Pediatric Trauma Care in Low- and Middle-Income Countries: A Brief Review of the Current State and Recommendations for Management and a Way Forward

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Abstract

Keywords

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Traumatic injuries are a significant cause of death and disability worldwide. The vast majority of these injuries occur in low- and middle-income countries (LMICs). Attention to protocolized care and adaptations to treatments based on availability of resources, regionalization of care, and the development of centers of excellence within each LMIC are crucial to improving outcomes and lowering trauma-related morbidity and mortality worldwide. Given limitations in the availability of the resources necessary to provide the levels of care found in high-income countries, strategies to prevent trauma and make the best use of available resources when prevention fails, and thus achieve the best possible outcomes for injured and critically ill children, are vital. Overall, a commitment on the part of governments in LMICs to the provision of adequate health care services to their populations will improve the outcomes of injured children. This review details the evaluation and management of traumatic injuries in pediatric patients and gives some recommendations for improvements to trauma care in LMICs.

Introduction

The World Health Organization (WHO) estimates that by 2020, injuries will constitute the leading “disease” globally and will likely account for 20% of all disability-adjusted life year (DALY) losses for the world’s population.¹ Traumatic injuries are a significant cause of death and disability worldwide causing over 5 million deaths annually including 830,000 children.² Ninety-five percent of these deaths

(both intentional and unintentional) occur in low- and middle-income countries (LMICs).² The death rate in LMICs is almost twice that in high-income countries (HICs) and the rate for DALYs in LMICs is more than three times that in HICs.³ The WHO estimates up to half of all children who present to a hospital with unintentional injuries will be left with a lifelong disability.³ The top five etiologies for unintentional injuries reported by the WHO are road traffic injuries (RTI), falls,

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burns, drowning, and poisoning.² Given resource limitations in LMICs, strategies to prevent trauma and carefully utilize available resources for the care of injured and critically ill children are vital. This review details the evaluation and management of traumatic injuries in pediatric patients and gives some recommendations for improvements to trauma care in LMICs.

Emergency Trauma Care

Trauma Systems

It is well established that systematization of trauma care reduces mortality by up to 15 to 20% and improves outcomes.^{4,5} These systems include prehospital care, initial hospital care, interhospital referral services, and rehabilitation.

Prehospital Trauma Care

Unfortunately, in LMICs, trauma care systems rarely exist. Injured children are often taken directly to the nearest hospital by laypeople with no formal training in transportation and resuscitation of trauma patients and less frequently by ambulances (public or private).⁶ The lack of prehospital care systems leads to many injured children arriving to the hospital clinically compromised due to the time lag, the type of first aid received (or not), and the mode of transportation to the hospital.⁶ In the absence of established prehospital trauma systems, the WHO recommends the development of layperson first-responder training programs as an essential step in establishing prehospital systems of care.⁷ Successful programs have been implemented in LMICs that identify and maximize existing resources adapting to learners with little formal education and are responsive to postimplementation evaluation.⁸

Emergency Department Evaluation and Management

Many hospitals in LMICs see large numbers of patients and have few staff, leading to delayed assessment and treatment.⁹ Dedicated emergency departments (ED) with emergency medicine specialists or trauma centers with trauma teams are usually nonexistent in this setting and most pediatric injuries are thus initially managed by health care providers with no additional training in pediatric trauma care. This significantly influences outcomes, which correlate more with the timing and appropriateness of medical attention received than the severity of injury sustained.¹⁰ The development and rollout of Emergency Triage, Assessment and Treatment plus training in this setting has helped to prioritize pediatric trauma cases in relation to other case presentations in the ED.¹¹ Good trauma outcomes have been achieved in some centers that have developed protocols for trauma management, including triage, and adopted Advanced Trauma Life Support (ATLS)[®] guidelines for the assessment, resuscitation, and early definitive management of injuries.¹² Guidelines on the resources necessary for appropriate pediatric trauma care are available from the WHO and the African Federation for Emergency Medicine that are adaptable based on the availability of resources.^{7,13} Studies from both Ghana and Trinidad and Tobago have shown continuing education in trauma for nonspecialist clinicians to be cost-effective.^{14,15}

