TITLE PAGE

Factors Influencing Outcomes of Trauma Patients Transferred in Trauma System by Air or Ground Ambulance: A Systematic Review.

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ABSTRACT

Factors Influencing Outcomes of Trauma Patients Transferred in Trauma System by Air or Ground Ambulance: A Systematic Review

OBJECTIVES: This systematic review aims to determine the effectiveness of ambulance transportation versus helicopter transportation on mortality for trauma patients.

METHODS: A systematic review of published and unpublished databases (to August 2023) was performed. Studies, reporting mortality, for people who experience trauma and were transported to a trauma unit by ambulance or helicopter were eligible. The Newcastle-Ottawa scale was employed to evaluate study quality.

RESULTS: Of the 7323 studies screened, 63 met the inclusion criteria. Thirty-two percent of these studies included patients with diverse injury types, while nine studies included patients across all age groups. The majority (92%) of the included data were retrospective in nature. Eighteen studies (28.57%) achieved the highest score on the Newcastle-Ottawa scale suggesting high-quality evidence. Seven studies examining 24-hour mortality reported variable findings. Eighteen studies reported mortality without exact time points through adjusted analyses, 17 favored air transport. Air transport showed an advantage across all subgroups in the adjusted data, while the unadjusted data presented relatively similar outcomes between the two modes of transport.

CONCLUSIONS: This systematic review found that adjusted analyses consistently favored air transport over ground transport. Unadjusted analyses showed no significant difference between the two modes of transport, except in specific subgroups. Further subgroup analyses revealed notable disparities between the two modalities, suggesting that these differences may be influenced by multiple factors. These findings highlight the need for further research to clarify the true impact of transport modality on trauma outcomes.

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MAIN DOCUMENT

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INTRODUCTION

Trauma is a global health challenge. In 2017, mortality increased by 5% compared to 1990, resulting in nearly 4.5 million deaths globally (1). Furthermore, non-fatal injuries, within the same interval-period, increased globally by 47%, impacting in excess of 520 million people (1). Addressing this critical issue necessitates strategic interventions. One suggested strategy has been centralizing trauma care at specialist trauma centers (2).

Rapid transportation of a patient who has sustained a traumatic injury to a trauma center for definitive care is a cornerstone of the trauma system (3-5). It positively affects mortality and morbidity outcomes by ensuring patients following trauma are transported to a hospital with the required specialties (6). Within a trauma system, the American College of Surgeons (ACS) divided level of care provided by hospitals into four levels (7). Level 1 (L1) and Level 2 (L2) trauma centers are identical in term of clinical care of severe trauma patients but only differ by some logistic criteria such as geographic area covered or being a leader in education activities. Other levels, namely Level 3 and Level 4, usually act as intermediate facilities where severe trauma patients are stabilized and transferred to a higher level, otherwise, they mainly treat trauma patients with minor injuries. The American College of Surgeons levels are widely used across the world.

Commonly, trauma patients are transported either by ground ambulance, or by air in helicopters (8). The comparative effectiveness of these modes of transportation has been the subject of extensive debate (6, 9-12). For instance, whilst helicopters excel in long-distance transportation, weather conditions and landing zone restrictions can impede their accessibility (13). Furthermore, the absence of clear guidelines governing the choice between these transportation methods may result in overuse of helicopters in high-income countries without commensurate effectiveness (14). For low-income countries, the costs of air transportation could be prohibitive for its adoption (15).

The ongoing debate regarding the effectiveness of one transportation method over the other underscores the need for a comprehensive examination of the existing literature. Four systematic reviews have previously compared ground to air transportation (14, 16-18). However, none have studied mode of transportation within trauma system on the wide scale irrespective of trauma patients' status or by country of origin in the last ten years, to understand effectiveness or identify factors which may influence outcomes. Accordingly, the purpose of this systematic review is to address this limitation and to compare the effect of air versus ground transportation on mortality for people who have experienced trauma. Secondly, the study aimed to identify key determinants which may influence mortality by mode of transportation.

METHODS

Study Design

This study has been reported in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist (see Supplemental File Table 1) (19). It was prospectively registered (PROSPERO: CRD42023421918).

Eligibility Criteria

This review included: quantitative or mixed-methods studies reporting quantitative data; full-text, peer-reviewed articles; primary research studies reporting data on mortality, presented in English. Studies published between January 1990 and August 2023 were included (20-22). This review excluded literature reviews or systematic reviews, case-studies or cohort studies with less than ten participants, studies reported after August 2023, and studies where participants were not transported to a trauma center or a specialist trauma hospital. This study did not place a restriction on the type of injuries, severity of injury, or the age of participants. Only studies that compared ground transport by ambulance to air transport by helicopter were included.

Search Strategy

The search strategy used the databases: CINAHL (EBSCOhost), EMBASE (Ovid), and MEDLINE (EBSCOhost). The EMBASE search strategy is detailed in Supplemental File Figure 1. This review commenced with the objective of identifying factors influencing trauma patients within trauma systems. Due to the extensive array of studies for screening and following consultations with other reviewers and a medical librarian, its focus was refined to investigate the influence of transportation mode on trauma patients within trauma systems. This refinement accounts for the large number of studies screened in the initial search. Moreover, additional relevant literature was identified through scrutinizing the references of included articles by August 2023. In instances where full-text access was unavailable, the primary investigator (SA) contacted corresponding authors to request access. All searches were performed by one reviewer (SA) after consultation with a medical librarian.

Study Identification

Eligibility screening involved a two-tiered process. Initially, titles and abstracts were reviewed. Those which were considered eligible were then assessed at full-text level. Each screening step was undertaken by one reviewer (SA) and independently verified by one of three reviewers (TS, PD, JC). Any discrepancies between reviewers were resolved through discussion or, if necessary, consultation with a third reviewer. All studies which met the eligibility criteria subsequently had data extracted.

Data Extraction

Data extraction was undertaken by one reviewer (SA) and independently verified by one of three reviewers (TS, PD, JC). Where disagreement arose, these were addressed through discussion. Data extracted included: publication year, study country, study duration, total and selected population, study design, participant age, sex, Injury Severity Score (ISS), Glasgow Coma Scale (GCS), vital signs, mechanism of injury, operational data including: response intervals and interventions, area covered by the trauma system, transportation costs, trauma center level, and health care clinician professional role.

While extracting data, some studies had more than one dataset to extract. In details, some studies used two mortality outcomes (i.e. different time-points), therefore each one were pooled in an appropriate subgroup (10, 23-30). In addition, some studies compared between two different countries using two different datasets of ground ambulance (physicians' group and paramedics or Emergency Medical Technician (EMT) group) with one dataset of air ambulance for each country (26, 31). These were pooled for each country depending on the criteria of subgroups. Some studies differ between the destination, mainly between Level 1 and Level 2 trauma centers (32-34).

