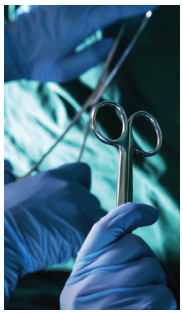

Chapter 3

Surgery and Trauma Care

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INTRODUCTION

The burden of death and disability attributable to lack of access to surgical care for traumatic injuries, as well as of nontraumatic chronic conditions and soft tissue and bone infections, falls most heavily on people in low- and middle-income countries (LMICs) (Ozgediz and others 2008; Spiegel and others 2008). Human and technical capacities are insufficient to address the existing burden of injuries in these countries. Selected surgical interventions for trauma have proven cost-effective in these settings, and innovative low-cost programs and interventions have improved trauma care outcomes at individual hospitals. It is critical that LMICs create or strengthen existing trauma systems to improve outcomes. Identifying effective and cost-effective interventions and strategies to inform the future direction of these resource-challenged countries is an essential step in this process.

The chapter on surgery in the *Disease Control Priorities in Developing Countries*, second edition (*DCP2*) (Jamison and others 2006) exposed the scarcity of relevant evidence on outcomes, effectiveness, and cost-effectiveness in the literature from the developing world; unfortunately, this situation has improved only mildly. Although some interventions and strategies have been identified (Tollefson and Larrabee 2012), deficiencies in both the quantity and the quality of data remain glaring (Vos 2009).

This chapter addresses the surgical aspects of care for these conditions. It presents available epidemiological data, as well as data on systematic approaches to trauma and interventions in specific anatomic areas.

International and National Advocacy for Improved Trauma Care

International and national organizations have begun to recognize and implement strategies for addressing the worldwide trauma pandemic. The World Health Organization (WHO) has developed guidelines with an internationally applicable metric for countries to use to evaluate and monitor resources for trauma care in their health care facilities and system-wide parameters. The creation of the WHO Global Alliance for Care of the Injured provides a common platform for greater political advocacy for increased attention and resource allocation to trauma care. World Health Assembly (WHA) Resolution 60.22 on trauma and emergency care services provides a high-level global political endorsement for improvements in trauma care. The Ministry of Health in Uganda targeted trauma care and injury prevention as one of the nation's top 10 health care priorities, following the review of data collected from a WHO-supported hospital-based injury surveillance system that demonstrated the significant burden of disease arising from injuries.

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GLOBAL BURDEN OF TRAUMA

One of the findings of the 2013 Global Health Estimates (GHE) study is that the ongoing epidemiological transition is shifting the global disease burden away from premature deaths (years of life lost, YLLs) and toward years lived with disability (YLDs) (WHO 2013b). Worldwide, the percentage of deaths due to injury has fallen from 9.4 percent to 9.1 percent.

During the same period, deaths due to musculoskeletal disorders have increased 34 percent (WHO 2013b), as summarized in table 3.1. The WHO report on road safety estimates that 1.25 million people died from road traffic injuries (RTIs) in 2010 (WHO 2013c). More than 75 percent of those were young males in their productive years. More than 50 percent of all deaths in LMICs were pedestrians and cyclists. For every death, it is estimated that 20 people are injured; of these injured, one will experience some form of permanent disability. The burden of RTIs is already disproportionally shouldered by LMICs (Ameratunga, Hijar, and Norton 2006), and most of the projected increase of this burden will occur in countries with rapid economic growth, in particular, China and India (Mathew and Hanson 2009; WHO 2013c).

Epidemiological Burden of Preventable Trauma Deaths

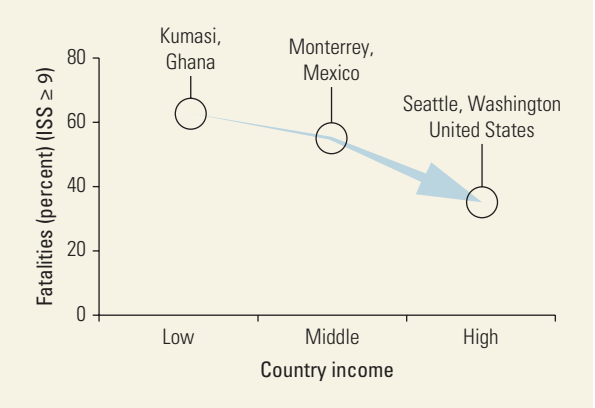
Decreasing the heavy burden imposed on individuals and society is the overarching mission of trauma systems and one of the main challenges for public health in this century (ACS 2006; Mock and others 2004). People in LMICs have as yet been unable to benefit as significantly from trauma system development as those in high-income countries (HICs) have. Case fatality rates for seriously injured patients (Injury Severity Score [ISS] ≥ 9) were significantly lower in an HIC (the United States), compared with a middle-income country (MIC) (Mexico), or a low-income country (LIC) (Ghana), as shown in figure 3.1 (Mock and others 1998).

Table 3.1 Worldwide Rankings of Injuries and Musculoskeletal Conditions for Deaths, YLDs, and DALYs, 2000–11

		Ranking		Change in rates per 100,000 population (percent)
		2000	2011	
All injuries	Deaths	n.a.	n.a.	–8.7
	YLDs	n.a.	n.a.	8.7
	DALYs	n.a.	n.a.	–15.3
Road traffic injuries	Deaths	11	9	8.9
	YLDs	16	15	–2.4
	DALYs	10	8	+0.9
Falls	Deaths	n.a.	n.a.	13.7
	YLDs	8	8	12.0
	DALYs	n.a.	17	4.0
Musculoskeletal disorders	Deaths	n.a.	n.a.	+34.0
	YLDs	n.a.	n.a.	+7.2
	DALYs	n.a.	n.a.	+8.3

Source: Data based on Global Health Estimates (WHO 2013b).
Note: DALYs = disability-adjusted life years; YLDs = years lived with disability; n.a. = not available.

Figure 3.1 Case Fatality Rates for Severely Injured People, 1998



Source: Data based on Mock and others (1998). Illustration courtesy of Intermountain Healthcare.
Note: ISS = Injury Severity Score. Income classifications are based on status at the time of the study. Ghana is now a lower-middle-income country, and Mexico is an upper-middle-income country.

Between 1.7 and 1.9 million lives, or 34–38 percent of all injury deaths in LMICs, could be saved if trauma care initiatives could be designed and implemented to reduce the case fatality rates among seriously injured patients to equal those in HICs (Mock and others 2012).

Systematic Approach to Trauma Care

Although this chapter concentrates on the effectiveness of individual interventions, such as operations, the overall organizational context within which these interventions are provided needs to be considered as an integral part of the health care system. Trauma care necessitates the rapid availability of trained personnel and readily available and sufficient equipment and supplies. Improving the availability of these human and physical resources and monitoring the care-provision process can significantly improve the outcomes. Better system-wide organization and planning for trauma care can help achieve these goals.

A trauma system encompasses the entire spectrum of services that a country or region has in place: prehospital care, initial emergency care, definitive hospital care

(care provided after initial resuscitation to definitively treat injuries), and long-term rehabilitation of injured survivors. It also encompasses the information systems needed to monitor and ensure quality of care along this spectrum. In HICs, a variety of elements commonly constitute a formal and well-organized trauma system (table 3.2).

These elements are facilitated by enabling legislation and oversight by appropriately empowered governmental agencies to achieve the basic goals for trauma systems (box 3.1).

Table 3.2 Elements of Trauma Care Systems that Coordinate with the Public Health System

Prevention
Prehospital Care
Standards for training for paramedics and for equipment on ambulances
Triage protocols for prehospital care
Definitive Hospital Care
Network of facilities with increasing trauma care capabilities
External verification of hospitals and trauma centers with different levels of capability for trauma care
Transfer guidelines and interfacility protocols
Rehabilitation
Process Improvement and Patient Safety Initiatives
Research
Trauma registries

Source: Authors.

