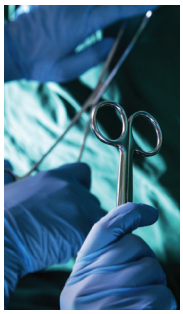


Chapter 14

Prehospital and Emergency Care

Amardeep Thind, Renee Hsia, Jackie Mabweijano,
Eduardo Romero Hicks, Ahmed Zakariah, and Charles N. Mock

INTRODUCTION

Disease or illness can strike at any time. If the condition is acute, or if the injury is life-threatening or limb-threatening, immediate care is needed. These time-dependent conditions that affect both adults and children may be due to medical, surgical, or obstetric conditions. They may result from acute injuries or illnesses or from exacerbations of chronic disease.

In low- and middle-income countries (LMICs), patients with such conditions may face delays of hours or even days before reaching the nearest medical facility or provider. Transportation may be provided by ambulance, but more often it is provided by laypersons using the handiest mode of transport available (Arellano, Mello, and Clark 2010; Khorasani-Zavareh and others 2009; Nguyen and others 2008; Ramanujam and Aschkenasy 2007). Health care before arrival at heath facilities may be provided by trained paramedics or by laypersons; quite often, however, no health care is provided (Bavonratanavech 2003; Khorasani-Zavareh and others 2009; Nguyen and others 2008; Solagberu and others 2009).

In contrast to systems in high-income countries (HICs), the prehospital and emergency medical systems of LMICs are often rudimentary. Justifiably, health systems in LMICs have focused on increasing access to health care by building facility-based health care systems. Such thinking is abetted by a perception that the provision of prehospital and emergency care is not cost-effective in LMICs (Kobusingye and others 2005), leading to policies that allocate the bulk of scarce health care resources elsewhere.

This chapter identifies the scale of the challenge by presenting data on the burden of disease that prehospital and emergency care systems in LMICs could potentially address. It then describes the common health care delivery structures in these countries and assesses the literature on costs and effectiveness of such mechanisms. It closes with a discussion of future directions in research and policy.

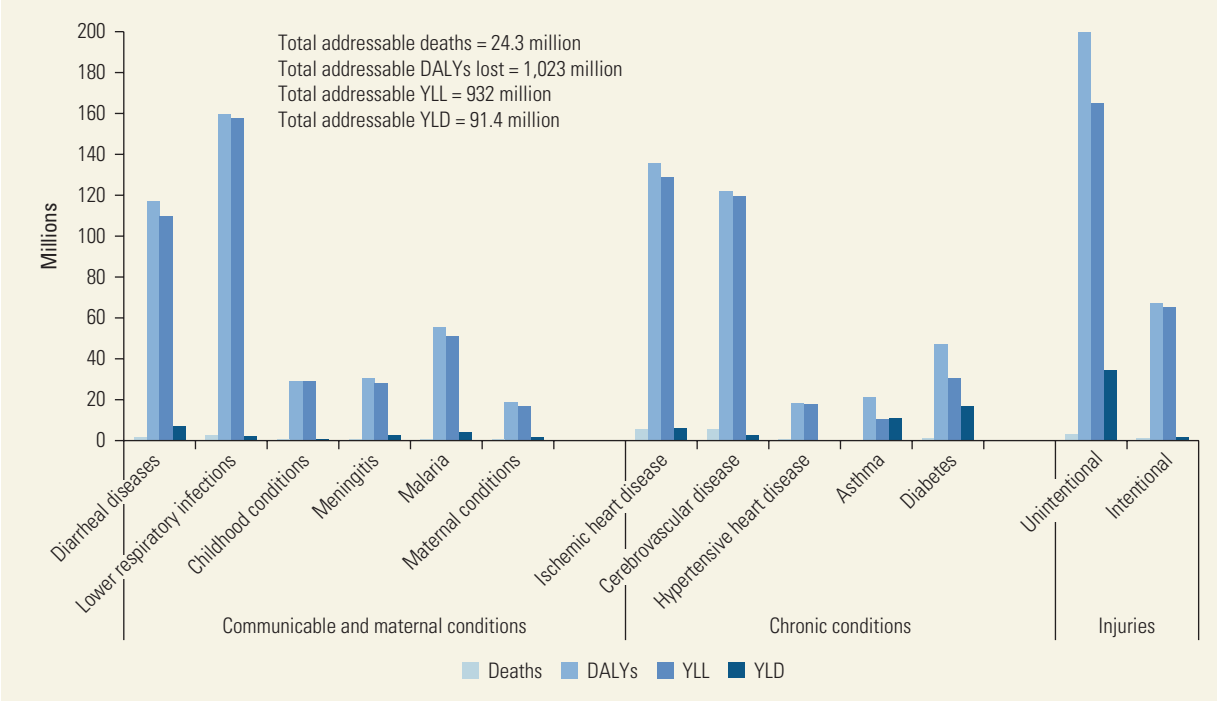
BURDEN OF DISEASE

The burden of disease that can potentially be addressed by prehospital and emergency care in LMICs (figure 14.1) was derived from the diseases and disease conditions used by Kobusingye and others in their chapter on emergency medical services in *Disease Control Priorities in Developing Countries*, second edition (Jamison and others 2006). The latest data for these conditions were extracted from the World Health Organization's (WHO's) Global Health Estimates (WHO 2013). Data for the diseases and conditions are clustered into three groups:

- Communicable and maternal conditions
- Chronic conditions
- Injuries

Corresponding author: Amardeep Thind, MD, PhD, University of Western Ontario, athind2@uwo.ca

Figure 14.1 Burden of Disease Potentially Addressable by Prehospital and Emergency Care in LMICs



Source: Data from WHO 2013.
Note: DALYs = disability-adjusted life years; LMICs = low- and middle-income countries; YLD = years lived with disability; YLL = years of life lost.

The communicable and maternal conditions group includes the following:

- Diarrheal diseases: cholera, other salmonella infections, shigellosis, *E. coli*, campylobacter, amoebiasis, cryptosporidiosis, rotavirus, typhoid and paratyphoid fevers
- Lower respiratory infections: influenza, pneumococcal pneumonia, haemophilus influenzae pneumonia, respiratory syncytial virus pneumonia, other lower respiratory infections
- Childhood conditions: diphtheria, whooping cough, tetanus, measles
- Meningitis
- Malaria
- Maternal conditions: hemorrhage, sepsis, hypertensive disorders of pregnancy, obstructed labor, and abortion

The chronic conditions group includes the following:

- Ischemic heart disease
- Cerebrovascular disease
- Hypertensive heart disease
- Asthma
- Diabetes

The injuries group includes the following:

- Unintentional: transport and nontransport injuries, and forces of nature
- Intentional: self-harm, interpersonal violence, war, and legal intervention

Our estimates suggest that out of the approximately 45 million deaths in LMICs each year, 54 percent, or 24.3 million, are due to conditions that are potentially addressable by prehospital and emergency care. This loss translates into a staggering 1,023 million DALYs, or 932 million years of life lost (YLL) to premature mortality. From a morbidity perspective, this disease burden translates into 91.4 million years lived with disability (YLD). While ischemic heart disease and cerebrovascular disease contribute the largest number of deaths, unintentional injuries are the single largest contributor to the DALYs. The largest contributors to YLL are unintentional injuries, lower respiratory infections, and ischemic heart disease.

In this array of disease burden, maternal conditions (hemorrhage, sepsis, obstructed labor, and abortion) and injuries may require surgical intervention. Nearly 19 percent (or 4.7 million) of these 24.3 million deaths in LMICs are surgically treatable. This number

corresponds to nearly 28 percent—285 million—of the DALYs, or 25 percent—286 million—of the YLL. From a morbidity perspective, surgically treatable conditions account for 38 million YLD, or 41 percent of the conditions that are potentially addressable by prehospital and emergency care.

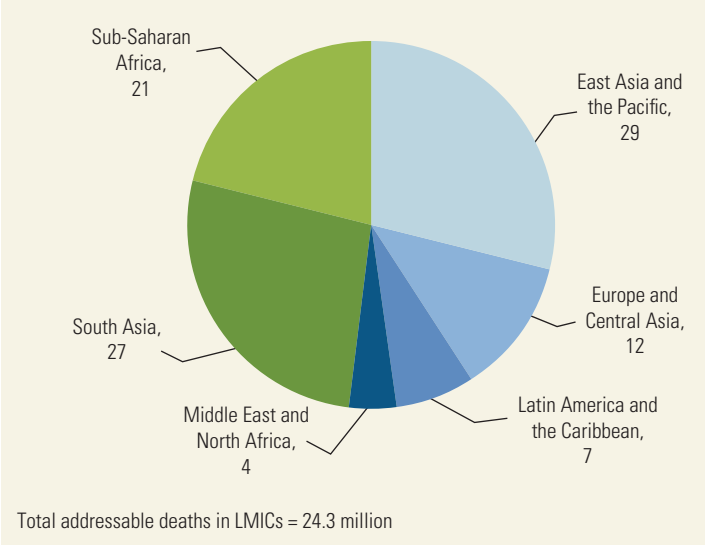
Figures 14.2–14.5 depict the regional variations in mortality, DALYs, YLL, and YLD. By virtue of their large populations, South Asia and East Asia and the Pacific account for 56 percent of the addressable deaths (figure 14.2). South Asia and Sub-Saharan Africa account for 61 percent of the DALYs (figure 14.3), and Sub-Saharan Africa contributes 33 percent of the YLL (figure 14.4). Morbidity is the highest in East Asia and the Pacific, which accounts for 31 percent of the YLD (figure 14.5).

