A systematic review of the impact of EMS experience and exposure to OHCA on patient outcomes.

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ABSTRACT

Aim – To conduct a systematic review to evaluate the impact of emergency medical service (EMS) practitioner's years of career experience and exposure to out-of-hospital cardiac arrest (OHCA) on patient outcomes.

Methods –We searched electronic databases (Ovid MEDLINE, EMBASE, CINAHL, Cochrane Central Register of Controlled Trials, Web of Science Core Collection) from inception until 10 April 2020. Studies were included that examined the exposures of interest on OHCA patient outcomes: good neurological outcome at discharge/30 days, survival to hospital discharge/30 days, survival to hospital and return of spontaneous circulation (ROSC). Prospero Registration: CRD42019153599.

Results –We included 7 of 22 observational studies shortlisted. Four of these studies examined the years of career experience of EMS personnel, and four studies examined their exposure to attempted resuscitation. The evidence for both exposures of interest was assessed as very-low certainty. Overall, we found no association between patient outcomes and years of career experience. However, the best evidence found, from two large studies, suggests greater recent exposure to cases of attempted resuscitation is associated with better outcomes (ROSC/survival to hospital discharge). One of these studies also reports lower survival to hospital discharge when the team attempting resuscitation had no exposure in the previous six-months.

Conclusion –Existing data is of low certainty, but suggests greater OHCA survival is seen in EMS with greater and recent exposure to resuscitation. This review highlights the need for EMS to monitor OHCA exposure, and the need for further research exploring the relationship between EMS exposure and patient outcomes.

INTRODUCTION

Out-of-hospital cardiac arrest (OHCA) outcomes are dependent on implementation of the 'chain of survival', which includes the provision of high quality resuscitation by emergency medical services (EMS).[1, 2] Effective resuscitation involves the delivery of evidence-based knowledge and skills that require learning, mastery, and deliberate practice.[3] Therefore, it makes sense that more experienced EMS practitioners and those with higher exposure to resuscitated cases should have better patient outcomes.

A systematic review conducted in 2014 attempted to answer this question, but found very little supporting evidence.[4] Dyson et al[4] found only three studies examining EMS practitioners' experience,[5-7] and only one study examining exposure to resuscitation.[8] All of these studies were of very-low quality and had a high-risk of bias, with significant variation in EMS structures and in definitions of experience and exposure. The statistical analyses were underpowered, due to small sample sizes, and very few adjusted for potential confounders.

There is no current recommendation from the International Liaison Committee on Resuscitation (ILCOR) about the effect of EMS experience and exposure to resuscitation on OHCA survival outcomes. The objective of this systematic review was to evaluate the impact of EMS practitioners' years of career experience and exposure to OHCA on patient outcomes on behalf on the ILCOR Education, Implementation and Teams (EIT) Task Force.

METHODS

The protocol for this systematic review was registered on PROSPERO international prospective register of systematic reviews (CRD42019153599). The PICO question was: Among adults and children who are in cardiac arrest in the out-of-hospital setting (P), does resuscitation by experienced emergency medical service practitioners or practitioners with higher exposure to resuscitation (I), compared with resuscitation by less experienced or lower exposed practitioners (C), result in improved patient outcomes?

Search Strategy

The authors developed the search strategy using the previous review[4] and input from an Alfred Health information specialist. Keywords included: prehospital; emergency medical service; cardiopulmonary resuscitation; professional competence; experience; exposure; and out-of-hospital cardiac arrest (Search strategy available from authors). The original search was conducted through the following databases to 14 October 2019: Ovid MEDLINE (1950-), EMBASE (1966-), CINAHL (1937), Cochrane Central Register of Controlled Trials, Web of Science Core Collection (1990-). The search terms were adapted for use with the different databases. We also reviewed the reference lists of all included studies and any systematic reviews found. We conducted an updated search between 14 October 2019 and 10 April 2020 and found no new eligible studies.

Study selection

All original research articles of all publication types (except case reports) were included. There was no restriction by OHCA aetiology or patient age. All studies reporting any type of EMS practitioners who perform resuscitations were included (e.g. emergency medical technicians [EMTs], paramedics -basic and advanced life support, prehospital physicians/nurses). Studies were included that examined EMS practitioners' years of clinical career experience or exposure to attempted resuscitation.

All titles and abstracts were independently screened against the inclusion criteria by two authors (JB and ZN) to identify potentially eligible studies. Full text articles were independently appraised in detail for the study selection criteria by two authors (JB and ZN). There were no disagreements.

Outcomes

The ILCOR EIT Taskforce ranked the following outcomes *a priori* as critical: good neurological outcome at discharge/30 days, survival to hospital discharge/30 days, survival to hospital (event survival) and return of spontaneous circulation (ROSC).