Outcomes

The primary outcome was 24-hour mortality. Planned secondary outcomes included: 30-day, 90-day, and 365-day mortality.

Data synthesis

Study heterogeneity was assessed by evaluating the data extraction table on the characteristics of the population, study design, and data collection approaches. This identified heterogeneity in study design and potential variability in contextual factors between studies, such as existing emergency service and health service provision. Accordingly meta-analysis was not appropriate, and a narrative analysis was performed. This was conducted to determine mortality of air versus ground transportation at the time-points of interest. Subgroup analyses to explore factors related to mortality outcome for the two modes of transport. These included study origin (continent), injury classification, clinician's professional role and direct transfers versus staged transfers to a treating trauma center. *Critical Appraisal*

The risk of bias for the included studies was assessed using the Newcastle-Ottawa Scale (NOS) for cohort studies (35). This tool evaluates bias based on three domains: selection, comparability, and outcome. One reviewer (SA) conducted the bias assessment, with independent verification by one of three reviewers (TS, PD, JC). Any disagreements were resolved through discussion.

RESULTS

Search Results

The results of the search strategy are presented as PRISMA flowchart in **Error! Reference source not found.** (19). A total of 8,905 records were identified through the primary search. Of these, 7,323 records were screened for title and abstract. Finally, 357 records were potentially eligible and reviewed at full-text. Of those, 63 met the eligibility criteria and were included in the analysis.

Study Characteristics

The majority of studies (75%) were published in the last two decades. Of the 42 studies conducted in North America, most (81%) were conducted in the United States of America (USA) (6, 8, 23, 28, 30, 32-34, 36-61), two included shared data involving the USA and another country (24, 62). Additionally, 15 studies were conducted in Europe (10, 25, 26, 31, 63-73), eight in Asia (9, 27, 29, 74-78), and one in Africa (79). Of the included studies, 32% (n=20) included patients with all injury types, while seven analyzed patients with blunt injuries (6, 41, 63, 68, 74, 78, 80), and six recruited people with a traumatic brain injury (TBI) (23, 24, 33, 34, 65, 67). In addition, 10 studies reported patients with ISS more than or equal to 16 (9, 26, 27, 29, 31, 32, 63, 65, 68, 78), two other studies enrolled patients with ISS ≥ 15 (67, 76), and one study analyzed people with ISS ≥ 16 and ≤ 67 (66). Regarding age groups, nine records studied all age groups (39, 47-50, 52, 68, 69, 74), and six focusing on pediatric cases (33, 37, 51, 56, 62, 73). Furthermore, 23 studies reported adult and older age groups (8, 9, 13, 23-25, 28-30, 32, 34, 46, 53, 55, 57, 58, 60, 72, 76, 78-81), two studied adult patients but excluded people older than 80 years (26, 31), and one study reported patients between 16 and 65 years old (6). Most included data were collected retrospectively with different study designs (92%). Among these, 23 studies used a cohort study design (8, 10, 13, 28, 31, 33, 45-48, 50, 52, 56, 60-62, 69, 70, 73, 74, 76, 80, 81). Five studies collected data prospectively (29, 63, 64, 68, 77), two used a cohort study design (64, 68). Two studies used match-pair cohort study (25, 79), and one study utilized both prospective and retrospective data (66). Full details of characteristics of included studies are presented at (**Error! Reference source not found.**).

Critical Appraisal and Quality of Studies

Eighteen studies scored a high risk of bias on the NOS (35). Of these, 14 studies focused on transportation to L1 or L2 trauma centers, and only eight had direct transportation data. Two studies had the lowest scores on the NOS (76, 77) (five and three points, respectively). This review identified some strengths in the included studies. For example, since some studies reported that helicopters in their context were only operated during daylight (63-65, 67), Tsuchiya et al. (9) compared between helicopter and ambulance transportation during the daylight only. In contrast, this review identified some weaknesses in the included studies. For instance, nine records excluded either dead on arrival data, emergency department (ED) mortality data, or both (29, 33, 41, 42, 51, 55, 58, 74, 81). Moreover, four studies reported missing data (32, 59, 79, 80), and two studies focused on specific contexts/injury patterns (43, 77). However, most included studies had scores of either 6 or 7 (68.25%). Overall, the quality of evidence was deemed moderate (Table 2).

Data Synthesis

Primary Outcome: 24-hour mortality

Seven studies reported 24-hour mortality (10, 23-27, 78). No study reported adjusted 24-hour mortality analysis data. However, all the seven studies reported unadjusted analysis. Only two studies reported significant results (23, 27). One study from USA favored ground transport for its cohort of patients with TBIs ($p<0.001$) (23). The other reported significantly lower 24-hour mortality for air transportation, particularly in severe trauma patients transported over distances greater than 30 kilometers ($p=0.022$) (27). Five studies reported no difference in 24-hour mortality by mode of transport (10, 24-26, 78).

Secondary Outcome: 30-day mortality

Six studies reported 30-day mortality (23, 65, 66, 68, 79, 80). Three studies reported adjusted analyses (23, 65, 68). Two studies reported a statistically significant difference in favor of air transport (23, 68). One study conducted in France focused on patients following severe blunt trauma (OR: 0.68; $p=0.035$) (68). The other presented the largest sample size, drawing on a national dataset in the USA, and focused primarily on adult and older populations with TBIs (OR: 0.55; $p=0<0.001$) (23). The other three studies reported unadjusted analysis. None demonstrated a statistically significant 30-day mortality difference between the two modes of transport.

Secondary Outcome: emergency department mortality

Five studies reported emergency department (ED) mortality (28-30, 43, 54). None reported adjusted ED mortality analyses. From the unadjusted analyses, two studies reported a significant difference in ED mortality between the mode of transportation (28, 30). One study reported a statistically significantly lower ED mortality after ground transportation over air transportation ($p<0.001$) (30). This study utilized data from specific trauma centers and focused on direct transportation from the scene to trauma centers in adult and older patients. Conversely, Ryb et al. (28) reported significantly lower ED mortality when patients were transported by air ($p=0.023$). This study utilized a national dataset of adult patients in the USA.