CURRENT DELIVERY SYSTEMS

To develop and enhance the capacity to provide effective emergency care, it is essential to view such care in the context of the overall health system rather than as a discrete and independent unit. Emergency care covers a range of services, from the care provided by laypersons at the scene to that provided in a dedicated trauma facility. Between these two phases lie the transportation systems, health centers, and first-level hospitals. Patient survival depends on how well each component functions.

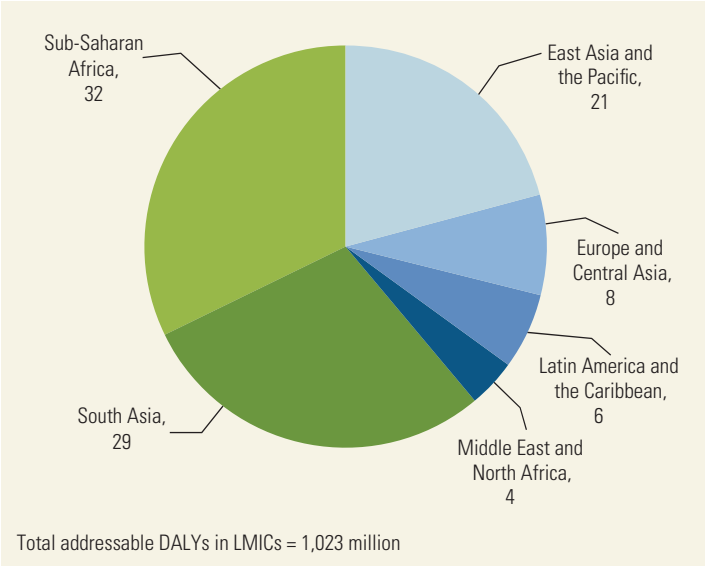
The organization and operation of the prehospital care system vary by country, but should be linked to the local hospitals or facilities to which patients are to be transported. When prehospital transportation is poor or absent, deaths occur that could have been prevented by inexpensive procedures (Mock and others 1998). Most maternal deaths may fall into this category. Poor quality of care at hospitals will lead to in-hospital deaths and may eventually discourage communities that might have the capacity to promptly transfer patients to such facilities (Leigh and others 1997). Skilled and motivated personnel, appropriate supplies, pharmaceuticals, equipment, coordination, and management oriented to the needs of the critically ill all contribute to making emergency care effective in reducing death and disability.

Figure 14.2 Regional Distribution of Deaths Addressable by Prehospital and Emergency Care in LMICs
Percent



Source: Data from WHO 2013.
Note: LMICs = low- and middle-income countries.

Figure 14.3 Regional Distribution of DALYs Potentially Addressable by Prehospital and Emergency Care in LMICs
Percent

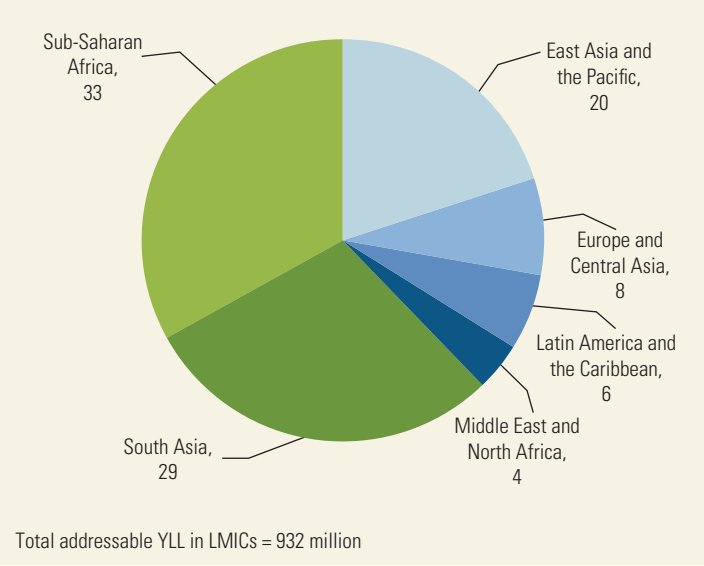


Source: Data from the WHO Global Health Estimates (WHO 2013).
Note: DALY = disability-adjusted life year; LMICs = low- and middle-income countries.

Tiers of Care

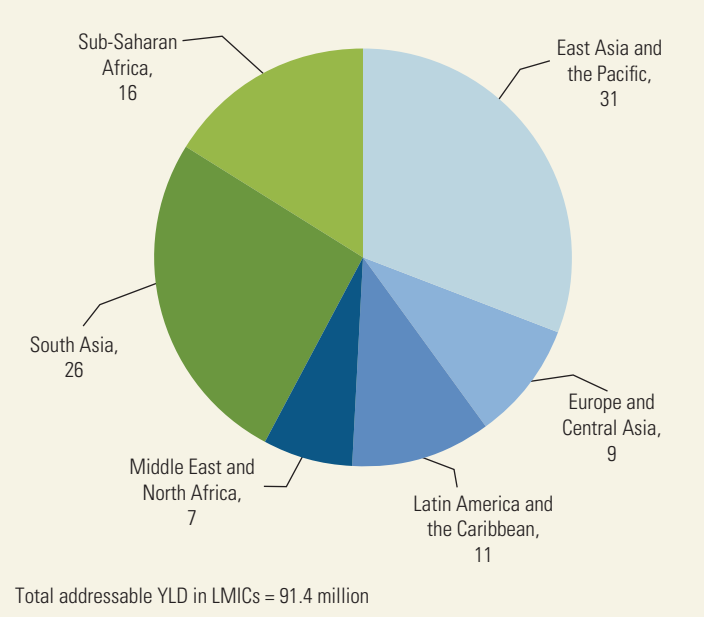
Tier One. Prehospital care encompasses the care provided by the community—from the scene of injury, home, school, or other location—until the patient arrives at a formal health care facility. This care should comprise basic and proven strategies and the most appropriate personnel, equipment, and supplies needed to assess, prioritize, and institute interventions to minimize the probability of death or disability. The most-effective strategies are basic and inexpensive; the lack of high-technology interventions should not deter efforts

Figure 14.4 Regional Distribution of YLL Potentially Addressable by Prehospital and Emergency Care in LMICs
Percent



Source: Data from WHO 2013.
Note: LMICs = low- and middle-income countries; YLL = years of life lost.

Figure 14.5 Regional Distribution of YLD Potentially Addressable by Prehospital and Emergency Care in LMICs
Percent



Source: Data from WHO 2013.
Note: LMICs = low- and middle-income countries; YLD = years lived with disability.

to provide good care. Even where resources allow them, the more invasive procedures performed by physicians in some prehospital settings, such as intravenous access and fluid infusion or intubations, do not appear to improve patient outcomes (Liberman and others 2003; Sampalis and others 1994, 1995, 1997).

Prehospital care should be simple, sustainable, and efficient. Because resource availability varies greatly across and within countries, different tiers of care are recognized. Where no formal prehospital system exists, the first tier of care may be composed of laypersons in the community who have been taught basic first aid techniques. Recruiting and training particularly motivated citizens who often confront emergencies to function as prehospital care providers can expand this resource (Geduld and Wallis 2011).

Tier Two. The second tier comprises paramedical personnel who use dedicated vehicles and equipment and are usually able to get to patients and take them to hospitals quickly. This second tier may involve the performance of advanced procedures or the administration of intravenous and other medications by physician or nonphysician providers, or both. This care is not always available in LMICs; few trained personnel and inadequate funding make around-the-clock coverage infeasible.

Although providing advanced life-saving measures in the prehospital environment may be beneficial in some cases, these benefits may be negated if such measures divert scarce resources from more basic interventions that can benefit far larger numbers of patients (Hauswald and Yeoh 1997). In most LMICs in East Asia and the Pacific, Latin America and the Caribbean, South Asia, and Sub-Saharan Africa, high maternal and child mortality are linked to inadequate emergency care, especially poor access to quality hospital care. In these settings, it is essential to integrate resources rather than to segregate systems for injuries and obstetric emergencies.

Personnel

Most of the world's population do not have access to formal prehospital care. In LMICs, personnel are not employed for the sole purpose of dealing with medical emergencies outside of hospitals, and transportation is not dedicated to the task of getting patients in need of emergency care to hospitals.

The following discussion introduces a scenario in which mortality rate reduction could be achieved in a health system in an LIC or LMIC by a small group of paramedics working together with a large group of trained lay responders. The scenario uses only emergencies caused by trauma, although it is expected that both paramedics and lay first responders would also save lives in medical or obstetric emergencies. Existing studies have not been large enough to document these effects, and they are not included in the estimates of cost-effectiveness.

