Is it the H or the EMS in HEMS that has an impact on trauma patient mortality? A systematic review of the evidence

Daniel P Butler, Imran Anwar, Keith Willett

ABSTRACT
Background and aim Prehospital care of trauma patients is a matter of great debate. The optimal transport method remains undecided, with conflicting data comparing helicopter and ground emergency medical transfer. This study systematically reviews the evidence comparing helicopter and ground transfer of trauma patients from the scene of injury.

Methods A systematic literature review of all population-based studies evaluating the impact on mortality of helicopter transfer of trauma patients from the scene of injury. We searched MEDLINE, CINAHL and EMBASE from January 1980 to December 2008 and selected and reviewed potentially relevant studies.

Results A search of the literature revealed 23 eligible studies. 14 of these studies demonstrated a significant improvement in trauma patient mortality when transported by helicopter from the scene. 5 of the 23 studies were of level II evidence with the remainder being of level III evidence. Data were then entered into an evidence table and references made to transport staffing, intubation rate, time at scene and time/distance of transfer.

Conclusions The role and structure of HEMS in a modern trauma service is a debate that is likely to continue. Prehospital care design should be specific to critical incident frequency, geographical arrangements of hospital facilities and travel times within each trauma network. It is also important to consider the benefits and capabilities of the emergency medical team separately from the transport method being considered. An effective helicopter EMS will ultimately depend on effective operating procedures and tasking protocols, clinical governance, and auditing of the helicopter EMS activity.

INTRODUCTION
Trauma is the fourth most common cause of death in the UK and the commonest cause for loss of life in the young, causing considerable loss of productivity and subsequent social and economic damage. The UK’s National Confidential Enquiry into Patient Outcome and Death (NCEPOD) report into trauma care within the UK concluded that ‘almost 60% of the patients...received a standard of care that was less than good practice’, with pre-hospital care and trauma networks found to be deficient.

Within the UK, patients may be transported by ground ambulance or, less commonly, by the helicopter emergency medical service (HEMS). The first major use of helicopter transfer for trauma patients was during the Korean War. It was not until 1987 that HEMS was created in the UK. There are now more than 20 helicopter air ambulances in the UK, most of which are run by charities.

The use of helicopters in the transport of trauma patients is thought to confer a benefit through four different means:
1. To retrieve patients from remote locations.
2. To provide the option to transport the patient directly to a specialist trauma centre.
3. To facilitate rapid transport of a specialist team to the scene of injury.
4. To expedite transfer of patients between facilities (not addressed in this review).

There remains considerable debate as to whether helicopter deployment for trauma patients is cost-effective. This is partly due to conflicting reports in the research literature on the impact of HEMS on trauma mortality, the low incidence of major trauma and the high cost of airframes and support.

In this systematic review, we aim to collate the evidence on the effect on mortality of HEMS and attempt to analyse whether it is the helicopter as a transport platform or the standard of the emergency medical service that accounts for any differences seen. A pervading difficulty is that the outcome of mortality will likely be affected by the whole trauma system including the hospital, surgical and critic care facilities and cannot be ascribed to prehospital interventions alone.

METHODS

Literature retrieval
Potentially eligible studies were identified by performing a systematic search of three electronic databases: MEDLINE (using PubMed), CINAHL and EMBASE (both using the National Library of Health). The time period for study inclusion was January 1980 to December 2008. The search terms used for the MEDLINE search were: ‘helicopter’, ‘HEMS’, ‘air ambulance’, ‘rotorwing’ and ‘rotorcraft’. The terms ‘HEMS’, ‘air ambulance’, ‘rotorwing’ and ‘rotorcraft’ were not recognised by the National Library of Health database and so EMBASE and CINAHL were searched using the terms: ‘helicopter’ and ‘ambulance’. The retrieved articles were limited to English language reports.

Selection of eligible studies
The abstracts of all studies that had potentially relevant titles were reviewed. Broad inclusion criteria were applied to the methods section of these abstracts to decide which studies should be sourced. If a study’s methodology could not be
determined from the abstract the paper was sourced for further review. The reference list of each sourced paper was screened to identify any additional manuscripts that could be included in the review. Strict inclusion and exclusion criteria (box 1) were then applied to potentially relevant papers to decide which would be eligible for inclusion in the systematic review. If there was uncertainty as to whether a paper should be included in the review, then the senior opinion (K.W.) was decisive.

Eligible studies were then read in detail and relevant data extracted. The strength of evidence presented by each manuscript was assessed using the Oxford Centre of Evidence Based Medicine guidelines, which grade evidence across five levels of study design.

### Presentation of results

Each eligible study was included in a comprehensive results table. If suitable, the authors of this paper calculated a mortality OR for those papers that had sufficient data to perform such a calculation and had not reported this ratio in the manuscript. This was included to assist in the comparison of results between studies.

### RESULTS

We screened 15,756 titles and identified 668 potentially relevant titles. Of these there were 135 abstracts that could potentially be included in this systematic review. This was reduced to 49 when duplicates were removed. All of these papers were sourced for further assessment. Following review of these papers, 23 eligible papers remained. The reasons for exclusion of 26 of the sourced papers was because they focused on or included interfacility transfers, did not only recruit trauma patients, studied HEMS triage criteria, used disability as the outcome, had unclear methodology, had no comparison group, compared two HEMS services, or were simply descriptive studies.