Data extraction

Extracted information from each study included: study setting; study population (OHCA patients); type of EMS practitioners; participant demographics and baseline characteristics; study methodology; study design; date and duration of the study; study inclusion and exclusion criteria; and details of EMS practitioner exposure and patient outcomes. Data were extracted independently by two authors (ZN and AN) using a pre-piloted electronic data extraction form. A third author (JB) reviewed final data for all outcomes.

Quality assessment

All included studies were independently assessed by two authors (ZN and AN) using the QUIPS risk of bias tool for assessing validity and quality.[9] The QUIPS tool has six domains which examines study groups, study attrition, prognostic factor measurement, confounding measurements, outcomes of interest, and analysis and reporting.[10] A third author (JB) arbitrated any disagreement regarding risk of bias assessment. The certainty of evidence for each outcome was assessed using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach.[11]

Data synthesis

We expected large variability between studies in terms of study design, interventions and outcomes. A qualitative analysis (rather than meta-analysis) was performed for the included studies to synthesise the findings, as there was high methodological and statistical heterogeneity.

RESULTS

Study selection

After removal of duplicates, the search identified 3635 unique records (Figure 1). After screening, seven observational studies fulfilled eligibility criteria and were included in the qualitative synthesis.[6-8, 12-15] One before-and after study[5] included in the previous review[4] was excluded, as this study did not quantify experience, but examined a change in the EMS structure (from physicians with prehospital experience to physicians with no prehospital experience).

Study characteristics

Included studies were conducted in Australia,[12] North America,[6, 14, 15] and Europe.[7, 8, 13] The characteristics of the studies are described in Table 1.

Of the included studies, there was variation in the OHCA cohorts studied. Some studies included both children and adults,[7, 12, 13, 15] presumed cardiac or medical aetiology,[8] and witnessed ventricular fibrillation.[6] Patient sample sizes (i.e. those with attempted resuscitation) in studies examining career experience varied between 276[13] and 15,362,[12] and between 232[8] and 15,362[12] for studies examining exposure.

Many different EMS structures were examined, including physician-based,[8, 13] basic and advanced life support paramedics[12, 14, 15] and emergency medical technicians (EMTs).[6, 7] The number of EMS personnel examined also varied in size, between 39[8] and 4151.[12]

Various methods to measure and calculate exposure to resuscitation were used across the studies. Some studies averaged exposure for each EMS practitioner over the whole study period,[8] whilst others examined exposure for a period of time leading up to each OHCA case.[12, 14] Studies also varied in the manner they compared EMS exposure in the analysis, which included divisions by a threshold established from the data,[8, 14] or by medians or quartiles of exposure.[12, 15] These studies also varied in whose exposure they examined, which included the exposure of the lead treating EMS personnel[8, 14, 15] or the exposure of the whole team on scene.[12] One study also conducted a number of sensitivity analyses, including examining different lengths of previous exposure, the EMS personnel with the most exposure, exposure for all OHCAs, and in OHCA subgroups.[12]

Risk of bias

Results for the assessment of risk of bias are reported in Figure 2. A low risk of bias was found for study participation, study attrition, prognostic factor measurement and outcome measurement. The risk of bias ranged from low to high for study confounding and statistical analysis. The overall certainty of evidence was rated as very low for all outcomes primarily due to a very serious risk of bias (GRADE Table -Supplementary materials).

Year of career experience

We identified four observational studies examining years of career experience (Table 2).[6, 7, 12, 13] No studies were found that examined the outcomes of survival with favourable neurologic outcome at discharge/30 days, event survival or ROSC.

Survival to discharge/30 days

For the outcome of survival to discharge/30 days we identified four studies.[6, 7, 12, 13] The largest study reported adjusted outcomes and examined the treating teams years of clinical experience and found no association with survival to hospital discharge: median ≤5 career years reference group, 5-8 years adjusted odds ratio (AOR)=1.17 (95% CI: 0.99-1.39), 8-11 years AOR=1.11 (95% CI: 0.93-1.34), and >11 years AOR=10.09 (95% CI: 0.91-1.29).[12] Two smaller studies, examined sub-groups of OHCAs, and also found no association with survival to discharge and the experience of the individual treating paramedics or treating EMS team.[6, 13] The remaining study reported an association between increased survival and emergency medicine technicians (EMTs) with >4 years experience (AOR 2.71, 95% CI: 1.17-6.32, P=0.02) and paramedics with >1 year of experience (AOR 2.68, 95% CI: 1.05-6.82, P=0.04).[7] However, this study did not fully account for the experience of the paramedics, as it did not include the previous career experience of some paramedics who were formerly EMTs.