Lay First Responders. The most basic tier of a prehospital system depends upon interested community members who serve as volunteers to learn simple, yet effective, first aid techniques. These laypersons should also ideally be able to recognize life-threatening conditions—whether obstetric, traumatic, or medical. Examples may range from traditional birth attendants or similar persons in the community who respond to obstetric emergencies to commercial taxi and minibus drivers who encounter traumatic injuries. Other examples include students or workers who receive training so that they can call for help and provide basic emergency care, such as cleansing wounds, stopping external bleeding with direct pressure, and splinting suspected fractures or necks in suspected cervical injuries. See box 14.1.

Materials to train laypersons with low rates of literacy are available, including *When Someone Is Hurt: A First Aid Guide for Lay Persons and Community Workers* (Varghese and Mohan 1998) and the British Red Cross's *Anyone Can Save a Life: Road Accidents and First Aid* (Fiander 2001). Context-specific first aid training materials have been developed, for example, in Ghana (Tiska and others 2004) and Uganda (Jayaraman and others 2009a, 2009b). These materials contain many illustrations so that learners can better understand the basic skills needed for first aid. Depending on the level of interest and availability of first responders, training can last for as little as one day or can extend to several weeks.

It is important that refresher training be incorporated into the program to allow learners to maintain and upgrade their skills; knowledge retention should be reassessed as well, as shown in previous studies of layperson training (Jayaraman and others 2009a, 2009b; Sangowawa and Owoaje 2012). An ongoing monitoring system, such as providing feedback on first aid provided, should be a major component of the system. The WHO provides a matrix of essential knowledge, skills, equipment, and supplies for prehospital providers (Kobusingye and others 2005). Emerging evidence indicates that even children as young as ages five to six years can be given basic first aid training and that their knowledge retention is good at six months (Bollig, Wahl, and Svendsen 2009; Bollig, Myklebust, and Ostringen 2011).

Husum and others (2003) and Husum, Gilbert, and Wisborg (2003) demonstrate that laypersons who are given first aid skills can effectively respond to emergencies in communities with high trauma burdens. In Ghana, it was demonstrated that taxi and minibus drivers trained in first aid could provide effective prehospital care (box 14.2) (Mock and others 2002). This experience has been replicated in other settings (Geduld and Wallis 2011; Jayaraman and others 2009a, 2009b).

Box 14.1

Critical Tasks for First Responders

The World Health Organization lists six critical tasks for first responders:

- Get involved
- Call for help
- Assess the scene for safety
- Assess the victim for life-threatening injuries
- Provide immediate assistance
- Secure essential equipment and supplies

Each of these components requires training and education—most bystanders fear getting involved, whether because of lack of knowledge or skills, or fear of exposure to body fluids, or other cultural and social barriers. Even something as simple as calling for help requires knowledge of available local resources, for example, taxi or ambulance services, private practitioners, and local police or fire departments. Scene safety includes ensuring that victims do not sustain additional injuries; this component could include managing crowds and traffic.

Source: Kobusingye and others 2005.

It is important to incorporate local needs so that the local training curricula, if they exist or are to be developed, can be adapted to address and meet specific considerations. For example, in a township outside Cape Town, South Africa, one study shows that the content of the course was adapted to specific township needs, including how to handle scene safety; penetrating injuries from violence; and medical issues, including drug overdose and alcohol abuse. This responsiveness to community needs seems to have enhanced the integration of the system into the community. This system was run by a community governing board and administered by community organizations already involved in the township (Sun, Shing, and others 2012; Sun, Twomey, and others 2012; Sun and Wallis 2011).

A study of midwives and traditional birth attendants in rural Cambodia also finds that a prehospital training course could significantly improve knowledge, compared with precourse levels, of interventions such as uterine packing to control hemorrhage and suturing tears (Chandy, Steinholt, and Husum 2007). A study from northern Iraq also shows a mortality benefit of

Box 14.2

Improving Trauma Care in the Absence of a Formal Ambulance System in Ghana

Background: The efficacy of a program that builds on the existing, although informal, system of prehospital transportation in Ghana was assessed. In Ghana, the majority of injured persons are transported to the hospital by some type of commercial vehicle, such as a taxi or bus.

Methods: A total of 335 commercial drivers were trained using a six-hour basic first aid course. The efficacy of this course was assessed by comparing the process of prehospital trauma care provided before and after the course, as determined by self-reporting from the drivers.

The course was conducted with moderate amounts of volunteer labor and gifts in kind, such as transportation to the course. The actual cost of the course amounted to US$3 per participant.

Results: Follow-up interviews were conducted on 71 of the drivers a mean of 10.6 months after the course. In the interviews, 61 percent indicated that they had provided first aid since taking the course. There was considerable improvement in the provision of the components of first aid in comparison to what was reported before the course (table B14.2.1):

Table B14.2.1 Provision of First Aid before and after Training

Percent of respondents

Component of first aid	Before	After
Crash scene management	7	35
Airway management	2	35
Bleeding control	4	42
Splint application	1	16
Triage	7	21

Conclusions: Even in the absence of a formal emergency medical system, prehospital trauma care can be improved by building on existing, although informal, prehospital transportation.

Source: Mock and others 2002.

first responder training (Murad and Husum 2010). Lay responders are likely to have an impact when the burden of emergencies from injuries and other causes is high. Attrition of both the responders and the skills is a concern unless they are frequently used.

Paramedical Personnel. In most middle-income countries (MICs) and some cities in low-income countries (LICs), trained paramedical personnel provide prehospital care (Mock and others 1998; Tannebaum and others 2001). These basic and advanced personnel are often paid ambulance personnel or, in some cases, specially designated cohorts of fire or police personnel who desire to acquire more medical skills. They receive professional instruction in both theory and practice, ranging from 100 to 400 hours (Sasser and others 2005). These personnel can be further categorized as follows:

- Those who are able to offer basic prehospital trauma care, including scene management, rescue, stabilization, and the transport of injured patients
- Those who can provide more advanced care, including services such as invasive airway techniques, as well as
- Systems-level developments, such as a complex regional call management center and an integrated communication network (Sasser and others 2005).

Transportation and Communication

After basic first aid has been provided and paramedical personnel have been deployed to the scene, transportation to the nearest and most appropriate health facility is critical. Efficient communication is vital to ensure that contact can be made between those who know that patients need help and the medical personnel who provide it. Although most LMICs have poor telecommunications infrastructure, cellular mobile phones are rapidly being adopted by individuals and offer an opportunity to bypass the need for traditional communications services (Kobusingye and others 2005).

In most of East Asia and the Pacific, South Asia, and Sub-Saharan Africa, where commercial ambulances may not be available, a range of options exists and can be further developed. These options include private motorized or nonmotorized vehicles (Joshipura and others 2003; Kobusingye and others 2002). In Malawi, transportation has even been achieved with bicycle

ambulances (Lungu and others 2001). The establishment of rudimentary ambulance systems has been successful even in low-resource settings such as Niger, including an intervention using solar-panel-powered radios to connect health centers with the second-level hospital (Bossyns and others 2005).

When ambulance services do exist in East Asia and the Pacific, South Asia, and Sub-Saharan Africa, they are often limited to transferring patients between health facilities rather than from the scenes of injury or from homes (Joshipura and others 2003). In MICs, however, ambulance services are a major component of existing emergency care systems (Arreola-Risa and others 2000; Mock and others 2002). Their presence reduces the interval between the recognition of an emergency and the arrival of patients at the hospital (Ali and others 1993, 1997; Arreola-Risa and others 2000).

The effectiveness of well-placed dispatch sites has also been demonstrated in urban populations, where the vehicles and personnel can be optimized. Shorter prehospital times, in general, are considered an important parameter of the quality of prehospital care. These times have the following components:

- *Notification time* is the time elapsed from the occurrence of the injury or the recognition of severe illness until the prehospital or ambulance system is notified.
- *Response time* is the time elapsed from notification until arrival of an ambulance to the site of the ill or injured person.
- *Scene time* is the time elapsed from the arrival of prehospital providers on the scene until departure.
- *Transport time* is the time elapsed from departure from the scene until arrival at the hospital or other treatment facility.

Notification time is influenced by the availability of telecommunications. Response time is influenced by the capabilities of a dispatch center to handle emergency calls, and especially by the geographic distribution of sites of ambulance dispatch. The greater the number of ambulance stations and the wider their distribution, the shorter are the response times.

Geographic distribution and associated response times can be improved in some circumstances by using a tiered or layered response system. This system requires a relatively larger number of basically trained and equipped first responders with wider geographic distribution, and a smaller number of centrally located and more highly trained and equipped second responders. This approach allows the first responders to respond more rapidly and involves second responders only if needed.

With close attention to keeping costs sustainably low, paramedical personnel could be introduced in large urban areas where they do not function at present. They could be stationed at dispatch sites with dedicated vehicles, fast communications with area hospitals, and links with other emergency services, such as fire and police departments. The communities served by the system should have a well-known and rapid method of calling the paramedical teams when an emergency arises. Both lay and paramedical teams require ongoing refresher courses so that their skills do not deteriorate.

