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Influence of prehospital physician presence on survival after severe trauma: Systematic review and meta-analysis

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Abstract

Background: As trauma is one of the leading causes of death worldwide, there is great potential for reducing mortality in trauma patients. However, there is continuing controversy over the benefit of deploying EMS physicians in the prehospital setting. The objective of this systematic review and meta-analysis is to assess how out-of-hospital hospital management of severely injured patients by EMS teams with and without physicians affects mortality.

Methods: PubMed and Google Scholar were searched for relevant articles and the search was supplemented by a hand search. Injury severity in the group of patients treated by an EMS team including a physician had to be comparable to the group treated without a physician. Primary outcome parameter was mortality. Helicopter transport as a confounder was accounted for by sub-group analyses including only the studies with comparable modes of transport. Quality of all included studies was assessed according to the Cochrane handbook.

Results: 2,249 publications were found, 71 full-text articles assessed and 22 studies included. Nine of these studies were matched or adjusted for injury severity. The odds ratio (OR) of mortality was significantly lower in the EMS physician-treated group of patients: 0.81; 95% confidence interval (CI): 0.71-0.92. When analysis was limited to the studies that were adjusted or matched for injury severity, the OR was 0.86 (95% CI: 0.73-1.01). Analysing only studies published after 2005 yielded an OR for mortality of 0.75 (95% CI: 0.64-0.88) in the overall analysis and 0.81 (95% CI: 0.67-0.97) in the analysis of adjusted or matched studies. The OR was 0.80 (95% CI: 0.65-1.00) in the sub-group of studies with comparable modes of transport and 0.74 (95% CI: 0.53-1.03) in the more recent studies.

Conclusion: Prehospital management of severely injured patients by EMS teams including a physician seems to be associated with lower mortality. After excluding the confounder of helicopter transport we have shown a non-significant trend toward lower mortality.

Level of evidence: level III

Type of study: Systematic review and meta-analysis

Keywords:

EMS physician, paramedic, trauma, mortality, prehospital emergency care

Background

Trauma is one of the major causes of death worldwide: approximately five million people die each year from traumatic injuries. In the United States, trauma is the leading cause of death of people under the age of 40, accounting for more than 160,000 deaths each year (1). More years of potential life are lost due to injury than to heart disease or cancer (2). Therefore, besides improving safety technology and in-hospital trauma care processes, in the out-of-hospital setting there are attempts to improve the care provided by emergency medical systems (EMS) in order to reduce mortality in trauma patients.

One major topic of controversy in this context is the deployment of EMS physicians in the out-of-hospital arena. The US and other English-speaking countries are typically supporters of paramedic-led prehospital trauma care, whereas in other predominantly European countries emergency physicians are an integral part of prehospital EMS and are dispatched to care for severely injured patients (3-5). However, in recent years several countries (e.g., the United Kingdom, Norway, Finland) have introduced a supplementary physician-based model for advanced critical care out of hospital, and in particular, rescue helicopters are staffed with EMS physicians (6-8).

Although "determining the value of physicians in the prehospital field, including their effect on outcomes", was defined as a key priority in emergency medicine research (9), up to now there is little evidence of the benefit of prehospital deployment of EMS physicians. Therefore, we performed a systematic literature review and meta-analysis to assess the effect on mortality of out-of-hospital hospital management of severely injured patients by physicians compared to paramedic-led prehospital care. The mode of patient transport (helicopter vs. ground-based) as a possible confounder was considered in sub-group analyses. Additionally, sub-group analyses of studies published in 2005 and onwards were performed to investigate the possible effect of improved education and training of physicians and paramedics in trauma management during the past decade.

Methods

The full protocol for the systematic review was registered on PROSPERO, an international prospective registry of systematic reviews (registration number CRD42017072426). The reporting of this meta-analysis follows the PRISMA statement guidelines (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) (10).

Search strategy

The database PubMed was searched with no restrictions on language, publication date or study size. Articles with publication dates up to July 2018 were reviewed. Papers were searched using text word searches on pubmed.de to include articles not yet indexed with MeSH terms. The search terms used were: (trauma OR injur*) AND (paramedic* OR prehospital OR "out of hospital" OR "emergency medical service" OR "emergency medical services" OR EMS OR ambulance OR HEMS) AND (doctor OR physician). To retrieve additional literature reports, the search was expanded by using the search engine Google Scholar with the same keywords. This search was limited to the 500 most relevant results. Additionally, reference lists of all relevant papers and the authors' personal literature collection were hand-searched in order to identify further articles not detected during the primary database search. All searches were conducted by two authors independently (AS, SS) and duplicate search results were removed. Three authors (AS, SS, JK) independently reviewed the titles and abstracts of the remaining studies, and all results that were obviously not related to the study question were eliminated. In the next step, the three authors (AS, SS, JK) independently reviewed the remaining abstracts, and studies that did not fulfil the inclusion criteria were removed, leaving those that did (Table 1). In cases of no available abstract, the full text was reviewed. If there was any disagreement between the reviewers, the study underwent full text analysis.

Full text was obtained for all selected and disputed studies. Three reviewers (AS, SS, JK) analysed the full text version of the selected studies, taking our review and meta-analysis questions into account. At this stage of the selection process, comparability of the patient cohorts in the intervention and comparison groups was evaluated. If there was a discrepancy at this stage, two additional reviewers not involved in the data search (BWB, MB) reviewed the publication. Finally, all included studies were analysed by two independent reviewers (OS, AL).

Study inclusion criteria

Retrospective and prospective, randomised and non-randomised studies reporting mortality or survival of trauma patients treated by paramedics or by a physician-staffed EMS team were considered. Studies were included irrespective of the mode of patient transport.