With Internet access becoming readily available in LMICs, tele-simulation could be the key to teaching and developing pediatric trauma resuscitation skills among health care providers in these settings. In a recent study, physicians in Gaborone, Botswana, were successfully taught how to insert intraosseous (IO) needles via tele-simulation with a simulator based in Toronto, Canada.¹⁶

Pediatric trauma care should be an integrated part of the undergraduate medical curriculum as well as a key rotation within postgraduate training programs in surgery, pediatrics, general practice, and emergency medicine. Development of trauma teams should be adapted to the local context in each LMIC and requires investments in education, training, and equipment.¹⁷

System-Based Injury Evaluation and Management

Traumatic Brain Injuries

Traumatic brain injury (TBI) is a leading cause of death and disability worldwide.¹⁸ LMICs bear the largest burden of TBI but have a paucity of prevention programs, poor prehospital and hospital-based care, and limited rehabilitation facilities, all leading to poor patient outcomes.^{18,19}

There are published guidelines for the management of severe TBI in infants and children.²⁰ The application of these guidelines in LMICs is variable given differences in neurotrauma resources.¹⁸ Rubiano et al note that sub-Saharan Africa, with a population of 600 million people, has 79 neurosurgeons compared with North America, with a population of 370 million people and 4,583 neurosurgeons.¹⁸ This points to the necessity of regionalization to optimize neurosurgical resources in LMICs. Some propose an Advanced Life Support in Brain Injury course similar to the ATLS and Advanced Cardiac Life Support courses to disseminate the knowledge necessary to improve outcomes across the health care spectrum from prehospital to rehabilitation.²¹

The initial evaluation of a child who has sustained a severe TBI involves a primary and secondary survey with an emphasis on the neurologic examination, determination of the Glasgow Coma Scale (GCS), and notation of any evidence of increased intracranial pressure (ICP). The goal of TBI management is the prevention of secondary brain injury by optimizing oxygenation and cerebral perfusion.^{20,22} An advanced airway and mechanical ventilation may be required. Intravenous fluid resuscitation with isotonic fluids and the use of inotropic support to maintain adequate mean arterial blood pressure are important. Radiographic evaluation of patients with severe TBI (GCS < 8) is ideally accomplished with cranial computed tomography (CT) to evaluate for fracture and intracranial pathology.^{23,24} CT scanners are not always available and less sensitive skull radiographs are used to determine if a fracture is present.^{24,25} Unfortunately, radiographs do not reveal intracranial lesions, but may aid in deciding where to drill a burr hole if necessary. When increased ICP or cerebral edema are present, osmolar therapy with hypertonic saline or mannitol is initiated.^{20,22} Ventriculostomy catheters to monitor ICP are usually indicated

when the GCS < 8, but this is often not possible in limited resource settings. Optic nerve sheath ultrasonography has also been used to detect elevated ICP.²⁶ Chesnut et al showed no significant differences in outcome for patients treated with ICP monitoring versus clinical examination and serial CT scans.²⁷ Surgical management, which includes drainage of extra-axial blood and/or decompressive craniectomy for intractable intracranial hypertension, is sometimes necessary. Ancillary aspects of care include maintenance of euthermia, provision of adequate sedation and analgesia, adequate caloric and protein intake with avoidance of both hyperglycemia and hypoglycemia, and seizure control.^{20,22}