Where paramedical personnel have already been integrated into the emergency care system, their numbers and organization—location, training, deployment, and monitoring—should be enhanced to improve response times and patient outcomes, especially for cardiac and obstetric emergencies. It is essential that such systems be evaluated, not only with metrics that assess the availability of services, for example, the number of units on duty or number of sites of ambulance dispatch, but also their cost-effectiveness.

The recommended ratio of one ambulance unit for every 50,000 people suggested by McSwain (1991) results in response times as low as four to six minutes. The ratio does not distinguish between basic and advanced life-support capabilities. Traffic congestion, poor maps, and poor road signs may all increase the response time in cities with poor infrastructure. In Monterrey, Mexico, one unit per 100,000 people manages an average response time of 10 minutes. Hanoi, Vietnam, with one unit for every 3 million people, has an average response time of 30 minutes (Mock and others 1998).

Where paramedical services exist in parallel to lay responder services, the two could be integrated under the same organizational unit. The paramedical staff will be more successful in urban areas, where distances between dispatch sites, communities served, and hospitals are short. Other enabling factors are good telecommunications; rapid and dedicated transportation; and coordinating capacity among the community, hospitals, and other emergency services.

Equipment and Supplies

The provision of appropriate equipment and supplies is essential; previous studies have shown that educational interventions to paramedics are less effective if equipment availability limits the ability of these trained personnel to implement their knowledge (Arreola-Risa and others 2007; McClure and others 2007). The WHO provides a comprehensive list of equipment and supplies needed for prehospital providers, which is shown in

annex 14A (Sasser and others 2005). Despite adequate provision, the utilization of appropriate equipment in LMICs is variable; a study from Malaysia finds that oxygen delivery devices were used in 45 percent of ambulance runs, the scoop stretcher in 29 percent, and wound dressings in only 23 percent (Ismail and others 2012).

HEALTH FACILITY–BASED SUBSYSTEMS

Health facility–based subsystems refer to the level within the health care system at which appropriate definitive care is delivered. Formal health facilities vary immensely across and within countries. In some countries, this subsystem may be a regional or second-level hospital with specialists; in others, a district or first-level hospital with general practitioners or nonspecialist doctors; and in still others, a health center with nonphysician clinicians. In some LMICs, some types of emergency medical care, for conditions such as acute diarrhea or severe malaria, may be effectively delivered at a health center staffed by nonphysician clinicians. However, such a facility will be inadequate for the management of severe multiple injuries or obstructed labor. The triage process in the prehospital subsystem should determine which patients receive transportation to which facility rather than merely transportation to the nearest facility. Precious time and lives may be lost when patients are taken to facilities where the desired care is not available.

The goal of an effective emergency medical system is the provision of emergency care to all who need it. This section presents guidelines on the necessary inputs. Two of the components in hospital emergency care are discussed in more detail: training, and equipment and supplies.

Training

Most in-service training for emergency care professionals working in hospitals is designed to address a particular problem, such as severe injuries, emergency pediatrics, or obstetric emergencies. Yet because of the resource constraints in LMICs, the same personnel will be confronted with all of these problems.

Few courses in emergency care have been rigorously evaluated (Black and Brocklehurst 2003). The Advanced Trauma Life Support course for physicians has resulted in improved patient outcomes in some settings, although it may be too expensive for most LMICs and inappropriate in settings in which the majority of patients are not seen by physicians. In a third-level hospital in Trinidad and Tobago, injury mortality was reduced by 50 percent following Advanced Trauma Life Support training (Ali and others 1993). Life-saving obstetric skills training contributed to a reduction in maternal deaths. In Kebbi state in Nigeria, training led to a reduction in case-fatality rates to 5 percent from 22 percent among women with obstetric complications (Oyesola and others 1997).

Similar trends were observed in other sites at which the intervention was implemented (Oyesola and others 1997). Emergency Triage Assessment and Treatment has been used in many countries to improve pediatric emergency care (WHO and UNICEF 2000). Other examples are Primary Trauma Care, which is a trauma management course to train doctors and other health workers in first-level hospitals and remote locations (Wilkinson and Skinner 2000), and Advanced Life Support in Obstetrics (http://www.aafp.org/also). These courses have been beneficial in standardizing protocol-based emergency care, but their outcome evaluations are still awaited. Box 14.3 describes public and private initiatives to facilitate training in India.

Equipment and Supplies

A list of resources for emergency care required at different levels is available in annex 14B. This template is flexible; countries can customize it to suit local conditions such as existing facility levels and prevailing burden of emergency disease conditions. Equipment and supplies at each level should match the knowledge and skills of the personnel available to use them.

One study provides sobering evidence that one of the key barriers to the provision of emergency and surgical care in Sub-Saharan Africa is lack of basic infrastructure; in an assessment of five countries (Ghana, Kenya, Rwanda, Tanzania, and Uganda), for example, only 22 percent to 46 percent of hospitals at all levels had dependable running water and electricity. Not one surveyed hospital met the minimum WHO standards for the provision of emergency and surgical care, suggesting that these infrastructure investments must be made in conjunction with investments in the human workforce (Hsia and others 2012).

COSTS AND EFFECTIVENESS

Costs

There is a paucity of literature delineating the costs of providing prehospital and emergency care, especially in LMICs. A few studies examine the costs of specific components of this system, but none evaluates the actual cost of the entire system. Reporting on the 10-year results of the implementation and expansion of a trauma

Box 14.3

Emergency Care Training in India

The training of personnel working in emergency medical services is crucial to the success of the efficient delivery of care. Evidence exists to support the usefulness of life-support training for emergency caregivers in low- and middle-income countries. Courses such as Advanced Trauma Life Support are available and well established in some high-income countries and middle-income countries. In most low-income countries, however, such training is not available, mainly because of prohibitive costs. The three-day Advanced Trauma Life Support course costs, on average, US$700 per trainee and is taught to 6 to 20 trainees at a time.

National Trauma Management Course

The National Trauma Management Course is a two-day course developed in India by the Academy of Traumatology with the help of international peers. The curriculum takes into account local conditions and capabilities. The cost is US$50 per trainee; local trainers teach 100 trainees at a time. Animal specimens, instead of expensive commercially produced mannequins, are used to teach life-saving procedures. More than 2,000 health professionals were trained in less than three years. The course has become a national training standard for immediate trauma care in India.

Private Initiatives

In addition, several private initiatives have increased the number of formally trained prehospital paramedics who have graduated to become Advanced Cardiac Life Support/Basic Life Support instructors. One example is the Stanford-Apollo EMT [Emergency Medical Technician]-Intermediate Training program at Apollo Hospital in Hyderabad and Chennai, in conjunction with the Stanford School of Medicine (Stanford, California). A second, also in conjunction with Stanford, is the GVK Emergency Management and Research Institute (EMRI) in Hyderabad. The first internationally affiliated paramedic program, the Post-Graduate Program in Emergency Care, began in 2007 to develop advanced clinical educators, who are essentially paramedic-instructors, with 15 two-week modules that include simulation, interactive case-based studies, and distance learning.

Prehospital Research Center

In 2008, the Post-Graduate Program in Emergency Care also began a prehospital research center at the GVK EMRI campus in Hyderabad, India, and conducts research on obstetric emergencies, chest pain, vehicular trauma, gastrointestinal emergencies, seizures, poisoning and suicide attempts, burns, shortness of breath, and nonvehicular trauma. The program was turned over to GVK EMRI in July 2009 and continues to train Indian paramedics. In May 2013, more than 5,700 ambulances were providing prehospital care to more than 750 million Indians, including 2,121,000 medical emergencies a day, making it the largest ambulance system in the world.

Prehospital Emergency Care Protocol

Another output from the Stanford-Apollo EMT Intermediate Training has been a Prehospital Emergency Care Protocol, published in 2012, for physicians, emergency medical technicians, and educators. These protocols did not exist before March 2011. The goals of these unique protocols are to ensure countrywide uniformity and consistency of prehospital care and to espouse evidence-based practice related to ambulance systems (when this evidence is available). More than 5,000 protocol manuals have been printed and placed in ambulances and call centers throughout India.

Sources: Mahadevan and others 2009; Mantha and others 2009.

system (consisting of trained laypersons, paramedics, and two trauma referral centers) in north and central Iraq, Murad, Larsen, and Husum (2012) note that the per patient treatment costs—medical treatment, evacuation, data gathering, and quality control—ranged from US$130 to US$180.

Perhaps the best exercise to date in estimating system-level costs is Kobusingye and others (2006). In their modeling exercise, they estimate system costs of establishing and running two types of prehospital and emergency care systems:

- One in which trained lay responders and paramedics provide care
- One in which staffed community ambulances provide care

For a population of 1 million, they assume that the trained laypersons and paramedics system will require 7,500 lay responders, with 2,500 trained on a rolling basis. The system would also require 50 trained paramedics annually. Training costs would include a classroom, copies of curricula, time costs, and remuneration of trainees and trainers. The training (and its costs) would be repeated every three years to maintain skill levels. Paramedics would be equipped with basic kits consisting of a stethoscope, gloves, bandages, and splint materials. Trained laypersons and paramedics would volunteer their services after training. Given these assumptions, Kobusingye and others' (2006) best estimate of cost was US$62,923 or US$0.06 per capita (ranging between US$30,254 and US$126,475).