Secondary Outcome: Mortality (irrespective of time-point)

Fifty-one studies reported mortality outcomes without specifying the exact time endpoints (6, 8-10, 13, 25, 27-30, 36-47, 49-53, 55-63, 67, 69-76, 81). Of these, 29 studies reported adjusted analysis (8-10, 25, 28-30, 32-34, 38, 40, 41, 44-46, 50, 51, 55, 56, 59, 61, 62, 67, 70-73, 75). Eighteen studies reported a significant difference between the two modes of transport (8-10, 28-30, 32-34, 41, 45, 46, 50, 62, 67, 70, 71, 73). Seventeen studies demonstrated statistically significantly lower mortality following air transport ($p<0.001$ to $p<0.05$) (9, 10, 28-30, 32-34, 41, 45, 46, 50, 62, 67, 70, 71, 73). The remaining study showed significantly lower mortality when patients were transported by ground (OR: 2.4) (8). The remaining 22 studies only reported unadjusted analyses. Of these, seven studies reported significant results (6, 27, 37, 43, 53, 63, 81). Three studies reported significantly lower mortality when patients were transported by air ($p<0.001$ – $p<0.05$) (27, 63, 81), whilst the remining four studies demonstrated significantly lower mortality for patients when transported by ground ($p<0.001$ to $p=0.019$) (6, 37, 43, 53).

Subgroup Analyses to Assess Factors Influencing Mortality

Subgroup Analysis: Continent

The differences in overall mortality outcomes between continents varied significantly. Thirty-nine studies were conducted in North America (6, 8, 13, 23, 24, 28, 30, 32-34, 36-62, 80, 81). Of these, 22 studies reporting adjusted analyses (8, 23, 24, 28, 30, 32-34, 38, 40, 41, 44-46, 48, 50, 51, 55, 56, 59, 61, 62). Thirteen studies reported a statistical difference between the mode of transport (8, 23, 28, 30, 32-34, 41, 45, 46, 48, 50, 62) where twelve studies favored air transport (OR: 0.41 to 2.35; $p<0.05$) (23, 28, 30, 32-34, 41, 45, 46, 48, 50, 62). One study reported reduced mortality following air transportation only for patients with high ISS (62). Populations varied amongst these studies with three analyzing patients following TBIs (23, 33, 34), one on severe injuries (32), one on blunt injuries (41). Seven were not limited to any type of injuries (28, 30, 45, 46, 48, 50, 62). In addition, six studies focused on adult patients (23, 28, 30, 32, 34, 46), two focused on pediatric patients (33, 62), and four studies were not limited to any specific age (41, 45, 48, 50). The remaining study with adjusted analyses favored ground transportation (OR: 2.4) (8). This study was not restricted to any type of injury but limited to adult patients.

The remaining 17 studies reported unadjusted analyses. Of these five studies reported statistically significant results (6, 37, 43, 53, 81). One study, conducted in Canada, showed lower mortality with air transportation (81), while the remaining significant results, from four studies, favored ground transportation (6, 37, 43, 53). One study was not restricted by age group or injury type(43), while one study focused on specific IISS (81), and one on blunt trauma (6). In terms of population age, one study focused on pediatric patients (37).

In Europe, 15 studies were analyzed (10, 25, 26, 31, 63-73). Ten studies reported adjusted analyses (10, 25, 64, 65, 67, 68, 70-73). Of those, six studies reported statistical differences between the mode of transport, all favoring air transportation (OR: 0.21 to 0.81) (10, 67, 68, 70, 71, 73). Two studies focused on patients following severe trauma (67, 68), one on blunt trauma (68), one on TBIs (67); three studies were not restricted to the type of injury (70, 71, 73). Five studies were not restricted to specific age (10, 67, 68, 70, 71), and one was limited to pediatric patients (73). The other four studies, with adjusted analyses, reported no difference between the two modes of transport (25, 64, 65, 72). Of the remaining five studies with unadjusted analyses, only one study reported a significant difference in favor of air transport ($p<0.05$) (63).

In Asia, eight studies were included (9, 27, 29, 74-78). Two studies reported adjusted analyses (9, 75). One reported statistically significant lower mortality when patients were transported by air (RR: 2.3%; 95% CI −4.2 to −0.5)(9). The other study showed no significant difference between the two modes of transport (75). However, amongst the remining six studies with unadjusted analyses, only two studies reported a significant difference, one favored ground transport (p=0.001) which was conducted in Qatar and did not restrict by injury type or age group (75), while the other study favored air transport (p=0.024) and was conducted in South Korea and focused on patients following severe trauma who travelled from the scene to the hospital for 30 km or more (27).

One study was conducted in Africa, namely South Africa, within the private sector. This reported no statistically significant difference in mortality by mode of transport (OR: 1.35, p=0.503) (79).

Subgroup Analysis: Injury Classification

Thirteen studies focused on patients following severe trauma (9, 26, 27, 29, 31, 32, 63, 65-68, 76, 78). The definition of severe trauma varied across studies. Two studies classified severe trauma as an ISS of greater than15 (67, 76), while the remaining studies used a threshold of greater than16. One study limiting the ISS range to between 16 to 66 (66). Of the 13 studies, three analyzed data on patients following blunt trauma (63, 68, 78), while two examined patients with TBI (65, 67). In terms of age groups, five studies did not restrict participants by age (27, 63, 65, 67, 68), four included patients older than 15 years (9, 27, 29, 32), one study included individuals aged 15 and above (76), one study included individuals aged 15 and above (26, 31), and one study included participants younger than 75 years. (66).

Six studies reported adjusted analyses (9, 29, 32, 65, 67, 68). Of these, five reported significantly lower mortality following air transportation ($p<0.001$ to $p=0.035$) (9, 29, 32, 67, 68), with the remining study report no difference between the two mode of transport (65). Seven studies reported unadjusted analyses (26, 27, 31, 63, 66, 76, 78). Two studies conducted in Italy, reported statistically significant lower mortality with air transport ($p<0.05$) (27, 63), while the remining five studies reported no difference between the two modes of transport.

Six studies focused on TBI (23, 24, 33, 34, 65, 67). All six studies reported adjusted analyses. Of these, four studies showed significantly lower mortality with air transportation ($p<0.001$ to $p<0.05$) (23, 33, 34, 67); the two studies showed no difference (24, 65).

Seven studies investigated blunt injuries (6, 41, 63, 68, 74, 78, 80). Two studies reported adjusted analyses, showing significantly lower mortality with air transportation (OR: 0.68to– 0.76; $p= 0.035$ to $p= 0.037$) (41, 68). The remining five studies reported unadjusted analyses. Of these, two studies reported a significant difference between air versus ground transportation (6, 63). One reported significantly lower mortality with ground transport ($p<0.001$) (6), while the other study showed significantly lower mortality with air transportation ($p<0.05$) (63). Among these seven studies, four studies limited by ISS (63, 68, 78, 80). Four studies did not impose age restrictions (41, 63, 68, 74), while two focused on patients aged 16 and above (78, 80), and one confined its sample to individuals aged 16 to 65 (6).

