Effect of Transfer Status on Mortality for Trauma Patients in the Developing Countries

By

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Master’s Paper Abstract

**Introduction:** Trauma injuries account for the greatest portion of surgical conditions worldwide and developing countries are disproportionately affected. Strengthening trauma care in developing countries is crucial to reducing global trauma mortality. Studies have shown an association between transfer status (direct transport versus inter-hospital transfers) and the outcome of trauma patients in developed countries. We first systematically reviewed and summarized trials that investigated this association in developing countries. We then assessed mortality differences between trauma patients transferred from a referral facility and those taken directly from the trauma scene to a trauma center in a Sub-Saharan African country.

**Methods:** We conducted a systematic literature search of MEDLINE and EMBASE to identify eligible studies from the developing countries investigating the association between transfer status and mortality and extracted data on study setting, patient characteristics, transfer status, mortality and strength of association. We then conducted a retrospective analysis of patients in the Kamuzu Central Hospital (KCH) trauma registry from 2008 to 2012. We then analyzed patient characteristics and performed logistic regression modeling for survival comparing the two patient groups.

**Results:** Five observational cohort studies from four developing countries were included in the systematic review. All studies reported favorable outcome for the direct admission group when compared to the transfer group, but the methodological quality of the studies was variable with intermediate to high potential for selection bias and confounding bias.

For the analysis at KCH, there were 4,997 patients transferred from referring facilities and 41,088 patients transported from the scene. There was no statistically significant clinical
difference between groups. Survival was 95.8 and 98.4% for transferred and scene patients, respectively. The adjusted mortality odds ratio was 1.63 (1.20-2.22); P<0.0001 for transferred versus scene patients, after controlling for age, sex, mechanism of injury, mode of transportation, hours to presentation, and initial AVPU.

**Conclusion:** Based on the systematic review, evidence derived from the studies with varying quality is not sufficiently robust to determine mortality differences by transfer status for trauma patients in the developing countries. Our analysis based at KCH in Malawi showed that trauma patients taken directly from the scene to the tertiary care center have improved survival. These findings suggest that efforts at improving trauma systems in this setting should be focused on strengthening pre-hospital care and basic stabilization at district hospitals.
Literature review:

Direct Transport versus Initial Secondary Care in Developing Countries: A Systematic Review
Literature Review Abstract:

Introduction: Previous studies have suggested an association between transfer status (direct transport to tertiary centers or inter-hospital transfers) and the outcome of trauma patients. The evidence is inconclusive and obtained mostly from developed countries. Given the high disease burden of trauma in developing countries, this study aimed to systematically review and summarize studies investigating the association between transfer status and mortality in trauma patients residing in developing countries.

Methods: A systematic literature search of MEDLINE and EMBASE was conducted to identity English observational studies and controlled trials from the developing countries examining the association between transfer status and mortality. Studies were selected based on specific eligibility criteria and data was extract on study setting, patient characteristics, transfer status, mortality and strength of association. Studies were also critically appraised for risk of biases.

Results: Five observational cohort studies were included in the review. The studies were conducted in four developing countries (China, Malaysia, Pakistan, and Iran). All studies reported association between transfer status and mortality - direct admission group had favorable outcome when compared to the transfer group. The methodological quality of the studies was variable, all having intermediate to high potential for selection bias and confounding bias.

Conclusion: Overall, the evidence derived from a limited number of studies with heterogeneous source population, different methods and varying quality is not sufficiently robust to determine mortality differences by transfer status for trauma patients in the developing countries.

Introduction

According to the 2010 Global Burden of Disease (GBD) Study, surgical diseases are estimated to contribute 11% to the global burden of disease, of which trauma injuries are the greatest portion.1 Developing countries are disproportionally affected - some countries in sub-
Saharan African have the highest ratios of trauma related disability adjusted life years (DALYs) lost per 1,000 people.\textsuperscript{2,3} When compared with high-income counterparts in the GBD 2010 study, the poorest billion people living in developing countries suffered about 800,000 more deaths in 2010 from non-communicable disease, such as injuries in those younger than 40 years. Because trauma injuries often occur during the most economically productive years of a person’s life (age 15-44), such injuries greatly debilitate a country’s working population.\textsuperscript{4} The strengthening of current trauma care in developing countries is therefore a crucial global public health agenda.

A comprehensive trauma system comprises the integration and continuum of care from adequate injury prevention to prompt pre-hospital care to multileveled acute care facilities and to post hospital rehabilitation.\textsuperscript{5} Such systems ensure timely, equitable, accessible and quality care for all patients sustaining trauma, but this is only available to patients residing in developed countries with mature trauma systems. Trauma patients in developing countries usually receive unplanned care at the pre-hospital stage by lay first responders, inconsistent transport medicine, and final care at health facilities with varying levels of resources and capabilities for trauma care.\textsuperscript{2} There have been many proposed evidenced-based strategies on the platform of injury prevention and management in low-resources settings including: training of lay first-responders, ensuring access to essential emergency equipment, task shifting to lower skilled practitioners to perform trauma care, improving medical transport, and concentrating specialized trauma care in a selected few centers.\textsuperscript{2} Given the scarcity of resources, there is great pressure to apply the limited local and global aid funds to public health interventions that are most likely to produce the desired change. Therefore, an important question needs to be addressed: are there mortality differences between trauma patients who are transported directly from the accident scene to the
closest trauma center when available and trauma patients who are treated at a regional health facility and later transferred to the trauma center?

While the literature is replete with data focused on this question, over 95% of the studies were conducted in developed countries. Given the drastically different available trauma structure, data from developed countries cannot be extrapolated to all settings, but can serve as a basis to build our understanding of the debate. Developed nations have clear criteria for categorizing hospitals by the level of trauma care they provide based on resources, trauma volume, quality of performance and other metrics, such as the American College of Surgeon’s Trauma Center Verification process. At the top of the tier are centralized trauma care facilities with concentrated resources, more specialized personnel, and better ancillary and diagnostic and therapeutic tools. Ample evidence have shown that trauma patients have better outcome at specialized designated trauma centers, usually tertiary care institutions, compared to their counterparts treated at regional non-trauma facilities. As a result of the concentration of trauma resources at a select few hospitals, emergency medical service (EMS) personnel are tasked with the decision of transporting the injured patients to the most appropriate care providing facility. Depending on the severity of the injury, availability of transport modalities, and proximity to a top tier trauma center, EMS personnel will either directly transport patients to a higher-level trauma center or bring patients to a more proximal facility with lower level trauma care for preliminary care. Two recent systematic reviews examined patient outcome differences between the “direct” (patients transported directly to a trauma center) and the “indirect” (patients transferred from another lower tiered hospital to a trauma center) groups reviewed equivalent risks, but acknowledges limitations of the review given heterogeneity in study design, health care settings, and numerous potential biases. Both systematic reviews included studies from all
developed countries, but one, and the results cannot be applied to determine the best principle of trauma patient transfer in developing countries.