Jayaraman and others (2009b) build on this framework to estimate the costs of scaling up their layperson first aid training pilot to cover Kampala, Uganda. They assume that 9,000 trainees (a range of 6,000 to 12,000) are required to cover the city's 1.2 million residents. Using Kobusingye and others' (2006) costs and costing assumptions, their base case scenario (of training 9,000 trainees over three years) results in an annual cost of US$47,854 or US$0.12 per capita; these costs increase to US$143,854 annually or US$0.36 per capita when the first aid kit and its restocking (US$16 each) are factored in (Jayaraman and others 2009b).

For a system that relies on staffed ambulances, Kobusingye and others (2006) assume that an ambulance unit serves 30,000 people and has a staff of seven paramedic-drivers. Accordingly, 33 such units are required for a population of 1 million; in addition, a supervisor will oversee three ambulance units per year. Ambulances can be purchased and retrofitted locally; they are assumed to have a useful life of nine years and to be driven 20,000 kilometers every year. Under these assumptions, the authors estimate the yearly cost of such a system in an urban area to be approximately US$1.27 million or US$1.27 per capita (a range of US$0.79 million to US$2.15 million), with a rural ambulance system costing three times as much.

Effectiveness

Although a prehospital and emergency care system can respond to a wide range of conditions, most studies in the literature report outcomes pertaining to trauma, with a small but growing body of literature on the effectiveness of first responders and paramedics.

Increasing evidence indicates the benefits of a well-functioning prehospital care system. Literature from high-income countries (HICs) suggests that for patients with serious injuries, preventable trauma deaths are reduced significantly after trauma system implementation (Kane and others 1992; Mullins and others 1994; Rutledge and others 1992). Similar evidence is emerging from Iraq, where the implementation and expansion of a trauma system in north and central Iraq reduced trauma mortality over a 10-year period to 4 percent from 17 percent (Murad, Larsen, and others 2012). A study from Portugal shows a reduction in mortality of approximately 50 percent in trauma patients who received some form of treatment in the prehospital phase (Gomes and others 2010). Work done in Cambodia and northern Iraq demonstrates a 9 percent reduction in mortality among trauma victims after the institution of a system comprising first-level responders and trained paramedics (Husum and others 2003); this study forms the basis of the cost-effectiveness analysis of trained laypersons and paramedics by Kobusingye and others (2006).

Experience from the northern Iraq system suggests an even greater impact of providing prehospital care to trauma patients. Murad and others (2012) report a mortality rate of 8 percent in road traffic accident patients managed onsite and evacuated by trained first responders and paramedics; the mortality rate is 40 percent in the patients admitted without any prehospital care. Similarly, a review of eight studies on prehospital care in LMICs to attempt to determine aggregate risk reduction for mortality, injury severity, and transport time found a 25 percent reduction in the risk of mortality with the implementation of a prehospital system; treatment effects were enhanced in rural settings. In addition, response times were reduced 66 minutes overall in rural settings, and 6 minutes in urban settings (Henry and Reingold 2012) (box 14.4).

An ambulance-based system can potentially save 700 lives annually: 200 from ischemic heart disease, 200 from obstetric emergencies, and 300 from trauma (Kobusingye and others 2006).

Evidence from LMICs suggests that providing basic life support (BLS) training to ambulance personnel can reduce trauma mortality, as evidenced by a decrease in mortality to 10.6 percent from 15.7 percent in Trinidad when such a system was established (Ali and others 1993). However, other LMICs are gravitating toward providing advanced life support (ALS) training to these personnel, rather than BLS training. This shift is, in part, due to evidence from HICs that attributes a reduction in trauma mortality to ALS training (Kirsch 1998; Reines and others 1988). A meta-analysis of 18 studies finds that provision of ALS care to nontraumatic cardiac arrest patients could increase their survival; it also finds no difference in survival in trauma patients who received ALS versus those receiving BLS (Bakalos and others 2011). Similarly, a Cochrane review did not find any differences in mortality among trauma victims cared for by BLS-trained versus

Box 14.4

Training Community Paramedics and First Responders: Experiences from Iraq and Cambodia

In northern Iraq (Sulaymaniyah Governorate) and northwest Cambodia (Battambang Province), two conflict areas with extensive minefields, the estimated mortality rates for mine casualties were approximately 40 percent. Based on the concept of the Village University, laypersons recommended by their village leaders were trained by outside trainers in basic prehospital life-support and life-saving skills—for example, keeping airways open and stopping bleeding. In 1997–99, a core group of 44 trainees received 150 hours of training in basic airway, breathing, and circulation techniques; each trainee subsequently trained 50 village first helpers in two-day training sessions 6 to 12 months after the initial training.

By the end of the fifth year of the program, 135 community paramedics and 5,200 first responders had been trained. Refresher courses were also provided for the paramedics and first responders.

Care had been provided to 1,061 trauma victims, with a reduction in the mean response time from 2.9 hours (1997) to 1.8 hours (2001) from time of injury to first medical contact, although there was no change in mean prehospital transit time. Mortality for these trauma patients was reduced from a pre-intervention level of 40 percent to 8 percent postintervention at the final stage.

Further studies have shown that the time from injury to first medical help decreased even more, to 0.6 hours, and time of injury to hospital decreased to 2.8 hours from 9.6 during the period 1997–2004. These studies have shown a high retention of paramedics (72 percent) over the period.

A study has documented the benefits of the first responder program separately from the paramedic program, showing that mortality rates were 9.8 percent in those seen by first responders, and 15.6 percent in those with only paramedic contact (difference of 6 percent, 95 percent confidence interval of 2 percent to 10 percent). Of those with an injury severity score greater than 15, mortality was lower (38 percent) in those treated by first responders, compared with 51 percent in those only seen by paramedics (95 percent confidence interval on the difference of 1 percent to 24 percent). In addition, those seen by only first responders had lower mortality rates than those seen by first responders and then paramedics (4.7 percent versus 13.4 percent, 95 percent confidence interval of 3 percent to 15 percent). This is likely because shorter travel times allow for direct handoff from first responder to facility, rather than longer transit times that allow for a handoff to a paramedic who then brings the patient to a treating facility. In other words, these studies show that mortality can be lower if the injured person is treated initially by a first responder before a paramedic arrives when travel times are long.

Finally, the effect of this two-tier prehospital rural trauma system with first responders and rural paramedics has been shown to have benefits for patients in road traffic accidents with long transport times, with a mortality rate of 8 percent in the intervention areas, compared with 44 percent in the control areas.

Source: Husum and others 2003; Murad and Husum 2010; Murad and others 2012; WHO 2010; Wisborg, Murad, Edvardsen, and Brinchmann 2008; Wisborg, Murad, Edvardsen, and Husum 2008.

ALS-trained ambulance personnel (Jayaraman and Sethi 2010). On the contrary, some evidence suggests that care provided by ALS-trained personnel might have worse outcomes (Stiell and others 2008).

This evidence suggests that an advanced prehospital emergency medical system should never be developed at the expense of a broad base of basic prehospital care. ALS interventions benefit a small subset of critically ill patients who may require a large investment of resources that may be less cost-effective. Some experts recommend that the development of these more advanced systems be delayed until additional evidence demonstrates that improved outcomes can be gained by such systems. Indeed, an analysis of ALS-level interventions in Monterrey and San Pedro, Mexico, showed no significant improvements in the mortality rates of transported patients, versus a BLS training project, which did reduce mortality from 8.7 percent to 4.7 percent (Arreola-Risa and others 2004, 2007; Hauswald and Yeoh 1997). Another disadvantage of ALS training for lay personnel is that the Mexican study showed low pass rates for students in the advanced cardiac life support course; only 29 percent passed, compared with more than 80 percent who passed the BLS courses. This result could have been due to the relatively low levels of schooling for the majority of medics (Arreola-Risa and others 2007).

Cost-Effectiveness

Table 14.1 summarizes the cost-effectiveness estimates of Kobusingye and others (2006). In a population of 1 million, a system of trained laypersons and paramedics is highly cost-effective at US$170 to avert one death; an ambulance-based system in an urban area costs US$1,818 to achieve a similar result. A different metric (cost per life year gained) yields similar results; the trained layperson and paramedic system costs US$7 per year of life gained; the urban ambulance–based system costs approximately 13 times as much.

Table 14.2 is a similar synopsis of an analysis of the cost-effectiveness of scaling up a pilot layperson first aid training program to cover all of Kampala (Jayaraman and others 2009b). Mortality reductions resulting from this training program were assumed to be 15 percent (based on Husum and others 2003); the authors repeat the calculations using a more conservative 7.5 percent reduction to perform a sensitivity analysis.

However, there are caveats. The inputs in Kobusingye and others (2006) were based on 2001 data; the results are reported in 2001 U.S. dollars and may not be reflective of today's economic environment. For example, the wide availability of cellular phones has revolutionized both the availability and the cost of communications in many LMICs, decreasing the need to have dedicated communications equipment for the prehospital and emergency care system.