Blunt Abdominal Injuries

The abdomen is the third most commonly injured part of the body after the cranium and extremities.²⁸ Intra-abdominal injuries (IAI) can cause significant morbidity and mortality, but outcomes are often linked with the presence of other injuries, particularly TBI.²⁸ Most IAI are due to motor vehicle-related crashes and falls.^{28,29} Evaluation of the patient with blunt abdominal trauma begins with a detailed history and physical examination. Significant abdominal tenderness should lead to concern for IAI.^{28,30} Increased severity of abdominal tenderness, abdominal distention, absence of bowel sounds, and peritoneal irritation all point to IAI that may require surgical intervention.³⁰ Children are less likely to present with the classic "seat-belt" sign on exam in LMICs, but its presence should lead to concern for bowel, renal, and spinal injuries.²⁹ Injuries to the spleen and liver are the most common IAI. The American Association for the Surgery of Trauma has classified these injuries.^{31,32} Bowel injuries occur in approximately 1 to 5% of blunt abdominal injuries.²⁸ The jejunum is most commonly injured, accounting for about one-third of all hollow-viscous injuries, followed by the duodenum.²⁸ A high index of suspicion and frequent reexamination are key to diagnosing these injuries, especially where imaging resources are limited. Initial management after blunt abdominal injuries involves making sure the patient's airway is patent and protected and that oxygenation is adequate, IV access is established, and resuscitation with isotonic fluids provided.²⁸ Ongoing close monitoring of vital signs, mental status, urine output, and frequent abdominal exams are important.²⁸ Imaging following abdominal trauma usually begins with Focused Assessment with Sonography for Trauma (FAST) evaluation.²⁸ This aids in identifying intraperitoneal blood or fluid that may indicate visceral injury,²⁸ but may miss up to 34% of solid organ injuries in children.²⁹ CT scans are a staple of the evaluation of abdominal trauma in HICs, but less likely to be available in LMICs.³⁰ The clinician is then forced to rely on physical diagnosis skills.

Notably, in HICs, up to 95% of blunt abdominal trauma can be managed nonoperatively.²⁸ CT and ultrasound imaging have made this possible, but have variable availability in LMICs.²⁹ However, the fact that most visceral injuries do not require surgery offers a potential opportunity in LMICs with limited surgical resources to achieve comparable outcomes with close clinical monitoring and supportive care. If urgent surgical intervention in these patients is needed,

centers where there is limited surgical capability should initiate resuscitation and plan for early transfer to a higher level of care.

Thoracic Injuries

Blunt thoracic trauma commonly arises from motor vehicle crashes (MVC) where children are frequently passengers or pedestrians in such events. Pediatric developmental physiology differs from adults, which plays an important part in their response to trauma.^{32,33} Due to more compliant, cartilaginous chest walls, high-energy injuries like rib and sternal fractures may not be radiographically apparent on initial investigation.³² Thoracic injuries are often associated with TBI and abdominal trauma because of the disproportionately smaller size of the chest compared with the head and abdomen.³⁴ It is imperative to assess the whole patient when they have chest trauma to rule out other injuries. Pediatric trauma scores may be of value in triaging and initiation of care.^{33,35} Evaluation of thoracic injuries involves doing a primary and secondary survey. Initial resuscitation follows ATLS guidelines. Imaging is required in addition to the FAST exam, usually radiographs and ultrasound. CT scan imaging and other advanced imaging techniques can be useful adjuncts but may not be readily available in LMICs, and are a strain on resources for both patients and health care facilities.³⁴ At a minimum, a chest radiograph should be obtained.

Initial resuscitation should follow the usual ABCs while ensuring C-spine immobilization for polytrauma patients. Clinical presentation is dependent on the type of injury. An underlying pulmonary contusion is usually more prognostic than the chest wall injury itself.³³ Rib fractures are usually very painful because of the inability to immobilize them. A high index of suspicion should be maintained for traumatic asphyxia for patients who present with tachypnea and facial petechiae.³³ Proper airway management takes priority in patients with tracheobronchial injuries. Other injuries may include a simple or tension pneumothorax, hemothorax, esophageal injuries, and diaphragmatic and cardiac injuries. Algorithms have been developed for these that can be adapted to the LMIC setting.³²

Blunt cardiac injury (BCI) is often underdiagnosed secondary to a lack of diagnostic modalities such as troponin screening, electrocardiography and echocardiography, and a low index of suspicion.^{36,37} Persistent tachycardia or other arrhythmia in the face of thoracic trauma should prompt an evaluation for BCI. In HIC, emergency thoracotomy has been described and has been shown to be lifesaving for children with penetrating cardiac injuries.^{38,39} In many LMIC settings, ER thoracotomy is not currently feasible, though temporizing measures such as pericardiocentesis or pericardial catheter placement may be possible. Consideration for early referral to a better-equipped trauma unit should be made after initial stabilization.