Data from the 23 eligible studies were entered into an evidence table (table 1). Consideration was given as to whether the data could be combined to complete a meta-analysis, but due to the inconsistency in patient inclusion criteria and outcome measures this was inappropriate.

Five of the included studies were of level II evidence, with the remainder being of level III evidence. Of those studies included, 19 compared HEMS with a ground medical transport (GMT), with 17 of these comparing the two transport modes delivering patients to the same hospital.

### Box 1 Inclusion and exclusion criteria for study

<table>
<thead>
<tr>
<th>Inclusion criteria:</th>
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</thead>
<tbody>
<tr>
<td>1. Study the mortality of trauma patients transported by HEMS from the scene.</td>
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<tr>
<td>2. Needs to have a comparative group (ie, preHEMS vs postHEMS, HEMS vs ground, HEMS vs MTOS).</td>
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<tr>
<td>4. English literature.</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Exclusion criteria:</th>
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</thead>
<tbody>
<tr>
<td>1. Level 4/5 evidence or panel based studies.</td>
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<tr>
<td>2. Studies that look at effect of HEMS on interfacility transfer.</td>
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<tr>
<td>3. Studies that compare two separate HEMS services.</td>
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<tr>
<td>4. Studies that include non-trauma patients.</td>
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</table>

Fourteen studies reported results that demonstrated a significant mortality rate improvement with HEMS, showing no significant benefit; the majority show a mortality benefit with HEMS. This variation may be a result of a number of factors.

First, the early evidence comes from the 1980s and it is likely that HEMS services utilised now are very different in tasking, equipment and prehospital support. It is for this reason that early data must be interpreted with caution. Second, the studies come from seven different countries, each of which has different geography and offers different HEMS services and different trauma systems available to receive the patient. Third, there is a variety in study methodology, comparator group selection (vs MTOS or GMT) and the level of statistical adjustment for confounding variables.

If there is a true difference in trauma patient mortality between those transported from the scene by HEMS and those by the GMT service then it may be a result of a number of factors (listed below).

### Transport of a physician to the scene

Depending on the training available for nurse and paramedic crews, a physician may bring an increased skill set to allow more definitive management of patients at an earlier stage. An experienced prehospital trauma physician may also bring a higher level of clinical judgement both during the initial management of patients and in deciding the most appropriate facility for the patients’ subsequent treatment. Studies have attempted to address this issue by comparing physician-staffed HEMS services with paramedic-staffed ground services, but these are, understandably, limited by the confounding factors of the transport method and the effectiveness of the receiving hospital. Assessing the benefit of transporting a physician to the scene can only be done effectively by comparing a HEMS/GMT service with and without a physician. One randomised control trial did compare the outcome of blunt trauma patients randomised to a HEMS service staffed by physician/nurse crews versus paramedic/nurse crews. Both crews were trained to perform the same level of interventions and transported patients to the same level 1 trauma centre and were, therefore, compared directly. The physician-staffed HEMS crew had a mortality rate...
<table>
<thead>
<tr>
<th>Author</th>
<th>Grade of Study evidence population</th>
<th>Study design</th>
<th>Inclusion criteria</th>
<th>Sample size</th>
<th>Staffing</th>
<th>Intubation rate</th>
<th>Time at scene (min)</th>
<th>Time and/or distance of transfer</th>
<th>Analysis</th>
<th>Adjustments</th>
<th>Outcomes</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>TRISS-based analysis of HEMS alone</td>
<td>Bartolacci</td>
<td>Westmead Hospital, Sydney Nurse and para-medic crew</td>
<td>Retrospective</td>
<td>Blunt trauma patients with ISS &gt;14</td>
<td>77 HEMS controls per HEMS patient</td>
<td>HEMS — physician GMT — paramedic</td>
<td>HEMS — 10% needed intubation on arrival to ED GMT — 37% needed intubation on arrival to ED</td>
<td>HEMS — HEMS — 18 min GMT — NS</td>
<td>TRISS based analysis of HEMS (Direct mortality comparison of HEMS vs GMT)</td>
<td>GMT controls matched to ISS within five points</td>
<td>Mortality at 48 h 50% reduction in TRISS predicted mortality (p&lt;0.001), 18 deaths predicted, nine actual deaths Adjusted W statistic of 12.18 (CI 5.3 to 19.1). (M stat=0.52) GMT vs HEMS mortality RR=1.43, CI 0.74 to 2.78 21% reduction in overall predicted mortality (p&lt;0.001) OR TRISS vs HEMS=1.32 (CI 1.07 to 1.63)* Predicted mortality 17%, actual mortality 14% (p&gt;0.05) OR TRISS vs HEMS=1.13 (95% CI 0.70 to 1.82)* 13% reduction from predicted mortality with HEMS (p=0.004). If TS between 4 and 13 then 39% reduction in mortality OR TRISS vs HEMS=1.21 (CI 1.09 to 1.34)* W statistic=4.16 =2.21 with HEMS (p value not specified)</td>
<td></td>
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<tr>
<td>Bax</td>
<td>Multiple HEMS services (seven centres)</td>
<td>Retrospective</td>
<td>All blunt trauma patients</td>
<td>1273 HEMS services — four had physician, three had nurse or paramedic</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>TRISS based analysis</td>
<td>Done at same time as MTOS collection for TRISS data, so no adjustment made</td>
<td>Mortality predischarge (time period not specified)</td>
<td>Mortality (time not specified)</td>
</tr>
<tr>
<td>Cameron</td>
<td>Melbourne, Australia</td>
<td>Retrospective</td>
<td>All trauma patients</td>
<td>254 HEMS</td>
<td>HEMS — paramedic</td>
<td>HEMS — 14% (58% of patients with GCS &lt;8 intubated)</td>
<td>HEMS — HEMS — 19 min/28 miles</td>
<td>TRISS based analysis</td>
<td>Only one group, so no need for control</td>
<td>Mortality (time not specified)</td>
<td></td>
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<td>Cameron</td>
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<td>HEMS — HEMS — 19 min/28 miles</td>
<td>TRISS based analysis</td>
<td>Only one group, so no need for control</td>
<td>Mortality (time not specified)</td>
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<tr>
<td>Jacobs</td>
<td>Connecticut, USA</td>
<td>Retrospective</td>
<td>All trauma patients. Scene trauma patients analysed as a subgroup</td>
<td>3620 HEMS</td>
<td>HEMS — nurse or paramedic</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>TRISS based analysis</td>
<td>Nil</td>
<td>Mortality predischarge (time frame not specified)</td>
<td></td>
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<tr>
<td>Younge</td>
<td>London, England</td>
<td>Prospective</td>
<td>Blunt trauma patients</td>
<td>632 HEMS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>TRISS based analysis (UK MTOS as control group)</td>
<td>Low M stat (0.61) led authors to calculate an adjusted W stat</td>
<td>Additional survivors (time frame not specified)</td>
<td></td>
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</table>