From a methodological perspective, certain assumptions are also important. Kobusingye and others (2006) assume that the trained laypersons and paramedics would offer their services on a volunteer basis. Both studies apply the outcome on a global basis, without taking into account regional variations. Systemic costs, or the additional burden to the health care system from additional visits, are not factored into their calculations. The ambulance system is assumed to have the same effectiveness in both rural and urban areas; the authors caution that "substantial uncertainty remains over actual effectiveness of the interventions in emergency medicine" (Kobusingye and others 2006, 1271).

FUTURE DIRECTIONS

This section summarizes considerations for LMICs as they develop their prehospital and emergency systems and highlights the gaps in evidence that hamper effective policy making.

Systems Organization

Effective emergency medical systems require careful planning, implementation, coordination, and communication

Table 14.1 Summary of Cost and Effectiveness of Interventions

U.S. dollars

	Intervention		
	Trained lay first responders and paramedic responders	Staffed community ambulance, urban	Staffed community ambulance, rural
Cost per 1 million population	62,923	1,272,705	3,827,376
Cost per death averted per 1 million population	170	1,818	5,468
Cost per life year gained per 1 million population	7	94	284

Source: Kobusingye and others 2006.
Note: Figures are unweighted averages.

Table 14.2 Cost-Effectiveness of Scaling Up Lay Person First Aid Training in Kampala

U.S. dollars

	Estimated 240 deaths averted (15 percent)		Estimated 120 deaths averted (7.5 percent)	
	Cost per death averted	Cost per life year saved	Cost per death averted	Cost per life year saved
Base case	598	25	1,196	50
Base case + US$32 supplies	1,798	75	3,596	150

Source: Jayaraman and others 2009b.

with local communities. The respective components should be linked to ensure that the entire system operates as a unit. A coordinator should be responsible for monitoring and coordinating all emergency medical care in the community or district; this coordinator should work with a central committee that reflects and represents the components.

Coordination costs are important and should not be overlooked in the development of a new emergency management system. Such costs include the salary of the coordinator, an efficient telephone or communication system, vehicle and fuel costs, and a budget to organize meetings of stakeholders at least twice a year (Bazzoli, Harmata, and Chan 1998; Nurok 2001).

Financing

To optimize outcomes, emergency care systems in LMICs should require explicit consideration of how poor people interact with these services and how barriers to acute care can be overcome. Issues of access become critical because the lack of money often keeps people from using emergency services. Direct payment of costs for transportation, medical treatment, and medications may well constitute a major barrier for poor people in every country. Emergencies frequently cripple individuals and families financially in these communities, often for many years. At the same time, evidence indicates that when services such as ambulance transport are provided, families are willing to pay (Bose and others 2012).

Financial protection for emergency health care in LMICs is a necessity that has not received adequate attention. The goal of such protection is to ensure that individuals and families do not spiral down the pathway to abject poverty as a result of obtaining needed health care. Such financial protection may be achieved by a number of different means, including community financing (Ande and others 1997; Desmet, Chowdhury, and Islam 1999; Macintyre and Hotchkiss 1999). Community loan funds to cover transportation and other requirements for emergencies, especially for obstetrics, have been explored with mixed results (Essien and others 1997; Shehu, Ikeh, and Kuna 1997). It is plausible that these approaches can help overcome barriers to accessing emergency medical services and should be considered.

Documentation and Quality Assurance

Ensuring the quality of emergency care for all people is critical. Lack of funds, lower-paying jobs, social class distinctions, ethnicity, and other affiliations make the already vulnerable poor susceptible to receiving substandard care. Systematic documentation and periodic audits or other processes to ensure quality need to be incorporated to maintain and improve patient care. The emergency medical system should include a quality management component that is simple and continuous and that allows for rapid changes.

Expensive technology and equipment and specialists should not be advocated for the urban privileged at the expense of the majority of the rural poor. The most difficult decisions concern balancing funds invested in the emergency care capacity of first-level and second-level centers against support for referral and transportation networks to feed third-level centers. These decisions are too variable and too system specific to allow uniform policy prescriptions. Two principles can help inform these difficult decisions:

- Collect data on costs, capacities, and outcomes.
- Enhance the integration of the emergency care to improve its functioning and lead to wiser investment allocations.

Legislation

The issues discussed in this chapter form the rationale for countries to enact specific legislation addressing the provision of emergency care. This area requires major cooperation between public health and the law, which together provide the legal framework for ensuring that all individuals who need emergency care can receive it, irrespective of their personal characteristics or their ability to pay. Having laws that protect trained individuals and laypersons as they provide such care is also important. Box 14.5 provides an example of how legislative action can help the coordination and creation of emergency care, from prehospital to hospital settings.

Research and Development Agenda

The research and development priorities for emergency care are challenging to define because emergency care is a neglected area of research in LMICs, and the needs are great. As a neglected topic, emergency care is part of the "10–90" gap of health research: less than 10 percent of global research investments are for problems affecting 90 percent of the world's population (GFHR and WHO 2002).

Research and Development Approach. The spectrum of research required is diverse and may be more easily understood with the help of the schematic in table 14.3.

- The rectangle is a schematic representation of the totality of the global burden of disease that can potentially be addressed by emergency care systems.

Box 14.5

Emergency Medical Services Coordination and Legislative Efforts in Colombia

Because of the heavy burden of trauma in Colombia, numerous cities had separate emergency medical systems, with varying protocols, training, and personnel. Some cities had volunteer systems; others had publicly funded firefighters or other civil employees. This lack of centralized organizational structure made it almost impossible to coordinate mass-casualty events across cities, such as in 1985 with the eruption of the Nevado del Ruiz volcano, which was responsible for the deaths of more than 22,000 individuals.

This challenge prompted a response to standardize training. Legislation mandated additional funds for the coordination of and authority over prehospital systems. To standardize processes nationwide, the Colombian Prehospital Care Association (ACAPH, Asociación Colombiana de Atención Prehospitalaria) was constituted from stakeholders, including physicians; private and public ambulance services; hospital administrators; university researchers; and volunteer groups, such as the civil defense, Red Cross, firefighters, and volunteer rescue agencies. The ACAPH developed standardized curricula for nurse assistants, emergency technicians, and emergency technologists. In addition, the ACAPH secured increased governmental legislation. At the time, there was already a quality plan with standardized protocols for hospital-based health care staff and coordination across hospitals; ACAPH advocated that prehospital care and training be included in the national guidelines.

These efforts ultimately resulted in the creation of the Prehospital Trauma Life Support and Basic Trauma Life Support course as well as the National Medical Prehospital Guidelines in 2005, which ACAPH developed in conjunction with the Health Sciences Institute (Instituto de Ciencias de la Salud) and the Ministry of Social Protection. Integration of prehospital and emergency medical services into national legislation continued in different resolutions to include various levels of ambulance services, which evolved into a separate decree for auditing the quality of care and accreditation of ambulance services.

The results of this national legislation have prompted six national universities to create formal prehospital career training programs, such as the National Emergency Medical Services Technologist Curriculum. In addition, coordination across emergency medical units has improved, as evidenced in the response to the 2008 Nevado del Huila volcano eruption. Although it is difficult to completely attribute the decline in mortality to these programs and legislation, injury deaths decreased from 44,000 in 2002 to 28,000 in 2007.

Source: WHO 2010.

- A portion of this potential burden is being addressed or reduced by existing interventions, defined by box A.
- If the efficiency of current interventions were enhanced and their coverage increased, then another portion of the burden defined by box B could be addressed; this increase in efficiency will require operations research, policy research, and social science research.
- If existing interventions that have not been implemented because of their high costs were made more cost-effective, then another portion of the burden defined by box C could be reduced. This process of making interventions more cost-effective will require economic analysis and clinical research in many instances.
- Finally, some portion of the burden has no existing interventions; basic and clinical research are required to develop and pilot interventions that can address other determinants of the emergency care–related burden in the future.

The schematic representation in table 14.3 is useful for demonstrating two critical needs:

- Essential research on emergency care in LMICs
- A diverse set of research studies and approaches to reduce the burden that emergency care systems can address

Priority Setting

Setting priorities for the research and development of emergency care systems needs to be a region-specific, rather than a country-specific, process. No current list exists of global research and development priorities, reflecting the need for more attention and investment in this area. This chapter does not prescribe a list of issues or topics for global research and development efforts, but rather highlights the gap in global research and development and suggests possible issues and topics

Table 14.3 Burden of Disease Potentially Addressed by Emergency Medical Services

D: No emergency care interventions currently available to address this burden		
A: Currently implemented emergency care interventions that are addressing this burden	B: Existing emergency care interventions that are able to address existing burden if efficiency enhanced	C: Potential emergency care interventions that could address this burden if they were made cost-effective

Source: Kobusingye and others 2006.

that may be broadly relevant to LMICs for these efforts in the short to medium term.

Methods for setting research priorities in the health sector are available, such as the Combined Approach Matrix promoted by the Global Forum for Health Research (GFHR and WHO 2002), and the Essential National Health Research process promoted by the Council on Health Research for Development. Countries and regions can use these approaches to help develop their individual emergency care research agendas.