Orthopedic Injuries

Data on orthopedic injuries in LMICs are limited, but they are second only to TBI in incidence.⁴⁰ The majority of these occur from falls, but MVC-related injuries are rising. In some LMICs,

child laborers may be injured while working. Orthopedic injuries in children differ from adults in regard to mechanisms of injury, fracture patterns, healing, and treatment.⁴¹ The most significant difference between adult and pediatric skeletons is the presence of the physis or growth plate, and physeal fractures represent approximately 18% of fractures.⁴¹ There are four distinct types of fractures seen in children including plastic deformity, torus fractures, greenstick fractures, and physeal fractures.⁴¹ A careful history and physical examination, with particular attention paid to the neurovascular status, are important. Provision of adequate analgesia is key in pediatric patients and facilitates evaluation and management. Radiographic evaluation of fracture in at least two planes, including the joint above and below, is necessary.⁴¹

Management begins with stabilization/splinting of the fractured extremity. Pelvic binding, if indicated for maintenance of hemodynamic stability, should be performed as part of the circulation assessment in the primary survey. Wounds should be irrigated with large amounts of clean water as needed for open fractures, and antibiotic therapy initiated if indicated, in addition to tetanus prophylaxis. External fixation and traction are applied as needed. The majority of patients would ideally benefit from specialized care with appropriate reduction and fixation, whether internal or external, as needed.^{42,43} Where surgical resources are available, open reduction and internal fixation of fractures can be provided.^{42,44} Unfortunately in LMICs, most of these patients are not seen by an orthopedic surgeon, but by a general surgeon or a nonsurgical provider with no orthopedic training.⁴⁰ Fractures are then managed conservatively either using closed reduction and casting or, in the case of open fractures, with external fixation to allow access to wounds. Stabilization and early transfer to a higher level of care, when needed, is key.

Burn Injuries

Burns that leave a child permanently disfigured and disabled have been described as being the most tragic event to ever befall a child.⁴⁵ Yet they continue to occur in record numbers with an estimated 265,000 burn deaths annually, 95% of which occur in LMICs.⁴⁶ Children less than 5 years of age have been consistently shown to be at great risk, with approximately 100,000 admissions per year, which is likely a vast underestimation.⁴⁷ Improvements in burn management, morbidity, and mortality have occurred in recent decades, with most burn centers in HIC reporting an LA50 (lethal total body burn surface area [TBSA] for 50% of patients) >90% TBSA.⁴⁸ Unfortunately there is an extremely large variability in outcomes reported across LMICs, with most reporting an aggregate LA50 < 40%⁴⁹ and many reporting 100% mortality with burns >40% TBSA. These poor outcomes are multifactorial but are most often related to delayed presentation and lack of trained personnel and burn centers.⁴⁹ Management continues to rely on early recognition of significant burns (>10–20% second or third degree), evaluation and management of airway involvement, and initiation of supportive care, including large bore intravenous catheter placement and fluid resuscitation. A survey of burn resuscitation in the African continent revealed that parenteral fluid

resuscitation protocols using lactated Ringers solution based upon the Parkland formula continue to be most prevalent.⁵⁰ There was also an increased utilization of enteral hydration in the form of oral rehydration solution (ORS), along with a focus on clinical end points such as urine output, rather than invasive monitoring, in comparison with higher resourced counterparts. Nonetheless, in certain resource-poor settings, ORS is a viable option for burn resuscitation.⁵¹ Patients with significant burns have better outcomes when treated at centers familiar with burn care, and therefore immediate transfer whenever possible is encouraged. These centers more commonly have access to typical burn therapies such as protocolized resuscitation, topical antibiotics, and skin grafting.⁵² These centers are more likely to employ contracture avoidance techniques like splinting and physiotherapy to prevent further morbidity. However, the importance of early recognition, resuscitation initiation, maintenance of euthermia, and basic wound dressings can and should be initiated at the first point of contact. Early referral to tertiary burn centers whenever possible is key. Burn prevention and education continue to lead the way in reducing the morbidity and mortality. The majority of childhood burns occur in the home and therefore public health interventions that target changing the type of fuel used for cooking/lighting, location of these fires, and storage of the fuel have preliminarily resulted in a reduction of burns (► Table 1).⁵³