Comparison of HEMS and GMT using TRISS-based analysis
<table>
<thead>
<tr>
<th>Author</th>
<th>Grade of evidence</th>
<th>Study population</th>
<th>Study design</th>
<th>Inclusion criteria</th>
<th>Sample size</th>
<th>Staffing</th>
<th>Intubation rate</th>
<th>Time at scene (min)</th>
<th>Time and/or distance of transfer</th>
<th>Analysis</th>
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</thead>
<tbody>
<tr>
<td>Baxt</td>
<td>3</td>
<td>University of California, San Diego</td>
<td>Retrospective</td>
<td>All blunt trauma patients</td>
<td>150 HEMS 150 GMT</td>
<td>HBMS — physician GMT — EMT or paramedic</td>
<td>NS</td>
<td>GMT staff only trained to use oesophageal obturator airway</td>
<td>NS</td>
<td>24 min (136 cases in rural setting) GMT — 10 min (16 cases in rural setting)</td>
<td>TRISS based analysis</td>
<td>No further adjustments. Showed age, mechanism of injury and incidence of head injury were not statistically different</td>
<td>Mortality predischarge (time period not specified)</td>
</tr>
<tr>
<td>Biewener</td>
<td>3</td>
<td>Dresden, Germany</td>
<td>Retrospective</td>
<td>Blunt trauma (ISS &gt; 6), alive on arrival to hospital, &lt;75 years of age</td>
<td>70 GMT</td>
<td>HBMS — physician GMT — physician</td>
<td>HEMS = 91% GMT = 75%</td>
<td>See right Accident to arrival at ED: GMT = 90 min GMT = 68 min</td>
<td>NS</td>
<td>TRISS based analysis (used USA MTOS data)</td>
<td>Nil — TRISS study</td>
<td>Mortality predischarge (time not specified)</td>
<td>21.4% reduction in mortality with HEMS, p &lt; 0.05 HEMS predicted 38.15 deaths, 39 actual deaths/ GMT predicted 39.86 deaths, 51 actual deaths). OR GMT vs HEMS = 1.47 (95% CI 0.94 to 2.29)* (MI stat = 0.618 HEMS, 0.867 ground) GMT predicted = 39.11, actual = 41 deaths HEMS predicted = 16.44, actual = 15 p value not specified OR GMT vs HEMS = 1.14 (CI 0.84 to 2.20)*</td>
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<tr>
<td>Buntman</td>
<td>3</td>
<td>Johannesburg, South Africa</td>
<td>Retrospective</td>
<td>Trauma patients. Not clearly specified, but states it excluded ‘minor injuries’. Patients excluded if dead on arrival to trauma unit.</td>
<td>306 GMT (BLS)</td>
<td>HBMS — NS GMT — any road transport to hospital, including civilian transport</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>TRISS based analysis</td>
<td>Nil</td>
<td>Mortality predischarge (time period not specified)</td>
<td>21.4% reduction in mortality with HEMS, p &lt; 0.05 HEMS predicted 38.15 deaths, 39 actual deaths/ GMT predicted 39.86 deaths, 51 actual deaths). OR GMT vs HEMS = 1.47 (95% CI 0.94 to 2.29)* (MI stat = 0.618 HEMS, 0.867 ground) GMT predicted = 39.11, actual = 41 deaths HEMS predicted = 16.44, actual = 15 p value not specified OR GMT vs HEMS = 1.14 (CI 0.84 to 2.20)*</td>
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<tr>
<td>Phillips</td>
<td>3</td>
<td>San Antonio, USA (Brookes Army Medical Center)</td>
<td>Retrospective</td>
<td>All trauma patients, paediatric and adult</td>
<td>687 GMT</td>
<td>HBMS — nurse and paramedic GMT — paramedic</td>
<td>NS Both intubation capable</td>
<td>HEMS — 24 min GMT — 14 min</td>
<td>TRISS based analysis</td>
<td>Nil</td>
<td>Mortality (time frame not specified)</td>
<td>21.4% reduction in mortality with HEMS, p &lt; 0.05 HEMS predicted 38.15 deaths, 39 actual deaths/ GMT predicted 39.86 deaths, 51 actual deaths). OR GMT vs HEMS = 1.47 (95% CI 0.94 to 2.29)* (MI stat = 0.618 HEMS, 0.867 ground) GMT predicted = 39.11, actual = 41 deaths HEMS predicted = 16.44, actual = 15 p value not specified OR GMT vs HEMS = 1.14 (CI 0.84 to 2.20)*</td>
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<tr>
<td>Schwartz</td>
<td>3</td>
<td>Connecticut, USA</td>
<td>Retrospective</td>
<td>Blunt trauma patients</td>
<td>93 HEMS 33 GMT</td>
<td>HEMS—physician GMT—Paramedic</td>
<td>HEMS—42% GMT—3%</td>
<td>HEMS — HEMS — 10 min GMT — 11 min</td>
<td>TRISS based analysis</td>
<td>Nil</td>
<td>Mortality (time frame not specified)</td>
<td>HEMS—2.23 SD better than national norm GMT—2.69 SD worse than national norm Significant difference HEMS predicted mortality—19.7%, actual 14.8% GMT predicted mortality—2.7%, actual—3.8% (p value not specified) OR GMT vs HEMS—2.44 (CI 1.22 to 4.88)*</td>
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<tr>
<td>Schwartz</td>
<td>3</td>
<td>Connecticut, USA</td>
<td>Retrospective</td>
<td>Blunt trauma patients</td>
<td>68 HEMS 605 GMT</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>TRISS based analysis</td>
<td>Insufficient subgroup data to adjust mortality</td>
<td>Mortality predischARGE (time frame not specified)</td>
<td></td>
</tr>
<tr>
<td>Braithwaite</td>
<td>3</td>
<td>Pennsylvania, USA</td>
<td>Retrospective</td>
<td>All trauma patients—split into five categories</td>
<td>15938 HEMS 6473 GMT (ALS capable)</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
<td>Adjusted mortality comparison</td>
<td>Controlled for age, Survival sex, ISS, RTS hypotension, rural urban status</td>
<td>Five ISS categories: 1. ISS 1—15 — no significant difference in survival 2. ISS 16—30 — HEMS 2.1 times more likely to survive (p&lt;0.05) 3. ISS 31—45 — HEMS 2.4 times more likely to survive (p&lt;0.05) 4. ISS 46—60 — HEMS 2.6 times more likely to survive (p&lt;0.05) 5. ISS 61—75 — no significant difference in survival</td>
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<tr>
<td>Davis</td>
<td>3</td>
<td>California, USA</td>
<td>Retrospective</td>
<td>Trauma patients with head AIS≥3</td>
<td>3017 HEMS 7295 GMT</td>
<td>HEMS—nurse + HEMS—41% physician, nurse or GMT—14% paramedic GMT—paramedic</td>
<td>NS NS</td>
<td>Adjusted mortality comparison</td>
<td>Age, sex, ISS, head AIS, injury mechanism, prehospital GCS, hypotension</td>
<td>Mortality (time frame not specified)</td>
<td>Adjusted OR GMT vs HEMS 1.9 (CI 1.6 to 2.2)</td>
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<table>
<thead>
<tr>
<th>Author</th>
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<th>Study design</th>
<th>Study population</th>
<th>Inclusion criteria</th>
<th>Sample size</th>
<th>Staffing</th>
<th>Intubation rate</th>
<th>Time at scene (min)</th>
<th>Time and/or distance of transfer</th>
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</tr>
</thead>
<tbody>
<tr>
<td>Frankema</td>
<td>2 Rotterdam, Netherlands</td>
<td>Prospective</td>