The review of evidence available in the field of emergency care as applicable to LMICs reveals many gaps in global knowledge. Following from the presentation in table 14.3 is the need to better understand the epidemiology of those conditions that can be addressed by emergency care systems in LMICs and which interventions in place address them. There is little knowledge of how to enhance the efficiency of these existing interventions and reduce their costs. Most important, the lack of intervention trials in LMICs creates a major research priority for the field of emergency care. Well-designed, locally appropriate interventions that establish their effectiveness are urgently needed and should include both interventions that may be available in HICs as well as new interventions. Economic analysis is another area for major research input in the field of emergency care, where cost and cost-effectiveness information from LMICs is scant. These gaps reflect the need for a more systematic analysis of where emergency care research investments should be directed for optimal results in the future.

CONCLUSIONS: PROMISES AND PITFALLS

Emergency care is a critical and integral component of national health systems in LMICs. Governments and ministries of health in these countries need to pay specific attention to the development of emergency care and to ensure that their evolution is both evidence based and appropriate to their national needs. More important, the context and implementation of emergency care should improve health equity and not widen existing health disparities.

This chapter highlights not only the urgent need for more attention to emergency care in LMICs, but also points out an opportunity for these countries to define better emergency care systems for their needs. In promoting the systematic development of evidence-based emergency care systems, LMICs could help define more effective and more cost-effective emergency systems than currently exist in HICs. This opportunity should not be lost as a result of political inattention or lack of funds; international and national stakeholders should move forward to stem the preventable loss of life from the lack of emergency care.

Too little is known about the true extent of the need for emergency care, the design that would work well for different communities and populations, and the costs and benefits of delivering emergency care. These gaps call for more investment in the research, development, and implementation of emergency care, especially in LMICs. Universal emergency care is consistent with the right to health care; by definition, emergency care is a matter of life and death. It is essential to endeavor to ensure that prompt, appropriate care is available in critical moments when delays in care—or the delivery of inappropriate care—could mean the loss of lives.

ANNEXES

The annexes to this chapter are as follows. They are available at http://www.dcp-3.org/surgery:

- Annex 14A. Matrix of Essential Knowledge, Skills, Equipment, and Supplies for Prehospital Providers
- Annex 14B. Essential Resources for the Delivery of Emergency Care in Hospitals

NOTE

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

REFERENCES

Ali, J., R. Adam, A. K. Butler, H. Chang, M. Howard, and others. 1993. "Trauma Outcome Improves Following the Advanced Trauma Life Support Program in a Developing Country." *Journal of Trauma* 34 (6): 890–98; discussion 898–99.

Ali, J., R. U. Adam, T. J. Gana, and J. I. Williams. 1997. "Trauma Patient Outcome after the Prehospital Trauma Life Support Program." *Journal of Trauma* 42 (6): 1018–21; discussion 1021–12.

Ande, B., J. Chiwuzie, W. Akpala, A. Oronsaye, O. Okojie, and others. 1997. "Improving Obstetric Care at the District Hospital, Ekpoma, Nigeria: The Benin PMM Team." *International Journal of Gynaecology and Obstetrics* 59 (Suppl 2): S47–53.

Arellano, N., M. J. Mello, and M. A. Clark. 2010. "The Role of Motorcycle Taxi Drivers in the Pre-hospital Care of Road Traffic Injury Victims in Rural Dominican Republic." *Injury Prevention* 16 (4): 272–74.

Arreola-Risa, C., C. N. Mock, A. J. Herrera-Escamilla, I. Contreras, and J. Vargas. 2004. "Cost-Effectiveness and Benefit of Alternatives to Improve Training for Prehospital Trauma Care in Mexico." *Prehospital Disaster Medicine* 19 (4): 318–25.

Arreola-Risa, C., C. N. Mock, L. Lojero-Wheatly, O. de la Cruz, C. Garcia, and others. 2000. "Low-Cost Improvements in Prehospital Trauma Care in a Latin American City." *Journal of Trauma* 48 (1): 119–24.

Arreola-Risa, C., J. Vargas, I. Contreras, and C. N. Mock. 2007. "Effect of Emergency Medical Technician Certification for All Prehospital Personnel in a Latin American City." *Journal of Trauma* 63 (4): 914–19.

Bakalos, G., M. Mamali, C. Komninos, E. Koukou, A. Tsantilas, and others. 2011. "Advanced Life Support versus Basic Life Support in the Pre-hospital Setting: A Meta-Analysis." *Resuscitation* 82 (9): 1130–37.

Bavonratanavech, S. 2003. "Trauma Care Systems in Thailand." *Injury* 34 (9): 720–21.

Bazzoli, G. J., R. Harmata, and C. Chan. 1998. "Community-Based Trauma Systems in the United States: An Examination of Structural Development." *Social Science and Medicine* 46 (9): 1137–49.

Black, R. S., and P. Brocklehurst. 2003. "A Systematic Review of Training in Acute Obstetric Emergencies." *BJOG: An International Journal of Obstetrics and Gynaecology* 110 (9): 837–41.

Bollig, G., A. G. Myklebust, and K. Ostringen. 2011. "Effects of First Aid Training in the Kindergarten: A Pilot Study." *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine* 19 (1): 13.

Bollig, G., H. A. Wahl, and M. V. Svendsen. 2009. "Primary School Children Are Able to Perform Basic Life-Saving First Aid Measures." *Resuscitation* 80 (6): 689–92.

Bose, S. K., K. D. Bream, F. K. Barg, and R. A. Band. 2012. "Willingness to Pay for Emergency Referral Transport in a Developing Setting: A Geographically Randomized Study." *Academic Emergency Medicine* 19 (7): 793–800. doi:10.1111/j.1553-2712.2012.01382.x.

Bossyns, P., R. Abache, M. S. Abdoulaye, and W. V. Lerberghe. 2005. "Unaffordable or Cost-Effective?: Introducing an Emergency Referral System in Rural Niger." *Tropical Medicine and International Health* 10 (9): 879–87.

Chandy, H., M. Steinholt, and H. Husum. 2007. "Delivery Life Support: A Preliminary Report on the Chain of Survival for Complicated Deliveries in Rural Cambodia." *Nursing and Health Sciences* 9 (4): 263–69.

Desmet, M., A. Q. Chowdhury, and M. K. Islam. 1999. "The Potential for Social Mobilisation in Bangladesh: The Organisation and Functioning of Two Health Insurance Schemes." *Social Science and Medicine* 48 (7): 925–38.

Essien, E., D. Ifenne, K. Sabitu, A. Musa, M. Alti-Mu'azu, and others. 1997. "Community Loan Funds and Transport Services for Obstetric Emergencies in Northern Nigeria." *International Journal of Gynaecology and Obstetrics* 59 (Suppl 2): S237–44.

Fiander, S. 2001. *Anyone Can Save a Life: Road Accidents and First Aid*. London: British Red Cross.

Geduld, H., and L. Wallis. 2011. "Taxi Driver Training in Madagascar: The First Step in Developing a Functioning Prehospital Emergency Care System." *Emergency Medicine Journal* 28 (9): 794–96.

GFHR (Global Forum for Health Research) and WHO (World Health Organization). 2002. *The 10/90 Report on Health Research 2001–2002*. Geneva: Global Forum for Health Research.

Gomes, E., R. Araujo, A. Carneiro, C. Dias, A. Costa-Pereira, and others. 2010. "The Importance of Pre-trauma Centre Treatment of Life-Threatening Events on the Mortality of Patients Transferred with Severe Trauma." *Resuscitation* 81 (4): 440–45.

Hauswald, M., and E. Yeoh. 1997. "Designing a Prehospital System for a Developing Country: Estimated Cost and Benefits." *American Journal of Emergency Medicine* 15 (6): 600–03.

Henry, J. A., and A. L. Reingold. 2012. "Prehospital Trauma Systems Reduce Mortality in Developing Countries: A Systematic Review and Meta-Analysis." *Journal of Trauma and Acute Care Surgery* 73 (1): 261–68.

Hsia, R. Y., N. A. Mbembati, S. MacFarlane, and M. E. Kruk. 2012. "Access to Emergency and Surgical Care in Sub-Saharan Africa: The Infrastructure Gap." *Health Policy and Planning* 27 (3): 234–44.

Husum, H., M. Gilbert, and T. Wisborg. 2003. "Training Pre-Hospital Trauma Care in Low-Income Countries: The 'Village University' Experience." *Medical Teacher* 25 (2): 142–48.

Husum, H., M. Gilbert, T. Wisborg, Y. Van Heng, and M. Murad. 2003. "Rural Prehospital Trauma Systems Improve Trauma Outcome in Low-Income Countries: A Prospective Study from North Iraq and Cambodia." *Journal of Trauma* 54 (6): 1188–96.

Ismail, M. S., A. B. Hasinah, M. N. Syaiful, H. B. Murshidah, T. J. Thong, and others. 2012. "Study on Advanced Life Support Devices in the Ambulances for Emergency Cases in Klang Valley, Malaysia." *La Clinica Terapeutica* 163 (2): 115–22.

Jamison, D. T., J. G. Bremen, A. R. Measham, G. Alleyne, M. Claeson, D. B. Evans, P. Jha, A. Mills, and P. Musgrove, eds. 2006. *Disease Control Priorities in Developing Countries.* 2nd ed. Washington, DC: World Bank and Oxford University Press.