Financial Resources for Trauma Care

The proper stewardship of scarce resources in LMICs is crucial. In many LMICs, misuse of resources and redirection of monies meant for health care and infrastructure development are common. However, the historical effects of structural adjustment programs, geopolitics, and foreign policy on the availability of these resources cannot be forgotten.⁵⁴ The WHO recognizes three categories that pertain to the provision of care where improvement efforts may be focused: physical resources such as equipment, organizational resources, and human resources, which include adequately trained staff. The WHO *Guidelines for Essential Trauma Care* published in 2004 outlined 11 core essential services that should be available, based on the level of care, from small rural clinics to tertiary centers.⁵⁵ It is important that governments in LMICs view these guidelines as a call to action and work to ensure at least the bare modicum of infrastructure required to provide care is available. Retention of hospital personnel has been problematic because of poor pay, lack of recognition, and frustration with the lack of resources.^{25,56} While some governments have tackled this problem with mandatory service before licensure, this is not a long-term solution.⁵⁶ The use of non-physicians for medical care provision when no physician is available, termed “task-shifting,” is another viable option.⁵⁵ In this model, clinical officers or community health workers are trained and assigned to do certain tasks that typically only a physician would. However, a more thoughtful and strategic approach to physician and nurse compensation may alleviate the “brain drain” that affects most LMICs and decreases the number of available caregivers. In addition, governments

must provide these caregivers with the tools they need to properly care for patients.

The importance of increasing the number of nurses in LMICs and providing them with ample training cannot be overstated. It is clear that while the focus of many strategies to improve health care in LMICs focuses on physician resources, these efforts have little chance of success without adequate nursing staff. Standardization and protocolized care as well as regionalization of trauma care may improve outcomes for patients in LMICs and result in better resource utilization.

^{3,25,54} Improvements in care provision in LMICs do not necessarily always require significant financial resources. One innovative project involved the use of lean methodology to improve care in a Ghanaian ED.⁵⁷ The study found that similar to HICs, the root causes of many system inefficiencies were due to inadequate staff training, poorly defined job responsibilities, poor communication, and lack of standardized workflow.⁵⁷ Overall, it will be important for LMICs to continue to work to build capacity, eliminate waste and corruption, apportion resources to health care as able, and work with