Box 3.1

Trauma Care System Goals

- Decrease the incidence and severity of trauma
- Ensure optimal, equitable, accessible care for all trauma patients
- Prevent unnecessary deaths and disabilities from trauma
- Contain costs and enhance efficiency
- Implement quality- and performance-improvement processes
- Identify appropriate resources and ensure their availability

Source: Adapted from U.S. DHHS (2006).

EFFECTIVENESS OF TRAUMA CARE SYSTEMS

Geographic areas that implement better-organized trauma systems that include the elements listed in table 3.2 are able to decrease trauma mortality. Better-organized trauma systems have been consistently shown to decrease mortality by 15–20 percent among treated patients. The effect is even more pronounced in lowering medically preventable deaths, that is, deaths from causes that should be able to be treated well in most locations, such as deaths from airway obstruction or splenic lacerations. Such medically preventable deaths are typically decreased by 50 percent in better-organized trauma systems. These findings are fairly consistent across multiple states in the United States and provinces in Canada, as well as several other HICs, including Australia, Israel, the Netherlands, and the United Kingdom (Siman-Tov, Radomislensky, and Peleg 2012; Tallon and others 2012). Better-organized trauma systems have also demonstrated improved functional outcomes among survivors of severe injuries (Gabbe and others 2012).

Improvements in the organization of trauma systems have generally been very low cost in comparison with the overall cost of trauma care. For example, strengthening the trauma care system in Quebec Province, Canada, led to a notable decrease in mortality of all severely injured persons province-wide from 50 percent in the early 1990s to 10 percent in the early 2000s. The costs of this reduction were low and sustainable. An initial expenditure of Can$2 million (US$1.5 million) was invested to elevate the four major trauma centers in the province to minimum criteria, especially with respect to infrastructure. This expenditure amounted to far less than 1 percent of the provincial health budget for that year. Subsequently, the only ongoing cost has been for the monitoring, evaluation, and regulatory oversight provided by the accreditation committee. These costs have been minimal because the work was mostly done by volunteer academics and trauma care clinicians (WHO 2010) (box 3.2).

The ability to demonstrate systemwide improvements in trauma mortality rates requires regionwide trauma registries or other health information systems to monitor mortality rates among injured persons. Such information systems are rudimentary or nonexistent in most LMICs. There have been almost no reports of effectiveness of systemwide improvements in these countries. Many lack designated national lead agencies to oversee trauma-related issues, including policy making, finance, establishment of trauma systems, training of personnel, and accreditation or licensing of trauma care providers (Zong and others 2011).

Box 3.2

Story of a Successful System-Wide Improvement: The Quebec Trauma System

The Problem

In 1989, trauma-related mortality was higher in Quebec than in the rest of Canada and the United States because of the following deficiencies:

- No prehospital triage system
- No communication system among centers to facilitate the arrival, referral, and transport of patients
- No prehospital treatment guidelines
- No province-wide, uniform hospital management standards
- No mechanism for quality control.

The Solution

The implementation of a province-wide trauma registry that included all trauma admissions allowed evidence-based policy decisions to be made and led to the phased implementation of a comprehensive trauma system:

- **Phase 1** (1993–94): Accreditation of trauma centers and initiation of a trauma care network, following American College of Surgeons guidelines
- **Phase 2** (1994–97): Creation of prehospital triage and interhospital transfer protocols. The registry had allowed the identification of a subset of patients with severe injuries, and these patients were now brought directly to first-level trauma centers.
- **Phase 3** (1997–present): Review, evaluation, and consolidation of the system. New second-level and third-level centers were accredited, and some older centers lost their accreditation. Protocols were reviewed and updated, as necessary; areas of subspecialty care were made operational.

The Results

- Overall mortality fell from 20 percent to 10 percent after accreditation of first-level trauma centers.
- Mean prehospital time declined from 62 to 44 minutes.
- Proportion of patients with Injury Severity Score > 25 treated at first-level centers went from 36 percent to 84 percent.
- Mortality for the subset of severely injured patients fell from 52 percent to 10 percent.
- The overall costs were very low (Can$2 million to start the program) and have remained sustainable.

Source: WHO 2010.

Nevertheless, several countries have made progress in implementing systemwide improvements. Sri Lanka has put in place a national trauma secretariat that is implementing some of the trauma system elements used in HICs, including a National Injury Surveillance System to monitor trauma care nationwide. Similarly, the Hanoi Health Department has documented progressive, sustainable improvements in the capabilities of its network of hospitals through better organization and planning, with no additional budget allocation to trauma care.

Although data to monitor patient outcomes systemwide are sparse in most LMICs, documented improvements in outcome have been made in some components of the trauma system, such as in prehospital settings. For example, improvements in prehospital care capabilities, especially through the provision of widespread first aid training for lay first responders, were found to be among the most cost-effective of all surgical interventions studied by *DCP3*, discussed in more detail in chapter 14.

Definitive Hospital Care

Poor infrastructure, limited human resources, unavailability of acute interventions, and lack of life-saving equipment and essential supplies for resuscitation plague health care facilities in LMICs trying to provide trauma care for their injured people (Choo and others 2010; Kushner and others 2010). The WHO and the International Association for Trauma Surgery and Intensive Care developed guidelines for essential trauma care services, including the following (Mock and others 2004):

- Standards for the care of the injured person
- Set of essential trauma care services

- Suggested resources necessary to offer these services
- Guidance to promote national efforts to deliver resources and services

The Essential Trauma Care Project established a set of 11 essential trauma care services that should be made available to all injured patients in any setting worldwide. This list can help hospitals, health care providers, ministries of health, and other stakeholders develop appropriate trauma care improvement initiatives (Mock and others 2006) (box 3.3).

In addition, the Essential Trauma Care Project, recognizing that every facility cannot have all the resources and skills of third-level care facilities, categorized resources and skills (essential, desired, irrelevant, or possibly required) to match the capabilities of different levels of facilities (first level, general practice, specialist, or third level) in an attempt to encourage appropriate improvements across the entire spectrum of fixed facilities in the system.

Box 3.3

Essential Trauma Care Services

Airway: Appropriately managed

Breathing: Supported until able to breathe independently

Pneumothorax/hemothorax: Diagnosed and treated expeditiously

Bleeding: Stopped, whether external or internal

Shock: Recognized and treated; intravenous fluids available

Brain injuries: Space-occupying lesions decompressed in a timely manner

Abdominal injuries: Promptly identified and treated appropriately

Extremity injuries: Corrected

Unstable spinal cord injuries: Recognized and managed with appropriate immobilization

Rehabilitation services: Provided to minimize long-term impairment

Medications: Made available for these services and for pain control.

Source: Mock and others 2004.

Although a network of facilities with increasing resources and capabilities may provide the best use of limited resources in LMICs, a variety of systems provide definitive care in different countries and regions of the world.

In China, 400,000 people die from trauma-related deaths each year (Zong and others 2011); trauma is the leading cause of death in males ages 18–40 years in China. Although no national guidelines or protocols guide trauma care, China has developed various types of regionalized trauma systems that have resulted in improved patient outcomes. Despite these regional improvements, only 1 percent of 19,712 hospitals in the country have established trauma departments.

Several LMICs have improved trauma care in the rural areas through education and simple infrastructure development (Henry and others 2012; Mock and others 2005). A trauma continuing education course taught in rural Ghana showed improvements in the initial management of trauma patients with torso and orthopedic injuries, in plastic surgical care, and in radiologic interpretation one year following training. Basic airway maneuvers (93 percent) and proper chest tube insertion (67 percent) increased significantly, while advanced airway utilization remained low (20 percent). Areas with less improvement appeared to be those requiring more advanced training, such as open fractures (33 percent), closed fractures (20 percent), and diagnosis of intra-abdominal injuries (20 percent) (Mock and others 2005).