Exposure to attempted resuscitation

We identified three studies examining exposure to attempted resuscitation, with median or average exposure to OHCA varying across these studies between 2 and 10/year.[8, 12, 15] Annual exposure for individual EMS personal also varied within these studies, with one study reporting 11% of EMS personnel had no exposure to an attempted resuscitation over the 7-year study period.[12]

Survival with favourable neurological outcome at discharge or 30 days

Survival with favourable neurologic outcome at discharge or 30 days was reported by one study as a secondary analysis.[15] These authors used the Cerebral Performance Category (CPC) to measure neurological outcome, and examined the averaged exposure of paramedic team leaders over one-year. The study reported no association of the outcome with exposure, but reported unadjusted data with insufficient numbers of events to be confident in the findings.[15]

Survival to discharge/30 days

We identified three studies that examined survival to discharge/30 days.[8, 12, 15] The largest study reported adjusted outcomes and examined the median exposure of the whole resuscitating team for three years preceding each OHCA case.[12] This study found that higher team exposure in the preceding three years was associated with increased survival to hospital discharge: compared to a median of ≤6 exposures, >6-11 exposures=AOR 1.26 (95% CI: 1.04–1.54), 11 to 17 exposures =AOR 1.29 (95% CI: 1.04–1.59), >17 exposures =AOR 1.50 (95% CI: 1.22–1.86). Dyson at al.[12] also found lower survival to discharge in patients treated by teams with no exposures in the preceding 6-months (AOR 0.70, 95% CI: 0.54–0.91) compared to those with recent exposure (<1 month).

The remaining two, smaller studies reported unadjusted outcomes and used the averaged exposure of team leaders to resuscitation over one-[15] and three-[8] year study periods. These studies found no association between unadjusted survival and exposure to resuscitation at cut-offs of five exposures over three years for EMS-physicians[8] or ten exposures over one-year for the lead paramedic.[15]

Event Survival

For the critical outcome of event survival (i.e. alive on arrival at hospital), we identified two studies.[8, 15] These studies reported unadjusted outcomes and used the averaged exposure of team leaders to resuscitation over one[15] and three year study periods.[8] These studies found no association between exposure to resuscitation and unadjusted event survival, using cut-offs of five exposures over three years for EMS-physicians[8] or ten exposures over one-year for the lead paramedic.[8].

ROSC

Two studies report on the critical outcome of ROSC.[14, 15] The largest study reported adjusted outcomes and examined the primary treating paramedic's exposure in the preceding five years.[14] This study found higher exposure of the treating paramedic was associated with increased ROSC. When compared to the <15 exposure reference group, those with ≥15 exposures had an AOR of 1.22 (95% CI 1.11–1.36). The other study also reported an unadjusted association between ≥10 exposures for the lead paramedic over a one-year period and achievement of ROSC (OR 1.30, 95% CI 1.01–1.69).[15]

DISCUSSION

Our systematic review of the literature examined whether EMS practitioner experience or exposure to resuscitation were associated with improved OHCA patient outcomes. We found no evidence to suggest practitioners with longer careers have improved patient outcomes, although the certainty of evidence for this component was very low. The overall certainty of evidence was also very low for exposure to attempted resuscitation; however, this evidence more consistently suggests that EMS with greater recent exposure have improved patient outcomes.[12, 14]

The two largest studies, which were at lowest risk of bias for confounding, calculated the preceding exposure to attempted resuscitation of the attending EMS for each case. These studies reported improved outcomes of ROSC[14] or survival to hospital discharge[12] with greater prior exposure to attempted resuscitation of the treating team,[12] and individuals within the team.[12, 14] The other two studies, which were likely to be underpowered, used the less accurate method of averaging the personnel's total exposure over the whole study period and found no association between exposure and patient outcomes,[8, 15] except for ROSC in one study.[15]

It is possible that some of the observed effects of experience and exposure relate to a selection bias in which patients EMS attempt to resuscitate. That is, more experienced EMS may select to attempt resuscitation on patients with factors known to improve survival, such as those with witnessed arrests, with bystander CPR or in a shockable arrest rhythm. This highlights the need to adjust for known predictors when examining experience and exposure. Only one study performed sensitivity analyses for potential selection bias, and found that EMS with high exposure and experience were less likely to attempt resuscitation even after adjustment for known predictors of survival.[12] Whether this finding relates to clinical competency or cynicism remains unknown, but must be explored in further research.