Table 1 Summary of trauma management by system

Type of injury	Evidenced-based adaptations for management in limited-resource settings	Evidenced-based adaptations for the extremely limited acute care setting
Traumatic brain injury	1. Recognition of altered consciousness and lateralizing signs	1. Recognition of altered consciousness and lateralizing signs
	2. Elevation of the head with midline positioning	2. Elevation of the head with midline positioning
	3. Oxygen administration; If indicated, intubation and mechanical ventilation	3. Oxygen administration (via cylinder or concentrator); if indicated, intubation with hand BVM ventilation for transport to higher level of care
	4. IV fluid resuscitation with isotonic fluids (avoid overhydration)	4. IV fluid resuscitation as able with isotonic fluids (avoid overhydration)
	5. CT scan if available to evaluate for fracture and other intracranial pathology	5. Cranial X-ray to evaluate for fracture (4-view)
	6. Hyperosmolar therapy (hypertonic saline [HTS], mannitol)	6. Hyperosmolar therapy (mannitol)
	7. HTS to maintain serum sodium 145–155	7. Intermittent dosing with mannitol to keep serum osmolality 300–320 mmol/L (avoid hyponatremia)
	8. ICP monitoring with ventriculostomy (GCS 3–8) and ongoing close neurologic examination. Goal ICP > 15 mm Hg	8. Ongoing close neurologic examination; recognition of lateralizing signs
	9. Surgical drainage of extra-axial blood (SDH, EDH). Surgical decompressive craniectomy if indicated	9. Burr hole if equipment and skilled provider available
	10. Maintenance of euthermia	10. Maintenance of euthermia
	11. Provision of adequate protein and caloric intake via gastric or postpyloric tube (avoid hyperglycemia)	11. Provision of adequate protein and caloric intake via gastric tube (avoid hyperglycemia)
	12. IV sedation and analgesia for patient comfort	12. IV or PO analgesia/sedation as needed for patient comfort
	13. Antiseizure prophylaxis (phenytoin, fosphenytoin, or levetiracetam) for 7 d postinjury	13. Antiseizure prophylaxis (phenobarbital) for 7 d postinjury
Blunt abdominal injuries	1. Recognition of signs and symptoms of serious intra-abdominal injury	1. Recognition of signs and symptoms of serious intra-abdominal injury
	2. FAST exam to look for intraperitoneal fluid/blood. Where available, consider CT scan. If not available, get abdominal X-ray	2. FAST exam to look for intraperitoneal fluid/blood. If ultrasound not available, consider abdominal X-ray. Also, consider DPL
	3. Urinalysis	3. Urinalysis
	4. Fluid resuscitation with isotonic fluids	4. Fluid resuscitation with isotonic fluids
	5. Close and ongoing monitoring of vital signs	5. Close and ongoing monitoring of vital signs
	6. Close monitoring of hematologic indices	6. Close monitoring of hematologic indices if available
	7. Transfusion with PRBCs for Hgb < 7 g/dL or hemodynamic instability	7. Transfusion for Hgb < 7 g/dL or hemodynamic instability. If no transfusion capability, early transfer to higher level of care for transfusion/surgical intervention
	8. Surgical intervention for hemodynamic instability that persists despite fluids/blood products or free air on radiographic studies	8. Early transfer for surgical intervention for hemodynamic instability or noted free air on radiographic studies

Table 1 (Continued)

Type of injury	Evidenced-based adaptations for management in limited-resource settings	Evidenced-based adaptations for the extremely limited acute care setting
Thoracic injuries	1. Early recognition of signs and symptoms of severe thoracic injuries (including doing primary and secondary surveys)	1. Early recognition of signs and symptoms of severe thoracic injuries (including doing primary and secondary surveys)
	2. Oxygen administration and if indicated, assisted ventilation	2. Oxygen administration
	3. Laboratory workup: CBC, type, and cross	3. Laboratory workup: CBC, type, and cross
	4. Appropriate fluid resuscitation	4. Appropriate fluid resuscitation
	5. X-ray/CT scan evaluation	5. Plain radiographs for evaluation
	6. Continuous monitoring of vital signs and serial evaluation	6. Continuous monitoring of vital signs and serial evaluation
	7. Tube thoracostomy as indicated	7. Tube thoracostomy as indicated
	8. Evaluation for possible surgical management/thoracotomy based on indications and early referral	8. Assessment and early referral for possible surgical management/thoracotomy
Orthopedic injuries	1. Early recognition of orthopedic injuries and check for circulatory and neurologic compromise	1. Early recognition of orthopedic injuries and check for circulatory and neurologic compromise.
	2. Stabilization/splinting of fractured extremity; pelvic binding if indicated	2. Stabilization/splinting of fractured extremity; pelvic binding if indicated
	3. Provision of adequate analgesia	3. Provision of adequate analgesia
	4. External fixation and traction as needed	4. External fixation and traction as needed
	5. Wound management as needed for open fractures and antibiotic therapy if indicated as well as tetanus prophylaxis	5. Wound management as needed for open fractures and antibiotic therapy if indicated as well as tetanus prophylaxis
	6. Open reduction and internal fixation of fractures as indicated	6. Closed reduction and casting
	7. Closed reduction and casting	7. Early transfer for surgical management for open fractures, complex closed fractures, pelvic fractures, especially with hemodynamic instability
Burns	1. Evaluate for inhalational injury and need for intubation	1. Evaluate for inhalational injury and need for supplemental oxygen
	2. Typical primary survey (ABCs) and classification of burn depth and extent (Lund-Browder chart)	2. Typical primary survey (ABCs) and classification of burn depth and extent (Lund-Browder chart)
	3. EARLY recognition of significant burn (>20% TBSA)	3. EARLY recognition of significant burn (>20% TBSA)
	4. Initiation of burn fluid resuscitation protocol	4. Initiation of burn fluid resuscitation protocol; if no IVF available, can use ORS
	5. Pain control with available opioid	5. Pain control with available opioid
	6. Cover burns with silvadene or antibiotic ointment such as bacitracin; if none available, Dakin solution or honey	6. Treat burns with silvadene or antibiotic ointment such as bacitracin, Dakin solution or honey
	7. Maintain euthermia	7. Maintain euthermia
	8. AFTER above, consider transfer	8. AFTER above, consider transfer