Only studies reporting mortality or survival were included. To ensure comparability of groups, studies had to be randomized or matched, or show comparable patient characteristics (in particular regarding the severity of injury, through the injury severity score [ISS], the abbreviated injury scale [AIS], or predicted mortality), or the original analysis had to be adjusted for confounding factors (particularly injury severity). Table 1 shows study inclusion criteria according to the PICOS system (11, 12).

Study exclusion criteria

Reasons for exclusion of studies were non-original data and inclusion of non-trauma patients. In addition, studies were excluded from the crude analysis if the absolute numbers of mortality could not be retrieved from the published data. Moreover, studies with diverging severity of injury between the two groups that were not adjusted for confounding had to be excluded, as well as studies that did not specify the mode of transport.

Quality assessment

Quality assessment as recommended in the Cochrane handbook (13) was carried out independently by two reviewers (DH, JK) using Cochrane's Revman 5 to estimate the risk of bias of each study. The risk of bias was rated as low, unclear, or high. All uncertainties were discussed and resolved by consensus with two other authors (MB, BWB).

Data extraction, statistical analysis, and subgroups

Two review authors (SS, AS) extracted information on study characteristics and outcomes independently. Extracted data included: last name of the first and the senior author, study title, journal, publication year, study design, study period, total number of patients, inclusion criteria of the study, mortality in the physician-treated and non-physician-treated groups of patients, comparison of injury severity between the physician-treated and non-physician-treated groups, mode of patient transport, and conclusion of the study. All extracted data were crosschecked by a third author (JK).

We performed fixed-effect and random-effects meta-analysis using inverse variance weighting for pooling, and we present odds ratios (OR) with 95% confidence intervals (CI) in tables and forest plots. In the random effects models, the DerSimonian-Laird estimate is used. Heterogeneity is quantified using the I-squared measure. All analyses were done using R version 3.5.1.

We differentiated between two types of studies included in our meta-analysis: studies with comparable patient characteristics (including injury severity) in both groups, either naturally or through randomisation, and studies adjusting or matching for injury severity using statistical methods (mainly logistic regression models).

As helicopter transport may be beneficial for trauma patients (14, 15), we additionally performed a subgroup analysis of studies in which an effect of helicopter transport could be excluded. This sub-group included studies with no helicopter transport in either group or with helicopter transport in the physician as well as in the non-physician group, as well as studies with helicopter transport in one of the two groups but comparable transport times and destinations (level I trauma centre) in both groups.

Training in prehospital trauma management has substantially improved (amongst other reasons mainly because of the introduction of international course concepts and a professionalization in the paramedical sector) during the last decade. For this reason, we additionally analysed the subgroup of studies published after 2005.

Results

Literature search

The PubMed search identified a total of 2,174 publications, and an additional 500 publications were retrieved from Google Scholar. Seventy-five publications were found through other sources (personal literature collections of the authors and references from publications retrieved via PubMed or Google Scholar). After exclusion of duplicates, a total of 2,249 records were screened by title and abstract. Thereof, 71 publications were retrieved for further assessment. Forty-nine studies had to be excluded because of unsuitable study design, outcome parameters or intervention, or because they were letters to the editor, commentaries, or review articles. Five studies were excluded for other reasons. A 1983 study by Baxt et al. (16) was excluded in consensus with all authors as we considered it likely that the outcome of the patients in this study was included in the study published by the same authors four years later, which we included in our meta-analysis (17); the study by Frankema et al. (18) was excluded from this meta-analysis after consultation of the authors revealed that data evaluated in their study were also included in the publication by den Hartog et al., which we included in our meta-analysis (19); one study had to be excluded in consensus with all authors because of an implausible odds ratio (OR) for mortality of 37 for the non-physician group compared to the physician group with an enormous 95% confidence interval of 2 to 749 (20); two studies conducted in the United States (US) did not contain a clear-cut differentiation between the physician-treated and the non-physician-treated groups, as in the US aeromedical flight crews may include EMS physicians or certified flight nurses (21, 22).

Finally, after review of the full-text publications, 22 studies remained eligible for the definitive analysis (see Supplemental Digital Content, Figure S1, http://links.lww.com/TA/B455).

Quality assessment

The results of quality assessment are shown in Figure 1.

Outcome

A descriptive analysis of the studies included in the qualitative analysis is shown in Table 2. In the overall analysis 22 studies were included. They had a pooled sample size of 54,991 severely injured patients, 13,629 of whom were treated by a team including a paramedic and an EMS physician and 41,362 of whom were treated by paramedics only. These numbers do not include the patients from the study of Roudsari et al., because this publication did not report any patient numbers (42). In the overall analysis of all included studies, the odds of mortality were significantly lower in the EMS physician group: OR from random effects meta-analysis: 0.81, 95% CI: 0.71-0.92 (Fig. 2). When analysis was limited to the studies that were adjusted or matched for injury severity (pooled sample size: 42,504), there was an OR of 0.86 (95% CI: 0.73-1.01). Analysing only more recent studies published after 2005 yielded an OR for mortality of 0.75 (95% CI: 0.64-0.88) in the overall analysis (pooled sample size: 41,186) and 0.81 (95% CI: 0.67-0.97) in the analysis of adjusted or matched studies (pooled sample size: 39,900).

In the sub-group of studies with comparable modes of transport (including 19,454 patients), we found an OR for mortality of 0.80 (95% CI: 0.65-1.00, Fig. 3A) and 0.74 (95% CI: 0.53-1.03, Fig. 3B) in the more recent studies (pooled sample size: 6,757). All results of the meta-analysis are summarized in Table 3.

Discussion

To our knowledge, this is the first meta-analysis looking at the effect of a physician-based EMS on mortality of severely injured patients. It includes 22 international studies with a large pooled sample size of more than 54,000 patients. The overall analysis of all available studies with comparable injury severity of patients in the EMS physician-treated group as well as the paramedic-treated group showed a significant reduction of odds of mortality in severely injured patients receiving physician-assisted prehospital care. This result can also be seen in the analysis of studies that were adjusted or matched for injury severity. Also, in the overall analysis of recent studies published 2005 and onwards and using data acquired after the year 2000, a significant reduction of odds of mortality could be observed in the overall analysis, as well as in the analysis of all studies that were adjusted or matched for injury severity.