Mongolia, using the Global Initiative for Emergency and Essential Surgical Care program, increased the percentage of rural health facilities with actual emergency rooms from 25 percent to 83 percent; the emergency room supplies availability increased from 5 percent to 65 percent over a two-year period (Henry and others 2012). Basic skills in wound debridement (15 percent to 55 percent), resuscitation (5 percent to 15 percent), fracture management (9 percent to 14 percent), and penetrating injuries (5 percent to 15 percent) all improved.

Interventions to improve prehospital trauma care have proven effective, but this area remains a significant challenge for poorer countries (Jayaraman and others 2009; Nielsen and others 2012). The quality of hospital care varies considerably according to available human and material resources (Mock 2011). Facilities that are integrated into a broader trauma system generally have better outcomes (Gruen and others 2012; O'Reilly and others 2013). McCord and Chowdhury (2003) were the first to report the cost-effectiveness analysis of a first-level hospital in rural Bangladesh that handled a heavy caseload of obstetrics but also general trauma: US$11 per disability-adjusted life year (DALY) averted.

A subsequent study in a pure trauma first-level hospital in Cambodia found a cost-effectiveness of US$78 per DALY averted (Gosselin and Heitto 2008). Another study comparing two Médecins Sans Frontières trauma hospitals in Haiti and Nigeria found a cost-effectiveness ratio of US$223 and US$172 per DALY averted, respectively, with almost all the difference attributable to pay scales and employee-benefit schemes (Gosselin, Maldonado, and Elder 2010).

Transfer Guidelines and Capabilities

The guidelines that have been refined over the past 30 years in HICs for transferring more severely injured patients to facilities with increased capabilities rely on physiologic, anatomic, and mechanistic indicators of severe injury (MacKenzie and others 2006). However, in many LMICs, formal referral systems do not exist or function poorly. In Cambodia, informal systems are used in which patients are transferred by taxi, accompanied by community volunteers (Nakahara and others 2010). Referral distances are often long and cost prohibitive for many families. Coordinated transfer of more critically injured patients to regional facilities with adequate human and physical resources could be an important method for more effectively using the limited resources in LMICs.

Rehabilitation

As injury-related disabilities increase, rehabilitation that assists with the reintegration of injured patients into functional society has broad implications. Physiotherapy and occupational therapy linked with vocational skills training programs are needed in LMICs to address the 1 billion people who are experiencing disabilities by providing the tools needed to help patients attain physical and socioeconomic independence and remain productive members of their communities (WHO 2013a).

LMICs are home to 80 percent of people with disabilities, and they are typically among the very poorest. In Haiti, the poorest country in the Western Hemisphere, Healing Hands for Haiti, a nonprofit nongovernmental organization working closely with the local health care community, provides rehabilitation education and training, clinical treatment, disability prevention, and public awareness of disability and rehabilitation.[1]

Land mines, which are prevalent in many LMICs, are responsible for approximately 26,000 new amputees per year; worldwide, there are more than 250,000 such amputees. Estimates range as high as 10 million to 25 million amputees worldwide when the effects of untreated chronic diseases, such as diabetes or vascular disease, are included. The Jaipur prosthesis, named for the town where it was designed, is a culturally appropriate, socially acceptable, low-cost but high-quality prosthetic foot that was developed in India through a partnership between an orthopedic surgeon (P. D. Sethi) and a local craftsman (Ram Chandra Sharma). Using local production methods, the Jaipur foot has been used in more than 22 countries, helping more than 900,000 amputees in developing and landmine-affected countries (Price 2013).

At its 66th assembly in 2013, the WHA adopted a resolution that calls for the WHO and member states to ensure equal access to health services for people with disabilities. This resolution, supported by 98 countries, serves as a clarion call for improved rehabilitation services in LMICs (WHO 2013a).

Research, Quality Improvement, and Patient Safety Initiatives

Trauma registries are integral for trauma research that can help monitor and improve trauma care, yet relatively few trauma registries exist in developing countries (O'Reilly and others 2013). A literature review of trauma registries in LMICs identified 84 articles; of these, 76 were sourced from 47 registries. Most were from China, the Islamic Republic of Iran, Jamaica, South Africa, and Uganda (O'Reilly and others 2013). There were large variations in processes and variables collected—some collecting less than 20 variables. A variety of ISSs were used, most commonly the standard ISS. Using information obtained from the Injury Control Center in Uganda, the Ministry of Health included injury as one of the top 10 health priorities facing the Ugandan people.[2]

Quality improvement (QI) programs have been shown to be valuable and inexpensive tools for strengthening the care of severely injured patients. The Royal Australasian College of Surgeons convened a meeting in Melbourne, Australia, in 2012 to explore experiences with trauma QI activities in LMICs in the East Asia and Pacific region (Stelfox and others 2012). Only 56 percent of the respondents reported having morbidity and mortality conferences, 31 percent monitored complications, 25 percent conducted preventable-death studies, and 6 percent used statistical methods for analyzing morbidity and mortality rates. The barriers for instituting QI programs included limited engagement and support from leaders, organizational diversity, heavy clinical workloads, and medico-legal concerns. One QI program implemented successfully at the facility level in Thailand is described in box 3.4.

Box 3.4

Success Story: A Quality Improvement Program at Khon Kaen Hospital, Thailand

The Problem

Clinicians at Khon Kaen Hospital in northern Thailand knew that they were seeing increasing trauma cases but lacked ways to document the increase to inform their recommendations for better prevention and improved trauma care.

The Solution

The hospital initiated a quality improvement (QI) program based on a trauma registry.

- **Phase 1:** Data retrieval, collection, and storage using participatory action research, peer review, and medical audits.
- **Phase 2:** Data generation to allow the identification of general problems involving diagnosis, early management, resuscitation, and monitoring, as well as specific problems involving rapid recognition and management of limb- and life-threatening injuries.
- **Phase 3:** Development of key performance indicators for the overall management of trauma patients, from prehospital care to rehabilitation after discharge upon recognition of potential pitfalls, such as delays, errors, and systemic inadequacies.

Examples include the following:

- Penetrating injuries are explored within one hour of arrival.
- Long-bone fractures are fixed within 48 hours of arrival.
- All patients with Glasgow Coma Scale <13 receive a head computed tomography scan.
- All patients are seen within four hours of arrival.

This QI program has been regularly evaluated and updated, as necessary.

The Results

Direct improvements: Mortality rates decreased 50 percent, delays in diagnosis decreased 70 percent, and diagnostic or therapeutic errors decreased 50 percent.

Indirect improvements: Improvements were made in the trauma referral plan, as well as in prehospital care and survival.

Source: WHO 2010.

Their recommendations on trauma QI and better data were included in the 2007 WHA resolution on trauma and emergency care (Mock 2007).

TRAUMA CARE OF SPECIFIC BODY REGIONS

Head, Neck, Face, and Spine

Traumatic injury epidemiology in LICs and LMICs remains a relatively neglected subject (Sitsapesan and others 2013). However, identifying the most commonly injured body regions is important in the design of the most appropriate and cost-effective treatment strategies (Stewart and others 2013). Health care providers trained in neurosurgery, otolaryngology, ophthalmology, plastic surgery, or dentistry would be better able to treat face, head, and neck injuries. Orthopedic and reconstructive surgical training might be more critical for addressing fractures.

Head injury is the leading cause of injury death in many countries (Qureshi and others 2013). An estimated 10 million people suffer traumatic brain injuries (TBIs) annually, making TBI an important public health problem. TBIs pose especially difficult problems in LICs and LMICs, where TBI rates are higher than in HICs, but existing health systems are inadequate to address the resulting disabilities (Hyder 2013). Authors in HICs, where resources are much greater, have published most of the guidelines for the management of severe brain injuries.

In Uganda, minor head injury (12 percent) was the third most common cause for trauma admission in one hospital; more severe injuries, such as intracranial hemorrhage (1.9 percent) and skull fracture (1.5 percent), were much less common (Hulme 2010). In Sierra Leone, a population survey identified injuries to the face, head, and neck combined as the

second most common cause of injuries reported (16 percent), following extremity injuries (55 percent) (Stewart and others 2013).