Subgroup Analysis: Health Clinician Professional Role

Four comparisons of professional role were made. These included ground physician versus air physician, ground EMT versus air physician, ground paramedics versus air paramedics, and ground paramedics versus air physician. Participants in these comparisons were directly transferred from the scene of injury to a trauma center.

The ground physician versus air physician subgroup included four studies (26, 31, 68, 73). Two studies reported significant adjusted analyses favoring air transportation (p=0.011 to p=0.035) (68, 73). The other two studies reported unadjusted analyses. None reported significant differences between ground versus air transportation (26, 31).

The second subgroup, ground EMTs versus air physicians, consisted of 12 studies (9, 26, 31, 36, 44, 47, 57, 68, 71, 73, 78, 81). Five studies reported adjusted analyses (9, 44, 68, 71, 73). Of these, four reported significantly lower mortality when patients were transported by air (p<0.001 to p=0.035) (9, 68, 71, 73), while the other study demonstrated no significant difference between the two modes of transport (44). The remining seven studies reported unadjusted analyses. Only one study reported significantly lower mortality for air transport (p<0.001) (81), while the other six studies showed no difference (26, 31, 36, 47, 57, 78).

The third comparison, ground paramedics versus air paramedics, involved four studies (44, 47, 57, 81). One study reported adjusted analyses, reporting no difference in mortality between air versus ground transportation (44). Three studies reported unadjusted analysis results. One study found a significant reduction in mortality when patients were transported by air with paramedics (p<0.001) (81), while the other two studies showed no difference between the two modes of transport (47, 57).

The final subgroup compared ground paramedics with air physicians in three studies (9, 36, 78). Only one study, using an adjusted analysis, showed significant mortality results favoring air transport (RR: 2.3%;95% CI −4.2 to −0.5) (9). Although the remining two studies reported unadjusted analyses, none reported significant difference between the modes of transport (36, 78).

Subgroup Analysis: Direct Transfers:

When investigating studies not limited to specific injury types or age groups and involving direct transfers to trauma centers, three studies were included (47, 48, 52). Only one study reported adjusted analyses, reporting significantly lower mortality for air transportation (48). Two studies reported unadjusted analyses, finding no difference in mortality between air versus ground when patients had direct transfers to trauma centers (47, 52).

When no restrictions were placed on age or specific injury types, and patients were directly transferred to Level 1 trauma centers, seven studies were included (42-44, 47, 48, 52, 61). Three reported adjusted analysis results (44, 48, 61). Only one study reported significant results favored air transportation (48), while the other two showed no difference (44, 61). The other four studies reported unadjusted analyses (42, 43, 47, 52). One study reported a significant difference favoring ground transportation (p=0.013) (43).

Table 6**Error! Reference source not found.Error! Reference source not found.**

DISCUSSION

This review of 63 studies report that air transport was associated with lower mortality when an adjusted analysis was applied. In contrast, the unadjusted analysis did not show any significant difference between the two modes of transport, except for studies involving severe trauma or those conducted in North America. Importantly, 53 studies demonstrated high-quality evidence, representing over 84% of the included studies offering confidence on the conclusions drawn from this analysis.

This systematic review found that more studies reported a significant reduction in total mortality with air transportation, irrespective of time-point. The number of studies examining 24-hour mortality, 30-day mortality, or ED mortality were relatively balanced in term of support for each mode of transport. In addition, this review revealed that, when adjusted analyses were applied, air transport was favored across all subgroups. In contrast, unadjusted analyses showed a preference for ground transport in North America, while air transport was favored in cases of severe trauma. The remaining unadjusted results were fairly balanced in supporting each mode. A significant number of studies showed no meaningful difference between air and ground transport, with more non-significant results found in unadjusted data than in adjusted data. Moreover, studies with the largest datasets reported lower ED mortality for air transport, although those supporting ground transport noted that their air cohorts had higher ISS. This variation could be explained from two perspectives. Firstly, of the seven studies that investigated 24-hour mortality, four studies focusing on specific ISS groups (10, 26, 27, 78), and two focused on TBI (23, 24). Brown et al. (45) highlights that the majority of patients transported by air invariably present with more severe injuries than are transported by ground. This suggests that the probability of deaths in the helicopter group was high, rendering transportation method less impactful on outcomes. This review observed a difference in the mean ISS between ground and air transportation, 19.5 and 23.3 respectively. It is therefore hypothesized that patients transported by air sustained more traumatic injuries and subsequently are at greater risk of death by injury status compared to those transported by ground. Secondly, none of the selected studies examining those endpoints specified their catchment area, whether rural or urban. In urban areas with shorter transport intervals, the effectiveness of helicopter transportation over ground ambulance transportation could be more debatable (11, 82, 83). However, given the high cost of helicopters in trauma systems, these results support efforts to review triage processes to target patients in need of this resource. While the findings indicate a preference for air transport in certain mortality outcomes, particularly within total mortality, caution must be exercised in interpreting these results due to variations in study populations, injury severity, and potential differences in the catchment area. This highlights the need for further research to fully understand the impact of transportation modality on trauma patient outcomes.

This review endeavored to understand the international effect of transportation mode on outcomes, dividing available records based on their original continents. However, the majority of continent-specified adjusted analyses favored air transportation (19 studies versus one study). Additionally, unadjusted analyses favoring ground transport were more prevalent in North America. This may be associated with trauma system maturity in these countries regarding advanced triage protocols, reducing the utilization of air transportation and possibly targeting more patients with higher risk of mortality, or rural settings. Moreover, Hirshon et al. (84) assessed helicopter experience at Maryland state for ten years and found that despite a reduction by 55% on the usage of helicopter, the mortality did not change. Malekpour et al. (85) conducted a comparative study at rural sitting and found that the odds of survival increased when patients were transported by helicopter, irrespective of injury severity. However, Malekpour et al. (85) study demonstrated a difference between the two groups in regard of level of care provided. The disparities in the effectiveness of ground transportation observed across continents underscore the dynamic interaction between health care systems and regional policies. While data from North America may highlight the maturity of trauma systems and advanced triage protocols, localized studies in various settings offer valuable insights into the diverse factors influencing transportation outcomes, emphasizing the importance of tailoring trauma care strategies to specific regional contexts and health care infrastructures.