It must be taken into account, however, that in some of the included studies, patients in the physician-treated group could be transported by helicopter and therefore had shorter transportation times, possibly benefitting from direct transport to a level I trauma centre, and there are several studies showing survival benefits for severely injured patients treated and/or transported by HEMS crews (43-45). Therefore, sub-group analysis was performed for studies with no helicopter transport in either group, with helicopter transport in both groups, or with comparable transportation times and transport destinations (direct to level I trauma centres) in both groups in spite of there being helicopter transport in only one group. The latter could be the case if the physician was transported by helicopter to the site of accident, but the patient was transported to the hospital by ambulance, or if the study was conducted in densely populated areas, where the time advantage of helicopter transport could not come into effect. Analysing these studies with comparable modes of transport, we found similar results, with ORs for mortality of 0.80 (95% CI: 0.65-1.00) overall and 0.74 (95% CI: 0.53-1.03) in more recent studies. The results in these subgroups were no longer significant, but still showed a trend toward reduced odds of mortality in the group of patients treated by an EMS team including physicians, even with comparable modes of transport.

There are several studies supporting a benefit of treatment by EMS physicians in the prehospital setting in certain situations such as cardiopulmonary resuscitation or in patients needing invasive procedures (e.g., airway management, intubation of the trachea, thoracostomy, etc.) (27, 46-48). As the number of invasive procedures performed by EMS crews in out-of-hospital patients is limited, it is very difficult to develop or maintain lifesaving skills (49-52). As an example, even after 150 attempts at intubating the trachea in elective surgical patients under optimal conditions in the operating room, the success rate is only 95% (53). In the out-of-hospital setting, conditions are generally more difficult, leading to more challenging prehospital airway management (54, 55). EMS physicians – who are often anaesthesiologists, intensivists or emergency physicians – can maintain airway skills, as well as other manual skills such as pleural drainage, in the operating room or during their work in the emergency department or intensive care unit.

On the other hand, training of paramedics in these core competences of emergency medicine has improved during the last years, and success rates of prehospital airway management are primarily dependent on manual skills and extensive practical training of the prehospital clinicians rather than their profession as a paramedic or a physician. For example, a recent large case series found that well-trained paramedics were equally effective in performing thoracostomies in the prehospital setting as physicians (56). Other studies have shown that well-trained paramedics are able to perform safe and effective analgesia and triage as well as to apply clinical judgement in trauma patients (57, 58). In addition, educational programs such as Advanced Trauma Life Support (ATLS) or Prehospital Trauma Life Support (PHTLS) have standardised prehospital care for major trauma during the past decades. This standardised approach to major trauma care may compensate for the lack of clinical experience (59-63).

The two studies showing the most pronounced benefits for physician-assisted treatment were conducted in patients with severe traumatic brain injury (TBI) (31, 33). These patients are known to benefit from prehospital advanced airway management preventing hypoxia, ensuring normoventilation, protecting against aspiration, as well as providing haemodynamic stability (54, 64-69). This encourages the assumption that it is these patients requiring rapid sequence induction and endotracheal intubation who benefit the most from an EMS physician-staffed system. In the study by Pakkanen et al., 98% of patients with severe TBI treated by physicians received advanced airway management, compared to 16% of those treated by paramedics (33). This hypothesis is supported by the results of the study by Garner et al., also included in our meta-analysis. The results of this study showed reduced 30-day mortality (29% vs. 45%, $p<0.01$) in those patients receiving additional EMS physician care with a 49% rate of endotracheal intubation, in comparison to the paramedic care group with only 10% of endotracheal intubation. Another study evaluating the outcomes of more than 21,000 patients with severe TBI (GCS ≤8) demonstrated that sedation before endotracheal intubation reduces mortality in these patients (70). It may thus be concluded that in particular severely injured patients with TBI benefit from experience in anaesthesia and rapid sequence induction (RSI), which only physicians are capable of in many EMS.

Another potential benefit of treatment by physicians in the prehospital setting – beyond better training in manual skills – is superior training in clinical assessment. One of the included studies, for example, showed significant differences in volume administration between the physician-treated and the paramedic-treated groups (27). The benefit of treatment by an EMS team with greater experience in trauma management has already been shown in a previous study (71). On the other hand, it cannot be ruled out that it was only the additional manpower that facilitated the decision-making process or patient care and thus improved outcome. However, the physician-treated group had longer on-scene times and prehospital times in several included studies, which is explained by additional advanced interventions in this group.

Finally, direct transfer of severely injured patients to a level I trauma centre has been shown to reduce mortality (72). The decision of the physician on-site to bypass nearer but less specialised trauma centres may have influenced our results in the overall analysis. However, in our sub-analyses with comparable modes of transport, all patients were transported to a level I trauma centre and this bias was excluded.

Strengths and limitations

The major strengths of our meta-analysis are the large pooled sample sizes and the elimination of the patients' mode of transportation as the major confounder, thus removing the known beneficial effect of helicopter transport for trauma patients. Another strength is the patient population included. We only included studies on patients with major trauma, and therefore patients who might benefit the most from small improvements.

The major limitation of our meta-analysis is the data quality. The included studies were mainly retrospective and observational; only two randomised trials could be included. Therefore, the majority of the included studies were at high risk of selection bias, and all included studies had a high risk of performance bias. Thus the results of our meta-analysis have to be interpreted with caution.

Furthermore, although we only included studies with no statistically significant difference in injury severity between groups, randomised studies, studies using matched-pairs analysis, or studies adjusting for differences in injury severity, some heterogeneity between groups still could not be excluded. Injury severity is compared by injury severity score, revised trauma score, abbreviated injury score and Glasgow Coma Scale, but not all studies adjusted for differences in physiologic parameters such as blood pressure, heart rate or oxygen saturation between the two groups.