<td>All trauma patients with ISS &gt; 15. Excluded if dead on arrival at scene, age &lt; 15, injuries invariably fatal (AIS-90 code 6)</td>
<td>107 attended by HEMS, 29 attended solely by GMT</td>
<td>NS. Both intubation capable</td>
<td>HEMS — physician GMT — paramedic</td>
<td>HEMS — 13 min (by road)</td>
<td>GMT — 23 min</td>
<td>Adjusted mortality comparison</td>
<td>Age, trauma mechanism, ISS, score, vital scores, time of day</td>
<td>90 day survival OR HEMS vs GMT = 2.2 (CI 0.92 to 5.9)</td>
<td>Blunt trauma survival OR = 2.8 (CI 1.07 to 7.52)</td>
<td></td>
</tr>
<tr>
<td>Oppe</td>
<td>2 Rotterdam, Netherlands</td>
<td>Prospective</td>
<td>All trauma patients. Excluded patients dead before arrival at hospital</td>
<td>210 attended by HEMS, 307 attended solely by GMT</td>
<td>NS NS NS NS</td>
<td>Adjusted mortality comparison</td>
<td>Adjusted for RTS and ISS</td>
<td>Mortality (time-frame not specified)</td>
<td>Maximum mortality reduction of 17% with HEMS (extensive statistical analysis)</td>
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<tr>
<td>Ringburg</td>
<td>3 Netherlands</td>
<td>Not specified</td>
<td>All trauma patients ≥ 15 years</td>
<td>260 HEMS assistance (no patients transported to hospital by HEMS) 1197 GMT 150 HEMS 10186 GMT</td>
<td>NS (GMT team not intubation capable)</td>
<td>HEMS — physician GMT — paramedic</td>
<td>HEMS — NS 35.4 min GMT — 24.6 min</td>
<td>Adjusted mortality comparison</td>
<td>Adjusted for on-scene RTS, ISS, age, mechanism of trauma, day/night time</td>
<td>Mortality within 1 month</td>
<td>Adjusted OR GMT vs HEMS = 1.0 (95% CI 0.8 to 1.3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Thomas</td>
<td>3 Massachusetts, USA</td>
<td>Retrospective</td>
<td>Blunt trauma patients</td>
<td>1150 HEMS 10106 GMT</td>
<td>HEMS — physician or nurse GMT — Paramedic</td>
<td>NS. All HEMS intubation capable, 90% ground intubation capable</td>
<td>NS NS</td>
<td>Adjusted mortality comparison</td>
<td>Controlled for age, ISS, prehospital level of care, receiving trauma centre</td>
<td>Mortality predischarge (time frame not specified)</td>
<td>OR GMT vs HEMS = 1.61 (CI 2.22 to 1.16)</td>
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<tr>
<td>Bax</td>
<td>3 California</td>
<td>Retrospective</td>
<td>Blunt head injury (GCS ≤ 8)</td>
<td>104 HEMS 129 GMT</td>
<td>HEMS — physician GMT — Paramedic</td>
<td>HEMS — 100% GMT — oesophageal airway only or EMT</td>
<td>HEMS — 17 min GMT — 30 min</td>
<td>GMT — 10 min</td>
<td>Direct mortality comparison</td>
<td>Showed no significant difference in GCS distribution, need for neurosurgery, or pathology</td>
<td>6 month mortality rate 40% GMT mortality 31% HEMS mortality (p &lt; 0.001) OR ground vs HEMS = 1.49 (CI 0.86 to 2.57) * OR GMT vs HEMS = 1.61 (CI 2.22 to 1.16)</td>
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<tr>
<td>Celli</td>
<td>3 Italy</td>
<td>Retrospective</td>
<td>Blunt trauma head injury patients (GCS ≤ 3, but not brain dead and in coma for &gt; 6 h after admission)</td>
<td>20 HEMS 24 GMT</td>
<td>HEMS — nurse HEMS — 80% physician (distribution not stated) GMT — paramedic, police, firefighter or private</td>
<td>NS NS</td>
<td>Direct mortality comparison</td>
<td>Showed no significant difference in age, GCS or associated injuries</td>
<td>6 month mortality rate HEMS mortality = 20% GMT mortality = 5% (p = 0.02) OR GMT vs HEMS = 4.73 (95% CI 1.22 to 18.39) *</td>
<td>Continued</td>
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<tr>
<td>Author</td>
<td>Grade of evidence</td>
<td>Study location</td>
<td>Study design</td>
<td>Inclusion criteria</td>
<td>Sample size</td>
<td>Staffing</td>
<td>Intubation rate</td>
<td>Time at scene (min)</td>
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<td>Cunningham</td>
<td>48</td>
<td>North Carolina, USA</td>
<td>Retrospective</td>
<td>All trauma patients.</td>
<td>1346 HEMS 17144 GMT</td>
<td>NS</td>
<td>NS</td>
<td>HEMS — 24 min GMT — 13 min</td>
<td>Direct mortality comparison and adjusted comparison</td>
<td>ISS, trauma score, mortality RR, age, length of transfer (time period not specified)</td>
<td>Overall non-significant improved survival in HEMS group. If ISS 21–30 and TS 5–8 then HEMS mortality 43.4%, GMT mortality 62.6% (p &lt; 0.05) If TS 9–12 then HEMS mortality 20%, GMT mortality 37.2% (p &lt; 0.05)</td>
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<td>Di Bartolomeo</td>
<td>49</td>
<td>Italy (North East)</td>
<td>Prospective</td>
<td>Blunt trauma cardiac arrest and ISS ≥ 16</td>
<td>56 HEMS 73 GMT</td>
<td>HEMS — physician GMT — nurse</td>
<td>NS</td>
<td>NS</td>
<td>Direct mortality comparison</td>
<td>Shoved groups were similar for injury mechanism, gender and time to CPR, but did not allow for age differences, time to hospital and performance of on-scene CPR</td>
<td>Survival to discharge (time frame not specified)</td>
<td>3.6% survival with HEMS, 0% survival with GMT (not significant). Also showed 16% ROSC in HEMS, 1% in GMT</td>
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<tr>
<td>Nardi</td>
<td>50</td>
<td>Italy (North East)</td>
<td>Prospective</td>
<td>Involuntary blunt trauma, ISS &gt; 15</td>
<td>42 HEMS 98 GMT(BLS)</td>
<td>HEMS — physician GMT — EMT, nine had non-intubation capable physician</td>
<td>HEMS — 81% GMT — 0%</td>
<td>NS</td>
<td>Direct mortality comparison</td>
<td>Groups were statistically similar with regard to age, sex and mean ISS, so no adjustments made</td>
<td>Mortality to discharge from ICU (time frame not specified)</td>
<td>HEMS mortality = 12%, GMT mortality = 32% (p &lt; 0.05) OR GMT vs HEMS = 3.42 (95% CI 1.23 to 9.56)*</td>
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<tr>
<td>Schiller</td>
<td>51</td>
<td>Arizona, USA</td>
<td>Retrospective</td>
<td>Blunt trauma patients with ISS 20–40</td>
<td>347 HEMS 259 GMT</td>
<td>HEMS — paramedic GMT — paramedic</td>
<td>HEMS — 53 min in city, 48 min outside city GMT — 37 min in city, 59 min outside city 92% ground patients from within city, 30% HEMS from within city</td>
<td>Direct mortality comparison</td>
<td>Reported mean TS</td>
<td>Mortality (time frame not specified) (HEMS 12.1, GMT 12.7), mean GCS (HEMS 9.6, GMT 10.4), age, days of hospitalisation and gender statistically similar</td>
<td>18% HEMS mortality 13% GMT mortality (p value not specified) OR GMT vs HEMS OR = 0.88 (95% CI 0.43 to 1.07)*</td>
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*Indicates OR calculated by authors of this paper.