Our objective is to systematically review and summarize the mortality differences in trauma patients residing in developing countries between those directly transferred to a hospital with trauma care compared to those who received care at another hospitals and were later transferred.

**Methods**

**Search Strategies and Information Sources**

Studies were identified by searching electronic databases. Computerized searches were performed using MEDLINE (from inception to February 1, 2014) and EMBASE (from inception to February 1, 2014). The search strategy was developed in consultation with a health science librarian and included the MeSH terms “wounds and injuries”, “developing countries”, “transfer”, “patient transportation”, “emergency services, hospital”, “mortality”, “treatment outcome”, “pre-hospital care”, “Africa south of the Sahara”, “tertiary care centers”, “patient admission”, “emergency medical services”. We also hand-searched the references list, related articles of the included studies as well as review articles to identify more studies.

**Eligibility Criteria**

Prospective and retrospective cohort, case-control, randomized and non-randomized controlled studies are eligible for the review. Case series were excluded due to concern for bias. Studies can include both pediatrics and adult trauma patients who received care in developing countries, defined by their Gross National Income per capital per year based on criteria set by the World Bank.$^{19}$ Traditional definition of trauma injury was used to include studies with patients
who suffered any physical damage as a result of an acute transfer of mechanical, electrical, radiation, chemical or thermal energy, or as a result of oxygen and heat deprivation. Patients that suffered both intentional and unintentional traumatic injuries such as road-traffic accidents, falls, self-inflicted harms, interpersonal or war violence, and burns are included. The studies included must examine the outcome (mortality differences) by transfer status, defined as direct (from accident scene to hospital) or indirect (from accident scene to another hospital for initial care and stabilization). We included studies where transfer status was a prognostic factor for outcome but not the primary exposure variable of interest. Since definitions of tertiary care center or trauma care hospitals vary greatly between different healthcare settings, we used the authors’ definitions of hospitals based on the available care resources in those countries. No time limits on journal publication date were set. Only studies in the English language were included.

**Study Selection**

One reviewer (YL) independently assessed the eligibility of the studies in an unblinded standardized format to identify relevant articles. Relevance and eligibility was based on review of the titles, and abstracts of the studies. Then, full text articles were obtained for identified articles. Studies were excluded at three levels of review - title, abstract and full text. Full text of articles was also reviewed if the title and abstract review was inconclusive.

**Data Collection and Risk of bias**

Information was extracted from the studies that met the inclusion criteria. Data items when available included: study design, country of origin, patient characteristics, transfer status,
mortality as an outcome and direction of results based on the hypothesis. The methodological quality and validity of the studies was assessed for potential selection bias, measurement bias and confounding. We examined the comparability of the patient study groups, distribution of loss to follow-up, methods of randomization, methods used for obtaining transfer status, mortality outcomes and the analysis strategies. Each study was assigned a quality metric based on the review ranging from poor, fair, good, to excellent. Studies were not excluded based on risk of bias and their validity. Study publication bias was considered but a formal assessment of the bias was not performed given the challenges of obtaining unpublished research, patient registries, and data from the developing countries.

**Synthesis**

A qualitative descriptive synthesis of the studies was done to generate a summary of the results. Given the heterogeneity of the study designs, healthcare settings, and measures of outcome, we did not perform a quantitative estimation of the effect size of transfer status on mortality outcome.

**Results:**

**Study Selection:**

A total of five trials were included in the review (Figure 1). The search of MEDLINE (from inception to February 1, 2014) and EMBASE (from inception to February 1, 2014) generated a total of 131 articles after discarding duplicates. References from systematic reviews and related articles generated 36 and 60 articles respectively. After review of title and abstract, a total of 197 articles were excluded because they did not meet the inclusion criteria. Of those excluded, 113 were based on topic relevance in regards to trauma, 18 excluded because they
were not research studies, 6 excluded based on study design, 37 excluded based on setting (developed countries vs. developing countries), and 23 excluded based on the intervention and comparison employed (not transfer status). After full text review, 25 additional articles were discarded based on criteria for setting, intervention/comparison and outcome.

**Study Characteristics: (Table 1)**

**Study Design**

No randomized controlled trials were identified in our literature search. Observational (prospective and retrospective) cohort studies published in English were used to assess mortality differences for patients directly admitted to a tertiary or definitive care center and those transferred from a lower tiered facility. Retrospective cohort studies collected data from existing trauma registries.²¹,²²

**Population and setting**

A total of 4,322 patients were included in all five of the studies (varied from 94 to 2662 patients). One study included only patients with severe trauma according to Injury Severity Scores,¹³ while 3 other studies included all trauma patients that reported to the hospital and activated their Trauma Team protocol.²¹–²³ Only one of those studies described the specifics and criteria for activation.²¹ The study in a Hong Kong teaching hospital included only head injury patients with traumatic extradural hematomas.²⁴ Two studies excluded pediatric patients less than 14 years old²³ and less than 12 years old¹³ while others included a heterogeneous group of trauma patients.

These studies were conducted in four different developing countries (China, Malaysia, Pakistan and Iran). Even though Hong Kong is a former British colony with higher standard of
living compared to the rest of the country but is still considered a Special Administrative Region of China. Therefore, the two studies that were conducted in Hong Kong were included in this review.\textsuperscript{21,24} The studies were conducted at varying levels of teaching or tertiary care centers with designated trauma teams. There were no consistent evaluation for the level of trauma care except for one study where the study site was designated US equivalent of level 1-2.\textsuperscript{21}

\textit{Intervention and comparator} \\
Transfer status was one of the many predictive factors of interest for determination of mortality in these studies. Other factors included basic demographic information (sex, gender), mechanism of injury (blunt, penetrating, burn, bites), severity of injury (Injury Severity Scores, Revised Trauma scores) mode of transport (ambulate, private vehicle), care received in the ED (fluid resuscitation, laceration repair) and time to definitive care.