Access to dedicated neurosurgical care is limited in LICs and LMICs (Alexander and others 2009). General surgeons or even medical officers with limited training care for the vast majority of head injury patients. Dedicated neurosurgical units are uncommon. Although TBI is a frequent problem in South Africa (25 percent of hospital admissions are due to TBI), only a small subset of patients actually require specialized neurosurgical care.

In resource-constrained settings, basic clinical evaluation tools such as the Glasgow Coma Score (GCS) and heart rate can effectively triage head injury patients and identify those most critically ill. In Malawi, a multivariate logistic regression model revealed that GCS and heart rate changes correlated closely with mortality: a drop in heart rate below 60 beats per minute (bpm) or an increase in heart rate above 100 bpm increased the odds of dying by 10.9 and 11.6 times, respectively (Qureshi and others 2013). Based on the GCS, the odds of mortality for moderate and severe head injury increases by 4- and 88-fold, respectively, compared with mild head injury. The presence of multiple injuries exacerbated head trauma; all deaths in the moderate head injury group were associated with multiple trauma.

Accordingly, simple methods to improve care for head injuries in LMICs could include the following:

- Immediate measurement should be made of GCS and vital signs.
- Triage guidelines should be based on GCS and neurologic examination.
- Health care personnel treating patients should consider whether injured patients with GCS 3 should take up limited beds and resources in intensive care units.
- Patients with multiple trauma injuries should receive higher triage priority and appropriate and accurate resuscitation to limit mortality and morbidity.

Survival rates among the most critical neurotrauma patients depend on the development of the trauma system, including access to emergency and neurointensive care units and neurosurgeons. Low compensation for trauma care and fear of being sued may serve as disincentives to the few neurosurgeons in these areas from participating fully in integrated neurotrauma care (Rubiano and others 2013).

Spinal cord injuries usually result from road traffic accidents, falls, or sports. In Nigeria, cervical spine injuries represent 46.2 percent of all spinal injuries; the two most common causes of cervical spine injuries are RTIs (67 percent) and falls (23 percent) (Solagberu 2002). Back injuries represent 12 percent of traumatic injuries in Sierra Leone (Stewart and others 2013). In austere environments where specialized rehabilitation resources are lacking, conservative management of spine injuries with complete paralysis almost inevitably leads to sores, infections, and sepsis (Gosselin and Coppotelli 2005). Those patients with no or incomplete spinal cord injuries generally fare better than those patients with complete paralysis, but the recovery time and amount of residual disability are worse than if they had received surgical treatment.

A study from Pakistan compares costs of operative and nonoperative management of spinal injuries with complete neurological deficits. The authors find that outcomes are worse for the patients who had received surgery, as evidenced by longer length of stay, longer rehabilitation time, and higher infection rates. The mean cost of treatment is higher in the operative group (US$6,500) as compared with the nonoperative group (US$1,490). The researchers conclude that, in their setting, patients with complete spinal cord injuries should be managed nonoperatively, with surgery only if rehabilitation is impeded as the result of pain or deformity (Shamim, Ali, and Enam 2011).

Thorax and Abdomen

Patients with injuries to the thorax and abdomen may present with higher ISS scores. Information on injuries to these areas is extremely limited in LMICs and may be underdiagnosed because of patient deaths in the field, the unavailability of diagnostic capability with computed tomography scanning, and the scarcity of comprehensive registries.

Qureshi and others (2013) suggest that patients with moderate head trauma and multiple trauma may have died because of the inability to diagnose and treat abdominal injuries. Perforation of abdominal viscera was only reported in 0.5 percent of trauma cases in a Ugandan hospital, while no chest injuries were reported (Hulme 2010). Twenty-three cases of isolated small bowel perforation from blunt abdominal trauma were identified over a four-year period in a hospital in Cameroon (Chichom Mefire and others 2014). Timely diagnosis was difficult because of lack of awareness of this injury by clinicians and poor diagnostic capability. Improved education and clinical awareness, serial exams, and repeated upright chest x-rays are likely to lead to earlier diagnosis and improve treatment in low-income environments.

Pelvis and Extremities

The musculoskeletal (MSK) system is the most common site of residual disability in trauma survivors (Mock and Cherian 2008). If there is one permanently disabled person for every road traffic death, each year RTIs alone would account for 1.25 million newly disabled persons (WHO 2013c). For LMICs, the literature contains many more studies on the prevention of injuries than on their treatment (Forjuoh 2003; Norse and Hyder 2009). In many LMICs, particularly in rural areas, the first, and often only, point of care is the traditional healer. Although these healers probably do more good than harm overall, avoidable sequelae of significant injuries are well documented (Dada and others 2009). Unfortunately, the preventable burden has never been quantified.

Management protocols and techniques for optimal outcomes of MSK injuries are in general well known and widely available in HICs. They most often involve some form of bone or soft tissue surgical procedure using high-end diagnostic and intraoperative imaging and monitoring technologies and expensive implants and products. LMICs have severe shortages of well-trained surgeons, anesthesiologists, nurses, rehabilitation specialists, and equipment. Providers often have no choice but to use conservative treatment with casts and splints or traction and bed rest, with predictably worse outcomes.

Most pelvic fractures heal uneventfully with conservative management; only a minority suffer significant deformity, shortening, or chronic pain. The upper extremity can tolerate a certain degree of shortening or deformity without affecting function, so conservative treatment of fractures of the humerus, forearm, wrist, or hand, which are almost routinely treated surgically in HICs, can still yield acceptable functional results. This is not true of displaced intra-articular fractures or neglected dislocations of the shoulder, elbow, or wrist joints. The economic repercussions of a useless upper extremity in a farmer or manual laborer are self-evident. The lower extremity is not as forgiving of negative outcomes as the upper one: shortening of more than 2 centimeters, angulation of more than 5–10 degrees in any plane, displaced intra- or periarticular fractures, or nonunions all lead to significant functional impairment and eventually chronic joint pain or low back pain. The superior results of surgical treatment over conservative management of hip fractures, femur fractures, severe knee ligament injuries, many tibia fractures, and ankle and foot fractures and dislocations have all been well established in HICs during the past half century. However, to this day, most of these fractures are treated conservatively with cast or traction in LMICs. The long-term advantages of surgical management of some tibial shaft fractures over cast treatment are still debated, but not so for hip or femur fractures.

Yet it has been longstanding dogma that, even if all necessary resources are available, surgery for MSK injuries would be too expensive in LMICs. However, the Surgical Implant Generation Network (SIGN) intramedullary nailing system was designed specifically for austere environments. SIGN is a nonprofit, nongovernmental organization that provides the implants at no cost to patients. As long as all cases are reported in an electronic central database, all implants are replaced for free. This user-friendly system has seen remarkable growth; during a period of approximately 15 years, more than 110,000 patients were treated by more than 5,000 surgeons in more than 200 hospitals in 53 LMICs, with results comparable to those in HICs (Sekimpi and others 2011). This system was introduced in Cambodia in 2007. A study comparing the first 50 patients who received nails for their femur fractures to the last 50 patients who were treated by traction showed that surgery had better clinical outcomes and was more cost-effective than traction (US$888 versus US$1,107 per DALY averted, respectively) (Gosselin, Heitto, and Zirkle 2009).

Cross-Cutting Issue for Care of Injuries to All Body Regions: Bleeding

Tranexamic acid has been found to be effective in lowering mortality in bleeding trauma patients. It is a low-cost, generic medication. One cost-effectiveness analysis estimated that the cost per year of life gained by administering tranexamic acid was US$48–US$$66, depending on the geographic location (Guerriero and others 2011).

BURNS

Burden of Disease

Burn injuries are among the most devastating of all injuries and a major global public health concern (Forjuoh 2006). Each year, more than 265,000 people die from fire-related burn injuries. Millions more suffer from burn-related disabilities and disfigurements, which have psychological, social, and economic effects on the survivors and their families. Fire-related burns account for 17 million DALYs lost worldwide annually (WHO 2013b). Strikingly, fires rank third worldwide for DALYs lost because of unintentional injury in Sub-Saharan Africa, second in Eastern Mediterranean and South-East Asian countries, and fifth in HICs.