Third, the timing of mortality measurement varied. Most of the studies measured mortality after 30 days or in hospital, but some waited until 6 months or 1 year.

Fourth, the total duration of prehospital time and the location of the accident site could not be accounted for. Also, patients' pre-existing conditions, physicians' experience and training, and the medical competence of EMS personnel might differ significantly and were mostly not reported, so that measures or competencies could not be compared. For example, in Japan paramedics are not allowed to establish an intraosseous access, a surgical airway or chest drains (73). In contrast, in other countries, flight nurses have extensive in-hospital work experience, possibly offsetting differences between physicians and paramedics. But studies from different countries were well mixed in each group. In addition, it is not possible to narrow down the crucial aspects of EMS physician care (knowledge, specific skills such as chest drainage, anaesthesia induction, vascular puncture skills, etc.). These factors cannot be assessed by this study and could have confounded our findings.

Finally, in the paramedic-led group there may have been patients who reached the hospital alive due to rapid transport but died during the subsequent treatment in the trauma room. Likewise, in the EMS physician-led group there may have been patients who were stabilised and only reached the trauma centre alive using advanced medical interventions, but died subsequently due to the enormous severity of their injuries.

Conclusion

The results of our meta-analysis show a clear benefit for the mortality of severely injured patients when an EMS team including a physician delivers prehospital care. After eliminating the bias of helicopter transport in the sub-group of studies with comparable mode of transport there is still a trend toward reduced odds of mortality.

Significance for future research

The best approach to investigate the effect of an EMS physician-based rescue system for severely injured patients would be a large prospective randomised controlled trial. Such a trial would need a huge number of patients, however. On the one hand, a substantial number of patients have a fatal prognosis after major trauma (especially after severe TBI), and on the other hand, the presence of an EMS physician only seems to be of importance in about 5% of all emergency calls (74-76). Furthermore, starting a randomised trial on EMS physician-assisted treatment of severely injured patients in countries where EMS includes prehospital physicians would be unethical. There may never be the level of evidence needed to answer this question. Therefore, despite the low quality of the studies included in this meta-analysis it may be the best evidence we will ever get.

The discussion of the results of our meta-analysis suggests that defining appropriate dispatching criteria for physicians in EMS teams (in a flexible system with ground and air response modes as well as physician and paramedic providers), the identification of relevant prehospital advanced medical interventions, and defining the level of clinical (in-hospital) experience needed to perform these interventions safely are very likely to produce the best outcome.

Author Contribution

JK designed the study and wrote the manuscript; JK, AS, and SS performed literature review, study selection, and data analysis; DH performed quality assessment; BWB and MB served as additional reviewers, made substantial contributions to the discussion, and critically revised the article for important intellectual content. AL and OS served as independent reviewers and performed statistical evaluation; all authors read and approved the final manuscript.

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Figure legends

Figure 1:

Quality assessment of all included studies.

Figure 2:

Odds ratio for mortality in the overall analysis of all included studies.

Figure 3:

A: Odds ratio for mortality in the sub-group of studies with comparable mode of transport.

B: Odds ratio for mortality in the sub-group of studies with comparable mode of transport published after 2005 and using data acquired after the year 2000.

Figure 1

	Random sequence generation (selection bias)	Allocation concealment (selection bias)	Blinding of participants and personnel (performance bias)	Blinding of outcome assessment (detection bias)	Incomplete outcome data (attrition bias)	Selective reporting (reporting bias)	Other bias
Abe et al. 2014	−	−	−	?	−	?	?
Baxt 1987	+	+	−	+	?	?	?
Berlot et al. 2009	−	−	−	?	?	?	?
Bieler et al. 2017	−	−	−	?	+	?	?
de Jongh 2012	−	−	−	?	+	?	?
den Hartog 2015	−	−	−	?	?	?	?
Di Bartolomeo 2001	−	−	−	−	?	?	?
Garner 1999	−	−	−	−	?	?	?
Garner 2001	−	−	−	−	?	?	?
Garner 2015	+	+	−	+	+	?	?
Hamman 1991	−	−	−	?	?	?	?
Iirola 2006	−	−	−	?	?	?	?
Lee 2003	−	?	−	?	?	?	?
Liberman 2013	−	−	−	?	?	?	?
Nicholl 1995	−	−	−	?	?	?	?
Pakkanen 2016	?	−	−	?	?	?	?
Pakkanen 2017	−	−	−	?	?	?	?
Roudsari 2007	−	−	−	−	?	?	?
Schmidt 1992	−	−	−	+	+	?	+
Suominen 1998	−	−	−	?	?	?	?
Tsuchiya 2016	−	−	−	+	+	?	?
Yeguiayan 2011	−	−	−	?	+	?	?

