



Hospital level interventions to improve outcomes after injury in India, a LMIC

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Background & objectives: Trauma is one of the leading causes of disability and death, worldwide. Ninety per cent of trauma related mortality occurs in low- and middle-income countries (LMICs). Despite this, there is paucity of literature emanating from LMICs with studies that present and/or evaluate feasible interventions that can have a measurable impact on outcomes after injury, primarily mortality. The current article aims at developing such interventions key elements of implementation and measures of compliance and impact.

Methods: A literature review was conducted to evaluate the status of injury care among LMICs worldwide. Based on this review, interventions were identified/developed, that (i) were feasible to implement within the constraints of available resources; (ii) could be implemented within a two year timespan; and (iii) would improve outcomes primarily, mortality. These interventions were then discussed at a symposium of experts and stakeholders from around the world.

Results: The literature review identified gaps across the entire spectrum of injury care at all levels – primary, secondary and tertiary prevention. Additionally, lack of data systems capable of ensuring quality of care and driving performance improvement was identified. Utilizing the review as the basis and focusing on hospital level interventions, one policy intervention, five in-hospital interventions and one major research question were identified/developed that met the defined criteria.

Interpretation & conclusions: Gaps in trauma care in LMICs at every level and in data systems were identified. Feasible interventions that can be implemented within the resource constraints of LMICs in a reasonable timeframe and that can have a measurable impact on injury related mortality were developed and are presented.

Key words Hospital - mortality - injury - intervention - outcome

Trauma is one of the leading causes of disability and death worldwide with annual deaths exceeding those caused by malaria, HIV/AIDS and tuberculosis,

combined^{1,2}. Reportedly, 90 per cent of trauma related deaths occur in low- and middle-income countries (LMICs)³ and are associated with tremendous economic

hardships for the impacted family⁴. In most LMICs, trauma systems are rudimentary, with post-injury care often delayed and not up to standards. Estimates suggest that if the care provided in LMICs was similar to that in high-income countries (HIC), approximately two million lives would be saved annually⁵. In a Delphi study examining in-hospital trauma deaths across five major hospitals in India, ~50 per cent of the deaths were deemed preventable⁶. Despite such grim statistics, there is paucity of research into resource appropriate interventions that can impact trauma mortality in LMICs⁷. The current study is a review of recent literature from LMICs specifically evaluating the gaps in care with the aims of (i) identifying/developing feasible hospital level interventions that could measurably impact outcomes, primarily mortality and (ii) identifying research area(s) that, if addressed, could help in furthering policy decisions in India.

A literature review focusing on the issues impacting trauma care/outcomes in LMICs demonstrates gaps in care at every level – primary, secondary and tertiary. The review organized by regions – Southeast Asia (excluding India), Central/South America, Europe/Central Asia and Africa is summarized in Table I⁸⁻¹⁹.

Material & Methods

Based on the preliminary review of literature (Table I⁸⁻¹⁹), common themes were identified. Next, an additional literature search was performed focusing on interventions that have proven to be successful in HICs that could be modified and implemented in the low resourced environment of LMICs. Based on these, interventions were developed by the authors. All interventions had to meet the following criteria: (i) implementable within the constraints of available resources; (ii) implementable in two-year time-frame; and (iii) have a measurable impact on outcomes. For each of the proposed interventions the SMART (Specific, Measurable, Achievable, Relevant and Time-bound) framework was utilized to ensure appropriateness of the intervention. Each intervention was drafted under four headings namely, (i) definition/description; (ii) key elements for effective implementation; (iii) measures of compliance to ensure effective implementation; and (iv) measures of impact to objectively evaluate effectiveness.