This review explored the impact of the level of care provided on transportation outcomes. Galvagno (86) posited that helicopter crews' level of experience could lead to improved survival rates. This review supports this suggestion that air transport offers an advantage across all professionals. Furthermore, when similar professional roles were compared (physician versus physician or paramedics versus paramedics) in cases of direct transfers, the results consistently favored air transportation. This could suggest the positive effect of patient volume on accumulated experience, short transportation distances under qualified supervision, or the lower severity of trauma patients transported. Further research is warranted to clarify this superiority. Moreover, among the studies comparing paramedics in air versus ground, one study using an adjusted analysis reported no significant difference between the two modes of transport. The lack of robust studies highlights the need for investigation into the effectiveness of paramedics' involvement in helicopter transport. Factors such as patient volume, transportation distances, and trauma severity should be considered to better understand potential benefits and optimize trauma care resources.

This systematic review sought to identify the various factors that could influence the air or ground transportation of patients following trauma. To assess the impact of prehospital care within a trauma system, it is essential to examine both short- and long-term mortality (87). While short-term mortality data provide insights into the immediate effects of prehospital transportation and early care, longer-term outcomes provide meaningful insight to patients on their trajectory following injury (88). However, projecting outcomes post-emergency department admission become increasingly more challenging due to contextual factors to recovery particularly related to service provision and societal factors to trauma recovery when examining a global perspective. This prohibited meta-analysis in this systematic review. To answer the longer-term outcome question, adjusting analyses and examining specific confounding factors to longer-term mortality is required when assessing mode of transportation following trauma. This should be considered in future studies to permit better understanding on mortality and to facilitate future systematic reviews and meta-analysis at a global perspective.

This systematic review has highlighted the absence of a standardized reporting system for prehospital data poses a significant barrier to the effective utilization of these data. For instance, only three studies (5%) reported both the mean and median ISS, while 26 studies (41%) reported only the mean ISS, and 16 studies (25%) reported only the median ISS. Despite this review identifying 46 variables, none were consistently reported across all included studies. The most frequently reported variables were sex, mean age, overall mortality, and the level of trauma centers. This underscores the importance of reporting trauma patient data within a robust framework. This structured approach to data reporting should be mandatory, particularly in studies related to prehospital care. A unified reporting model, endorsed by leading institutions in the field, would significantly enhance the quality and utility of trauma research. Furthermore, this proposed model for trauma data reporting should be adopted by academic journals to ensure that essential data are consistently available in trauma studies.

LIMITATIONS

Several limitations in this review warrant mention. Firstly, this review did not detect any data from some developed countries like Australia or Scandinavian countries, with no data from South America. This limits the potential generalizability of the finding to these countries. Secondly, there was a high level of study heterogeneity which made meta-analysis prohibitive. This may indicate the absence of standardized reporting in trauma studies and underscores the need to unify reporting requirements and classification criteria. For instance, discrepancies in age and injury classifications were noted among studies. Given these limitations and the apparent gaps in data from certain regions, further research is imperative to build on current understand and more robustly understanding the impact of transportation modes on trauma outcomes and improve standardized reporting in future trauma studies. However, this review's strengths include its comprehensive search strategy without limiting to specific injury types.

CONCLUSIONS

Given the differences between the two cohorts and the international scope of this review, it was not feasible to draw a definitive conclusion through meta-analyses. This was evidenced by the significant heterogeneity observed between the two cohorts across various subgroup analyses. However, the adjusted analysis results indicated a significant advantage of air transport over ground transport across various subgroups. Nevertheless, within the constraints imposed by the current limitations of available data, this review tentatively suggests a potential association between lower mortality rates and the use of air transportation compared to ground transportation for patients following trauma. Further research with robust methodologies and standardized data collection is needed to more robustly understand this relationship, enhance utilization modes of transportation, and to understand the optimal mode of transport for specific types of trauma patients and trauma systems following injury.

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AUTHORSHIP STATEMENT:

SA: devised research project, build search strategy, screening for eligibility, extracting data, perform data analysis, write up primary drafts, approved final draft, guarantor.

PT: devised research project, verify screening for eligibility, verify extracting data, audit data analysis, edit primary drafts. approved final draft.

JC: devised research project, verify screening for eligibility, verify extracting data, audit data analysis, edit primary drafts. approved final draft.

TS: devised research project, verify screening for eligibility, verify extracting data, audit data analysis, edit primary drafts. approved final draft.

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TABLE CAPTIONS & FIGURE CAPTIONS

Figure 1: PRISMA flow chart.

Figure 2 footnotes: PRISMA flow chart. The first search was completed by April 2023. The additional search was completed by August 2023.

Table 1: Characteristics of included studies.

Table 2 footnotes: Characteristics of included studies.

Table 3: Critical appraisal of Studies Using Newcastle-Ottawa Scale

Table 4 footnotes: Critical appraisal of Studies Using Newcastle-Ottawa Scale

Supplementary Files:

Supplemental File Figure 1: Sample of research strategy using EMBASE (Ovid)

Supplemental File Figure 2 footnotes: Sample of research strategy using EMBASE (Ovid)

Supplemental File Table 1: PRISMA 2020 Checklist

Supplemental File Table 2 footnotes: PRISMA 2020 Checklist

Supplemental File Table 3: Qualifying characteristics of critical appraisal questions.

Supplementa*l* File Table 4 footnotes: Qualifying characteristics of critical appraisal questions.

Table 5: Characteristics of included studies.