Figure 2

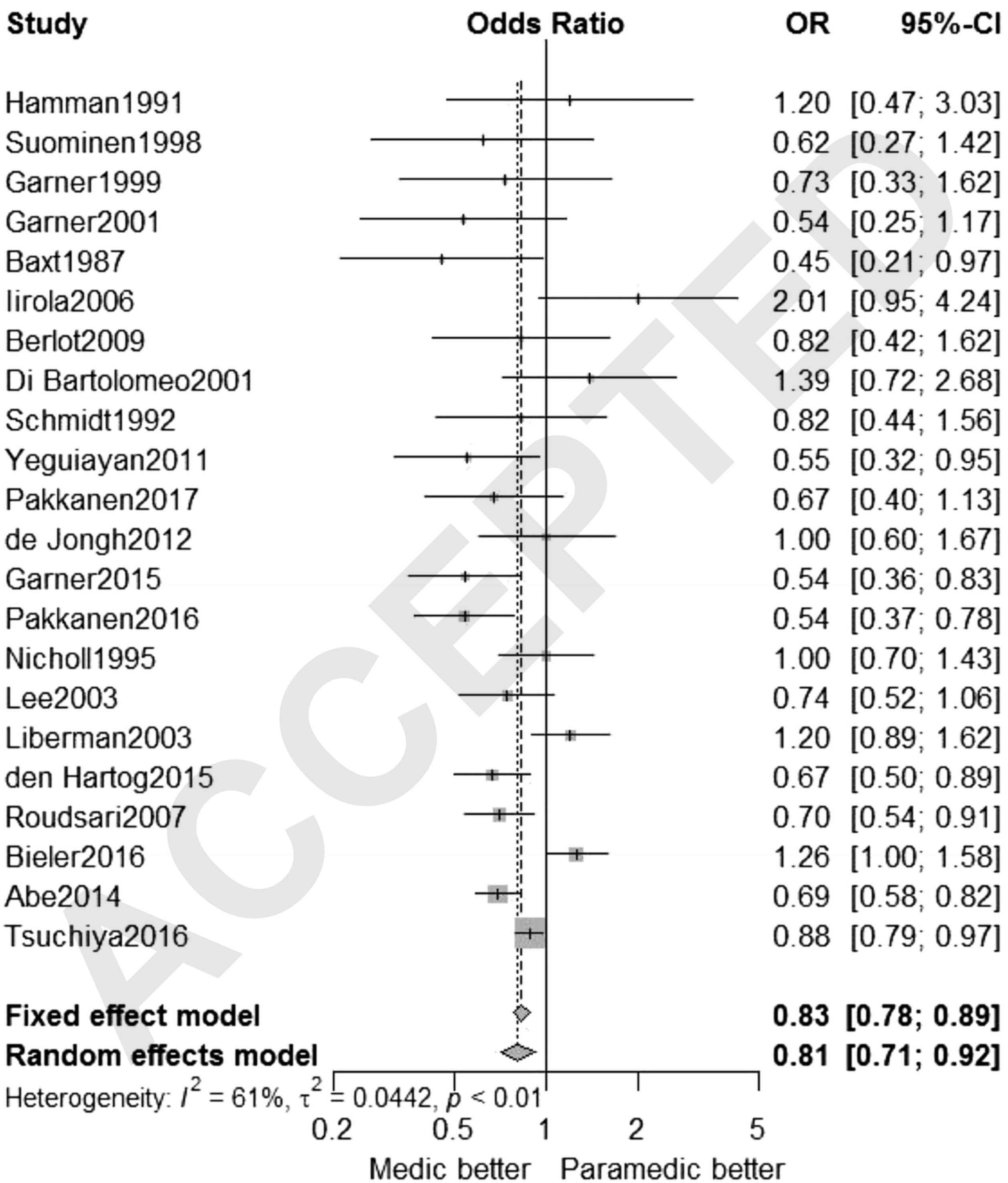
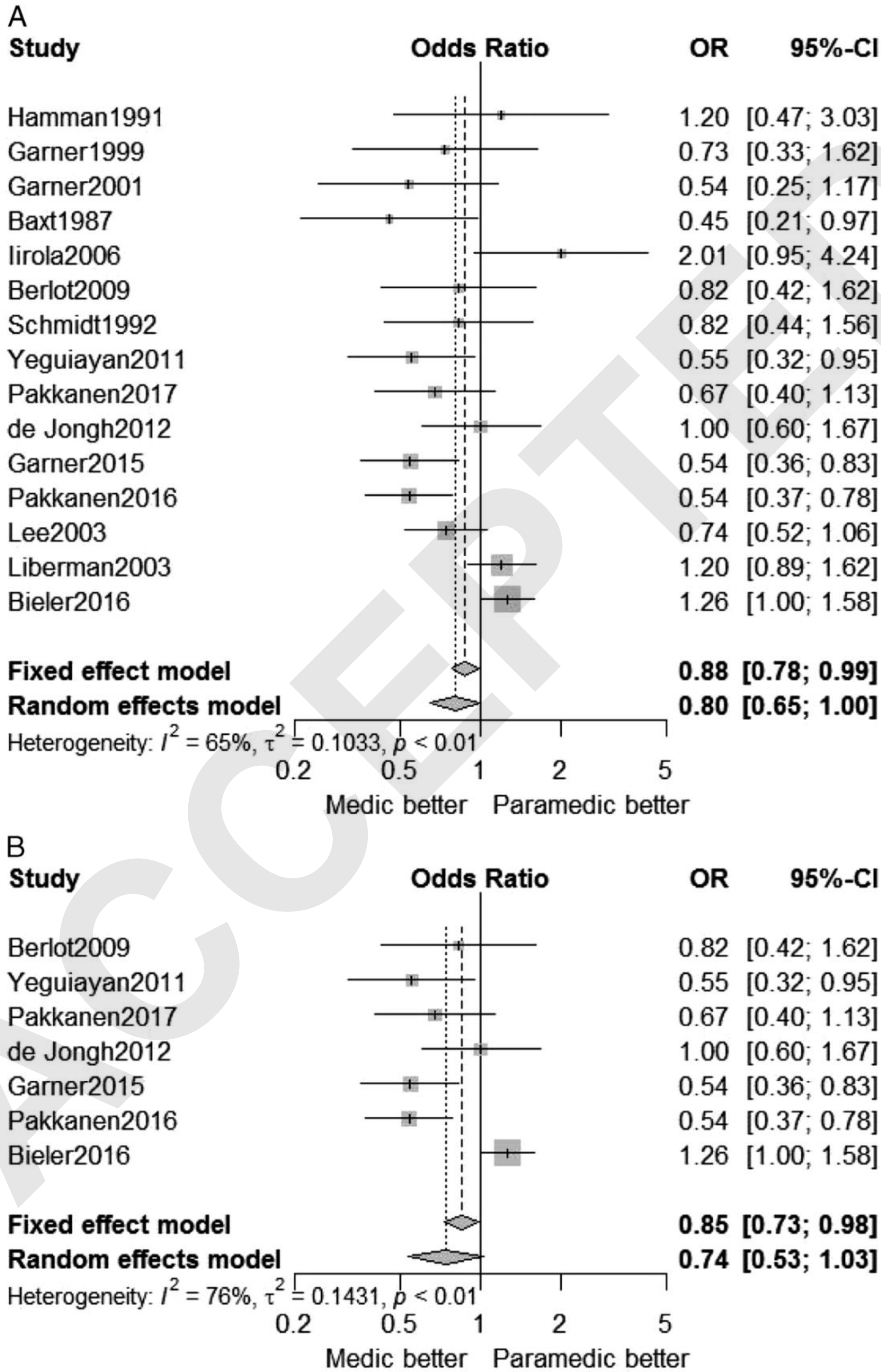