The vast variation in exposure seen across and within the EMS in our review highlights the need for EMS to monitor their staff's exposure to attempted resuscitation. In particular, one study reported no exposure for one-in-ten paramedics over a seven year period,[12] and exposure to rare cases (e.g. trauma and paediatrics) was extremely low.[16] At present, because of the heterogeneity in existing studies, we are unable to determine whether a threshold point exists in the number of OHCA exposures where outcomes improve. Two studies commented on this relationship, but reported conflicting findings and suggested the threshold may vary by the outcome measured. One study suggested a linear relationship with survival to hospital discharge,[12] whereas another suggested a plateau at fifteen cases over five-years for ROSC.[15] More research is needed that examines a wider range of patient outcomes, preferably by measuring preceding exposure for each EMS personnel involved in the resuscitation attempt rather averaging methods.[16]

Previous research has identified various strategies for dealing with low OHCA exposure in EMS. These strategies include the rotation through EMS units exposed to higher rates of OHCA and deployment of EMS with higher exposure to OHCA cases. The accessibility of such strategies are likely to vary, and may not be feasible in all EMS. It has also been proposed that personnel with low exposure are supplemented with other forms of learning to inform knowledge and practice, such as high-fidelity simulation.[12, 14] Given the variation recently reported in EMS resuscitation training practices,[17] this strategy may be a useful proxy for exposure in low exposure settings and for rare OHCA cases (e.g. paediatrics and neonates). Although, not tested in the EMS setting for this purpose, team simulation has been found to be effective for maintaining ALS skills in hospital settings and are associated with improved OHCA patient outcomes.[18, 19]

Limitations and future research

This review was limited by the heterogeneity of the included studies, mainly the different definitions of cases, exposure, and outcomes studied. We recommend future research in this area use existing methods[12, 14] to calculate the prior exposure of the treating practitioners for each case. There is also the need to examine a broader range of outcomes, including short- and long-term outcomes, and to determine if a threshold of exposure exists. Research is also required that examines the effect of repeated exposure by the same teams (i.e. does resuscitating in the same team result in better outcomes) and that examines regional differences (i.e. rural regions with lower exposure may have different hospital capabilities).

Conclusion

In summary, our systematic review suggests higher exposure to attempted resuscitation cases, but not years of clinical experience, is associated with improved OHCA patient outcomes. While further high-quality research in this area is needed, we recommend that EMS monitor exposure and develop strategies for EMS personnel with low exposure to resuscitation.

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Conflicts of Interest

JB and AL are members of the ILCOR EIT Task Force. JF is a member of the ILCOR Scientific Advisory Committee. AL is a Trustee of the Resuscitation Council UK. JB, ZN, and JF are committee members of the Australian Resuscitation Council. JF receives research funding from St John (Ambulance) Western Australia. ZN is an employee of Ambulance Victoria.

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References

1. Cummins RO, Ornato JP, Thies WH, Pepe PE. Improving survival from sudden cardiac arrest: the "chain of survival" concept. A statement for health professionals from the Advanced Cardiac Life Support Subcommittee and the Emergency Cardiac Care Committee, American Heart Association. Circulation. 1991;83:1832-47.
2. Nolan J, Soar J, Eikeland H. The chain of survival. Resuscitation. 2006;71:270-1.
3. Cheng A, et al. Resuscitation Education Science: Educational Strategies to Improve Outcomes From Cardiac Arrest: A Scientific Statement From the American Heart Association. Circulation. 2018;138:e82-e122.

4. Dyson K, Bray J, Smith K, Bernard S, Finn J. A systematic review of the effect of emergency medical service practitioners' experience and exposure to out-of-hospital cardiac arrest on patient survival and procedural performance. Resuscitation. 2014;85:1134-41.
5. Silfvast T, Ekstrand A. The effect of experience of on-site physicians on survival from prehospital cardiac arrest. Resuscitation. 1996;31:101-5.
6. Gold LS, Eisenberg MS. The Effect of Paramedic Experience on Survival from Cardiac Arrest. Prehospital Emergency Care. 2009;13:341-44.
7. Soo LH, Gray D, Young T, Skene A, Hampton JR. Influence of ambulance crew's length of experience on the outcome of out-of-hospital cardiac arrest. European Heart Journal. 1999;20:535-40.
8. Bjornsson HM, Marelsson S, Magnusson V, Sigurdsson G, Thorgeirsson G. Physician experience in addition to ACLS training does not significantly affect the outcome of prehospital cardiac arrest. European Journal of Emergency Medicine. 2011;18:64-7.
9. Hayden JA, van der Windt DA, Cartwright JL, Cote P, Bombardier C. Assessing bias in studies of prognostic factors. Ann Intern Med. 2013;158:280-6.
10. Hayden JA, Cote P, Bombardier C. Evaluation of the quality of prognosis studies in systematic reviews. Ann Intern Med. 2006;144:427-37.
11. Guyatt GH, et al. GRADE: an emerging consensus on rating quality of evidence and strength of recommendations. BMJ. 2008;336:924-6.
12. Dyson K, et al. Paramedic Exposure to Out-of-Hospital Cardiac Arrest Resuscitation Is Associated with Patient Survival. Circulation: Cardiovascular Quality and Outcomes. 2016;9:154-60.
13. Lukic A, et al. Analysis of out-of-hospital cardiac arrest in Croatia - survival, bystander cardiopulmonary resuscitation, and impact of physician's experience on cardiac arrest management: a single center observational study. Croat Med J. 2016;57:591-600.