Burn is a disease of poverty; the burden of burn injury falls predominantly on the world's poor, with 95 percent of fire-related burn deaths occurring in LMICs. Not only are burn deaths and injuries more common in people of lower socioeconomic status, but the survivors find that their poverty levels worsen after recovery (Peck, Molnar, and Swart 2009). The high incidence of burns in this population is driven by negative impact factors, including the influx of people to urban areas, haphazard urban development, inadequate electrification of homes, paraffin used as a primary energy source, and lack of preventive programs.

The worldwide incidence of death from fire-related injuries in 2004 was estimated to be 3.8 per 100,000 population, with the highest rates in Southeast Asia and Sub-Saharan Africa. The incidence of burns in LMICs is 4.4 per 100,000 population, compared with an incidence of 0.84 per 100,000 population in HICs (WHO 2013b). In Bangladesh, the incidence of nonfatal burn injury is 166.3 per 100,000 per year (Mashreky and others 2009).

In addition, the epidemiology of burn injuries is also different in LMICs, where it is predominantly a pediatric and geriatric disease (Ahuja and Bhattacharya 2002). Children, especially those under age five, have been shown to constitute the highest risk group of burn victims, followed by those ages 20–29. Of the studies that reported data on childhood burns, children under age four had a disproportionately higher number of burns; they accounted for nearly one-third of the total number of burn cases, all age groups considered. In many settings, including Brazil, Côte d'Ivoire, India, and Malawi, this age group accounts for nearly half of all childhood burns (Forjuoh 2006).

Burn centers are usually part of large urban hospitals and act as referral centers for patients from smaller first-level hospitals and health centers. Burn units are dedicated units within hospital structures that manage care for patients of all ages; burn units typically have dedicated nurses and staff. In LMICs, most existing burn centers are situated in large cities and are insufficient for the high incidence of injuries. Although management in these centers is based primarily on standard principles, hospitals are ill-equipped with staff and support facilities. In addition to inadequate physical structures, these centers are invariably plagued by lack of resources, lack of operating time, and shortages of blood. Often, no dedicated burn surgeons are available; general surgeons without formal burn training are involved in burn care. Burn nursing is also not a recognized concept. Resuscitation is often delayed because patients have to travel long distances and transport facilities are poor. Ambulance and prehospital services are practically nonexistent (Atiyeh, Masellis, and Conte 2009). Furthermore, coordination between first-level hospitals and third-level burn centers is limited.

Cost-Effectiveness of Burn Care

Burn care requires a significant number of dedicated expert personnel and is resource intensive. When choosing between different treatment options, the available funds, personnel, and required expertise must be weighed. Reliable information relating costs to clinical outcomes is needed. Burn-care costs have been the subject of very few investigations and are among the least studied topics by health services researchers, particularly in LMICs (Atiyeh and others 2002). In a prospective study by Ahachi and others, the direct hospitalization cost of managing major acute burns in Lagos, Nigeria, was examined to identify the factors that influenced cost. The researchers found that the average daily cost of treating a burn patient was approximately US$6, and that the average overall cost for a burn admission was approximately US$62; the costs of wound dressings, hospital admission, and surgery constituted 29.5 percent, 25.7 percent, and 19.1 percent, respectively, of the total amount spent (Ahachi and others 2011). In a similar study in Bangladesh, the average cost for serious and major burns was US$166 and US$58 per burn injury, respectively. For the treatment of a severe burn, a family spent an average of US$462 (Mashreky and others 2009).

Prehospital care of burn victims using simple measures, such as irrigation with clean cool water and clean dressings, is of particular importance where access to hospital care is commonly delayed. Prehospital care is discussed at greater length in chapter 14.

Cost-Effectiveness of Hospital Management

Although very little literature exists on the effectiveness of burn centers compared with smaller local burn units, data suggest that the early burn excision frequently done in burn centers improves the survival of patients (Church and others 2006). Patients with burns exceeding 90 percent of total body surface area (TBSA) regularly survive in the world's best centers; this rate is in stark contrast to the mortality for burns exceeding 40 percent of TBSA in most LMICs, which approaches 100 percent (WHO 2002b). Cost-effective burn treatment to conserve scarce resources includes emphasizing early fluid resuscitation and ensuring proper compliance with established resuscitation protocols, such as the Parkland formula.

Increasingly aggressive surgical approaches, with early tangential excision and wound closure, are standard practice in burn units in HICs. Such approaches

likely represent the most significant change in recent years and have led to improvements in mortality rates of burn victims at substantially lower costs than waiting for the eschar—the dead burned skin that forms a scab over the burned area—to peel off. In the absence of proper burn-care facilities, blood supply, and other resources such as dressings, and with inadequately trained personnel, such aggressive therapy in burn victims can induce further trauma and result in suboptimal outcomes (Munster, Smith-Meek, and Sharkey 1994). Smaller burns over critical areas such as joints are better suited to this technique (WHO 2011). However, for a large percentage of patients with extensive burns in most LMICs, early excisional surgery is not available.

Triage. With the realities of inadequate access to surgical facilities in the LMIC environment, closed burn wound dressing, eschar separation, and delayed skin grafting will help to separate patients with less extensive injuries (less than 40 percent of TBSA) with the potential to survive from those patients with extensive wounds exceeding 50 percent of TBSA with poor survival who should be triaged to palliative care (Ahuja and Bhattacharya 2004).

Wound Care. Local wound care in developing countries is one of the greatest barriers to effective burn wound management; wound-care products and dressing supplies are not easily obtainable or are too expensive. Cool running water at a temperature between 10 and 15 degrees centigrade for 20–30 minutes is considered adequate burn first aid treatment (Skinner and Peat 2002). In one study of burn treatment in LMICs that included all countries in Latin America and the Caribbean, the Middle East and North Africa, and Sub-Saharan Africa, plus China, India, and other countries in Asia and adjoining islands, cool water was applied to the burned area as a first aid therapy in one-third of the cases, a ratio comparable to that observed in some HICs (Forjuoh 2006). Silver-based dressing and ointment should be used, if available. However, the use of locally available and effective wound-care alternatives, amniotic membrane in particular, is cost-effective and ideal as a biological dressing. Amniotic membrane remarkably reduces the cost of dressing changes and the periods of stay in hospitals. It also significantly reduces nursing time and thereby nursing costs (Atiyeh, Gunn, and Hayek 2005). It is often in ample supply if the facility has a busy obstetrics department. However, other considerations, such as cultural acceptability or the risk of HIV or hepatitis infections, also need to be considered.

The medicinal properties of honey and other hive products have been well described for a variety of medicinal and nutritional purposes, including the treatment of burn wounds. The beneficial effects of honey include the cleansing of wounds, absorption of edema fluids, antimicrobial activity, promotion of granulation tissue, epithelialization, and the improvement of nutrition. Another cost-effective, locally available burn dressing is the banana leaf dressing (BLD). Its preparation is very simple: a banana leaf is washed, pasted to bandage cloth with flour paste, dried for 24 hours, rolled, packed into a paper bag, and autoclaved. This process can be easily taught to previously treated patients, relatives of patients, and literate as well as illiterate individuals. Banana leaves are readily available in most cities, towns, and villages in LMICs. It is even possible to have a patch of land with a banana plantation within the hospital premises in a busy burn unit. BLD, being totally nonadherent, tends to slip. BLD is 160 times cheaper than Soframycin-impregnated gauze, 1,750 times cheaper than collagen sheet, and 5,200 times cheaper than biosynthetic dressing (Atiyeh, Masellis, and Conte 2009). More recently, moist exposed burn ointment (MEBO), a traditional Chinese burn remedy, was reported to provide an adequate moist environment for optimal healing without the need for a cumbersome and expensive protective dressing. Its main active component is beta-sitosterol in a base of beeswax and sesame oil. MEBO has been found to be a useful alternative in the treatment of partial-thickness burns because of its convenient method of application; it could be a valuable treatment modality in LMICs (Atiyeh and others 2003).