Study
Odds Ratio
OR
95%-CI
Hamman1991 1.20 [0.47; 3.03]
Suominen1998 0.62 [0.27; 1.42]
Garner1999 0.73 [0.33; 1.62]
Garner2001 0.54 [0.25; 1.17]
Baxt1987 0.45 [0.21; 0.97]
Iirola2006 2.01 [0.95; 4.24]
Berlot2009 0.82 [0.42; 1.62]
Di Bartolomeo2001 1.39 [0.72; 2.68]
Schmidt1992 0.82 [0.44; 1.56]
Yeguiayan2011 0.55 [0.32; 0.95]
Pakkanen2017 0.67 [0.40; 1.13]
de Jongh2012 1.00 [0.60; 1.67]
Garner2015 0.54 [0.36; 0.83]
Pakkanen2016 0.54 [0.37; 0.78]
Nicholl1995 1.00 [0.70; 1.43]
Lee2003 0.74 [0.52; 1.06]
Liberman2003 1.20 [0.89; 1.62]
den Hartog2015 0.67 [0.50; 0.89]
Roudsari2007 0.70 [0.54; 0.91]
Bieler2016 1.26 [1.00; 1.58]
Abe2014 0.69 [0.58; 0.82]
Tsuchiya2016 0.88 [0.79; 0.97]
Fixed effect model 0.83 [0.78; 0.89]
Random effects model 0.81 [0.71; 0.92]
Heterogeneity: I^2 = 61%, τ^2 = 0.0442, p < 0.01
0.2 0.5 1 2 5
Medic better Paramedic better
ACCEPTED

Figure 3



A
Study
Odds Ratio
OR
95%-CI
Hamman1991 1.20 [0.47; 3.03]
Garner1999 0.73 [0.33; 1.62]
Garner2001 0.54 [0.25; 1.17]
Baxt1987 0.45 [0.21; 0.97]
Iirola2006 2.01 [0.95; 4.24]
Berlot2009 0.82 [0.42; 1.62]
Schmidt1992 0.82 [0.44; 1.56]
Yeguiayan2011 0.55 [0.32; 0.95]
Pakkanen2017 0.67 [0.40; 1.13]
de Jongh2012 1.00 [0.60; 1.67]
Garner2015 0.54 [0.36; 0.83]
Pakkanen2016 0.54 [0.37; 0.78]
Lee2003 0.74 [0.52; 1.06]
Liberman2003 1.20 [0.89; 1.62]
Bieler2016 1.26 [1.00; 1.58]
Fixed effect model 0.88 [0.78; 0.99]
Random effects model 0.80 [0.65; 1.00]
Heterogeneity: I^2 = 65%, τ^2 = 0.1033, p < 0.01
0.2
0.5
1
2
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Medic better
Paramedic better
B
Study
Odds Ratio
OR
95%-CI
Berlot2009 0.82 [0.42; 1.62]
Yeguiayan2011 0.55 [0.32; 0.95]
Pakkanen2017 0.67 [0.40; 1.13]
de Jongh2012 1.00 [0.60; 1.67]
Garner2015 0.54 [0.36; 0.83]
Pakkanen2016 0.54 [0.37; 0.78]
Bieler2016 1.26 [1.00; 1.58]
Fixed effect model 0.85 [0.73; 0.98]
Random effects model 0.74 [0.53; 1.03]
Heterogeneity: I^2 = 76%, τ^2 = 0.1431, p < 0.01
0.2
0.5
1
2
5
Medic better
Paramedic better

Table 1: Study inclusion criteria according to PICOS	
P – Patient	All patients suffering acute traumatic injury. Paediatric, adult or unselected groups.
I – Intervention	Out-of-hospital care or interventions provided by physicians that were targeted dispatched to critically injured patients.
C – Comparator	Out-of-hospital care or interventions provided by any other prehospital provider.
O – Outcome	Mortality or survival
S - Study design	Any study design including a comparative element: randomised controlled trials, matched-pairs analyses, before-after design or observational studies with a comparative element.