\textbf{Outcome (Primary and Secondary)} \\
All studies reported association between transfer status (direct admission vs. inter-hospital transfer) and mortality. Other secondary outcome of interest included disability, length of stay, and preventable vs. expected morality.

\textbf{Risk of bias within and across studies (Table 2)} \\
The methodological quality of the studies was variable. All studies have intermediate to high potential for selection bias and confounding bias. Only 3 out of 5 studies directly compared the transfer and direct admission groups and in addition revealed unequal characteristics between the groups and limited comparibility.\textsuperscript{13,21,24} The most common variable that was unequally distributed between the two groups is injury severity. Transferred trauma patients had higher
injury severity scores or injury presentation compared to direct admission in Sethi et al. and Poon et al, while direct admission patients had more severe injuries in Kam et al. It’s unclear if studies controlled for confounding in their analyses. Measurement bias was assessed to be between intermediate to high – two studies did not describe the personnel and process of data collection, \(^{21,24}\) while three others described using trauma registry and designated personnel. \(^{13,22,23}\) External validity was limited in these studies given the large variations in trauma care across different developing nations. Overall quality of the included studies ranged from poor to fair.

**Results of individual studies and Synthesis of results (Table 3)**

All studies revealed that the direct admission group had favorable outcome in terms of mortality compared to the transfer group. All studies reported on adjusted in-hospital (or in emergency department) mortality rates. Kam et al. further categorized mortalities into preventable and non-preventable but did not specific by transfer status. They concluded that the implementation and formation of trauma team contributed to the improved survival in the direct admission patients. Poon et al. who focused only on patients with intracranial hematomas after head injury showed that direct admission prevented further clinical deterioration such as hematoma expansion, herniation, and coma. Khan et al. did not find statistical associations between mortality and transfer status as well as delay in time to definitive care. Moini et al. found no significant differences in severity of injury and mortality between the two groups based on transfer status, but based on W scores from statistic analysis, direct transport of patients improve mortality outcome. Sethi et al. found that transferred patients had higher injury severity scores and more injuries from road traffic accidents. They were also more likely to have worse outcomes – mortality, longer length of stay and more severely disabled. These differences were statistically significant.
Given the heterogeneity of the study designs, healthcare settings, and measures of outcome, we did not perform a quantitative estimation of the effect size of transfer status and mortality outcome.

Discussion:

Summary of evidence
Overall, the evidence is not sufficiently robust to determine mortality differences by transfer status for trauma patients in the developing countries. Literature search revealed a few studies conducted in the developing countries that used transfer status as the focused comparator of interest. The limited cohort studies included in this review showed great heterogeneity in outcome and statistical significance but the general trend favors the direct admission group to have better outcome in terms of mortality.

Limitations and uncertainties
Included studies pose limitations for drawing a well-supported conclusion due to their medium to high potential of selection bias, measurement bias, and confounding. The studies included varying details of their analysis plan and methods. Transfer status was not the main comparator of interest; studies generally investigated demographics of injury such as population characteristics, severity and outcomes (mortality, length of stay, disability). Study design and source population had great heterogeneity. Outcome of the studies had varying statistical significance, not supporting a clear conclusion. External validity was limited as well given the variations in population and trauma systems between different developing countries. Meaningful compilation of outcomes from the different countries was difficult.

On the level of the literature and search, several limitations exist. The selected studies were based on limited literature search process. The articles were restricted to English and full
abstract, which can pose a barrier to obtaining literature published in developing countries. The MESH terms used were a portion of all possible terms associated with the research question. Publication bias may account for some of the effect we observed from the studies. Most developing countries do not have existing trauma registries to provide data on trauma characteristics and outcome. In addition, studies in developing countries are less likely to be accepted and published in American and European journals.

Prospective collection of injury data as a form of trauma registries is becoming more feasible in developing countries.\textsuperscript{25} In the absence of a formal registry with epidemiological data, prediction models can be used in place to estimate incidents and mortality, such as in the case of Malawi with binomial regression and capture-recapture statistical model.\textsuperscript{26} Once an accurate assessment of disease burden is possible, and then studies can investigate risk factors and moderators for injuries, such as transfer status.

\textbf{Conclusion:} We conducted a systematic review that investigated the mortality differences in trauma patients from developing countries who are either directly transported from the scene of injury to a tertiary care hospital with definitive trauma care or received care at a lower tiered health care facility and subsequently transferred to a tertiary care center. The evidence derived from a limited number of studies with heterogeneous source population, different methods and varying quality is not sufficiently robust to determine mortality differences by transfer status for trauma patients in the developing countries.
References:


Figures and Tables:

Figure 1: Flow diagram of study selection
<table>
<thead>
<tr>
<th>Study</th>
<th>Study Location</th>
<th>Hospital</th>
<th>Study Design</th>
<th>Patient population</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poon et al. 1991\textsuperscript{24}</td>
<td>Hong Kong, China</td>
<td>Teaching hospital, catchment of 0.9 million, accepts referrals from district hospitals</td>
<td>Prospective cohort</td>
<td>Traumatic extradural hematoma</td>
</tr>
<tr>
<td>Sethi et al. 2002\textsuperscript{13}</td>
<td>Malaysia</td>
<td>3 hospitals combined: both central national tertiary hospital and regional tertiary care hospital, receives both direct admission (catchment 2 million) through ED and transfers (15 referring hospitals)</td>
<td>Prospective cohort</td>
<td>Major trauma patients defined in previous studies</td>
</tr>
<tr>
<td>Kam et al. 1998\textsuperscript{21}</td>
<td>Hong Kong, China</td>
<td>Teaching hospital with designated trauma team (between US equivalent of level 1-2)</td>
<td>Retrospective cohort</td>
<td>All trauma patients at the hospital whose injuries activated the Trauma Team</td>
</tr>
<tr>
<td>Khan et al. 2010\textsuperscript{23}</td>
<td>Pakistan</td>
<td>University hospital with designated trauma team</td>
<td>Retrospective cohort</td>
<td>All trauma patients presenting to this hospital via direct admission or transfers</td>
</tr>
<tr>
<td>Moini et al. 2000\textsuperscript{22}</td>
<td>Iran</td>
<td>3 different University hospital with designated trauma team</td>
<td>Prospective cohort</td>
<td>Trauma patients reporting to these university hospitals</td>
</tr>
</tbody>
</table>
Table 1: Characteristics and population of included studies (Continued)