AIS, Abbreviated Injury Score; ALS, advanced life support; BLS, basic life support; ED, emergency department; EMT, emergency medical technician; GCS, Glasgow Coma Scale; GMT, ground medical transport; HEMS, helicopter emergency medical service; ISS, Injury Severity Score; NS, not specified; ROSC, return of spontaneous circulation; (R) TS, (Revised) Trauma Score; TISS, Trauma Score—Injury Severity Score (a score used to predict probability of survival). W statistic—excess number of survivors per 100 when compared with patients from Major Trauma Outcome Study (MTOS). M statistic represents the degree of similarity between the sample group and patients from the MTOS (1.00 = identical patient group).
practice, has, however, contradicted this; the two crews were
perspective, consecutive observational cohort study of a change in
in the cohorts. The M-statistic (a measure of the similarity of
dance. The authors compared actual mortality rates with those
was equivalent to a level 1 trauma centre. Patients in the HEMS
staffed GMT service transporting to 20 hospitals, one of which
distances to the scene of injury as well as to the receiving trauma
fl a difference in outcome may be in
This difference in mortality was signi
other work,25 a retrospective cohort study performed by Younge
However, not specified, and it should be noted that a 4-year
was within an urban setting, but what must be considered is the
trauma system in which the study was performed. HEMS
patients could be transported from the scene in three different
ways to 20 different receiving hospitals, only one of which was
a major trauma centre. This is in contrast to many of the studies
included in this review (including that by Younge et al25), which
compare HEMS and GMT transporting to the same major
trauma centre. A potential benefit of HEMS is the ability to
transfer patients directly from the scene to the most appropriate
definitive treatment facility and, therefore, when studying the
effect of HEMS on trauma patient mortality, the treatment
facility should be considered as part of the service. This was
suggested, but not proven, by Nicholls for only the most
severely injured.