All proposed interventions were then presented and discussed at a symposium held at All India Institute of Medical Sciences (AIIMS), New Delhi on September 30-October 1, 2023. The symposium was organized

by the Transdisciplinary Research, Action, and Implementation network for Trauma (TRAIN Trauma India). The symposium brought together a group of experts to discuss the current state, assess existing best practices, and explore future directions for research and intervention in trauma care using a system-level approach. The current report focussing on in-hospital interventions is from one of five working groups. The other four groups focussed on other areas of trauma care. The symposium was attended by >50 participants and saw representation from multiple institutions in the field of trauma surgery, including experts from academic centers across India, as well as a multidisciplinary multinational global health team from seven countries with a longstanding history of collaboration in India. Surgeons in attendance represented both rural and urban contexts, spanning levels of care from primary to tertiary hospitals. Disciplines represented at the conference included surgery, emergency medicine, anaesthesia, radiology, nursing, patient advocates, policy makers, and representatives from international non-governmental organizations (NGOs). On Day 1 of the symposium, the proposed interventions were presented to the attendees followed by a facilitated discussion for each specifically focusing on the applicability, and feasibility in the LMIC setting. All discussions/comments were recorded. These discussions/comments were collated and the proposed interventions modified accordingly. On Day 2 of the symposium, the modified interventions were again presented, discussed and finalized by consensus which are presented in this article.

Results

Based on the literature review (Table I⁸⁻¹⁹), the broad themes identified are presented in Table II. Based on these, interventions at the hospital level were developed under three domains: (i) one relevant to policy; (ii) five relevant to the in-hospital setting; and (iii) one relevant to trauma readiness of Indian hospitals.

Policy domain: At the policy level it is critical to establish a system of designating specific hospitals as 'Trauma Centers'. A large number of studies^{20,21} and the experience in the US^{20,21} have demonstrated that when injured patients, especially those with major injuries, are managed at designated trauma centers, outcomes are better^{20,21}. Trauma centers are hospitals that have elected to commit the needed resources – structure, personnel, data systems *etc.*, to provide optimal care

Table I. List of studies with key findings and recommendations regarding post injury care in low- and middle- income countries (LMICs)

Region	Study/key findings	Recommendations
SE Asia excluding India		
Pakistan	Khalil <i>et al</i> ⁸ : Evaluation of 22 secondary & Tertiary care hospitals in Karachi, Pakistan <ul style="list-style-type: none"> • Inadequate diagnostic equipment • Lack of trained personnel 	<ul style="list-style-type: none"> • Training: Develop cost effective locally relevant courses & provider certifications • Designation: Develop trauma center designation process
Nepal	Kharel <i>et al</i> ⁹ : Assessment of 7 tertiary care hospitals <ul style="list-style-type: none"> • Lack of protocols • Lack of trained personnel • Lack of diagnostic testing resources • Lack of data systems • Lack of financial support 	<ul style="list-style-type: none"> • Protocols: Develop & implement protocols • Education: Inter-institutional collaboration • Funding: Adequate governmental funding to support equipment, trained personnel, & data systems
Central/South America		
Peru	LaGrone <i>et al</i> ¹⁰ : Surgeons' perceptions of trauma care in a globalized world <ul style="list-style-type: none"> • 'Brain drain' to HIC • Inability to use standard protocols in the local context Lagrone <i>et al</i> ¹¹ : Mixed methods assessment of quality improvement programmes <ul style="list-style-type: none"> • Lack of data systems • Lack of prioritization of QI by providers • Provider preference for autonomy over standardization 	<ul style="list-style-type: none"> • Provider support: Initiatives to improve provider satisfaction locally • Data systems: Develop trauma registries • QI programmes: Prioritize QI programmes through education & incentives
Columbia	Ramachandran <i>et al</i> ¹² : Comparing outcomes at 2 first-level trauma centers <ul style="list-style-type: none"> • Lack of pre-hospital care • Lack of data systems resulting in poor quality, incomplete & non-standardized records Munoz-Valencia <i>et al</i> ¹³ : A population-based analysis correlating blood banks per city & mortality from traumatic haemorrhage <ul style="list-style-type: none"> • Lack of universal blood availability 	<ul style="list-style-type: none"> • Pre-hospital: Improved training & resources • Data systems: Develop data systems & support to have trained personnel manage the systems • Investments: Development of blood resources
Europe/Central Asia		
Turkey	Squyer <i>et al</i> ¹⁴ : Comparing trauma mortality in Turkey vs US <ul style="list-style-type: none"> • Lack of pre-hospital care • Lack of protocols • Lack of data systems 	<ul style="list-style-type: none"> • Pre-hospital: Improved training & care • Protocols: Develop & implement protocols • Data system: Invest in data systems to track care & drive performance/QI
Africa		
Kenya	Wesson <i>et al</i> ¹⁵ : Hospital compliance with WHO trauma checklist <ul style="list-style-type: none"> • Lack of data systems • Lack of trauma specific training • Lack of speciality resources 	<ul style="list-style-type: none"> • Investment: A need for strong investments in all aspects of trauma care
Rwanda	Ntakiyiruta <i>et al</i> ¹⁶ : Geo-spatial evaluation of trauma surgical procedures <ul style="list-style-type: none"> • Lack of pre-hospital care • Poor resuscitation practices at district hospitals • Delayed & excessive transfers to tertiary care hospitals • Poor support for timely transport including monetary • Poor specialist care in tertiary hospitals 	<ul style="list-style-type: none"> • Training: Improved training of lay persons to provide basic pre-hospital care & training programmes for improving trauma care at secondary (district) hospitals • Transport: Strengthening transport systems