Study ID	Country	Study design	Sample size	Age	Injury type	Level TC
Schwartz 1990	USA	Retrospective study	162	-	MVC	-
Nardi 1994	Italy	Prospective Observational Study	140	-	Blunt + ISS ≥ 16	L2
Nicholl 1995	UK	Prospective cohort study	803	-	All	-
Moront 1996	USA	Retrospective study	4356	-	< 15	L1
Brathwaite 1998	USA	Retrospective study	22411	-	All	L1,L2
Kerr 1999	USA	A retrospective, descriptive, statistical study	23002	-	All	TC
Phillips 1999	USA	Retrospective study using TRISS	792	All	All	L1
Di Bartolomeo 2001	Italy	Retrospective study	184	-	TBI + ISS ≥ 16	-
Thomas 2002	USA	Retrospective study	16699	-	Blunt	L1
Lerner 2003	USA	Retrospective study	1877	-	All	L1
Biewener 2004	Germany	Prospective and retrospective	403	≤ 74	ISS ≥ 16 & ≤ 66	H
McCowan 2006	USA	Retrospective study	575	-	All	L1
Mitchell 2007	Canada	Retrospective cohort study	791	> 15	blunt & ISS ≥ 12	L1,L2,L3,L4
Berlot 2009	Italy	Retrospective evaluation	194	-	TBI + ISS ≥ 15	L1
McVey 2009	Canada	Retrospective cohort study	1649	Adult	-	L1,L2
Talving 2009	USA	Retrospective study	3373	-	All	L1
Brown 2010	USA	Retrospective cohort study	258387	-	All	-
Stewart 2011	USA	Retrospective cohort study	10184	All	All	L1,L2
Sullivent 2011	USA	Retrospective cohort study	56744	≥ 18	All	L1,L2
von Recklinghausen 2011	USA	Retrospective cohort study	2164	All	All	L1
Bulger 2012	USA & Canada	Secondary analysis of two randomised trials	2049	≥ 15	TBI or hypovolemic shock	L1,L2
de Jongh 2012	The Netherlands	Match-pair cohort study	372	≥ 16	All	L1
Desmettre 2012	France	Prospective cohort study	1958	All	Blunt + ISS ≥ 16	L1
Galvagno Jr 2012 L1	USA	Retrospective study	159511	> 15	ISS ≥ 16	L1
Galvagno Jr 2012 L2	USA	Retrospective study	63964	> 15	ISS ≥ 16	L2
Rose 2012	USA	Retrospective chart review	2471	All	All	L1
Andruszkow 2013	Germany	Retrospective cohort study	13220	All	ISS ≥ 9	L1,L2
Ryb 2013	USA	Retrospective cohort study	192422	≥ 18	All	L1,L2, other
Abe 2014	Japan	Prospective Observational Study	24293	> 15	ISS ≥ 16	-
Hannay 2014	USA	Retrospective cohort study	13802	All	all	L1
Missios 2014 L1	USA	Retrospective cohort study	11309	< 16	TBI	L1

Missios 2014 L2	USA	Retrospective cohort study	4395	< 16	TBI	L2
Timm 2014 (physician)	Germany	Retrospective cohort study	10821	16 - 80	ISS ≥ 16	L1
Timm 2014 (EMT)	Germany	Retrospective cohort study	4632	16 - 80	ISS ≥ 16	L1
Timm 2014 (EMT)	The Netherlands	Retrospective cohort study	635	16 - 80	ISS ≥ 16	L1
Timm 2014 (physician)	The Netherlands	Retrospective cohort study	629	16 - 80	ISS ≥ 16	L1
Bekelis 2015 L1	USA	Retrospective study	127831	Adult	TBI	L1
Bekelis 2015 L2	USA	Retrospective study	81698	Adult	TBI	L2
Kim 2015	S. Korea	Retrospective cohort study	1626	All	Blunt	L1
Meizoso 2015	USA	Retrospective cohort study	3733	All	All	L1
Stewart 2015	USA	Retrospective study	14405	≤ 17	-	L1
Ahmed 2016	USA	Retrospective study	1269	-	Need CPR within 1st hour	L1,L2
Andruszkow 2016	Germany	Retrospective cohort study	52281	-	ISS ≥ 9	L1,L2
Brown 2016	USA	Retrospective study	1697675	≥ 16	-	Mixed
Buchanan 2016	Canada	Historical observational cohort study	3146	≥ 18	ISS ≥ 12	L1
Shaw 2016	USA	Retrospective cohort study	4522	≥ 15	-	L1
Tsuchiya 2016	Japan	Retrospective study	21289	> 15	ISS ≥ 16	
Al-Thani 2017	Qatar	a retrospective observational study	4596	-	All	L1
Celik 2017	Turkey	Multicentric prospective observational study.	390	-	Terror attacks	L1
Kim 2017	S. Korea	Retrospective cohort study	312	≥ 15	ISS ≥ 15	L1
Madiraju 2017	USA	Retrospective study	4218	> 18	-	L1
Polites 2017	US & Puerto Rico	Retrospective cohort study	43523	≤ 18	-	L1,L2
Aiolfi 2018	USA	Retrospective study	145559	≥ 16	TBI	-
Chen 2018	USA	Retrospective study	153729	≥ 16	-	-
Farach 2018	USA	Retrospective cohort study	1709	0 - 20	-	L1
Taylor 2018	USA	Retrospective analysis	400	16 - 65	Blunt	L1
Zhu 2018	USA	retrospective observational study	1049	≥ 15	-	L1
Hakakian 2019	USA	Retrospective study	903	-	All	L1
Timm 2019 (EMT)	Germany	Retrospective study	296	16 - 80	ISS ≥ 16	L1
Timm 2019 (EMT)	The Netherlands	Retrospective study	296	16 - 80	ISS ≥ 16	L1
Timm 2019 (Physician)	Germany	Retrospective study	879	16 - 80	ISS ≥ 16	L1

Timm 2019 (Physician)	The Netherlands	Retrospective study	879	16 - 80	ISS ≥ 16	L1
Weinlich 2019	Germany	Retrospective cohort study	1646	-	All	L1
Ageron 2020	France	retrospective observational study	9458	-	-	L1
Beaumont 2020	UK	Retrospective study	61733	≥ 16	-	L1
Stassen 2020	South Africa	A retrospective, case-control study	410	≥ 18	-	L1
Bläsius 2021	Germany	Retrospective cohort study	2755	(1 - 16)	-	L1,L2,L3
Nabeta 2021	Japan	Retrospective study	1674	≥ 16	Blunt + ISS ≥ 16	L1
Schneider 2021	USA	retrospective single-centre review	3967	≥ 18	-	L1
Sutherland 2021	USA	Retrospective cohort study	9586	≥ 16	-	L1
Elkbuli 2022	USA	Retrospective cohort study	12633	-	All	L1
Lee 2022	S. Korea	Retrospective study	139	-	ISS ≥ 16	TC not L1 yet

Abbreviation:

CPR: Cardiopulmonary resuscitation
EMT: Emergency Medical Technician
ISS: Injury Severity Score
L1: Level 1 trauma centre
L2: Level 2 trauma centre
L3: level 3 trauma centre
L4: Level 4 trauma centre
MVC: Motor Vehicle Collision
S. Korea: South Korea
TBI: Traumatic Brain injury
UK: United Kingdom
USA: United States of America