Exposure therapy is often the method of choice because gauze dressings are considered expensive. The exposure method is particularly suitable for the treatment of pediatric burn injuries, especially in a tropical climate where patients are nursed under mosquito nets to keep flies and other insects away from open burn wounds. In an observational study by Gosselin and Kuppers comparing open and closed dressing in burn wounds, the open method had as good or better early outcomes than the closed method, at significantly lower cost; it is the recommended treatment for burns in environments similar to the one in this study (Gosselin and Kuppers 2008).

Pain Management. Pain management, particularly in children, is another factor that divides the developed from the developing world. Provision of pain relief in the face of limited resources and a limited spectrum of analgesics, if any are available, is a challenge. In a study of the patterns of pediatric analgesic use in Sub-Saharan Africa, paracetamol and ibuprofen were widely

employed, constituting approximately 60 percent of all analgesics, while morphine was used in only 0.2 percent of cases. This falls short of the WHO standards (Madadi and others 2012).

Antibiotic Use. Because of the paucity of studies, whether the use of prophylactic systemic antibiotics is effective and cost-effective in preventing infective complications remains unclear; however, the available evidence does not support its use for prophylaxis (ICHRC 2013).

Adequate Nutrition. Healing a burn injury demands a great deal of energy from the body. Adequate nourishment, including adequate protein, calories, vitamins, and micronutrients, is essential to support healing. Some burn units have started to introduce "Plumpy'nut," a high-protein and high-energy peanut-based food that is readily available as a nutritional supplement for malnourished children, to the burn nutrition regimen. A two-month Plumpy'nut regimen for a child costs US$60.

Rehabilitation. In addition to burn-related mortality, burn-related disabilities have substantial functional and economic impacts. Functional disability is defined in the Global Burden of Disease report as disability-adjusted life years (DALYs), or the number of years lost due to poor health, disability, or early death (Murray and Lopez 1996). Worldwide, burns covering more than 20 percent of TBSA rank first among injury types causing short- or long-term disability. The WHO estimates that 116 million people have suffered such burns—approximately four times the number of people with HIV/AIDS at 31 million people (WHO 2008).

Rehabilitation of burn patients must begin immediately after the injury; the delay between inpatient and outpatient therapy should be minimized to facilitate a quick return of functional patients to society (Takayanagi, Kawai, and Aoki 1999). Part of the rehabilitation process is the prevention and treatment of postburn scarring, the most common and frustrating complication because of its aesthetic and functional consequences (van den Kerckhove 2001). The lack of available personnel significantly limits inpatients and outpatient postburn rehabilitation. The ability to train family members in basic physical and occupational therapy skills, such as range of motion exercises, is a cost-effective way to reduce the extent of disabilities. Effective rehabilitation can minimize the need for reconstruction. Local surgeons, where available, need to be trained in basic plastic surgical techniques, such as contracture release (see chapter 13).

Burn prevention strategies are well recognized as being very cost-effective, more so than burn treatment (see chapter 20).

Future Developments in the Treatment of Burns

Mandatory reporting of burn admissions to a central registry can generate data invaluable for evaluating strategies and prevention programs. Optimizing the current information system is achievable by customizing coding developments already underway; combining data from the various agencies to form a national burn injury database will provide the best national overview of burns.

Large-scale awareness programs aimed at policy makers, politicians, professionals, the general public, and the media are required to communicate the burden, impact, and losses due to burn-related injuries. Recognizing that burns are a public health problem, and making burn prevention and management a national programmatic priority, can ensure that sufficient funds are available for such programs.

Telemedicine is an effective tool for accurately evaluating the condition of patients with burns. This tool can reduce undertriage or overtriage for transport, improve resource utilization, and enhance and extend burn center expertise to many rural communities at low cost (Saffle and others 2009). Data specific to burn assessment and diagnosis using telemedicine suggest that this is a safe, reliable, and cost-effective means to attain consultation from specialists for patients in underserved areas (Kiser and others 2013). As this technology has evolved, it has become only slightly more expensive than a standard computer with a high-speed Internet connection.

ORTHOPEDICS

In many HICs, orthopedic surgeons manage acute MSK injuries and their more chronic sequelae, as well as nontrauma-related MSK conditions ("cold" orthopedics). Congenital and hereditary MSK conditions are addressed in chapter 8; this section considers only acquired MSK diseases and conditions.

The world population is aging: the global life-expectancy-adjusted median age will increase from 26.6 years as of 2014 to 31.1 years by 2050 (Lutz, Sanderson, and Scherbov 2008). The burden of age-related conditions, such as osteoporosis, will rise accordingly with the increase in prevalence of known risk factors, such as menopause, physical inactivity, tobacco and alcohol abuse, nutritional deficiencies such as for calcium and vitamin D, and the wider use of medications such as corticosteroids (Lunenfeld and Stratton 2013).

Osteoporosis predisposes people to insufficiency fractures—trauma-related fractures that would not cause failure of normal bone. Females are affected more than males and suffer more disability than males (Guralnik and others 1997). One study in Thailand showed that life expectancy at age 60 is 20.3 years for males and 23.9 years for females, yet disability-free life expectancy is 16.4 and 18.2 years, respectively (Jitapunkul and others 2003).

Traumatic Injuries

It has long been an orthopedic maxim that displaced fractures, particularly if intra-articular, have a better functional outcome if reduced and fixed, surgically if necessary. The shoulder, wrist, spine, and pelvis are common insufficiency fracture sites; although acutely disabling, most such fractures will heal without significant long-term disability without surgical treatment, even if displaced.

This outcome is not true for fractures of the lower extremity, in particular the hip. The personal, familial, and societal burden of hip fractures in elderly patients is well documented in HICs. Such information is lacking for most LMICs, but it is estimated that worldwide, there were 1.7 million hip fractures in 1990. This incidence is forecast to grow fourfold to 6 million by 2050 (WHO 2003). The mortality rate is approximately 20 percent, and the lifetime risk for a 50-year-old female is estimated to be 40 percent, the same as for coronary heart disease.

Early surgery to repair or replace the hip prevents the complications related to prolonged bed rest, including pressure sores, deep vein thrombosis, and urinary or pulmonary infections. It also leads to better functional outcomes with less mal-unions or painful nonunions than conservative bed treatment. However, even in the best-case scenario, one of every two patients suffers some form of permanent disability (WHO 2003). A study in Singapore reported that overall costs for surgical care of hip fractures were actually less than for conservative management (Lee and others 2012). Hip fractures have doubled or tripled in the past 30 years in Asia. If the same trend persists, the societal and economic burden will be nearly unsustainable by 2050 (Mithal and Kaur 2012).

Nontraumatic Conditions

Global aging will also increase acquired chronic MSK conditions, such as degenerative osteoarthritis (OA), inflammatory arthropathies (IA), and neoplasms (primary or metastatic).

A decade ago, OA was estimated to be the fourth leading cause of disability worldwide, most of it attributable to the involvement of the hip and knee (WHO 2002a). The GHE study estimates it accounts for approximately 16 percent of all MSK-related DALYs (WHO 2013b); it is strongly associated with aging and heavy physical occupational activity. In HICs, end-stage OA is most commonly treated with total joint replacement (TJR), a procedure unavailable for the vast majority of sufferers in LMICs. It is estimated that the Asian population older than age 65 will double between 2010 and 2040, and the OA burden will increase accordingly (Fransen and others 2011). Because surgical treatment will remain out of reach for most people, prevention strategies targeting such risk factors as obesity will have the greatest impact. In China, for example, each year only about 50,000 (0.05 percent) of the estimated 120 million OA sufferers receive TJRs (Huang, He, and Wang 2012). Although this number has increased by approximately 15 percent every year in the past 10 years, the unmet need will clearly remain enormous for the foreseeable future.