14. Tuttle JE, Hubble MW. Paramedic Out-of-hospital Cardiac Arrest Case Volume Is a Predictor of Return of Spontaneous Circulation. The Western Journal of Emergency Medicine. 2018;19:654-59.

15. Weiss N, et al. Does Experience Matter? Paramedic Cardiac Resuscitation Experience Effect on Out-of-Hospital Cardiac Arrest Outcomes. Prehospital Emergency Care. 2018;22:332-37.

16. Dyson K, et al. Paramedic exposure to out-of-hospital cardiac arrest is rare and declining in Victoria, Australia. Resuscitation. 2015;89:93-8.

17. Dyson K, et al. Paramedic resuscitation competency: A survey of Australian and New Zealand emergency medical services. Emerg Med Australas. 2017;29:217-22.

18. Andreatta P, Saxton E, Thompson M, Annich G. Simulation-based mock codes significantly correlate with improved pediatric patient cardiopulmonary arrest survival rates. Pediatr Crit Care Med. 2011;12:33-8.

19. Knight LJ, et al. Improving code team performance and survival outcomes: implementation of pediatric resuscitation team training. Crit Care Med. 2014;42:243-51.

Table 1. Summary of characteristics of included studies.

Study (year) Country	Study design (study period)	Patients (n)	Practitioner (n)	Adjusted for	Definitions of low experience or exposure
Years of career experience					
Dyson (2016) Australia	Retrospective cohort study (2003-12)	Attempted resuscitations all aetiologies (n=15,362)	Paramedics (n=3,590)	Age, sex, location, witness, bystander cardiopulmonary resuscitation, EMS response time, shockable rhythm, presumed cardiac etiology, presence of an intensive care paramedic, number of paramedics on scene	Median of ≤5 years of experience of paramedic first on scene Median of ≤5 years of experience of all attending paramedics
Gold (2009) USA	Retrospective cohort study (2002-2006)	Witnessed VF (n=699)	Paramedics (n=185)	Age, bystander CPR, sex and location	EMS with 0-4 years experience
Lukic (2016) Croatia	Retrospective cohort study (2007-2013)	Attempted resuscitations all aetiologies (n=276)	Physicians (n=34)	Age, sex, response time, duration of resuscitation, presenting rhythm, physician's experience	Physicians working in EMS for less than one year
Soo (1999) England	Retrospect cohort study (1991-1994)	Presumed cardiac aetiology (n=1,071)	Paramedics (n=100) and EMTs (n=275)	Presenting rhythm (EMT), CPR technique (paramedic)	Medical technicians ≤5 years of experience Paramedic ≤1 year of experience
Exposure to attempted resuscitation					
Bjornsson (2011) Iceland	Prospective cohort study (1999-2002)	Attempted resuscitations presumed cardiac aetiology (n=232)	Physicians (n=39)	Unadjusted, stratified by rhythm	Physicians attempted resuscitation ≤5 over four year period

Dyson (2016) Australia	Retrospective cohort study (2003-12)	Attempted resuscitations all aetiologies (n=15,362)	Paramedics (n=3,590)	Age, sex, location, witness, bystander CPR, EMS response time, shockable rhythm, presumed cardiac etiology, presence of an intensive care paramedic, number of paramedics on scene	Median of ≤6 exposures to attempted resuscitations of treating team in preceding 3 years Median of ≤6 exposures to attempted resuscitations of highest exposure treating paramedic in preceding 3 years
Tuttle (2018) USA	Retrospective cohort study (2012-2014)	Adult bystander- or EMS-witnessed, non-traumatic aetiologies (n=6,405)	Paramedic (n=N/A)	Age, sex, race, shockable presenting rhythm, layperson/first responder CPR, EMS response time	Paramedics attempted resuscitation ≤15 in preceding 5 years
Weiss (2018) USA	Retrospective cohort study	Attempted resuscitations all aetiologies (n=1,145)	Paramedics (n=343)	Unadjusted	Paramedics attempted resuscitation ≤10 over one year period

Table 2. Findings of included studies examining career years of experience.