Abbreviations: BVM, bag valve mask; CBC, complete blood count; CT, computed tomography; DPL, diagnostic peritoneal lavage; EDH, epidural hematoma; FAST, Focused Assessment with Sonography for Trauma; GCS, Glasgow Coma Score; ICP, intracranial pressure; IVF, intravenous fluid; ORS, oral rehydration solution; PO, oral; PRBCs, packed red blood cells; SDH, subdural hematoma; TBSA, total body burn surface area.

international and local private partners to improve systems of trauma care.

A significant barrier to trauma care in LMICs is poverty. In most LMICs, many people are not able to afford the cost of medical care. Public funding of health care services allows injured patients to be evaluated and treated promptly free of charge instead of first having to find the funds to pay out of pocket. This reduces delays in seeking care. However, it is vitally important that these public health facilities are properly funded and managed.

Prevention

Given the paucity of available resources, the importance of injury prevention in LMICs cannot be overstated. Published in 2008, the *World Report on Child Injury Prevention* set out seven key recommendations for injury prevention.⁵⁸ These were the following:

- Integration of child injury into a comprehensive approach to child health and development.

- Development and implementation of child-injury-prevention policies and plans of action.
- Implementation of specific actions to prevent and control child injuries.
- Strengthening of health systems to address childhood injuries.
- Enhancement of the quality and quantity of data for child-injury prevention.
- Definition of research priorities.
- Increasing awareness of and target investments toward child-injury prevention.

These recommendations are a sound basis for moving forward. Multiple studies have shown that injuries in children are preventable through the combination of education, legislation and enforcement, environmental modifications, and promotion of safer products and safety devices.⁵⁹ Recognition of an “epidemiologic transition” in LMICs from acute infectious diseases and malnutrition to injuries as a leading cause of mortality is important.⁶⁰ Key to decreasing the morbidity and mortality associated with childhood injuries is the concept of injury control.⁶⁰ This encompasses not just primary prevention, but also secondary prevention, which includes improved prehospital care, regionalized trauma care, and optimized hospital care. It also includes tertiary prevention, which entails rehabilitation of the injured child to return to as much of their baseline state as possible.⁶⁰ Rehabilitation is particularly challenging given the scarcity of rehabilitation physicians in LMICs, which has led the WHO and other groups to propose community-based rehabilitation provided by families.⁶⁰ While injury prevention is only slowly gaining traction in LMICs, advances have been made in several countries. In Vietnam for example, significant inroads have been made in raising community awareness about injury prevention and legislation mandating helmet use by all riders and passengers on motorcycles has the potential to decrease morbidity and mortality in a country where these are the principal mode of transportation.⁵⁹ The Road Safety in 10 Countries project has made some progress in reducing injuries from RTI in the countries involved.⁶⁰ In Bangladesh, the Saving of Lives from Drowning project aims to reduce the high burden of childhood drowning and is one of the largest childhood-drowning-prevention projects ever undertaken in LMICs.⁶¹

Conclusion

Trauma remains a leading cause of morbidity and mortality worldwide with a significant part of the burden on children in LMICs. Attention to protocolized care and adaptations to treatment based on availability of resources are key. Regionalization of care, development of centers of excellence within each LMIC, and an emphasis on injury prevention are fundamental to improving outcomes and lowering trauma-related morbidity and mortality worldwide. Overall, a commitment on the part of governments in LMICs to the provision of adequate health care services to their populations will not only be a bulwark against the scourge of acute infectious diseases, but also improve the outcomes of injured children in these settings.

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