IAs include rheumatoid arthritis (RA), gout, sero-negative arthropathies, and a myriad of mono- or polyarthropathies associated with autoimmune diseases. According to the GHE, RA and gout account for approximately 5 percent of the burden attributable to MSK disorders (WHO 2013b). Although data on the IA burden in LMICs are unavailable, inadequate rheumatology services suggest that it is likely to be quite high. It is estimated that for the more than 4 billion people in LMICs, the prevalence of RA is between 8 million and 12 million (Chopra and Abdel-Nasser 2008). The WHO has devised the Community Oriented Program for the Control of Rheumatic Diseases, which is being implemented in many LMICs with the goal of collecting community-based data on pain and disability from rheumatic conditions (Chopra and Abdel-Nasser 2008).

The need for surgery for IA (synovectomy, tendon transfers, fusion, or arthroplasty) is less common than for OA. Medical management can be quite effective for many years, but depends on early and accurate diagnosis and the availability of human and technological resources, appropriate medications, and rehabilitative services (Woolf, Erwin, and March 2012). Many of these resources remain unavailable in LMICs, making educating the public and raising awareness of preventive strategies crucial. Such strategies include weight control, regular exercise, balanced diet, avoidance of tobacco and alcohol use, and modification of the work environment (Mody and Cardiel 2008). The higher prevalence of chronic infections,

such as tuberculosis, HIV/AIDS, and hepatitis B or C, makes the medical management of IA even more challenging.

MSK tumors are rare. Primary MSK malignancies are not even on the neoplasm list of the GHE framework. Secondary, or metastatic, disease is more common, particularly with common primary cancers, such as those of the lung, breast, or prostate. A combination of chemotherapy, radiation, and surgery is often standard in HICs. No data are available from LMICs, but late presentation (often pathologic fracture) and lack of adjuvant therapies preclude any attempt at limb-saving surgery. Palliative amputation is often the only option. When limb-saving surgery is available and indicated, procedures such as autoclaving and then re-implanting diseased bone can be an acceptable alternative to prohibitively expensive prosthetic replacement (Khattak and others 2006).

Although rarely requiring surgery, low back pain (LBP) and neck pain are extremely common. They encompass a variety of etiologies: mechanical pain, perivertebral soft tissue problems, disk disease, degenerative conditions, and even malingering. The worldwide prevalence of LBP is estimated to be 10 percent; even if only 1 percent of those cases require surgical treatment, the unmet need is tremendous. Depending on duration and the presence or absence of leg pain, the disability weight for LBP in the Global Burden of Disease 2010 ranges from 0.269 to 0.374 (profound intellectual disability has a disability weight of 0.157; severe chronic obstructive pulmonary disease has a disability weight of 0.383), which reflects the significance of perceived impairment by the survey responders (Salomon and others 2012). Personal, societal, and economic burden are high and well documented in HICs; it is unlikely that the burden would be substantially different in LMICs, although no reliable data exist.

Table 3.3 summarizes the changes in rates between 2000 and 2011 for the above conditions.

Table 3.3 Change in Rates of Nontraumatic Musculoskeletal YLDs and DALYs, 2000–2011

Condition		Change in rates per 100,000 population (percent)
Osteoarthritis	YLDs	14.8
	DALYs	14.8
Rheumatoid arthritis	YLDs	7.2
	DALYs	9.2
Back and neck pain	YLDs	5.4
	DALYs	5.5
Other musculoskeletal conditions	YLDs	6.3
	DALYs	9.5

Source: Data based on Global Health Estimates (WHO 2013b).
Note: DALYs = disability-adjusted life years; YLDs = years lost to disability.

INFECTIONS

Soft Tissue Infections

General surgical cases, including incision and drainage of abscesses, represent a high proportion of overall procedures at hospitals in LMICs (Ivers and others 2008). Surgical site infections are the second most commonly reported nosocomial infections in Sub-Saharan Africa, following urinary tract infections. In obstetric patients, surgical site infections were higher in LMICs than in HICs and were the most frequent nosocomial infection (Amenu, Belachew, and Araya 2011; Chalya and others 2012). Independent risk factors for increased nosocomial infections included age greater than 40 years, length of hospital stay, and an admitting diagnosis of trauma.

However, geographic variables present important barriers to timely access to health services (Spiegel and others 2011). Delayed presentation, inadequate antibiotic treatment before admission, shock on admission, compromised immune status with HIV positivity and low CD4 counts, and malnutrition lead to higher morbidity and mortality rates and may be part of the underlying increased risk in trauma patients. In obstetric patients, the omission of even one dose of antibiotics was associated with increased wound infection rates in Ethiopia (Amenu, Belachew, and Araya 2011).

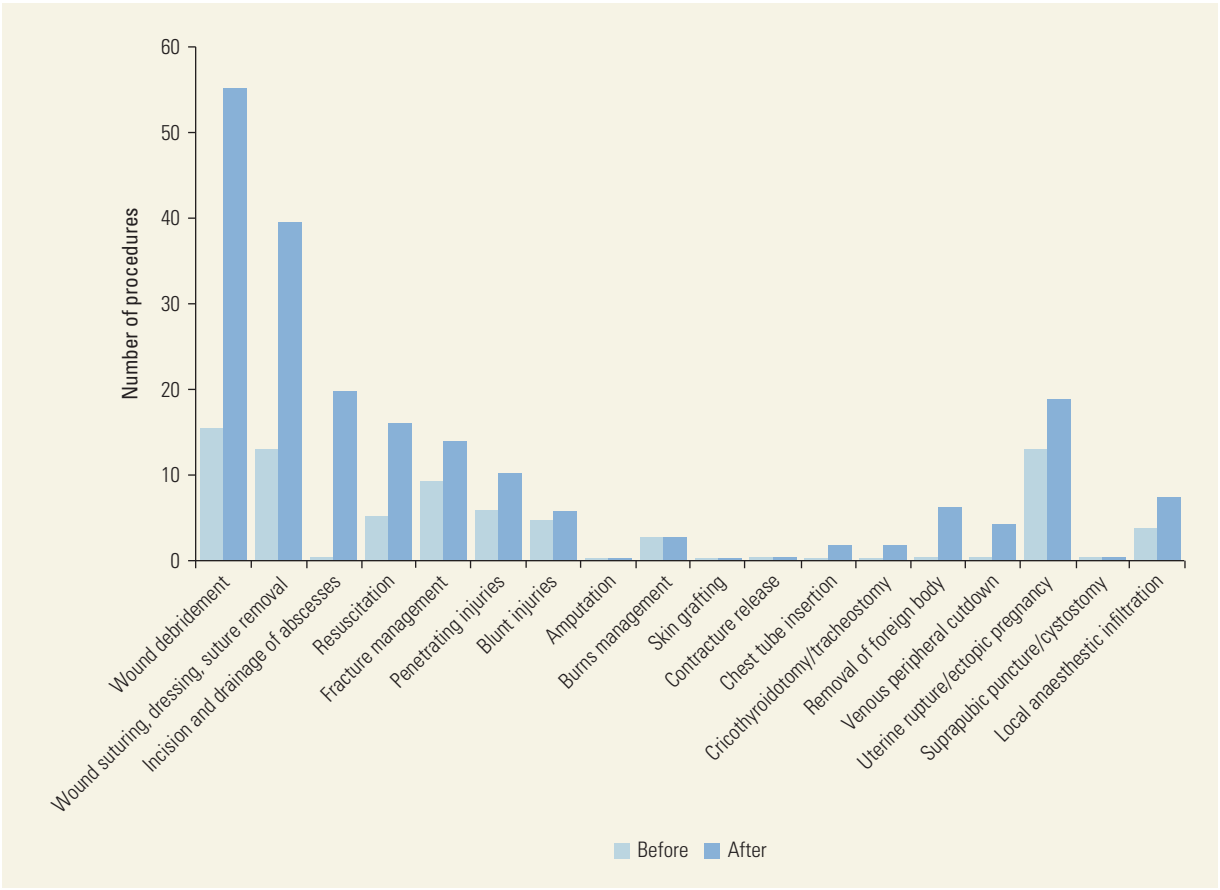
Surveys employing the WHO Tool for Situational Analysis to Assess Emergency and Essential Surgical Care have identified significant gaps in infrastructure, human resources, life-saving and disability-preventing surgical interventions, and essential equipment in many LMICs (Kushner and others 2010; Spiegel and others 2011). Incision and drainage capabilities seem to exist in 75–100 percent of first-level facilities (local dispensaries, first-level health care facilities, and local hospitals), and general practitioners and nonphysician clinicians without significant surgical training perform the majority of procedures. Lack of supplies is the most common reason cited when patients are referred to higher-level facilities for incision and drainage. A coordinated countrywide initiative to strengthen surgical services at the first-level hospitals in Mongolia documented significantly increased capabilities to perform