Study (year) Country	**Career years of experience**	**Survival to discharge**
Dyson (2016) Australia	Median (IQR) career experience of team =8 (5-11) years	Team: 5-8 years experience AOR=1.17 (95% CI 0.99-1.39); 8-11 years AOR=1.11 (95% CI 0.93-1.34); >11 years AOR=1.09 (95% CI 0.91-1.29)
Gold (2009) USA	Approximate mean (SD) career experience of paramedics =9.8 (7.4) years	Every career year of experience: First on scene: AOR=1.01 (95% CI 0.99–1.03) Paramedic performing procedures: AOR=1.02 (95% CI 1.00–1.04) Team: AOR=1.01 (95% CI 1.00–1.03)
Lukic (2016) Croatia	-	Physicians: < 1 year experience =28% Physicians > 1 year experience =20% (p=0.41)
Soo (1999) England	Median (IQR) career experience of EMT =2.3 (0.8-5.5) years Median (IQR) career experience of paramedics =1.3 (0.7-2.25) years	Leading EMT >4 years experience =AOR: 2.58 (95% CI 1.11-6.03) Leading paramedic >1 year experience =AOR: 2.68 (95% CI 1.05-6.82)

SD: Standard deviation; AOR: Adjusted odds ratio; IQR: interquartile range; EMT: emergency medical technician.

Table 3. Findings of included studies examining exposure to attempted resuscitation.

Study (year) Country	Exposure to attempted resuscitation	ROSC	Event survival	Survival to discharge	Good neurological outcome
Bjornsson (2011) Iceland	Mean physician exposure=4* over 3-years	-	Physicians 1-5 OHCA exposures over 3-years =19% vs >5 OHCA =20% (p= 0.87) (unadjusted)	Physicians ≤5 OHCA exposures over 3-years = 19% vs ≥6 OHCA exposures =20% (p=0.87) (unadjusted)	-
Dyson (2016) Australia	Median (IQR) paramedic exposure =2 (1-3) per year (11% had no resuscitation exposure over 7-year study period) Median (IQR) team exposure =11 (6-17) cases in preceding 3-years	-	-	Team: every increase in median exposure AOR=1.01 (95% CI 1.01-1.02) Team: >6-11 exposures in preceding 3-years AOR=1.26 (95% CI 1.04–1.54); >11 to 17 exposures AOR=1.29 (95% CI 1.04–1.59); >17 exposures AOR=1.50 (95% CI 1.22–1.86) Paramedic with highest exposure: >6-11 exposures in preceding 3-years AOR=1.09 (95% CI 0.79–1.49); >11 to 17 exposures (AOR=1.32 (95% CI 0.96–1.83); >17 exposures AOR=1.58 (95% CI 1.15–2.18)	-
Tuttle (2018) USA	Mean (SD) paramedic exposure =23.6 (20.3) in preceding 5-years	Primary treating paramedic: ≥15 OHCA exposures in preceding 5-years AOR=1.22 (95% CI 1.11-1.36)	-	-	-

Weiss (2018) USA	Median (IQR) paramedic exposure =10 (1-26) in 1-year	≥10 OHCA exposures in 1-year RR=1.30 (95% CI 1.00, 1.69) (unadjusted)	≥10 OHCA exposures in 1-year RR=0.62 (95% CI 0.33-1.16) (unadjusted)	≥10 OHCA exposures in 1-year RR=1.02 (95% CI 0.76-1.37) (unadjusted)	≥10 OHCA exposures in 1-year RR=0.62 95% CI 0.33-1.16) (unadjusted)

SD: Standard deviation; AOR: Adjusted odds ratio; IQR: interquartile range; EMT: emergency medical technician.
*no SD given

Figure 1. PRIMSA diagram.