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Region	Study/key findings	Recommendations
Sub-Saharan Africa	<p>Boschini <i>et al</i>¹⁷: Impact of direct vs indirect transfer on trauma mortality</p> <ul style="list-style-type: none"> • Lack of pre-hospital care • District hospitals staffed with poorly trained personnel • Lack of communication between transferring hospitals • Poor support for timely transfer • Lack of well-trained surgical specialists in tertiary hospitals 	<ul style="list-style-type: none"> • Pre-hospital: Improve pre-hospital systems • Training: Trauma specific training at secondary hospitals to manage less injured patients locally & identify patients for transfer to tertiary hospital early & improve trauma education/surgical training at tertiary hospitals <p>Transport: Improve transport infrastructure</p>
South Africa	<p>Clarke <i>et al</i>¹⁸: Gap between trauma workload & capacity in a rural health district, & Hardcastle <i>et al</i>¹⁹: Hospital disease burden & care in a heavily populated province</p> <ul style="list-style-type: none"> • Trauma patients evaluated by poorly trained personnel often non-physicians • Poor physical plants • Lack of interest in trauma training • Severe lack of trained personnel 	<ul style="list-style-type: none"> • Investment: Upgrade facilities • Personnel: Invest in human capital - training & incentives

WHO, World Health Organization; HIC, high income countries; QI, quality improvement; SE, southeast

Table II. Common themes from the literature review along with intervention areas to improve care of the injured in LMICs

Phase of care/systems	Common themes	Intervention area
Primary prevention (Pre-injury)	<ul style="list-style-type: none"> • Low rates of adoption of known prevention strategies by individuals (helmets <i>etc.</i>), & at structural (pedestrian lanes <i>etc.</i>) & policy levels (driving under influence laws <i>etc.</i>) 	<ul style="list-style-type: none"> • Policy
Secondary prevention (Pre-hospital)	<ul style="list-style-type: none"> • Lack of pre-hospital care/triage • Poor coordination of care across hospitals 	<ul style="list-style-type: none"> • Personnel; training; equipment; protocol/guidelines • Communication
Secondary prevention (In-hospital)	<ul style="list-style-type: none"> • Lack of standardized approach to the initial management of trauma care • Lack of protocols & the inability to follow protocols due to lack of resources • Lack of specialist services 	<ul style="list-style-type: none"> • Training; protocols/guidelines • Training; resources; protocols/guidelines • Personnel; training
Tertiary prevention (Post-hospital)	<ul style="list-style-type: none"> • Lack of rehabilitative services 	<ul style="list-style-type: none"> • Personnel; training; equipment
Data systems	<ul style="list-style-type: none"> • Lack of understanding of data systems • Lack of trained personnel who can input, extract, & analyze data • Lack of understanding of how the analyzed data can be utilized to assess & improve care • Lack of resources to develop & maintain data systems <i>eg.</i>, Registry 	<ul style="list-style-type: none"> • Training • Personnel; training • Training • Resources

to the injured person. The World Health Organization (WHO) Guidelines for essential trauma care considers a process of designation/verification of trauma centers as a critical element of overall trauma system development^{22,23} (Supplementary Material: Box 1).