<table>
<thead>
<tr>
<th>Study</th>
<th>Patient number</th>
<th>Inclusion Criteria</th>
<th>Direct admission</th>
<th>Transferred</th>
<th>Outcome</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poon et al. 1991(^{24})</td>
<td>104</td>
<td>All patients with extradural hematomas reported to this hospital</td>
<td>71</td>
<td>33</td>
<td>Mortality (secondary: disability)</td>
</tr>
<tr>
<td>Sethi et al. 2002(^{13})</td>
<td>484</td>
<td>All severely injured patients (age of 12 years and older) that required admission for &gt;72 hours, died after arrival, or transferred. Excluded admissions for minor traumas</td>
<td>286</td>
<td>198</td>
<td>Mortality (secondary: disability)</td>
</tr>
<tr>
<td>Kam et al. 1998(^{21})</td>
<td>94</td>
<td>Patient with suspected major trauma, criteria based on Revisited Trauma Score (RTS)</td>
<td>60</td>
<td>34</td>
<td>Mortality (stratified by preventable and expected)</td>
</tr>
<tr>
<td>Khan et al. 2010(^{23})</td>
<td>978</td>
<td>All trauma patients meeting the trauma team activation criteria, age &gt;14 years old</td>
<td>411</td>
<td>567</td>
<td>Mortality</td>
</tr>
<tr>
<td>Moini et al. 2000(^{22})</td>
<td>2662</td>
<td>Trauma patients who had been admitted to the hospital for 1 day or dead upon arrival</td>
<td>1509</td>
<td>1153</td>
<td>Mortality (morbidity, length of stay)</td>
</tr>
<tr>
<td>Total</td>
<td>4322</td>
<td></td>
<td>2337</td>
<td>1985</td>
<td></td>
</tr>
</tbody>
</table>
Table 2: Quality of included studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Selection Bias</th>
<th>Measurement bias</th>
<th>Confounding</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poon et al. 1991</td>
<td>**: comparable initial groups, unclear inclusion and exclusion criteria</td>
<td>**: did not specify how assessment of outcome was achieved</td>
<td>*: transferred patients had higher skull fractures</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sethi et al. 2002</td>
<td>**: transferred group had more severe injuries, more head injuries and motor vehicle accidents</td>
<td>*: trained personnel for data collection on injury, demographics and outcome assessment (equal and valid)</td>
<td>**: inter-hospital transferred patients had higher injury severity scores</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kam et al. 1998</td>
<td>**: direct admission with more people in high ISS categories</td>
<td>**: case note collection by undesignated group</td>
<td>**: direct admission had higher injury severity scores, unclear if analysis adjusted for this</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Khan et al. 2010</td>
<td>***: no direct comparisons between transfer and direct admission patients</td>
<td>**: data extracted from trauma registries. Injury scores calculated from them. Unclear who completed the assessment.</td>
<td>***: no direct comparisons between transfer and direct admission patients</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moini et al. 2000</td>
<td>***: no direct comparisons between transfer and direct admission patients</td>
<td>*: 3 different group of physicians performed data collection for the registry</td>
<td>***: no direct comparisons between transfer and direct admission patients</td>
</tr>
</tbody>
</table>

*: Low bias  
**: Intermediate Bias  
***: High Bias
Table 2: Quality of included studies (Continued)

<table>
<thead>
<tr>
<th>Study</th>
<th>Analysis</th>
<th>Applicability</th>
<th>Overall Quality Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Poon et al. 1991²⁴</td>
<td>entirely lack description of statistically analysis</td>
<td>to only head trauma patients with hematomas in Hong Kong</td>
<td>Poor</td>
</tr>
<tr>
<td>Sethi et al. 2002¹³</td>
<td>A predictive model of survival based on hospital transfer</td>
<td>to all severe trauma patients &gt; 12 yrs in Malaysia reporting to different levels of tertiary care center</td>
<td>Fair</td>
</tr>
<tr>
<td>Kam et al. 1998²¹</td>
<td>Very little description of statistical analysis</td>
<td>to major trauma at a level 1-2 trauma center in Hong Kong</td>
<td>Poor</td>
</tr>
<tr>
<td>Khan et al. 2010²³</td>
<td>Descriptive analysis and OR to compare association of survival with various factors</td>
<td>Pakistani trauma patients to a hospital with designated trauma care</td>
<td>Poor - Fair</td>
</tr>
<tr>
<td>Moini et al. 2000²²</td>
<td>A predictive model to assess contributions to survival</td>
<td>Trauma patients in Tehran, Iran</td>
<td>Poor - Fair</td>
</tr>
</tbody>
</table>
Table 3: Outcome of the studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Direct</th>
<th>Transfer</th>
<th>Favors</th>
<th>Statistical Difference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mortality n (%)</td>
<td>Total</td>
<td>Mortality n (%)</td>
<td>Total</td>
</tr>
<tr>
<td>Poon et al. 1991</td>
<td>3 (4%)</td>
<td>71</td>
<td>8 (24%)</td>
<td>33</td>
</tr>
<tr>
<td>Sethi et al. 2002</td>
<td>20 (7.2%)</td>
<td>286</td>
<td>24 (12.4%)</td>
<td>198</td>
</tr>
<tr>
<td>Kam et al. 1998</td>
<td>21 (35%)</td>
<td>60</td>
<td>14 (41%)</td>
<td>34</td>
</tr>
<tr>
<td>Khan et al. 2010</td>
<td>28 (6.8%)</td>
<td>411</td>
<td>46 (8.1)</td>
<td>567</td>
</tr>
<tr>
<td>Moini et al. 2000</td>
<td>24 (2%)</td>
<td>1509</td>
<td>30 (3%)</td>
<td>1153</td>
</tr>
<tr>
<td>Total</td>
<td>96 (4.1%)</td>
<td>2337</td>
<td>122 (6.1%)</td>
<td>1985</td>
</tr>
</tbody>
</table>
Original research:

The Effect of Direct and Indirect Trauma Transfer to a Tertiary Center on Survival in a Sub-Saharan African Setting
Original Research Abstract

Introduction: Strengthening trauma care in developing countries is crucial to reducing global trauma mortality. To assess effectiveness of a developing trauma system, we hypothesize that there are survival differences between trauma patients transferred from a referral facility and those taken directly from the trauma scene to a trauma center.

Methods: We conducted a retrospective analysis of patients in the Kamuzu Central Hospital (KCH) trauma registry from 2008 to 2012. Analysis of patient characteristics and logistic regression modeling for survival comparing patient groups was performed.