Table 2: Overview of all included studies				
Study title **First author and year of publication** **Country**	**Characteristics of intervention and comparator group**	**Mortality in intervention group**	**Mortality in comparator group**	**Conclusion of study**
Studies with comparable injury severity				
Prehospital care and survival of paediatric patients with blunt trauma Suominen, 1998 (23) Finland	Physician-staffed ALS unit (anaesthetists or other experienced ALS-trained physicians), ground or helicopter transport EMT staffed BLS unit, ground transport	11/49 = 22%	23/72 = 32%	Overall trend toward reduced mortality in paediatric blunt trauma when prehospital care was provided by physician-staffed ALS units compared with EMT-staffed BLS units.
Effect of physician-staffed helicopter emergency medical service on blunt trauma patient survival and pre hospital care Iirola, 2006 (24) Finland	Physician staffed ALS unit (resident in anaesthesiology), helicopter transport Non physician staffed BLS unit, ground transport Time from first dispatch until arrival in Turku university hospital 63 min in physician group vs. 53 min in non-physician group	25/81 = 31%	14/77 = 18%	The physician-staffed helicopter emergency medical service was not beneficial for blunt trauma patients in this setting.
Effects of 2 patterns of prehospital care on the outcome of patients with severe head injury Di Bartolomeo, 2001 (25) Italy	Physician staffed unit (anaesthetists), helicopter transport Non physician staffed BLS unit, ground transport	28/92 = 30%	22/92 = 24%	This study was conceived to investigate the assumed advantages of the combined helicopter, physician and ALS rescue. No increased benefit compared with the simpler rescue group could be demonstrated.
Influence of prehospital treatment on the outcome of patients with severe blunt traumatic brain injury: a single-centre study Berlot, 2009 (26) Italy	Physician staffed unit (anaesthetists), helicopter transport Non physician staffed unit, ground transport Prehospital time in physician group 66 min vs. 38 min in non-physician group	19/89 = 21%	26/105 = 25%	The intervention of an experienced and well-trained HEMS team (…) has been associated with better patient survival and reduced neurological disabilities as compared with patients who were offered only basic treatments.
Addition of physicians to paramedic helicopter services decreases blunt trauma mortality Garner 1999 (27) Australia	Physician staffed unit (anaesthetist, emergency or intensive care physician), helicopter transport Paramedic staffed unit, helicopter transport	10/67 = 15%	27/140 = 19%	Direct comparison of the physician to the paramedic treatment group showed a substantial difference in mortality. Between eight and 19 extra survivors per 100 treated patients in the physician group were estimated.

Helicopter transport of trauma victims: does a physician make a difference? Hamman, 1991 (28) USA	Physician staffed unit (emergency physician), helicopter transport Paramedic and nurse staffed unit, helicopter transport	12/145 = 8.3%	8/114 = 7%	No demonstrable advantage to patient care or patient outcome when treated by a team including a physician.
Physician-staffed helicopter emergency medical service has a beneficial impact on the incidence of pre hospital hypoxia and secured airways on patients with severe traumatic brain injury Pakkanen, 2017 (29) Finland	Physician staffed unit (anaesthetists), helicopter transport EMT (BLS) or Paramedic (ALS) staffed unit, ground transport Total mission time in physician group 82 min vs. 54 min in non-physician group, time from dispatch to arrival on scene 12 min in physician group vs. 8 min in non-physician group	40/85 = 47%	103/181 = 57%	The introduction of a physician-staffed HEMS unit resulted in a beneficial impact on patient care reflected by a decreased incidence of prehospital hypoxia and an increased number of patients with secured airways. This may have contributed to the observed improved neurological outcome during the HEMS period.
Efficacy of pre hospital critical care teams for severe blunt head injury in the Australian setting Garner 2001 (30) Australia	Physician staffed unit (anaesthetist, emergency medicine or intensive care physician), helicopter or ground transport Paramedic staffed unit, ground transport Prehospital time in physician group 113 min vs. 45 min in non-physician group	9/46 = 20%	78/250 = 31%	Prehospital treatment of patients with severe head injuries resulting from road traffic accidents by physician-staffed teams was associated with better outcomes compared to patients treated by paramedics using written protocols.
The Head Injury Retrieval Trial (HIRT): a single-centre randomised controlled trial of physician pre hospital management of severe blunt head injury compared with management by paramedics only Garner, 2015 (31) Australia	Paramedic staffed ground transport + physician arriving by helicopter (anaesthetist, trauma or intensive care physician) Paramedic staffed unit, ground transport Prehospital time in physician group 48 min vs. 44 min in non-physician group. Transport time in both groups 13 min	60/195 = 29%	81/180 = 45%	Reduction in 30-day mortality in adult patients with blunt trauma with GCS<9 receiving physician prehospital care.
On scene helicopter transport of patients with multiple injuries - comparison of a German and an American system Schmidt, 1992 (32) Germany/USA	German HEMS staffed with physician (trauma surgeon) North American HEMS staffed without physician (paramedic or flight nurse)	21/221 = 10%	21/186 = 11%	Early airway intervention and ventilatory control can produce improved early and overall survival in trauma patients. The therapeutic interventions required to accomplish this task are in the armamentarium of doctors, flight nurses and paramedics.