The question of whether HEMS confers a mortality benefit by
being able to transport a physician to the scene of injury is one
with no clear answer. Multiple other factors need to be
considered, including the most appropriate way to deliver the
physician to the scene (GMT vs HEMS) and the proximity to
the receiving trauma centre.

Transport of advanced airway skills to the scene
An important distinction must be drawn between the presence
of a physician and the ability to manage an airway to a high
standard (ie, intubation and ventilation management capable).
They are neither mutually inclusive nor exclusive. Head injury is
known to be an important predictor of mortality in trauma
cases56 and a procedure known to be of great benefit in the
management of these patients is that of endotracheal intubation
(ETI). A study by Davis et al 200541 showed that prehospital
ETI as opposed to emergency department intubation in HEMS-
transported patients with severe head injuries improved outcome
significantly (OR 1.4, 95% CI 1.1 to 1.8).

Helicopter EMS allow a small number of highly skilled and
experienced healthcare professionals, trained in ETI, to reach
a large number of trauma patients over a wide area.

Transporting a team experienced in managing trauma patients
HEMS allow an experienced trauma team to cover a far greater
distance than would be possible by GMT. This has the benefit of
allowing a healthcare team to increase their experience and
proficiency in managing trauma patients by caring for such
patients on a daily basis. The resources to train multiple ground
crews to the same level of expertise would be great and might
not be cost-effective.57

The way in which an experienced team is delivered to the
scene is open to debate. Since 1995, the Netherlands has changed
its approach to prehospital care. Helicopter-transported medical
teams (HMT), consisting of specially trained trauma physicians
and paramedics, attend the scene of injury to provide an addi-
tional therapeutic option to that available with the GMT team
alone, but the helicopter only rarely transports the patient to
hospital.52 Factors that contributed to that policy include the
disadvantages of noise, disorientation and limited space when
using helicopters for patient transfer.