Results: There were 4,997 patients transferred from referring facilities and 41,088 patients transported from the scene. The transferred and scene cohorts were similar in age and sex. The mechanism of injury for transferred patients was 78.1% blunt, 14.5% penetrating, and 7.4% other, whereas for the scene group was 70.7% blunt, 24.0% penetrating, and 5.2% other. Mean time to presentation were 51.3 and 16.8 hours for transferred and scene patients, respectively. There was no statistically significant clinical difference between groups. Survival was 95.8 and 98.4% for transferred and scene patients, respectively. The adjusted mortality odds ratio was 1.63 (1.20-2.22); P<0.0001 for transferred versus scene patients, after controlling for age, sex, mechanism of injury, mode of transportation, hours to presentation, and initial AVPU.

Conclusion: Trauma patients taken directly from the scene to the tertiary care center have improved survival. These findings suggest that efforts at improving trauma systems in this setting should be focused on strengthening pre-hospital care and basic stabilization at district hospitals.
Introduction

“Surgery may be thought of as the neglected stepchild of global public health”, said Dr. Paul Farmer, a Harvard professor of Infectious disease, the co-founder of Partners In Health, and an activist in the fight against health disparities.¹ With the surge of international efforts to address global health disparities in developing countries, non-communicable conditions such as surgical diseases are slowly receiving more attention as new evidences of their importance surface.

Trauma injuries account for the greatest portion of surgical conditions worldwide.² According to the 2010 Global Burden of Disease (GBD) Study, in the year 2010, trauma injuries caused a total of 5.1 million deaths, far exceeding the combined number of deaths from HIV-AIDS, malaria and tuberculosis (3.8 million).³

Developing countries are disproportionally affected by injuries.⁴ Some countries in sub-Saharan Africa have the highest ratios of trauma related disability adjusted life years (DALYs) per 1,000 people.² Furthermore, because trauma injuries often occur during the most economically productive years of a person’s life (age 15-44), such injuries greatly debilitate a country’s working population.⁵ Contrary to previous beliefs, several studies have been able to demonstrate that surgical care can achieve equivalent cost-effectiveness measurements as traditional public health interventions, such as measles-mumps-rubella vaccinations.⁵ Therefore, the strengthening of current trauma care in developing countries is crucial to the global public health agenda.

A comprehensive and mature trauma system comprises the integration and continuum of care from adequate injury prevention to prompt pre-hospital care to multileveled acute care facilities and to post hospital rehabilitation.⁶ In the absence of such a system - the case in many low to medium-income countries - there is great pressure to apply the limited resources to public health interventions most likely to improve the system. Many evidenced-based strategies on the
platform of injury prevention and management in low-resources settings have been proposed including: training of lay first-responders, ensuring access to essential emergency equipment, task shifting to lower skilled practitioners to perform trauma care, improving medical transport, and concentrating specialized trauma care in a selected few centers.\(^4\) In order to elucidate the area in need of improvement, an important question needs to be addressed: is there association between transfer status (direct admission from scene or inter-hospital transfer) and mortality outcomes in trauma patients? While the literature is replete with data focused on this question\(^7,8\), over 95\% of the studies were conducted in developed countries, making the results impossible to interpret in a drastically different trauma care structure, such as the one in Malawi.

In Malawi, the health delivery system is structured in a tiered fashion with tertiary care centers located at major urban cities such as Lilongwe and Blantyre and basic medical care provided through district hospitals scattered across the country. The district hospitals are usually staffed with clinical officers (COs), non-surgeon-physician personnel unequipped to treat complex surgical conditions. The district hospitals would refer and transfer patients to tertiary facilities as needed. The UNC–Malawi Surgical Initiative (MSI) is a partnership formed in 2006 between the University of North Carolina Department of Surgery and Kamuzu Central Hospital (KCH), a tertiary care facility located in Malawi’s capital city Lilongwe, that aims to address the burden of surgical disease in the resource limited setting of Malawi by conducting research, engaging in residency training, and performing clinical work. One of the major initiatives of the collaboration was the establishment of injury surveillance by building and maintaining a trauma registry at KCH.

In order to assess effectiveness of KCH’s developing trauma system and elucidate areas of improvement for trauma care in Malawi in general, we conducted a retrospective cohort study
using the trauma registry to investigate potential survival differences between trauma patients transferred from a regional referral facility and those taken directly from the trauma scene to the tertiary trauma center.

Methods

Study setting and Data Collection

The data was collected at Kamuzu Central hospital (KCH) in Lilongwe, Malawi. KCH serves as tertiary referral center for the estimated 6 million people residing in the central regions of Malawi. The hospital has 1000 beds, a 24-hour casualty department, an intensive care unit, four fully functional operating theaters, and six clinical officer anesthetists. The hospital has one computed tomography machine and a rudimentary pathology department. Starting in February 2008, trained data entry clerks present 24 hours a day interviewed and collected information for the KCH trauma registry. The registry included data on identifying information, basic demographics, method of arrival, characteristics of injury and patient depositions and outcomes.

Variables

The exposure variable of interest is transfer status (transferred from other health facilities vs. directly transported from the scene of trauma) and the outcome variable of interest is mortality. The registry provided data on other variables such as identifying information, basic demographics (age, sex), method of arrival or transportation mode, time of injury (season of the year), mechanism and severity of injury, and depositions (admitted, dead on arrival, decreased in the hospital, discharged). Severity of injury of was determined by the AVPU scale. Mode of transport upon arrival at the hospital is categorized into non-motorized (including walk, bicycle), motorized (motorcycle, bus, private and public vehicle) and emergency vehicles (ambulance, policy). Mechanism of injury is categorized into blunt force trauma (including motor vehicle
accident, fall, crush, hit), penetrating trauma and others (burn, electrical injury, drowning, hanging, and poison).

Systematic Review
A brief systematic review was conducted that investigated the mortality differences in trauma patients from developing countries who are either directly transported from the scene of injury to a tertiary care hospital with definitive trauma care or received care at a lower tiered health care facility and subsequently transferred to a tertiary care center (Appendix 1). The literature search revealed a limited number of studies generated from developing countries that investigated the research topic. The evidence derived from a limited number of studies with heterogeneous source population, different methods and varying quality is not sufficiently robust to determine mortality differences by transfer status for trauma patients in the developing countries.

