07-2.46), but not after adjusting for other factors (aOR 1.40, 95% CI 0.88-2.2). (Table 2).

Association between BCPR with ROSC and Survival Outcomes

There was a significantly higher number of patients achieving any ROSC after receiving BCPR compared to no BCPR (24.6% vs 18.6%; p = 0.02). However, the survival to hospital discharge rate was similar between the BCPR group and non-BCPR group (10.9% vs. 11.1%respectively; p=0.47). After controlling for age, sex and aetiology, status of witness, initial rhythm, time of the day and season, BCPR was associated with significantly higher odds of any ROSC (aOR 1.37, 95% CI 1.03-1.81) but not survival-to-hospital-discharge (aOR 1.01, 95% CI 0.66-1.55) (Table 3 and Table 4).

Association of Demographic and Pre-Hospital Factors with ROSC and Survival Outcomes

In the multivariable logistic regression analysis, BCPR (aOR 1.37, 95% CI 1.03-1.81), age (aOR 1.05, 95% CI 1.03-1.07), witnessed (aOR 2.17, 95% CI 1.68-2.79), shockable rhythm, (aOR 3.96, 95% CI 2.62-5.99), asphyxia (compared to medical, aOR 1.58, 95% CI 1.07-2.32) and daytime event (aOR 1.59, 95% CI 1.24-2.03) were associated with any ROSC (Figure 2).

Survival-to-hospital-discharge was associated with the presence of a witness (aOR 2.55, 95% CI 1.70-3.83), a shockable rhythm (aOR12.7, 95% CI 7.68-21.2), asphyxia (compared to medical 2.24, 95%CI 1.21-4.15) and summer (compared to spring, aOR 1.98,95% CI 1.15-3.39) (Figure 2) but not BCPR (aOR 1.01, 95% CI 0.66-1.55).

Discussion

We analysed more than 2300 paediatric OHCA cases, collected prospectively across 4 years from 11 EMS regions in England to describe the BCPR rate and its association with ROSC and survival. Several key findings were identified. BCPR was performed in 69.6% of the paediatric OHCA cases; however, the rate of BCPR varied across regions in England. Although a shockable rhythm was seen more often in cases BCPR cases, two thirds of those receiving BCPR were initially unwitnessed. Further, BCPR was associated with any ROSC but was not associated with an improvement in the survival-to-hospital-discharge rate.

In this study, BCPR was performed in two-thirds of paediatric OHCAs, a higher proportion than previous reports from the United States,[4] Korea[19] and Japan[20] (47%, 50%, 52%, respectively), but lower than a recent report from Sweden (75%). [11] Although previous studies have reported similar BCPR rates to ours, the study sample sizes were smaller compared to our cohort. [6, 21] The higher BCPR rate seen in our study may be due to national differences in the public's BCPR knowledge and education. In the UK there has been a substantial investment in CPR training by the British Heart Foundation, Resuscitation Council and other organisations. [22] In a UK survey of the general public by Hawkes et al, 60% reported having been trained in CPR [23], and several programs targeting parents, schools and the workplace have been established to increase the proportion of people able to perform CPR. [22] Furthermore, the use of technology and the media to raise awareness of the importance of BCPR through the Lifesaver web application and the delivery of simple messages on how to act in OHCA situations may have also influenced the BCPR rate. [22] [24]

The BCPR rate in paediatric OHCA did vary across EMS regions (ranging from 57.7% to 83.7%). This is consistent with previous published results combining a majority of adult cases with some paediatric cases from the OHCAO registry. [14] The authors of that study suggested that this was due to data quality, where some of the EMS sites had a considerable amount of missing data compared to others. In our study, not all EMS regions submitted data for each study year period which could partially explain the variation in the rates of BCPR. However, in England, there are differences in regional socioeconomic patterns, which could account for some of the variation as well. For example, some regions are more densely populated, some are more urban, while others are predominantly rural. [25] A recent adult study in England found that a low BCPR rate was associated with urban areas, a low education level and greater deprivation. [25] In that study, low BCPR rate in urban areas was due to greater level of deprivation compared to rural areas plus people may have believed EMS would rapidly arrive and therefore BCPR was not required. Fosbol et al, in an adult cardiac arrest study, showed that low-income areas and areas with a large elderly population were also linked to low BCPR rates. [26] The authors suggested that the elderly were not as well-trained to perform BCPR compared to younger people. In the paediatric population, a report from the United States also showed variation in BCPR between regions (26.2%-69.4%), but the reasons for the differences were unclear. [27] Other reports have linked variations in BCPR rates to the level of education,[28] and have shown that these rates are lower in communities with a low education level (45%-54%). Further examination is needed to determine the factors associated with regional variation in BCPR among children in England.