Table 6: Critical appraisal of Studies Using Newcastle-Ottawa Scale [35].*

Study	Selection				Comparability	Outcome			Total score
	Representativeness of the Exposed Cohort	Selection of the Non-Exposed Cohort	Ascertainment of Exposure	Demonstration That Outcome of Interest Was Not Present at Start of Study	Comparability of Cohorts on the Basis of the Design or Analysis	Assessment of Outcome	Was Follow-Up Long Enough for Outcomes to Occur	Adequacy of Follow Up of Cohorts	
Schwartz 1990	0	0	1	1	1	1	1	1	6
Nardi 1994	0	1	1	1	1	1	0	1	6
Nicholl 1995	1	1	1	1	1	1	1	1	8
Moront 1996	0	1	1	1	1	1	1	1	7
Brathwaite 1998	1	1	1	1	1	1	1	1	8
Kerr 1999	1	1	1	1	1	1	1	1	8
Phillips 1999	1	1	1	1	1	1	1	1	8
Di Bartolomeo 2001	0	1	1	1	1	1	1	1	7
Thomas 2002	0	1	1	1	1	1	1	1	7
Lerner 2003	1	1	1	1	1	1	1	1	8
Biewener 2004	0	0	1	1	1	1	1	1	6
McCowan 2006	1	0	1	1	1	1	1	1	7
Mitchell 2007	0	1	1	1	1	1	1	1	7
Berlot 2009	0	1	1	1	1	1	1	1	7
McVey 2009	0	0	1	1	1	1	1	1	6
Talving 2009	1	1	1	1	1	1	1	1	8
Brown 2010	1	1	1	1	1	1	1	1	8
Stewart 2011	1	1	1	1	1	1	1	1	8
Sullivent 2011	0	1	1	1	1	1	1	1	7
von Recklinghausen 2011	0	1	1	1	1	1	1	1	7
Bulger 2012	0	0	1	1	1	1	1	1	6
de Jongh 2012	1	1	1	1	1	1	1	1	8
Desmettre 2012	0	1	1	1	1	1	1	1	7
Galvagno Jr 2012	0	1	1	1	1	1	1	0	6
Rose 2012	0	1	1	1	1	1	1	1	7
Andruszkow 2013	1	1	1	1	1	1	1	1	8
Ryb 2013	0	1	1	1	1	1	1	1	7
Abe 2014	0	1	1	1	1	1	1	1	7
Hannay 2014	1	1	1	1	1	0	1	1	7
Missios 2014	0	1	1	1	1	1	1	1	7
Timm 2014	0	1	1	1	1	1	1	1	7

Bekelis 2015	0	1	1	1	1	1	1	1	7
Kim 2015	0	1	1	1	1	1	1	1	7
Meizoso 2015	1	1	1	1	1	1	1	1	8
Stewart 2015	0	1	1	1	1	1	1	1	7
Ahmed 2016	0	1	1	1	1	1	1	1	7
Andruszkow 2016	1	1	1	1	1	1	1	1	8
Brown 2016	0	1	1	1	1	1	1	1	7
Buchanan 2016	0	1	1	1	1	1	1	1	7
Shaw 2016	0	1	1	1	1	1	1	1	7
Tsuchiya 2016	0	1	1	1	1	1	1	1	7
Al-Thani 2017	1	1	1	1	1	1	1	1	8
Celik 2017	0	0	0	1	1	0	0	1	3
Kim 2017	0	0	1	1	1	1	1	0	5
Madiraju 2017	0	1	1	1	1	1	1	1	7
Polites 2017	0	1	1	1	1	1	1	1	7
Aiolfi 2018	0	1	1	1	1	1	1	1	7
Chen 2018	0	1	1	1	1	1	1	1	7
Farach 2018	0	1	1	1	1	1	1	1	7
Taylor 2018	0	1	1	1	1	1	1	1	7
Zhu 2018	0	1	1	1	1	1	1	0	6
Hakakian 2019	1	1	1	1	1	1	1	1	8
Timm 2019	0	1	1	1	1	1	1	1	7
Weinlich 2019	1	1	1	1	1	1	1	1	8
Ageron 2020	1	1	1	1	1	1	1	1	8
Beaumont 2020	0	1	1	1	1	1	1	1	7
Stassen 2020	0	1	1	1	1	1	1	0	6
Bläsius 2021	0	1	1	1	1	1	1	1	7
Nabeta 2021	0	1	1	1	1	1	1	1	7
Schneider 2021	0	1	1	1	1	1	1	1	7
Sutherland 2021	0	1	1	1	1	1	1	1	7
Elkbuli 2022	1	1	1	1	1	1	1	1	8
Lee 2022	1	1	1	1	1	1	1	1	8

Abbreviation:

0: Did not meet the criteria.
1: Did meet the criteria.

* Qualifying characteristics of each question presented at (Supplemental File Table 6) .