Analysis
A total of 51,361 trauma patients were included in the retrospective analysis; their data were collected between 2008-2012. We performed bivariate analysis to assess characteristic and demographic differences between the patients who were directly admitted from accident scene (scene cohort) and the patients transferred from regional referring facilities (transfer cohort). We also examined differences in mechanism, and location of injuries and mean time to presentation between the two cohorts. We used Pearson’s chi-square test to assess differences in proportions and Student t-tests were used to assess differences in means. We then used logistic regression modeling to assess survival differences between the two cohorts adjusting for measured confounders. We reported the adjusted survival odds ratio, after controlling for age, sex,
mechanisms of injury, mode of transportation, hours to presentation and results of initial
disability/neurological assessment (AVPU = alert, verbal stimuli response, painful stimuli
response, or unresponsive). We also performed sensitivity analyses to address missing values in
the variables outcome (mortality) and transfer status. The first analysis assumed that all missing
values in the variable mortality were either alive or dead. The second analysis assumed that all
missing values in the variable transfer status were either transfer or direct from the scene. Data
was analyzed using STATA (Release 12: StataCorp LP, College Station, TX, USA). Statistical
significance was defined by a two-sided alpha of 0.05.

Results:

There were 51,361 trauma patients included in the study. For those with data on transfer
status (n=46,085), 41,088 (89.2%) were admitted to KCH directly from the scene and 4,997
(10.8%) were transferred from other facilities. Table 1 summarizes demographic, injury specific
and outcome data of the patients based on their transfer status. The mean age of patients in the
transfer group was slightly higher compared to that in the scene group, which is statistically
significant but not clinically significant. Distribution of gender in the two groups was similar,
consistent with a predominantly male composition. There was more alcohol involvement in the
scene group compared to the transfer group (7% vs. 4%; P<0.001). Far more trauma patients in
the transfer group arrived by emergency vehicles compared to patients in the scene group (73% vs.
8%; P<0.001). Patients from the scene group suffered significantly more penetrating injuries
(24% vs. 15%; P<0.001) and less blunt force injuries (71% vs. 78%; P<0.001) compared to the
transfer group. Transferred patients on average presented to the tertiary care center much later
than the scene group (51 hours vs. 17 hours; P<0.0001). For transferred patients, they were more
likely to have a low or high AVPU score (1.9% vs. 0.6% and 44% vs. 38%) and less likely to
have a medium AVPU score (54% vs. 62%) compared to the patients coming from the scene (P<0.001).

In terms of outcome, transferred patients are significantly more likely to be admitted to the wards (56% vs. 12%; P<0.001). For the 6,349 patients with data on length of stay, transferred patients stayed in the hospital longer (14.8 days vs. 10.4 days; P<0.0001). In terms of the ultimate outcome, transferred patients have a statistically higher mortality compared to patients from the scene (4% vs. 2%; P<0.001).

Results of the logistic regression model are shown in Table 2 demonstrating the relationship between transfer status and mortality, adjusted for confounders. This unadjusted regression model showed that the crude odds ratio for mortality in the transfer group as compared to the scene group is 2.65. Additional bivariate analysis of the relationship between items in Table 1 and mortality revealed possible confounders. All possible confounders were included in the fully adjusted model. After testing for the significance of certain confounders and their impact on the odds ratio, a reduced model was generated. The reduced model adjusted for age, sex, alcohol involvement, mode of transport, mechanism of injury, hours to presentation, and initial AVPU scores. In the final reduced model, the odds ratio for mortality associated with being transferred compared to directly admitted from the scene was 1.63 (1.20-2.22); P<0.0001, meaning that the patients transferred to KCH from other facilities have 1.63 times the odds of dying compared to patient directly admitted to KCH.

**Sensitivity Analysis:**
Results of the sensitivity analysis were presented in Table 3 and 4. There were 4,278 missing data points for the variable outcome, in terms of mortality. When all patients with missing outcome were assumed to be alive, odds ratio of mortality associated with being
transferred decreased to 1.12 (0.84-1.51); P<0.0001, which became no longer clinically significant since the confidence interval included the null. When all missing outcomes were assumed to be dead, odds ratio increased to 3.25 (2.90-3.63); P<0.0001. Similar analysis was done for the 1,302 patients with missing data points in transfer status. When patients with missing data point for transfer status were assumed to come directly from the accident scene, odds ratio of mortality associated with beings transferred stayed the same 1.64 (1.21-2.23); P<0.0001. When the missing values were assumed to be from the transferred group, the odds ratio became 1.58 (1.17-2.15); P<0.0001.

**Discussion:**
There are ample evidences among literatures of the developing countries that address the question whether if direct transport from a trauma scene to a center of definitive care improves mortality. Given that the result cannot be extrapolated to a drastically different trauma structure in the developing country, we investigated this question based on the local trauma registry in Kamuzu Central Hospital, a Malawian tertiary care center located in its capital city Lilongwe.

Our results indicate that trauma patients transferred to the tertiary care center after first receiving care at a district hospital compared to patients transported directed from the scene of the trauma have increased risk for mortality.

There are several explanations for our observations. Tertiary care centers in Malawi are equipped with far more medical expertise and resources compared to regional district hospitals or rural primary health centers.\(^{10}\) Rural health centers usually serve an area of 50 village and 30,000 people, equipped with treating basic infections, abrasions, pre-natal and perianal care.\(^ {11}\) They are staffed by clinical offers with limited skill sets. One tier superior to rural health centers, there are 23 district hospitals where basic diagnostic and laboratory testing are available, along
with expertise provided by a few fully trained doctors. The central tertiary care centers such as KCH have a concentration of trauma resources such as commutated tomography, laboratory testing, operating theaters and more health care personnel. Even though tertiary care centers have more resources and health care workforce relative to district hospitals and rural health center, Malawi’s health care delivery on the whole currently does not meet the demand of the heavy disease burden, especially for surgical care. Per capital health expenditure is US$25 and there are only 2 physicians per 100,000 Malawians and around 16 surgeons (mostly non-Malawian) for the entire country. The Emergency Human Resources Plan aimed to increased salary support for healthy professionals implemented by the Malawian government and its developmental partners have shown some impact in increasing workforce and training institutions; however, distribution of health care workforce is still skewed towards the larger urban cities such as Lilongwe. These disparities in resources across the tiered health delivery system can partially explain the results observed in this study.