In this study, the overall survival-to-hospital-discharge rate was 10.8%, which was similar to previous findings from the USA [29] and the Donoghue et al [10] review, but higher than reports from Korea. [19, 30] However, unlike the USA and Korean reports, in our study BCPR was not associated with hospital survival improvement. A potential explanation was the low proportion of OHCA cases that were witnessed. Overall, only 34.1% of the cases were witnessed, and only 34.9% of the cases that received BCPR were witnessed. Although witnessed status was independently associated with ROSC and survival, the low proportion of witnessed patients that received BCPR may have affected any longer-term positive effect of BCPR due to delays in starting resuscitation efforts. Furthermore, the quality of the BCPR delivered was not assessed in our study has been demonstrated to be an important factor in in-hospital cardiac arrest settings. [31]

The rate of BCPR was similar across all age groups. However, infants comprised the largest proportion of OHCA cases (33.4%), a result similar to previous reports.[32] In our data, nearly two-thirds of infants received BCPR. However, infant OHCA cases, which include sudden infant death syndrome (SIDS), are often unwitnessed,[28, 32] therefore have an unknown time prior to attendance to the infant and any attempted BCPR. This prolonged duration may increase the likelihood of a poor outcome although there will be a strong emotive drive for parents and carers to commence BCPR regardless of any time delay.

A shockable rhythm has been linked to better outcomes in children; however, it is less common in children compared to adults. In this study, while only a small proportion of cases had a shockable rhythm (6.9%), it was associated with a higher rate of BCPR. Previous reports on both adults and children have identified BCPR as being associated with higher rates of ventricular fibrillation/pulseless ventricular tachycardia.[33] In a Japanese study, 60% of cases, where a shockable rhythm was identified, had undergone BCPR. [34] Also in a study by Herlitz et al,[35] the occurrence of a shockable rhythm increased following BCPR in scenarios of both early and late EMS arrival times. Therefore, it is possible that BCPR may prolong the duration of a shockable rhythm and increase the likelihood of it being recorded as an initial rhythm by EMS teams. The physiological mechanism for this remains unclear, but is likely related to continued myocardial perfusion.

Strengths and Limitations

This is the first study using data from the OHCAO registry in England to examine the association between BCPR and survival outcomes focused on a paediatric population. The OHCAO registry minimises heterogeneity in case identification and variability in EMS reporting through the standardisation of OHCA data collection following Utstein guidelines. Furthermore, our study sample was large, which minimised potential sources of bias. However, there were several limitations. While the study covered all of the regions of England, the results may not be generalizable to other countries or healthcare settings. Also, inherent with observational study design, there may have been unmeasured confounding effects that could have influenced our results. Furthermore, there was a small proportion of cases excluded with missing BCPR (n=258; 10.9% of total) and survival outcome data (n=29; 1.2%). Most data were missing due to some centres not recording particular variables for separate, short time periods, so the analysis results are likely to remain robust with 90% BCPR cases included. Type of chest compressions performed was unavailable for analysis. Data regarding the bystanders' level of CPR training or the use of dispatcher-assisted CPR (which is used by English EMS) were also unavailable, which could have affected the quality of the CPR given. Some studies have suggested that dispatcher-assisted BCPR has a better outcome than BCPR without EMS. [(19)]

Conclusions

In a large national cohort of paediatric OHCA cases, two thirds received BCPR although the rate of BCPR varied across EMS regions. While BCPR increased the probability of achieving any ROSC, it did not improve the eventual survival-to-hospital-discharge rate. A large proportion of cases that underwent BCPR did not have their OHCA witnessed. Further, there is a need to study the demographic and socio-economic factors that may underlie variation in the BCPR rate. More effort to increase education and training programs in the community might help in improving outcomes.