In-hospital domain: At the in-hospital level, five interventions were developed: (i) designated space for resuscitation; (ii) designated trauma team; (iii) utilizing WHO checklist; (iv) application of resource appropriate

‘trauma tool’ for initial evaluation; and (v) utilizing resource appropriate protocols for management of specific injuries.

Designated space: A polytrauma patient needs expeditious evaluation, diagnosis and treatment of immediately life-threatening conditions and plan for further management, imaging/intervention *etc.* In this regard, the WHO recommends that a designated area in the emergency department be created where all appropriate

equipment for evaluation, monitoring, and lifesaving interventions is immediately available (Supplementary Material: Box 2). The details of what is immediately available within the designated resuscitation area will be dependent on the resources available at the hospital and hence each hospital will have to carefully evaluate what is appropriate in their environment.

Designated team: In addition to the designated resuscitation area, to rapidly evaluate a patient with major injuries, diagnose and treat immediately life-threatening conditions and make a plan for further management, imaging/intervention *etc.*, the patient should be evaluated by a skilled ‘trauma team’ capable of performing these actions in an expeditious manner. In most developed trauma systems, this team is summoned to assemble, preferably prior to patient arrival^{24,25}. The team consists of providers who have the requisite skill and training to rapidly assess the injured patient, diagnose immediately life-threatening conditions and provide lifesaving interventions, and develop a plan of care appropriate to the patient’s needs. Additionally, the team should have support staff (*e.g.* nurses, respiratory therapists, *etc.*) who can support the provision of care and also document the care process (Supplementary Material: Box 3).

WHO Checklist: Checklists are highly effective in ensuring that all essential elements of a process are actually completed. They have been utilized in multiple diverse fields/environments and have demonstrated improved compliance with the elements of the process which lead to reduction in missed elements and improved outcomes. The WHO has proposed a basic trauma checklist to be completed after the initial evaluation, primary and secondary survey is completed and before the trauma team disperses. Studies have demonstrated that using the WHO Trauma Checklist reduces mortality, improves care, and increases patient satisfaction with care^{21,26,27} (https://cdn.who.int/media/docs/default-source/emergencies-trauma-care/trauma-congress-630_a3e8707b-6cd6-4482-a3cf-70019f677abe.pdf?sfvrsn=3a553ced_8&download=true).

To be effective, the WHO checklist has the following assumptions: *a)* there is a designated resuscitation area/space for the initial management of a major trauma patient; *b)* resuscitation area/space is equipped with monitoring equipment *eg.*, oximeter, *etc.*; *c)* a trauma team evaluates all major trauma patients; and *d)* the trauma team has the requisite training to identify and intervene for immediately life-threatening conditions

eg., tension pneumothorax, *etc.* If a hospital has all of these in place, the WHO checklist is an effective intervention (Supplementary Material: Box 4).

Resource appropriate ‘trauma tool’: The WHO checklist is a highly effective and well validated tool to improve trauma team performance and reduce the incidence of missed essential steps in the early management of an injured patient^{21,26,27}. However, as mentioned above, for the WHO checklist to be effective, the hospital has to have a certain degree of maturity in terms of managing injured patients; have a designated resuscitation area with appropriate equipment and a designated trauma team with requisite training. In LMICs many hospitals do not have that level of maturity and the initial evaluation and management of a trauma patient is often performed by basic physicians or at times by non-physician providers who do not have specialized training in early evaluation and management of an injured patient. In such environments the most obvious and prominent injury *e.g.*, a fracture, becomes the dominant injury and occult injuries within body cavities (chest, abdomen, and pelvis) are often missed. A simple resource appropriate trauma tool that ‘forces’ the provider to look for occult injuries may be highly effective in reducing missed injury and improving outcomes, even in the hands of providers without specialized training (Supplementary Material: Box 5). An example of such a tool with resource appropriate strategies for high resourced, resource constrained and low resourced environments is presented in Supplementary Table.