Our results also elucidate other explanations for the association between transfer patients and higher mortality. The transferred patients are most likely to arrive via emergency vehicle than private or other motorized vehicles (73% vs. 8%). Studies based on the same source population and trauma registry have previously revealed that transport by private vehicle was much shorter than by ambulance and ambulances are preferentially used for transport over longer distances. In addition, there is not an officially organized emergency medical service in Malawi and ambulances are always in short supply as is the case in Lilongwe. The significantly longer hours to presentation in the transferred group may further explain the higher mortality. Another possible explanation for the differences in mortality is that the transferred patients were more severely injured to begin with. However, the AVPU score as a measure of injury severity was
equivalent in the two groups. When categorized into low, medium and high groups, transferred patients had more proportions of patients in both the low and the high AVPU score groups. In addition, after adjustment for initial AVPU score, the transferred group still had 1.63 times the odds of mortality compared to patients from the scene.

The results of our study are consistent with some current literature. To address the question of direct admission vs. transfer, the debate between the “scoop and run” principle versus the stabilize to transfer strategy has generated strong views among clinicians but inconclusive evidence among studies. Our results are consistent with the “scope and run” philosophy, which is the currently accepted dogma; it argues that all trauma patients be routinely taken to top level trauma centers and any delay in time to definitive care has tremendous implications for outcome. This “scoop and run” principle is supported by various studies that have shown higher mortality in transfer patients compared to those admitted directly and time to trauma center as an independent predictor of mortality. On the other side of the argument, studies have also shown that the initial treatment of life-threatening injuries (either at the scene or the first hospital) before arrival at a trauma center leads to better outcome. Two recent systematic reviews examined patient outcome differences between the “direct” (patients transported directly to a trauma center) and the “indirect” (patients transferred from another lower tiered hospital to a trauma center) groups reviewed equivalent risks, but acknowledges limitations of the review given heterogeneity in study design, health care settings, and numerous potential biases. However, both systematic reviews included studies from only developed countries. Therefore, we need to be cautious interpreting our results in the setting of these previous studies as their conclusions cannot be applied to determine the best principle of trauma patient transfer in developing countries. Given that, our results can shed light on the delivery of trauma care in
developing countries and have implications for other Sub-Saharan African countries, policy
makers, development partners, researchers and clinicians.

Injury contributes to a large portion of death and disability in sub-Saharan Africa, with road
traffic accidents being the greatest cause of all. Current estimation of injury incidences and
related mortality is limited, given that accurate epidemiological data from official nationwide
registration systems in Africa is scarce. Underreporting of trauma injuries therefore leads to
inaccurate estimation of the true disease burden. This issue is being addressed by the
development of hospital based registry systems for prospective collection of injury data in Sub-
Saharan African countries, such as in Malawi. Overall, our data from KCH’s trauma registry is
informative for identifying injury patterns, risk factors, and preventive measures.
Epidemiological results from our registry when compared to other surrounding regions in Sub-
Saharan Africa have elucidated similar injury patterns – young males between the age of 15-44
years old, and victims of road traffic accidents and assault. Our findings of transferred patients
being associated with higher mortality may have implications for other regions of sub-Saharan
Africa with tertiary care centers in urban cities. Similar results were obtained at a trauma center
in Durban, South Africa. However, it’s important to recognize that in the rural setting, initial
stabilization at the nearest regional hospital may be the only option before transfer over a great
distance. Therefore, our results are more applicable within larger urban cities limits, such as
Lilongwe and cannot be extrapolated to rural trauma.

In terms of public health interventions given the increased odds of mortality in the transferred
patients in Malawi, priority should be given to build adequate pre-hospitalization care services to
deliver trauma patients from the accident scene to a tertiary care center with definitive trauma
care. In addition, concentration of resources at a designated trauma center will allow for better
treatment of their patients once transferred. Ample evidences have shown that trauma patients have better outcome at specialized designated trauma centers, usually tertiary care institutions, compared to their counterparts treated at regional non-trauma facilities.\textsuperscript{23,24} In a resource limited setting like Malawi, appropriation of funding from the government and developmental partners need to be evidence guided. Budgetary allocations should be directed to building the necessary infrastructure of an emergency medical service, including vehicles for transportation, specialized training, dispatch communication network, resources and equipment for basic and advanced life support care.

In addition to building infrastructure, building human resources is equally important. To address the significant workforce shortage crisis and brain drain of health professional in African countries, specialized trainings programs is another area in need of attention.\textsuperscript{25} In-country residency programs have the potential to produce a generation of surgeons to best serve their home and to become leaders and advocates for surgical care in their countries.\textsuperscript{25,26} Alternatively, task-shifting from surgeons to trained clinical officers to perform basic surgical procedures can also prove to be an effective strategy while the shortage of fully-trained surgeons persist.\textsuperscript{27}

Several limitations exist within our study. First, trauma registries raise concerns for completeness, quality and consistency across different collectors. Missing data is a potential weakness that is only partially mitigated by sensitivity analyses. Second, AVPU score is not an official injury severity measurement scale. Injury Severity Score, as the anatomic measurement of injury severity would have been a better assessment. Third, The transferred patients had similar initial AVPU scores when compared to those directed transported to the tertiary care center from scene. However, the conditions of patients that were not transferred who received care in district hospitals were unknown. There was no comparison between those transferred and
those who were admitted, treated, and discharged at the district hospital; patients who were transferred were critically ill but also stable enough for the transfer. In addition, early mortality at the district hospital could not have been accounted for in this study. Therefore, baseline characteristics of the transferred group are only the best representations of the unknown source population, generating a source of selection bias. Last, external validity of the study is limited to patient populations residing in urban centers of Malawi and other similar Sub-Saharan African countries where there is a tertiary care center providing definitive trauma care.