Conflicts of Interest

Dr Scholefield is funded by a National Institute for Health Research ((NIHR-CS-2015-15-016) Fellowship award. However, this project was not funded by the National Institute for Health Research. The views expressed are those of the authors and not necessarily those of the NHS, the National Institute for Health Research, or the Department of Health and Social Care.

Gavin Perkins is GDP is Director of the OHCAO Registry which is funded by the Resuscitation Council UK and British Heart Foundation and an Editor for Resuscitation. This research is supported by the National Institute for Health Research (NIHR) Applied Research Collaboration (ARC) West Midlands. The views expressed are those of the author(s) and not necessarily those of the NIHR or the Department of Health and Social Care.

Sarah Berhane is funded by NIHR Biomedical Research Centre (NIHR BRC) grant. However, NIHR BRC did not fund this project.

Acknowledgements

The OHCAO registry is funded by the Resuscitation Council U.K. and British Heart foundation and supported by the National Institute for Health Research (NIHR) Applied Research Collaboration (ARC) West Midlands. However, this project was not funded. The views expressed are those of the author(s) and not necessarily those of the NIHR, funders or the Department of Health and Social Care.

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Figure Legends

Figure 1. Bystander cardiopulmonary resuscitation (BCPR) rate: A) across EMS regions (ordered by decreasing BCPR rate), and B) by year

Figure 2. The adjusted odds ratio with 95% confidence intervals for: A) Survival to hospital discharge, and B) any return of spontaneous circulation (ROSC)

Supplemental Fig 1. Patient flow chart. OHCA, out-of-hospital cardiac arrest; ROSC, return to spontaneous circulation

Supplemental Table 1. Association between BCPR and age

Supplemental Fig 2. Paediatric out-of-hospital cardiac arrest by time of day

Supplemental Table 2. The number of cases per EMS region per year

Tables

Table 1 Demographic characteristics of paediatric OHCA cases associated with BCPR

	Total		BCPR		No BCPR		p-value
	N	%	N	%	N	%	
Total	2363	100	1646	69.6	717	30.4	
Age[a]	2363						
(median, IQR)	3.4 (0.5-12)		3.4 (0.5-11.9)		3.1 (7.0-12.1)		0.11
Sex[b]							
Male	1357	58.7	960/1610	59.6	397/700	56.7	0.19
Female	953	41.3	650/1610	40.4	303/700	43.3	
Aetiology[c]							
Medical	1862	82.8	1310/1577	83.0	552/670	82.3	0.23
Trauma	144	6.4	90/1577	5.7	54/670	8.0	
Drowning	40	1.7	29/1577	1.8	11/670	1.6	
Drug overdose	26	1.1	18/1577	1.1	8/670	1.1	
Asphyxia	175	7.7	130/1577	8.2	45/670	6.7	
Status of witness[d]							
Witnessed	776	34.1	550/1572	34.9	226/698	32.3	0.22
Initial rhythm[e]							
Shockable	144	6.8	114/1480	7.7	30/615	4.8	0.02
AED[f]							
AED use	35	2.4	35/943	3.7	0/472	0.0	<0.001
Time of day[g]							
Daytime	755	34.0	518/1541	34.0	237/679	34.9	0.55

Season							
Spring	640	27.0	443/1646	26.9	197/717	27.4	
Summer	563	23.8	397/1646	24.1	166/717	23.1	0.51
Autumn	600	25.3	428/1646	26.0	172/717	23.9	
Winter	560	23.7	378/1646	22.9	182/717	25.3	
Year							
2014	485	20.5	348/1646	20.6	152/891	21.2	
2015	467	19.7	333/1646	18.6	166/717	23.1	
2016	441	18.6	301/1646	18.7	129/717	17.9	<0.01
2017	452	19.1	312/1646	18.8	137/717	19.1	
2018	518	21.9	385/1646	23.0	133/717	18.5	
Outcomes[h]							
Survival to hospital discharge	225	10.8	157/1454	10.8	68/612	11.1	0.83
Any ROSC	523	22.8	393/1592	24.6	130/697	18.6	0.002

BCPR, bystander cardiopulmonary resuscitation; IRQ, Interquartile range; AED, automated external defibrillator. ROSC, return of spontaneous circulation;