Resource appropriate protocols: Once the initial evaluation of the patient is complete, immediately life-threatening conditions have been addressed and all injuries have been diagnosed through resource appropriate imaging, the identified injuries need to be managed. Protocols are evidence-based management practices that lead to optimal outcomes. Implementation of protocols or practice management guidelines have demonstrated improved outcomes in varying settings including LMIC²⁸⁻³¹. However, many of the protocols in the literature were developed in HIC and are highly resource intensive. These resources, specifically imaging, blood products *etc.*, may not be available in hospitals in LMICs. Each hospital should endeavour to develop its own protocols that may be based on the ones developed in HICs but then are modified based on the available resources (Supplementary Material: Box 6). A detailed discussion of specific protocols is beyond the scope of the current study, and will be highly dependent upon the available resources.

Trauma readiness domain: There is wide variation among Indian hospitals with regard to readiness and ability to adequately evaluate and manage patients brought in to the Emergency department including those with injuries as demonstrated by a recent report conducted by AIIMS, New Delhi, under the auspices of NITI Aayog³². That report focused on the Emergency department only and included readiness for all emergencies. We propose a RedCap based assessment tool based on the American College of Surgeons, Committee on Trauma pre-review questionnaire (ACS COT PRQ), modified to Indian context that will assess injury care in depth and across the entire continuum from Primary, through Secondary to Tertiary prevention. The tool assess structure (physical plant; resources including personnel), processes of care (including performance improvement), and data systems devoted to the care of the injured patient. The primary aim of the intervention would be to identify strengths and weaknesses at Indian hospitals at various levels – primary, secondary, tertiary and quaternary – in terms of their ability to take care of patients with major injury. This will allow future interventions to be developed that could improve outcomes.

Discussion

Recent literature (as reviewed in this study) from LMICs with regard to the status of trauma care indicates weaknesses across entire continuum of care from primary, through secondary to tertiary prevention. Additionally, a severe lack of effective data systems to assess the care provided and to drive performance improvement also emerged. No single study can possibly address all of these issues. The current study focused on hospital level interventions in India, a LMIC, that are feasible within the available resource constraints; can be implemented over two-year timespan; and predicted to have a measurable impact on risk-adjusted outcomes, primarily mortality.

In the Indian context, the Delphi study of preventable deaths by Roy *et al*⁶ demonstrated that early deaths were primarily related to airway issues and haemorrhage control. The study recommended standardized care pathways and management protocols. More recently, a study by Amato *et al*³³ compared risk adjusted mortality in India and USA and demonstrated that among injured adults brought to the hospital alive, risk-adjusted mortality in India was much higher than the crude difference and treatment location, was by far the greatest independent predictor of mortality among similarly

injured patients. Additionally, the authors demonstrated that the odds of increased mortality in India were higher for the young vs the old; less injured vs the more injured; and less physiologically compromised vs the more compromised³³. These findings were later duplicated among the paediatric population³⁴. While troubling, these findings, taken together with the Delphi study, suggest that low fidelity and relatively ease to implement interventions that do not require major additional resources, can have a major impact on trauma related mortality⁷. The present study proposes specific feasible in-hospital interventions that can be implemented within the constraints of available resources and that can directly lead to measurable improvement in risk adjusted outcomes, primarily mortality. The study also identified a specific research question that can inform policy development by identifying the areas of greatest need at various hospital levels.

Overall, despite 90 per cent of trauma deaths occurring in LMICs, research into feasible interventions that can reduce trauma related mortality in LMICs is severely lacking. The current study evaluates the major challenges and describes six feasible interventions that can improve trauma related mortality. Additionally, it proposes a research question and a methodology to evaluate in great detail, the state of readiness of hospitals to provide care for the injured.

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