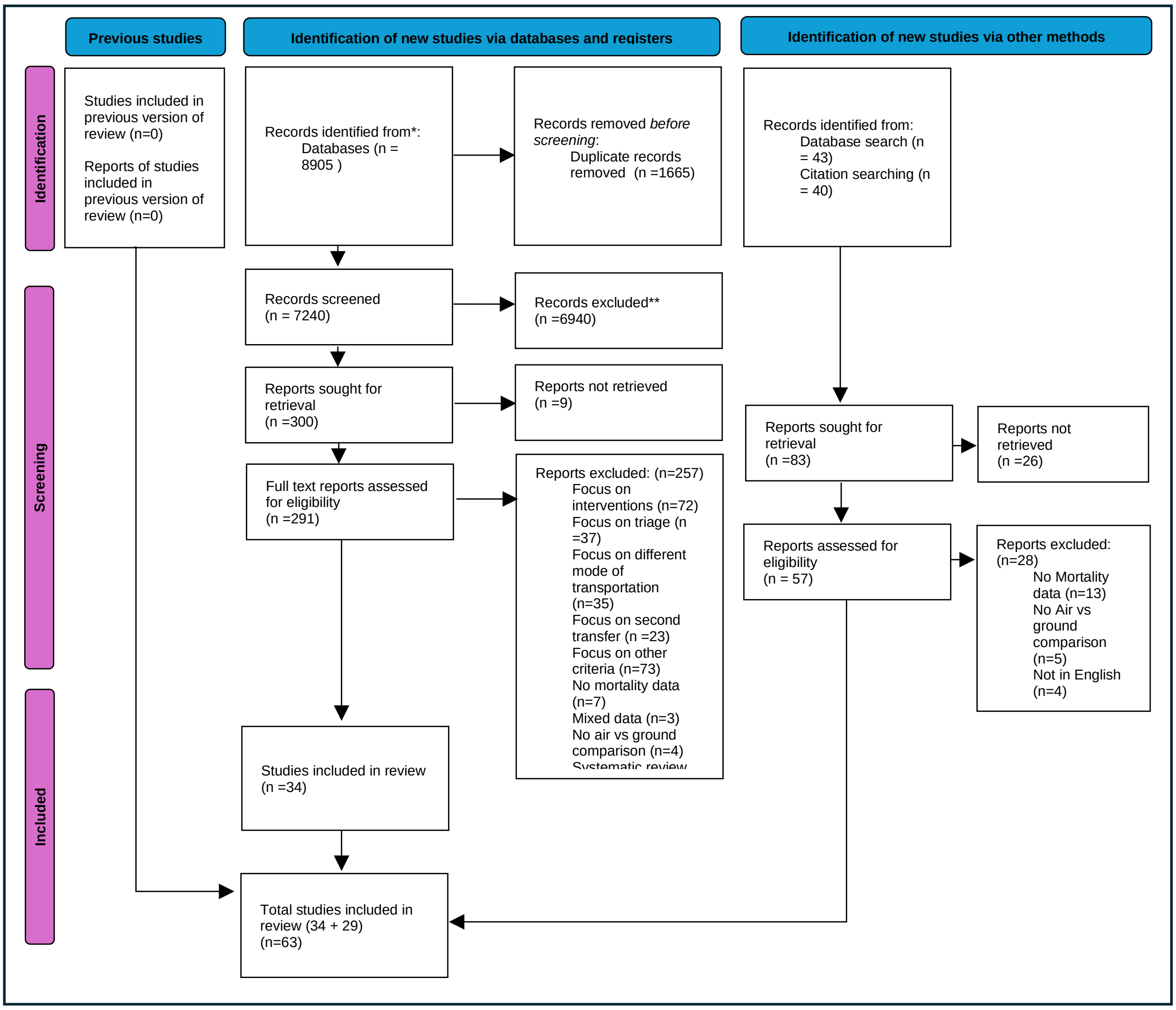

Figure 3: PRISMA flow chart. The first search was completed by April 2023. The additional search was completed by August 2023.

Supplemental File Figure 3: sample of research strategy using EMBASE (Ovid)

Embase <1974 to 2023 April 19>

1	Major trauma cent*.ab.	1536
2	major trauma network*.ab.	77
3	special* trauma cent*.ab.	78
4	trauma cent*.ab.	27737
5	trauma system*.ab.	2322
6	non trauma cent*.ab.	200
7	trauma servic*.ab.	1720
8	trauma care.ab.	4809
9	implementation of trauma.ab.	134
10	trauma implementation.ab.	8
11	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10	33198
12	trauma center.mp. or exp emergency health service/	135539
13	11 and 12	23992
14	trauma.ab.	326875
15	injur*.ab.	1172492
16	trauma*.ab.	504269
17	patien*.ab.	11263015
18	exp injury/	2602282
19	exp wound/	334589
20	18 or 19	2602282
21	14 or 15 or 16 or 17	12042214
22	20 and 21	1602155
23	outcome.ab.	1748652
24	mortalit*.ab.	1410057
25	morbidit*.ab.	710580
26	survival.ab.	1694732
27	functio*.ab.	5259383
28	recover*.ab.	999822
29	wellbe*.ab.	39558
30	rehab*.ab.	262490
31	fatal*.ab.	221244
32	quality of life*.ab.	565478
33	well-bein*.ab.	127353
34	23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32 or 33	10088933
35	exp critical care outcome/ or exp outcome assessment/	848041
36	exp hospital mortality/ or exp in-hospital mortality/ or exp mortality rate/ or exp out-of-hospital mortality/ or exp mortality/ or exp mortality risk/ or exp mortality risk score/	1380311
37	exp morbidity/	432100
38	35 or 36 or 37	2284428
39	34 and 38	1601053
40	13 and 22	18869
41	39 and 40	6628
42	limit 41 to (english language and yr="1990 - 2023")	6528

Supplemental File Table 5: PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	Title
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	Introduction, Para 1,2
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	Introduction, para 4
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	Eligibility criteria, para 1
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	Search strategy, para 1
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	S file 1
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	Study identification, para 1
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	Data extraction, para 1
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	Outcomes, para 1
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	N/A
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	Critical appraisal, para 1
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	Data synthesis, para 1
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	Data synthesis, para 1
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary	N/A

Section and Topic	Item #	Checklist item	Location where item is reported
		statistics, or data conversions.	
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	N/A
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	Data synthesis, para 1
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	Data synthesis, para 1
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	Data synthesis, para 1
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	N/A
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	Data synthesis, para 1
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	Search results, para 1/ Figure1
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	Figure 1
Study characteristics	17	Cite each included study and present its characteristics.	Study characteristics, para 1
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	Critical appraisal and quality of studies, para 1
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	Data synthesis, para 1,2,3,4,5,6,7,8,9
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	Data synthesis, para 1,2,3,4,5,6,7,8,9
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	Data synthesis, para 1,2,3,4,5,6,7,8,9
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	Data synthesis, para 1,2,3,4,5,6,7,8,9
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	High quality assessment,

Section and Topic	Item #	Checklist item	Location where item is reported
			para 1
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	N/A
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	Data synthesis, para 1,2,3,4,5,6,7,8,9
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	Discussion, para 2,3,4
	23b	Discuss any limitations of the evidence included in the review.	Discussion, para 5
	23c	Discuss any limitations of the review processes used.	Discussion, para 5
	23d	Discuss implications of the results for practice, policy, and future research.	Discussion, para 5
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	Study design, para 1
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	Study design, para 1
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	Search strategy, para 1
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	Cover letter
Competing interests	26	Declare any competing interests of review authors.	Cover letter
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	N/A

Supplemental File Table 6: Qualifying characteristics of critical appraisal questions.

Domain	Criterion	Qualifying characteristics
Selection	Representativeness of the Exposed Cohort	This criterion was met when study was not limited to specific injury type.
	Selection of the Non-Exposed Cohort	This criterion was met when the two study groups (ground and air) were drawn from the same community or the same dataset.
	Ascertainment of Exposure	This criterion was met when study used a valid source of data.
	Demonstration That Outcome of Interest Was Not Present at Start of Study	This criterion was met when study did not investigate trauma before it happens. Due to the nature of trauma injuries, all included studies met the criterion.
Comparability	Comparability of Cohorts on the Basis of the Design or Analysis	This criterion was met when the comparison was drawn from the same dataset, same area or same population.
Outcome	Assessment of Outcome	This criterion was met when considerable identification of trauma was followed (i.e medical records or through codes on database records)
	Was Follow-Up Long Enough for Outcomes to Occur	This criterion was met when study period was 12 months or more
	Adequacy of Follow Up of Cohorts	This criterion was met when study reported complete follow up of sample or reported lost to follow up which unlikely to introduce bias.