[a] Age was treated as a continuous variable

Data were missing in

[b] Sex (n=53)

[c] Aetiology (n=116)

[d] Status of witness (n=93)

[e] Initial rhythm (n=268)

[f] AED (n=948)

[g] Time of the day (n=143)

[h] Survival to hospital discharge (n=297) and any ROSC (n=74)

Table 2. Odds ratios for BCPR for demographic characteristics of paediatric OHCA cases

	Unadjusted OR (95% CI)	P value	Adjusted[a] OR (95% CI)	P-value
Age[b]	1.01(0.99-1.02)	0.08	1.00 (0.98-1.02)	0.82
Female	0.88 (0.74-1.06)	0.19	0.95 (0.77-1.17)	0.66
Aetiology				
Medical		**Reference**		
Trauma	0.70 (0.49-0.99)	0.04	0.64 (0.42-0.97)	0.03
Drowning	1.11 (0.55-2.23)	0.76	1.00 (0.45-2.25)	0.98
Drug overdose	0.94 (0.40-2.19)	0.90	0.73 (0.28-1.86)	0.51
Asphyxia	1.21 (0.85-1.73)	0.27	1.13 (0.75-1.69)	0.54
EMS region[c]				
9		**Reference**		
1	2.58 (164-4.04)	<0.001	3.08 (1.72-5.51)	<0.001
2	1.67 (1.01-2.77)	0.04	1.91 (1.00-3.63)	0.04
3	1.58 (1.17-2.13)	0.002	1.51 (1.10-2.06)	0.009
4	1.50 (1.08-2.09)	0.01	1.64(1.09-2.46)	0.01
5	1.33 (0.88-2.01)	0.17	1.56 (0.75-3.27)	0.22
6	1.07(0.75-1.51)	0.69	0.97 (0.64-1.48)	0.91
7	1.02 (0.69-1.50)	0.90	0.98(0.60-1.60)	0.94
8[d]				
10	0.68 (0.40-1..16)	0.16	2.38 (0.51-11.1)	0.26
11	0.68 (0.51-0.90)	0.007	0.69 (0.51-0.94)	0.01
Witnessed	1.12 (0.92-1.35)	0.22	1.02 (0.81-1.29)	0.82
Shockable rhythm	1.62(1.07-2.46)	0.02	1.40 (0.88-2.2)	0.15
Time of day				

Daytime	0.94 (0.78-1.14)	0.55	0.86 (0.81-1.29)	0.18
Seasons				
Spring		**Reference**		
Summer	1.06 (0.83-1.36)	0.62	0.98 (0.66-1.19)	0.44
Autumn	1.10 (0.86-1.41)	0.41	0.99 (0.74-1.32)	0.95
Winter	0.92 (0.72-1.17)	0.52	0.83 (0.62-1.11)	0.22

BCPR, bystander cardiopulmonary resuscitation; OR, odds ratio.

[a] Odd ratios were calculated adjusting for age, sex, aetiology, ambulance services, status of the witness, initial cardiac rhythm, the time of day and the season

[b]Age was treated as a continuous variable

[c] The number of cases by each EMS services : EMS 1=166, EMS 2=100,EMS 3= 383, EMS 4=268,EMS 5=139, EMS 6=204, EMS 7=152, EMS 8=3,EMS 9=527, EMS 10=64, EMS 11=357

[d] EMS services was excluded from the analysis due to the small sample size.

Table 3. Multivariable logistic regression for any ROSC

	Total	**Outcome**		**Unadjusted**		**Adjusted**[a]	
	N=2289	**N**	**%**	**OR (95% CI)**	**P-value**	**OR (95% CI)**	**P-value**
Bystander	2289	523	100				
BCPR	1592	393/523	75.1	1.42 (1.14-1.78)	0.002	1.37 (1.03-1.81)	0.02
Age[b]	2289	523	100	1.06 (1.04-1.08)	<0.001	1.05 (1.03-1.07)	<0.001
Sex	2261	519	99.2				
Female	933	189/519	36.4	0.76 (0.62-0.94)	0.01	0.83 (0.64-1.06)	0.14
Aetiology	2175	572	95.4				
Medical	1793	401/503	79.7		**Reference**		
Trauma	143	30/503	5.9	0.92 (0.60-1.39)	0.70	0.76 (0.47-1.25)	0.29
Drowning	40	10/503	1.9	1.15 (0.66-2.38)	0.69	0.82 (0.29-2.29)	0.71
Drug overdose	26	8/503	1.5	1.54 (0.66-3.57)	0.31	1.00 (0.38-2.59)	0.99