incision and drainage of abscesses, wound suturing, and wound debridement (Henry and others 2012) (figure 3.2). Additionally, the development of formal emergency rooms with adequate supplies and the implementation of basic standards and guidelines for emergency care have dramatically improved timely access to and availability of these basic procedures (figure 3.3).

Bone Infections

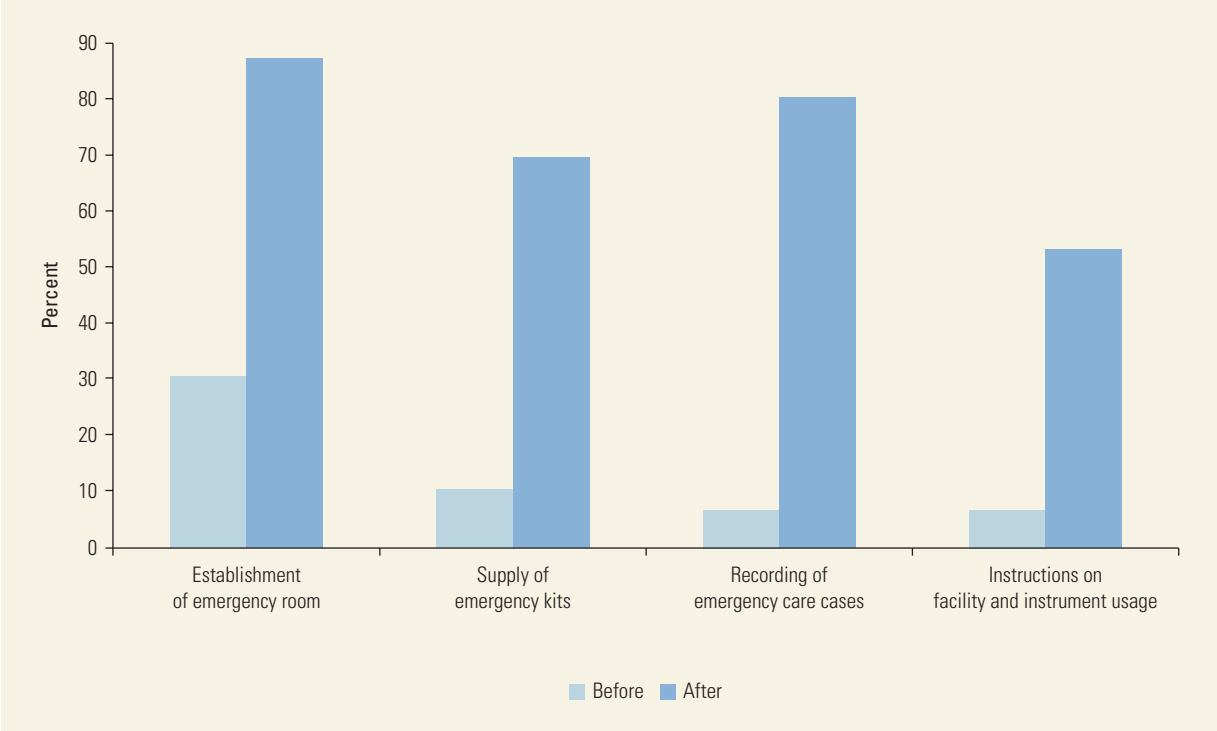
Osteomyelitis, literally the infection of bone or its marrow, is most often due to hematogenous (via the blood vessels) seeding in children, or as a complication of open fractures or orthopedic surgical procedures in patients of all ages. There is a paucity of information in the literature concerning the epidemiology, burden of disease, and cost-effectiveness of treatment for osteomyelitis. Recognizing the complexity, labor intensiveness, complications, and anticipated costs of treating this condition when chronic, it is clearly better to prevent the condition by performing a select number of simple and cost-effective surgical procedures in the acute phase. These procedures may be considered to be preventive strategies aimed at reducing the risks of developing a chronically infected state; they include drainage of an abscess or debridement of an area of bone destruction, and prompt irrigation, debridement, and stabilization of open fractures. A literature search identified no reliable information on cost-effectiveness; we hypothesize but cannot prove that a multistage, resource-intensive treatment course of chronic osteomyelitis would not be cost-effective. However, preventive surgical strategies are much simpler, can be delivered at the first-level or referral level in most cases, and are likely to be more cost-effective.

Figure 3.2 Surgical Procedures Performed before and after Training at First-Level Facilities



Source: Henry and others 2012, figure 6. With permission from Springer Science and Business Media.
Note: Before = prior to training; after = two years posttraining, first-level health care workers.

Figure 3.3 Pilot at First-Level Facilities: Evaluation before and after Two Years Countrywide Training



Source: Henry and others 2012, figure 5. With permission from Springer Science and Business Media.
Note: Before = prior to training; after = two years posttraining, first-level health care workers.

CONCLUSION

Throughout LMICs, the rates of trauma-related death and disability are increasing, a trend that is projected to continue. Timely access to surgical care can play a key role in improving outcomes; such access has been shown to be effective and cost-effective. Too often, however, the lack of access to surgical care means that medically preventable deaths occur and avoidable disabilities are incurred.

The toll in human terms is clear and cries out to be addressed. The toll in economic terms is no less clear: Societies lose the present and future contributions of productive members; poor families suffer increased poverty because of the relatively high costs of medical care as well as the loss or disability of members. Poor families are limited in their coping mechanisms, and paying for medical care may involve the liquidation of essential assets or heavy borrowing. Families might not be able to afford to send children to school or must send them to work to replace the contribution of the deceased or disabled family member.

Reliable data, particularly data obtained through improved surveillance and monitoring systems, are needed to better inform the decisions of policy makers as they make difficult choices in allocating scarce resources.

The international community can assist policy makers by developing and implementing guidelines and by regularly monitoring and evaluating them. Appropriate education and training programs, combined with the infusion of basic material and technical resources, may partially alleviate the brain drain crisis.

The creation and strengthening of trauma systems would also reinforce both the human and the material resources of existing health care systems.

NOTES

The World Bank classifies countries according to four income groupings. Income is measured using gross national income (GNI) per capita, in U.S. dollars, converted from local currency using the *World Bank Atlas* method. Classifications as of July 2014 are as follows:

- Low-income countries (LICs) = US$1,045 or less in 2013
- Middle-income countries (MICs) are subdivided:
  - Lower-middle-income = US$1,046 to US$4,125
  - Upper-middle-income (UMICs) = US$4,126 to US$12,745
- High-income countries (HICs) = US$12,746 or more

This chapter used the World Health Organization's geographical classification for six regions: African Region, Region of the Americas, South-East Asia Region, European Region, Eastern Mediterranean Region, and Western Pacific Region.

1. Healing Hands for Haiti. http://www.healinghandsforhaiti.org/Home/tabid/38/language/en-US/Default.aspx.
2. WHO and VIP (Violence and Injury Prevention). "Violence and Injury Prevention and Disability (VIP): Uganda." http://www.who.int/violence_injury_prevention/surveillance/countries/uga/en/index.html.

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