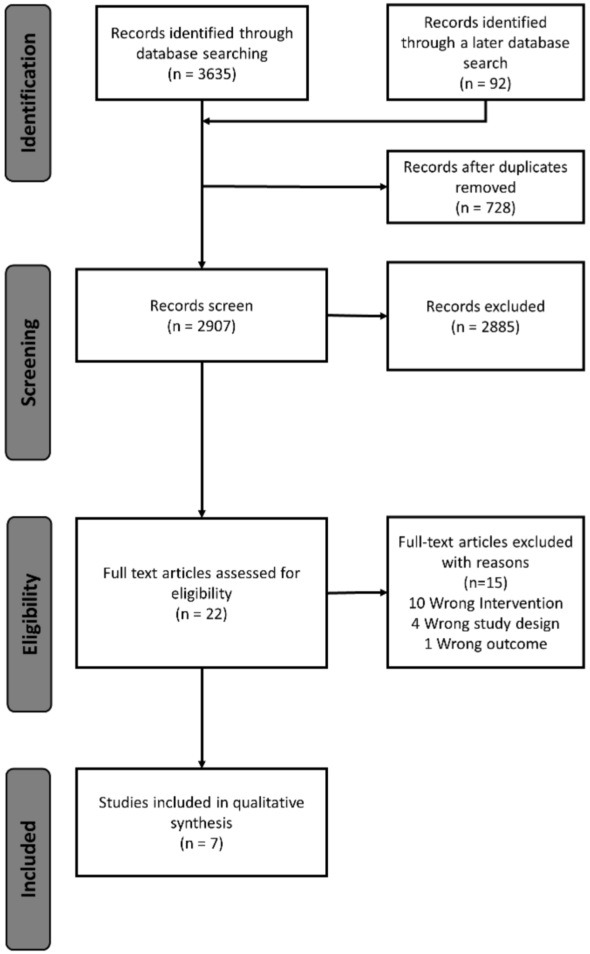
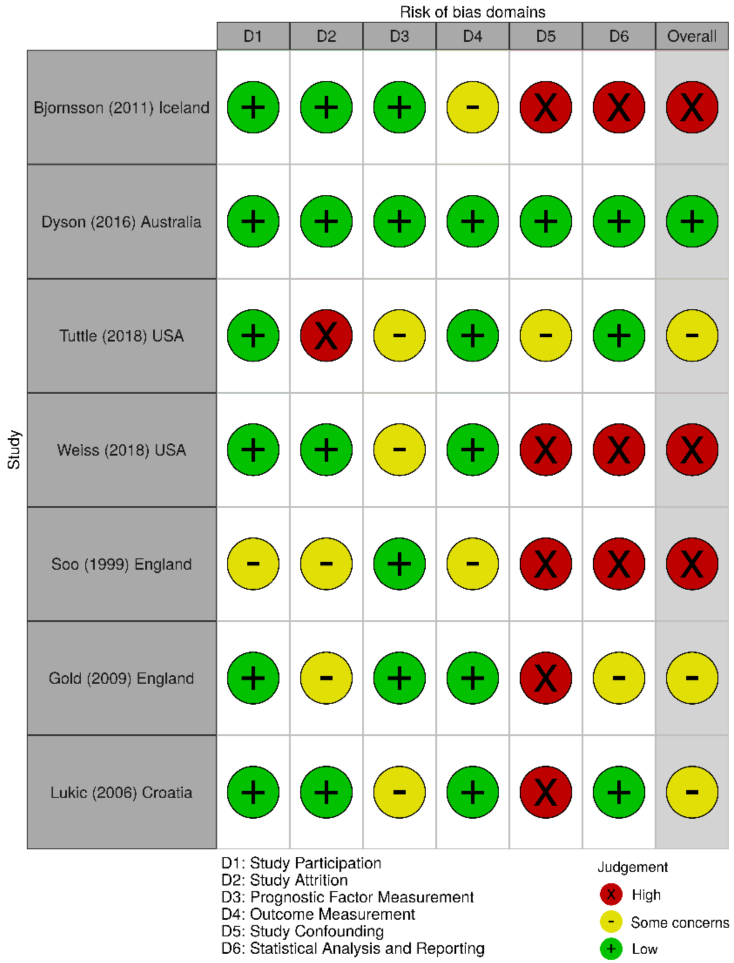

Identification
Records identified through database searching (n = 3635)
Records identified through a later database search (n = 92)
Records after duplicates removed (n = 728)
Screening
Records screen (n = 2907)
Records excluded (n = 2885)
Eligibility
Full text articles assessed for eligibility (n = 22)
Full-text articles excluded with reasons (n=15)
10 Wrong Intervention
4 Wrong study design
1 Wrong outcome
Included
Studies included in qualitative synthesis (n = 7)

Figure 2. Risk of bias in included studies.



GRADE evidence table -Experience

Certainty assessment							№ of patients	Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations		Relative	Absolute		
Survival to 30 days/ hospital discharge with good neurological outcome											
0	-	-	-	-	-	-	-	-	-	-	CRITICAL
Survival to 30 days/ hospital discharge											
4	observational studies	serious [a]	Unable to assess [a]	not serious	serious [a]	none	20,612	Not estimable	See comment [a]	⨁◯◯◯ VERY LOW	CRITICAL
Event survival											
0	-	-	-	-	-	-	-	-	-	-	CRITICAL
ROSC											
0	-	-	-	-	-	-	-	-	-	-	CRITICAL

Explanations

a. Considerable heterogeneity in samples and measurement of exposure, includes studies with unadjusted analysis

GRADE evidence table -Exposure

Certainty assessment							№ of patients	Effect		Certainty	Importance
№ of studies	Study design	Risk of bias	Inconsistency	Indirectness	Imprecision	Other considerations		Relative	Absolute		
Survival to 30 days/ hospital discharge with good neurological outcome											
1	observational study	Serious [a]	n/a	not serious	serious [a]	none	1,145	Not estimable	See comment [a]	⊕◯◯◯ VERY LOW	CRITICAL
Survival to 30 days/ hospital discharge											
3	observational studies	serious [b,c]	Unable to assess [b,]	not serious	serious [b,c]	none	16,739	Not estimable	See comment [b]	⊕◯◯◯ VERY LOW	CRITICAL
Event survival											
2	observational studies	serious [b,c]	Unable to assess [b]	not serious	serious [b,c]	none	1,377	Not estimable	See comment [b]	⊕◯◯◯ VERY LOW	CRITICAL
ROSC											
2	observational studies	serious [b,c]	not serious	not serious	not serious	none	7,550	Not estimable	See comment [b]	⊕◯◯◯ VERY LOW	CRITICAL