Asphyxia	173	54/503	10.7	1.57 (1.12-2.21)	0.009	1.43 (0.96-2.14)	0.07
Witness status	2219	510	97.8				
Witnessed	765	290/510	56.8	3.42 (2.79-4.20)	<0.001	2.17 (1.68-2.79)	<0.001
Initial rhythm	2083	431	81.1				
Shockable rhythm	143	85/431	19.7	6.75 (4.74-9.61)	<0.001	3.96 (2.62-5.99)	<0.001
Time of day	2148	489	93.6				
Daytime	724	216/489	44.1	1.79 (1.45-2.20)	<0.001	1.59 (1.24-2.03)	<0.001
Seasons	2289	523	100				
Spring	619	128/523	24.4	**Reference**			
Summer	548	122/523	23.3	1.09 (0.83-1.45)	0.51	1.04 (0.74-1.46)	0.80
Autumn	581	150/523	28.6	1.33 (1.02-1.74)	0.03	1.07 (0.76-1.49)	0.67
Winter	541	123/523	23.5	1.12 (0.85-1.49)	0.39	0.99 (0.70-1.40)	0.99

ROSC, return of spontaneous circulation; BCPR, bystander cardiopulmonary resuscitation; OR, odds ratio.

[a] Odd ratios were calculated adjusting for the prespecified variables of age, sex, aetiology, status of the witness, initial cardiac rhythm, the time of day and the season

[b]Age in years was treated as a continuous variable

Table 4. Multivaraible logistic regression for survival-to-hospital-discharge

	Total	Outcome		Unadjusted		Adjusted[a]	
	N=2066	N	%	OR (95% CI)	P-value	OR (95% CI)	P-value
Bystander	2066	225	100				
BCPR	1454	157/225	69.7	0.96 (0.71-1.30)	0.83	1.01 (0.66-1.55)	0.94
Age[b]	2066	225	100	1.01 (0.99-1.03)	0.14	0.98 (0.95-1.01)	0.32
Sex	2025	223	99.1				
Female	828	74/223	33.1	0.69 (0.51-0.92)	0.01	0.73 (0.49-1.08)	0.12
Aetiology[c]	1998	218	96.8				
Medical	1646	181/218	83.0		**Reference**		
Trauma	132	8/218	3.6	0.52 (0.25-1.08)	0.08	0.77 (0.33-1.77)	0.54
Drowning	36	4/218	1.8	1.01 (0.35-2.89)	0.98	0.57 (0.06-4.80)	0.60
Drug overdose	26	5/218	1.3	1.05 (0.31-3.55)	0.93	0.95 (0.18-4.85)	0.95
Asphyxia	158	27/218	10.0	1.30 (0.81-2.10)	0.26	2.24 (1.21-4.15)	0.01
Witness status	1989	215	95.5				
Witnessed	687	138/215	64.1	3.99 (2.97-5.37)	<0.001	2.55 (1.70-3.83)	<0.001
Initial rhythm	1832	161	71.5				
Shockable rhythm	120	56/161	34.7	13.3 (8.89-20.1)	<0.001	12.7 (7.68-21.2)	<0.001
Time of day	1933	208	92.4				

Daytime	667	95/208	45.6	1.69(1.26-2.26)	<0.001	1.36 (1.70-3.83)	0.11
Seasons[d]	2066	225	100				
Spring	562	49/225	21.7		**Reference**		
Summer	504	61/225	27.1	1.44 (0.96-2.14)	0.07	1.98 (1.15-3.39)	0.01
Autumn	531	67/225	29.7	1.51 (1.02-2.23)	0.03	1.60 (0.93-2.76)	0.08
Winter	469	44/225	21.3	1.19 (0.78-1.81)	0.40	0.98 (0.53-1.81)	0.95

OR, odds ratio; BCPR, bystander cardiopulmonary resuscitation.