Prehospital severe traumatic brain injury – comparison of outcome in paramedic versus physician staffed emergency medical services Pakkanen 2016 (33) Finland	Physician-staffed unit (anaesthetist), helicopter or ground transport Paramedic staffed unit, ground transport Total mission time in physician group 72 min vs. 54 min in non-physician group	116/270 = 42%	104/181 = 57%	In this observational retrospective study the results point to outcome benefit from physician-staffed EMS treating TBI patients. Mortality was significantly lower and neurological outcome better in patients in the physician-staffed EMS group compared to the paramedic-staffed EMS group.
The impact of a physician as part of the aeromedical pre hospital team in patients with blunt trauma Baxt, 1987 (17) USA	Physician-staffed unit, helicopter transport Paramedic-staffed unit, helicopter transport	11/316 = 3%	19/258 = 7%	Statistically significant reduction in the mortality of patients with blunt trauma treated by a medical helicopter emergency care service staffed by a flight nurse and flight physician could be demonstrated compared with that staffed by a flight nurse and flight paramedic.
level of prehospital care and risk of mortality in patients with and without severe blunt head injury Lee, 2003 (34) Australia	Physician-staffed unit (anaesthetist, emergency or intensive medicine physician), ground transport Paramedic-staffed unit (BLS or ALS), ground transport	44/224 = 20%	289/1167 = 25%	No benefit from advanced interventions specifically in patients with severe head injury relative to patients with other types of severe injury. Insufficient evidence to suggest that paramedic or physician led prehospital care decreased mortality in those who survived to ICU admission.
Studies with matched groups of patients or adjusting for injury severity				
Medical prehospital management reduces mortality in severe blunt trauma: a prospective epidemiological study Yeguiayan, 2011 (35) France	SMUR (emergency physician, nurse and specially trained ambulance driver), ground transport Fire brigade unit (BLS), ground transport	407/2439 = 17%	29/190 = 15%	This study suggests that SMUR management is associated with a significant reduction in 30-day mortality.
The effect of Helicopter Emergency Medical Services on trauma patient mortality in the Netherlands De Jongh, 2012 (36) The Netherlands	Physician staffed unit (anaesthetist or trauma surgeon), helicopter or ground transport Paramedic staffed unit, ground transport Prehospital time in physician group 69 min vs. 38 min in non-physician group	66/186 = 36%	48/186 = 26%	No indication that the assistance of the HEMS added a survival advantage compared to EMS-only-based prehospital trauma care.
Effects of London helicopter emergency medical service on survival after trauma Nicholl, 1995 (37) United Kingdom	Physician-staffed unit, helicopter transport Paramedic-staffed unit, ground transport	92/337 = 27%	77/466 = 17%	Any benefit in survival is restricted to patients with very severe injuries and amounts to an estimated one additional survivor of major trauma each month. Overall the whole caseload of HEMS, however, there is no evidence that it improves the chance of survival in trauma.
Multicentre Canadian study of prehospital trauma care Liberman, 2003 (38) Canada	Physician-staffed unit (ALS), ground transport EMT (BLS) or paramedic (ALS) staffed unit, ground transport	801* 35%	8604* 24% (paramedic, ALS) or 18% (EMT, BLS)	In urban centres with highly specialized level I trauma centres, there is no benefit in having on-site ALS for the prehospital management of trauma patients.

Survival benefit of physician-staffed Helicopter Emergency Medical Services assistance for severely injured patients Den Hartog 2015 (19) The Netherlands	Physician-staffed unit (trauma surgeon or anaesthetist), helicopter or ground transport Paramedic staffed unit (PHTLS), ground transport	184/681 = 27%	307/1495 = 21%	An additional 5.33 lives saved per 100 dispatches of the physician-staffed HEMS. Given the excellent statistical power of this study (>90%), physician-staffed HEMS is confirmed to be an evidence-based valuable addition to the EMS systems in saving lives of severely injured patients.
Outcomes after helicopter versus ground emergency medical services for major trauma–propensity score and instrumental variable analyses: a retrospective nationwide cohort study Tsuchiya, 2016 (39) Japan	Physician staffed unit (1-2 physicians and a nurse), helicopter transport EMT or paramedic staffed unit, ground transport	882/3980 = 22%	974/3980 = 24%	HEMS was associated with a significantly lower mortality than GEMS in adult patients with major traumatic injuries after adjusting for measured and unmeasured confounders.
Association between helicopter with physician versus ground emergency medical services and survival of adults with major trauma in Japan Abe, 2014 (40) Japan	Physician-staffed unit, helicopter transport EMT and fire-fighter staffed unit, ground transport	546/2090 = 26%	5765/22203 = 26%	Among patients with major trauma in Japan, transport by helicopter with a physician may be associated with improved survival to hospital discharge compared to transport with ground emergency services after controlling for multiple known confounders.
Does the presence of an emergency physician influence prehospital time, prehospital interventions and the mortality of severely injured patients? A matched-pair analysis based on the trauma registry of the German Trauma Society Bieler, 2017 (41) Germany	Physician-staffed unit, ground transport Non physician-staffed EMS unit, ground transport	185/1235 = 15%	152/1235 = 12%	This retrospective analysis does not allow definitive conclusions to be drawn about the optimal model of prehospital care. It shows, however, that there was no significant difference in mortality although patients who were attended by non-physician teams received fewer prehospital interventions with similar on-scene times.
International comparison of prehospital trauma care systems Roudsari, 2007 (42) USA/Canada/Australia/New Zealand/Germany	Physician-staffed ALS unit Non physician-staffed ALS unit No information about transport mode	Early trauma fatality was less common in physician-staffed EMS compared with non-physician EMS: OR: 0.70, 95% CI: 0.54-0.91		Prehospital trauma care systems that dispatch a physician to the scene may be associated with lower early trauma fatality rates, but not necessarily with significantly better outcomes on other clinical measures.

Table 3: Overview of the results of the meta-analysis. Odds ratios (OR) and 95% confidence intervals are based on random-effects meta-analysis. Additionally the total number of patients and number of included studies in the respective meta-analysis is presented.

**Note: The study by Roudsari et al. did not report the absolute number of patients included in their analysis (42). Therefore, the absolute number of included patients is higher than indicated. (This only refers to the columns "All studies" and "Matched/adjusted studies", as the mode of transport was not specified in the study by Roudsari et al. (42))*

***Note: In the two most rigorous sub-groups "Matched/adjusted studies, 2005-2017" and "All studies with comparable mode of transport, 2005-2017" there is an overlap of 3 studies with a total of 5.471 patients.*

Table 3: Overview of the results of the meta-analysis.			
OR (95% confidence interval)	All studies	Matched/adjusted studies	All studies with comparable mode of transport
1987-2017	n = 54,991* 22 studies **0.81 (0.71-0.92)**	n = 42,504* 9 studies **0.86 (0.73-1.01)**	n = 19,454 15 studies **0.80 (0.65-1.00)**
2005-2017	n = 41,186* 11 studies **0.75 (0.64-0.88)**	n = 39,900*,** 7 studies **0.81 (0.67-0.97)**	n = 6,757** 7 studies **0.74 (0.53-1.03)**

Supplemental Figure 1. Flow diagram showing numbers of studies screened, assessed for eligibility, and included in the review, with reasons for exclusions at each stage according to PRISMA.