**Conclusion:**
Our study based on a hospital based injury surveillance registry revealed that direct transport of trauma patients from the accident scene to a tertiary care center without initial assessment and treatment at a regional health facility confers a survival advantage. With limited resources to improve trauma care in this setting, attention should be focused on building and strengthening pre-hospitalization medical services and focusing trauma education (initial trauma assessment, resuscitation/ stabilization and early transfer at district hospitals.
References:


22. Cheddie S, Muckart DJJ, Hardcastle TC, Hollander D Den, Cassimjee H, Moodley S. O RIGINAL A RTICLES Direct admission versus inter-hospital transfer to a level I An


## Figures and Tables:

### Table 1: Demographic, injury characteristics and outcome of trauma patients in scene vs. transfer groups

<table>
<thead>
<tr>
<th>Sample Characteristic</th>
<th>Total</th>
<th>Transfer (%) (n=4,997)</th>
<th>Scene (%) (n=41,088)</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean age in years (SD)</td>
<td>23.1 (15.6)</td>
<td>24.1 (18.5)</td>
<td>23.0 (15.0)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>1: &lt;14</td>
<td>15,949 (32)</td>
<td>2,525 (39)</td>
<td>13,424 (31)</td>
<td>0.03</td>
</tr>
<tr>
<td>2: 15-44</td>
<td>29,332 (59)</td>
<td>3,082 (47)</td>
<td>26,250 (61)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>3: &gt;=45</td>
<td>4,311 (9)</td>
<td>910 (14)</td>
<td>3,401 (8)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Male</td>
<td>35,922 (72)</td>
<td>4,644 (71)</td>
<td>31,278 (72)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Female</td>
<td>14,060 (28)</td>
<td>1,920 (29)</td>
<td>12,140 (28)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Alcohol</td>
<td>3,161 (6)</td>
<td>293 (4)</td>
<td>2,868 (7)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Season</td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>1: Rainy</td>
<td>12,092 (24)</td>
<td>1,502 (23)</td>
<td>10,590 (24)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>2: Lush/green</td>
<td>12,706 (25)</td>
<td>1,577 (24)</td>
<td>11,129 (26)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>3: Cold dry</td>
<td>12,471 (25)</td>
<td>1,721 (26)</td>
<td>10,750 (25)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>4: Hot dry</td>
<td>12,761 (26)</td>
<td>1,772 (27)</td>
<td>10,989 (25)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Transport (n=49,886)</td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>0: Non-motorized means</td>
<td>3,179 (6)</td>
<td>221 (3)</td>
<td>2,959 (7)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>1: Motorized vehicle</td>
<td>38,581 (78)</td>
<td>1,577 (24)</td>
<td>37,004 (85)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>2: Emergency vehicle (ambulance/police)</td>
<td>8,006 (16)</td>
<td>4,744 (73)</td>
<td>3,264 (8)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Mechanism of injury (n=50,326)</td>
<td>1: Blunt injury</td>
<td>2: Penetrating injury</td>
<td>3: Other (burn/hanging/drowning/poisoning, other)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>--------------------------------</td>
<td>----------------</td>
<td>---------------------</td>
<td>-----------------------------------------------</td>
<td>--------</td>
</tr>
<tr>
<td></td>
<td>35,464 (71)</td>
<td>5,073 (78)</td>
<td>30,391 (71)</td>
<td>0.53</td>
</tr>
<tr>
<td></td>
<td>11,278 (23)</td>
<td>944 (15)</td>
<td>10,224 (24)</td>
<td>0.23</td>
</tr>
<tr>
<td></td>
<td>2,725 (6)</td>
<td>477 (7)</td>
<td>2,240 (5)</td>
<td>0.06</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Initial AVPU (SD)</th>
<th>3.37 (0.53)</th>
<th>3.39 (0.60)</th>
<th>3.36 (0.52)</th>
<th>0.0001</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Low (1)</td>
<td>389 (0.8)</td>
<td>122 (1.9)</td>
<td>267 (0.6)</td>
<td>0.61</td>
</tr>
<tr>
<td>2. Medium (2-3)</td>
<td>29,813 (61)</td>
<td>3,502 (54)</td>
<td>26,311 (62)</td>
<td>0.44</td>
</tr>
<tr>
<td>3. High (4)</td>
<td>18,846 (38)</td>
<td>2,813 (44)</td>
<td>16,033 (38)</td>
<td>0.52</td>
</tr>
</tbody>
</table>

| Hours to presentation (n=49,011) | 21.4 (117.6) | 51.3 (233.0) | 16.8 (87.0) | <0.0001 |

<table>
<thead>
<tr>
<th>Admission disposition (n=49,706)</th>
<th>0: Discharged from ED</th>
<th>1: Admitted to wards</th>
<th>2: Died in ED/brought in dead</th>
<th>&lt;0.001</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>40,330 (79)</td>
<td>2,756 (43)</td>
<td>37,574 (87)</td>
<td>0.79</td>
</tr>
<tr>
<td></td>
<td>8,816 (20)</td>
<td>3,636 (56)</td>
<td>5,180 (12)</td>
<td>0.43</td>
</tr>
<tr>
<td></td>
<td>560 (1)</td>
<td>57 (1)</td>
<td>503 (1)</td>
<td>0.01</td>
</tr>
</tbody>
</table>

| Length of stay (n=6,349) | 11.8 (16) | 14.8 (18) | 10.4 (15) | <0.0001 |

| Survived to discharge Died | 45,501 (98) | 4,895 (96) | 40,606 (98) | <0.001 |
|                           | 872 (2)     | 211 (4)    | 661 (2)     |        |
Table 2: Logistic regression model for mortality by transfer status.

<table>
<thead>
<tr>
<th>Logistic regression model</th>
<th>Odds Ratio (95% CI)</th>
<th>P Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unadjusted: Transferred/Scene</td>
<td>2.65 (2.26-3.10)</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Fully adjusted: Transferred/Scene</td>
<td>1.63 (1.19-2.22)*</td>
<td>&lt;0.0001</td>
</tr>
<tr>
<td>Reduced: Transferred/Scene</td>
<td>1.63 (1.20-2.22)**</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

*Adjusted for age, sex, alcohol involvement, mode of transport, season, mechanism of injury, hours to presentation, initial AVPU score.

** Adjusted for age, sex, alcohol involvement, mode of transport, mechanism of injury, hours to presentation, initial AVPU score.

Table 3: Sensitivity analysis addressing missing outcome

<table>
<thead>
<tr>
<th>Missing = alive</th>
<th>Missing = dead</th>
</tr>
</thead>
<tbody>
<tr>
<td>Original Model</td>
<td>Missing = alive</td>
</tr>
<tr>
<td>OR (95% CI); P value</td>
<td>1.12 (0.84-1.51)</td>
</tr>
<tr>
<td>P value</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>

Table 4: Sensitivity analysis addressing missing transfer status

<table>
<thead>
<tr>
<th>Original Model</th>
<th>Miss = scene</th>
<th>Miss = transfer</th>
</tr>
</thead>
<tbody>
<tr>
<td>OR (95% CI); P value</td>
<td>1.64 (1.21-2.23)</td>
<td>1.58 (1.17-2.15)</td>
</tr>
<tr>
<td>P value</td>
<td>&lt;0.0001</td>
<td>&lt;0.0001</td>
</tr>
</tbody>
</table>