[a] Odd ratios were calculated adjusting for age,sex, aetiology, status of the witness, initial cardiac rhythm, the time of day and the season

[b]Age in years was treated as a continuous variable

[c]Medical was used as the reference group for the aetiology ORs

[d] Spring was used as the reference group for the season ORs

Bystander cardiopulmonary resuscitation for paediatric out-of-hospital cardiac arrest in England: an observational registry cohort study

Contributors H Albargi : Designed the study, designed data collection tools, wrote the statistical analysis plan, drafted and revised the paper. S Mallett: wrote the statistical analysis plan, revised the paper. S. Berhane: wrote the statistical analysis plan, revised the paper. S. Booth, C Hawkes, G D Perkins, M Norton and T Foster: revised the paper. B Scholefield : Designed the study, designed data collection tools, wrote the statistical analysis plan, and revised the paper.

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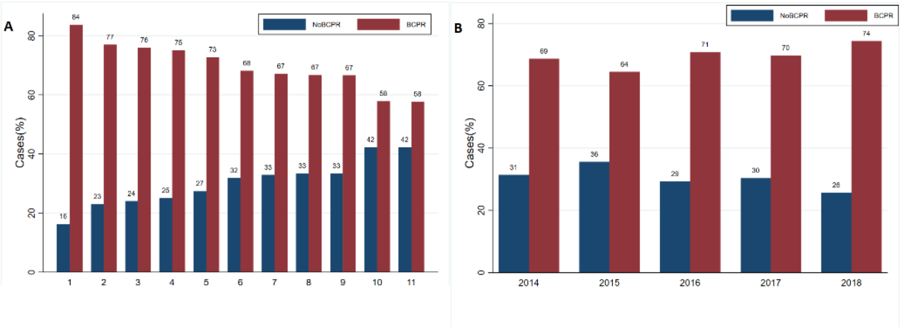
Disclosure

Dr Scholefield is funded by a National Institute for Health Research ((NIHR-CS-2015-15-016) Fellowship award. However, this project was not funded by the National Institute for Health Research. The views expressed are those of the authors and not necessarily those of the NHS, the National Institute for Health Research, or the Department of Health and Social Care.

Gavin Perkins is GDP is Director of the OHCAO Registry which is funded by the Resuscitation Council UK and British Heart Foundation and an Editor for Resuscitation. This research is supported by the National Institute for Health Research (NIHR) Applied Research Collaboration (ARC) West Midlands. The views expressed are those of the author(s) and not necessarily those of the NIHR or the Department of Health and Social Care.

Sarah Berhane is funded by NIHR Biomedical Research Centre (NIHR BRC) grant. However, NIHR BRC did not fund this project.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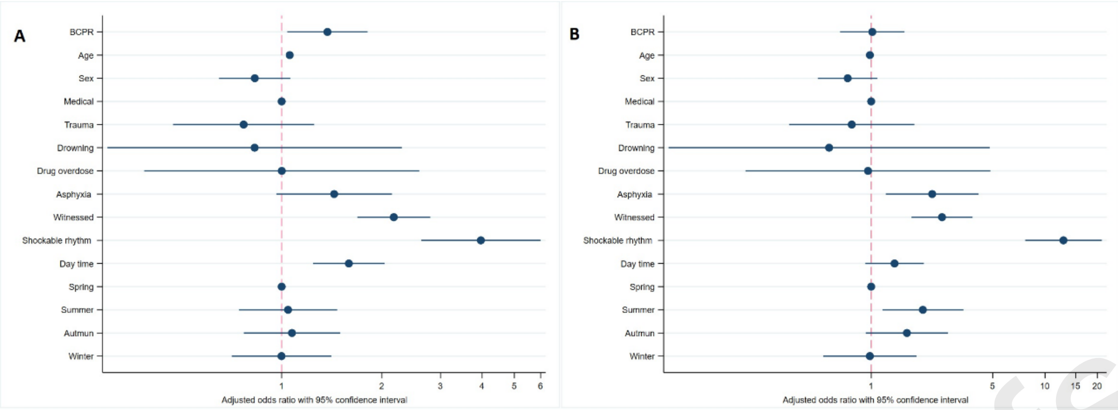
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1 5 10 15 20
Adjusted odds ratio with 95% confidence interval