35% lower than that predicted by the trauma score—injury
severity score (TRISS) method, whereas the nurse-staffed HEMS
crew had a mortality rate that was the same as that predicted.
This difference in mortality was significant. Similar results were
shown in a retrospective cohort study.24 Other work,25 a retro-
spective, consecutive observational cohort study of a change in
practice, has, however, contradicted this; the two crews were
compared 2 years apart.

The aforementioned studies all focus on the effect that the
presence of a physician on a HEMS has on mortality. There is,
however, a core debate as to the benefit of a physician at the
injury scene irrespective of the transfer mode. Work by Liberman
et al25 compared three groups of trauma patients, all of whom
were injured in an urban setting and transported by GMT to
a level 1 trauma centre. Group 1 received physician-provided
advanced life support (ALS), group 2 paramedic-provided ALS
and group 3 emergency medical technician (EMT)-provided
basic life support (BLS). The results showed that those receiving
physician-provided ALS had the highest mortality rate and those
receiving EMT-provided BLS the lowest (group 1 25%, group 2
20%, group 3 19%). There was, however, a significantly higher
mean Injury Severity Score (ISS) and on-scene time in the
physician group. No attempt was made to control for this
difference in mean ISS, but in patients with severe but surviv-
able injuries (ISS 25–49) there was still a significantly higher
mortality rate in the physician group. It must be emphasised
that the work by Liberman et al was within an urban setting and
earlier work by Messick et al in 1990 showed that ALS training
for paramedics attending trauma patients in a rural setting
provided a significant improvement in mortality.54 Such
a difference in outcome may be influenced by the longer
distances to the scene of injury as well as to the receiving trauma
unit. The literature25 53 may therefore suggest that ALS,
particularly that provided by physicians, serves no additional
benefit in urban settings. The fact that this contradicts the
evidence for the effect of a physician on trauma patient
mortality with helicopter-supported EMS is of interest. This
may be a result of the, in general, greater prehospital times
reported with a HEMS service and the services often being
deployed over larger distances. The higher skill base and clinical
decision-making of a physician may then confer more benefit
and become significant.

The effectiveness of GMT in an urban environment should be
taken into consideration when a HEMS service is being evalu-
atd in that setting. Work by Nicholl et al in 199554 in the UK
focused on the mortality outcomes associated with the use of
the London HEMS, representative of an urban setting. This
study compared a physician-staffed HEMS with a paramedic-
staffed GMT service transporting to 20 hospitals, one of which
was equivalent to a level 1 trauma centre. Patients in the HEMS
group were all attended by physician-staffed HEMS and trans-
ported to hospital either by helicopter, by GMT with a physician
in attendance, or by GMT with no-one from HEMS in attend-
dance. The authors compared actual mortality rates with those
predicted by TRISS and found that HEMS had a 15.6% increase
in mortality from predicted and the GMT service had a 2.4%
crease from predicted. After adjusting for the nature and
severity of injuries, Nicholl et al found no difference in survival
in the cohorts. The M-statistic (a measure of the similarity of
injury severity mix to the prediction database eg, MTOC55) was,
however, not specified, and it should be noted that a 4-year
study performed by Younge et al,53 2 years of which included the
same patient population used by Nicholl et al, found an
M-statistic of 0.61, which was below the acceptable value of
0.88. The study by Younge et al found an adjusted W statistic
(adjustment for a patient caseload of high injury severity) of
4.16±2.21, meaning that between two and six extra trauma
patients in every 100 transported by HEMS rather than GMT
survive. Younge included only patients transported by HEMS to
a major trauma centre, unlike Nicholl et al, who included all
patients transported to 19 other hospitals. The results from the
study performed by Nicholl et al should be interpreted with both
interest and caution. It questions the effectiveness of HEMS
within an urban setting, but what must be considered is the
trauma system in which the study was performed. HEMS
patients could be transported from the scene in three different
ways to 20 different receiving hospitals, only one of which was
a major trauma centre. This is in contrast to many of the studies
included in this review (including that by Younge et al53), which
compare HEMS and GMT transporting to the same major	rauma centre. A potential benefit of HEMS is the ability to
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The question of whether HEMS confers a mortality benefit by
being able to transport a physician to the scene of injury is one
with no clear answer. Multiple other factors need to be
considered, including the most appropriate way to deliver the
physician to the scene (GMT vs HEMS) and the proximity to
the receiving trauma centre.
Prehospital care

There are three studies included in this systematic review that compare the outcome of trauma patients in the Netherlands who are attended to by HEMS and those who are not. Two of these demonstrated a mortality benefit with HMT attendance\textsuperscript{42, 43} and the third showed no significant difference.\textsuperscript{44} These data suggest that an improvement in outcome in those attended by HEMS is more a result of the presence of an experienced trauma team than the transport method. Such a system could be considered in other countries with similar geography, such as the UK.