Explanations

a. Unadjusted analysis, insufficient numbers of events to be confident in the direction of the outcome estimates.

b. Considerable heterogeneity in samples and measurement of exposure

c. Includes studies with unadjusted analysis

Section/topic	#	Checklist item	Reported on page #
TITLE			
Title	1	Identify the report as a systematic review, meta-analysis, or both.	1
ABSTRACT			
Structured summary	2	Provide a structured summary including, as applicable: background; objectives; data sources; study eligibility criteria, participants, and interventions; study appraisal and synthesis methods; results; limitations; conclusions and implications of key findings; systematic review registration number.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known.	3
Objectives	4	Provide an explicit statement of questions being addressed with reference to participants, interventions, comparisons, outcomes, and study design (PICOS).	3-4
METHODS			
Protocol and registration	5	Indicate if a review protocol exists, if and where it can be accessed (e.g., Web address), and, if available, provide registration information including registration number.	3
Eligibility criteria	6	Specify study characteristics (e.g., PICOS, length of follow-up) and report characteristics (e.g., years considered, language, publication status) used as criteria for eligibility, giving rationale.	4
Information sources	7	Describe all information sources (e.g., databases with dates of coverage, contact with study authors to identify additional studies) in the search and date last searched.	4
Search	8	Present full electronic search strategy for at least one database, including any limits used, such that it could be repeated.	4
Study selection	9	State the process for selecting studies (i.e., screening, eligibility, included in systematic review, and, if applicable, included in the meta-analysis).	4
Data collection process	10	Describe method of data extraction from reports (e.g., piloted forms, independently, in duplicate) and any processes for obtaining and confirming data from investigators.	5
Data items	11	List and define all variables for which data were sought (e.g., PICOS, funding sources) and any assumptions and simplifications made.	5

Risk of bias in individual studies	12	Describe methods used for assessing risk of bias of individual studies (including specification of whether this was done at the study or outcome level), and how this information is to be used in any data synthesis.	5
Summary measures	13	State the principal summary measures (e.g., risk ratio, difference in means).	n/a
Synthesis of results	14	Describe the methods of handling data and combining results of studies, if done, including measures of consistency (e.g., I^2) for each meta-analysis.	5

Section/topic	#	Checklist item	Reported on page #
Risk of bias across studies	15	Specify any assessment of risk of bias that may affect the cumulative evidence (e.g., publication bias, selective reporting within studies).	n/a
Additional analyses	16	Describe methods of additional analyses (e.g., sensitivity or subgroup analyses, meta-regression), if done, indicating which were pre-specified.	n/a
RESULTS			
Study selection	17	Give numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage, ideally with a flow diagram.	6
Study characteristics	18	For each study, present characteristics for which data were extracted (e.g., study size, PICOS, follow-up period) and provide the citations.	6-7
Risk of bias within studies	19	Present data on risk of bias of each study and, if available, any outcome level assessment (see item 12).	7
Results of individual studies	20	For all outcomes considered (benefits or harms), present, for each study: (a) simple summary data for each intervention group (b) effect estimates and confidence intervals, ideally with a forest plot.	Table
Synthesis of results	21	Present results of each meta-analysis done, including confidence intervals and measures of consistency.	7-9
Risk of bias across studies	22	Present results of any assessment of risk of bias across studies (see Item 15).	7, Supp
Additional analysis	23	Give results of additional analyses, if done (e.g., sensitivity or subgroup analyses, meta-regression [see Item 16]).	n/a
DISCUSSION			
Summary of evidence	24	Summarize the main findings including the strength of evidence for each main outcome; consider their relevance to key groups (e.g., healthcare providers, users, and policy makers).	10
Limitations	25	Discuss limitations at study and outcome level (e.g., risk of bias), and at review-level (e.g., incomplete retrieval of identified research, reporting bias).	11-12

Conclusions	26	Provide a general interpretation of the results in the context of other evidence, and implications for future research.	12
FUNDING			
Funding	27	Describe sources of funding for the systematic review and other support (e.g., supply of data); role of funders for the systematic review.	12

From: Moher D, Liberati A, Tetzlaff J, Altman DG, The PRISMA Group (2009). Preferred Reporting Items for Systematic Reviews and Meta-Analyses: The PRISMA Statement. PLoS Med 6(7): e1000097. doi:10.1371/journal.pmed1000097

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