To expedite transport of patients from the scene to hospital

Although a helicopter service is often suggested as being able to expedite the transport of patients to the appropriate facility, the data often do not support such a hypothesis. Of the studies included in this review that record the time at the scene and duration of transfer, the majority show that both are increased with helicopter EMS. It must be remembered, however, that this does not account for distance of transfer — a factor that may be greater in the HEMS group as a result of both tasking to remote locations and a preference for bypassing local hospitals to access definitive care in a major trauma centre. A study by Ringburg et al in 2007\textsuperscript{44} focused on the impact that HEMS attendance to trauma patients had on overall on-scene times (OST) and subsequent mortality. HEMS patients had significantly longer mean OST than the group only attended by the GMT team (54 vs 24 min), but no mortality difference was seen after controlling for multiple patient and trauma characteristics. The authors concluded that HEMS does lead to an increase in OST, but that this is neutralised by the increased survival brought by HEMS attendance.

A possible explanation for the prolonged prehospital time is that the presence of a physician increases the number of procedures undertaken at the scene. That study by Ringburg et al\textsuperscript{44} compared a physician-staffed helicopter EMS and a paramedic-staffed GMT team. Interestingly, however, two recent UK-based studies\textsuperscript{58, 59} both demonstrated that the addition of doctors to a HEMS crew did not alter OST, but did increase the number of advanced medical interventions performed at the scene.

The increased prehospital time often seen with HEMS may therefore be a result of longer transfer distance, more on-scene intervention and being preferentially deployed in cases of prolonged extrication. It may also be due to logistical factors, such as delayed helicopter deployment awaiting greater clinical information, patients held on scene awaiting HEMS, identifying a suitable landing site, and moving the patient to and from the helicopter.

Triage to the definitive treatment facility

Helicopter EMS have the ability to travel greater distance than GMT in the same time. This means that patients transported by HEMS are potentially able to be taken directly to a specialist trauma facility or one where definitive care can be delivered, avoiding secondary transfers. The importance of this was demonstrated by the work of Biewener et al in 2004.\textsuperscript{35} Four hundred and three trauma patients were managed in four different ways: 1. HEMS transport to a university hospital (HEMS–UNI); 2. GMT to a university hospital (GMT–UNI); 3. GMT to a regional hospital (GMT–REG); and 4. GMT to a regional hospital with subsequent transfer to a university hospital (INTER). This showed that mortality of the GMT–REG group was almost double that of the HEMS–UNI group (41.2 vs 22.1%, \(p=0.002\)). The authors also showed that there was no significant difference in mortality between the GMT–UNI and HEMS–UNI group after adjustment. The authors, therefore, concluded that the difference in mortality rate seen between the HEMS–UNI and GMT–REG group was a result of the receiving facility, not the transport method.

The degree to which either HEMS or GMT will be superior with regards to triaging patients to the correct facility will depend on accuracy of triage tools, geographical locations of incidents and hospitals, and the trauma system that functions within the region.

DISCUSSION

Reliably establishing the effect of helicopter EMS on the mortality of trauma patients transported from the scene remains challenging. The logistical and ethical barriers to a randomised controlled trial comparing HEMS with GMT in the transport of trauma patients are numerous. This has resulted in cohort studies and large registry-based studies forming the evidence base detailed above. The strategies used to assess trauma care are also limited and are ably discussed by Thomas et al.\textsuperscript{55}

In recognition of these limitations of the current evidence base, careful consideration must be given to the cost-effectiveness of running an active HEMS. Work by Snooks et al in 1996\textsuperscript{22} documented the cost per successful mission (a mission in which a patient was attended) in four UK-based HEMS units and found that each successful mission could cost between £404 and £1689 depending on service configuration, the crew and funding.

HEMS in the UK are currently operated by numerous private companies, many of which are funded by charitable donations. There is currently a lack of any unifying standard operating procedures and tasking protocols, clinical governance, or auditing of the helicopter EMS activity. These helicopters can usually only operate during daylight hours and have limited capability in difficult weather conditions. The UK Search and Rescue Framework published in April 2008\textsuperscript{60} describes the integration of multiple organisations (government, military and charitable) in providing a coastal and sea emergency service with centralised management and tasking. The helicopters currently in this UK SAR service are capable of a much higher level of operation, 24 h a day in almost all weather conditions. Such a Framework will act as guide for a future UK HEMS service and may contribute to trauma network planning.

The debate over the role and structure of HEMS in a modern trauma service is likely to continue. The authors recommend that when designing regional trauma networks there should be a needs assessment for prehospital care specific to each network based on critical incident frequency and travel times. The benefits and capabilities of the emergency medical teams on scene should be considered separately from those of using helicopters or land vehicles as the transport platform; helicopters may be one of the solutions for moving the EMS or patient or both. It is likely that prehospital EMS services, operating in different trauma systems, with different terrain and geographical arrangements of hospital facilities, will come to different conclusions about the appropriate need for either or both of these resources. Such conclusions should be based on event incidence modelling and accrued outcome data, and devise a service that can deliver the required care at all times of the day and night.

Competing interests None.

Provenance and peer review Not commissioned; externally peer reviewed.
REFERENCES


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