Jayaraman, S., J. R. Mabweijano, M. S. Lipnick, N. Caldwell, J. Miyamoto, and others. 2009a. "Current Patterns of Prehospital Trauma Care in Kampala, Uganda and the Feasibility of a Lay-First-Responder Training Program." *World Journal of Surgery* 33 (12): 2512–21.

———. 2009b. "First Things First: Effectiveness and Scalability of a Basic Prehospital Trauma Care Program for Lay First-Responders in Kampala, Uganda." *PLoS One* 4 (9): e6955.

Jayaraman, S., and D. Sethi. 2010. "Advanced Trauma Life Support Training for Ambulance Crews." *Cochrane Database of Systematic Reviews* 1: CD003109. doi:10.1002/14651858.CD003109.pub2.

Joshipura, M. K., H. S. Shah, P. R. Patel, P. A. Divatia, and P. M. Desai. 2003. "Trauma Care Systems in India." *Injury* 34 (9): 686–92.

Kane, G., N. C. Wheeler, S. Cook, R. Englehardt, B. Pavey, and others. 1992. "Impact of the Los Angeles County Trauma System on the Survival of Seriously Injured Patients." *Journal of Trauma* 32 (5): 576–83.

Khorasani-Zavareh, D., B. J. Haglund, R. Mohammadi, M. Naghavi, and L. Laflamme. 2009. "Traffic Injury Deaths in West Azarbaijan Province of Iran: A Cross-Sectional Interview-Based Study on Victims' Characteristics and Prehospital Care." *International Journal of Injury Control and Safety Promotion* 16 (3): 119–26.

Kirsch, T. D. 1998. "Emergency Medicine around the World." *Annals of Emergency Medicine* 32 (2): 237–38.

Kobusingye, O. C., D. Guwatudde, G. Owor, and R. R. Lett. 2002. "Citywide Trauma Experience in Kampala, Uganda: A Call for Intervention." *Injury Prevention* 8 (2): 133–36.

Kobusingye, O. C., A. A. Hyder, D. Bishai, E. R. Hicks, C. Mock, and others. 2005. "Emergency Medical Systems in Low- and Middle-Income Countries: Recommendations for Action." *Bulletin of the World Health Organization* 83 (8): 626–31. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2626309/.

Kobusingye, O. C., A. A. Hyder, D. Bishai, M. Joshipura, E. R. Hicks, and others. 2006. "Emergency Medical Services." In *Disease Control Priorities in Developing Countries*, edited by D. T. Jamison, J. G. Bremen, A. R. Measham, G. Alleyne, M. Claeson, D. B. Evans, P. Jha, A. Mills, and P. Musgrove, 2nd ed. 1261–80. Washington, DC: World Bank and Oxford University Press.

Leigh, B., H. B. Kandeh, M. S. Kanu, M. Kuteh, I. S. Palmer, and others. 1997. "Improving Emergency Obstetric Care at a District Hospital, Makeni, Sierra Leone: The Freetown/Makeni PMM Team." *International Journal of Gynaecology and Obstetrics* 59 (Suppl 2): S55–65.

Liberman, M., D. Mulder, A. Lavoie, R. Denis, and J. S. Sampalis. 2003. "Multicenter Canadian Study of Prehospital Trauma Care." *Annals of Surgery* 237 (2): 153–60.

Lungu, K., V. Kamfose, J. Hussein, and H. Ashwood-Smith. 2001. "Are Bicycle Ambulances and Community Transport Plans Effective in Strengthening Obstetric Referral Systems in Southern Malawi?" *Malawi Medical Journal* 12: 16–18.

Macintyre, K., and D. R. Hotchkiss. 1999. "Referral Revisited: Community Financing Schemes and Emergency Transport in Rural Africa." *Social Science and Medicine* 49 (11): 1473–87.

Mahadevan, S., M. Strehlow, A. Chiao, G. Ramana Rao, D. Shelke, and others. 2009. *Development of a Self-Sustaining Paramedic Educational Program in India*. Guwahati, India: EMCON.

Mantha, A., A. Gupta, M. Strehlow, and S. Mahadevan. 2009. *Development of a Focused Leadership Curriculum for Paramedic Students in India*. Guwahati, India: EMCON.

McClure, E. M., W. A. Carlo, L. L. Wright, E. Chomba, F. Uxa, and others. 2007. "Evaluation of the Educational Impact of the WHO Essential Newborn Care Course in Zambia." *Acta Paediatrica* 96 (8): 1135–38.

McSwain, N. 1991. "Prehospital Emergency Medical Systems and Cardiopulmonary Resuscitation." In *Trauma*, edited by E. Moore, K. Mattox, and D. Feliciano. Norwalk, CT: Appleton and Lange.

Mock, C. N., G. J. Jurkovich, D. nii-Amon-Kotei, C. Arreola-Risa, and R. V. Maier. 1998. "Trauma Mortality Patterns in Three Nations at Different Economic Levels: Implications for Global Trauma System Development." *Journal of Trauma* 44 (5): 804–12; discussion 812–14.

Mock, C. N., M. Tiska, M. Adu-Ampofo, and G. Boakye. 2002. "Improvements in Prehospital Trauma Care in an African Country with No Formal Emergency Medical Services." *Journal of Trauma* 53 (1): 90–97.

Mullins, R. J., J. Veum-Stone, M. Helfand, M. Zimmer-Gembeck, J. R. Hedges, and others. 1994. "Outcome of Hospitalized Injured Patients after Institution of a Trauma System in an Urban Area." *Journal of the American Medical Association* 271 (24): 1919–24.

Murad, M. K., and H. Husum. 2010. "Trained Lay First Responders Reduce Trauma Mortality: A Controlled Study of Rural Trauma in Iraq." *Prehospital and Disaster Medicine* 25 (6): 533–39.

Murad, M. K., D. B. Issa, F. M. Mustafa, H. O. Hassan, and H. Husum. 2012. "Prehospital Trauma System Reduces Mortality in Severe Trauma: A Controlled Study of Road Traffic Casualties in Iraq." *Prehospital and Disaster Medicine* 27 (1): 36–41.

Murad, M. K., S. Larsen, and H. Husum. 2012. "Prehospital Trauma Care Reduces Mortality. Ten-Year Results from a Time-Cohort and Trauma Audit Study in Iraq." *Scandinavian Journal of Trauma, Resuscitation and Emergency Medicine* 20: 13.

Nguyen, T. L., T. H. Nguyen, S. Morita, and J. Sakamoto. 2008. "Injury and Pre-hospital Trauma Care in Hanoi, Vietnam." *Injury* 39 (9): 1026–33.

Nurok, M. 2001. "The Death of a Princess and the Formulation of Medical Competence." *Social Science and Medicine* 53 (11): 1427–38.

Oyesola, R., D. Shehu, A. T. Ikeh, and I. Maru. 1997. "Improving Emergency Obstetric Care at a State Referral Hospital, Kebbi State, Nigeria: The Sokoto PMM Team." *International Journal of Gynaecology and Obstetrics* 59 (Suppl 2): S75–81.

Ramanujam, P., and M. Aschkenasy. 2007. "Identifying the Need for Pre-hospital and Emergency Care in the Developing World: A Case Study in Chennai, India." *Journal of the Association of Physicians of India* 55: 491–95.

Reines, H. D., R. L. Bartlett, N. E. Chudy, K. R. Kiragu, and M. A. McKnew. 1988. "Is Advanced Life Support Appropriate for Victims of Motor Vehicle Accidents: The South Carolina Highway Trauma Project." *Journal of Trauma* 28 (5): 563–70.

Rutledge, R., J. Messick, C. C. Baker, S. Rhyne, J. Butts, A. Meyer, and others. 1992. "Multivariate Population-Based Analysis of the Association of County Trauma Centers with per Capita County Trauma Death Rates." *Journal of Trauma* 33 (1): 29–37; discussion 37–28.

Sampalis, J. S., S. Boukas, A. Lavoie, A. Nikolis, P. Frechette, and others. 1995. "Preventable Death Evaluation of the Appropriateness of the On-Site Trauma Care Provided by Urgences-Sante Physicians." *Journal of Trauma* 39 (6): 1029–35.

Sampalis, J. S., A. Lavoie, M. Salas, A. Nikolis, and J. I. Williams. 1994. "Determinants of On-Scene Time in Injured Patients Treated by Physicians at the Site." *Prehospital and Disaster Medicine* 9 (3): 178–88; discussion 189.

Sampalis, J. S., H. Tamim, R. Denis, S. Boukas, S. A. Ruest, and others. 1997. "Ineffectiveness of On-Site Intravenous Lines: Is Prehospital Time the Culprit?" *Journal of Trauma* 43 (4): 608–15; discussion 615–07.

Sangowawa, A. O., and E. T. Owoaje. 2012. "Building Capacity of Drivers in Nigeria to Provide First Aid for Road Crash Victims." *Injury Prevention* 18 (1): 62–65.

Sasser, S., M. Varghese, A. Kellerman, and J.-D. Lormand, eds. 2005. *Prehospital Trauma Care Systems*. Geneva: World Health Organization.

Shehu, D., A. T. Ikeh, and M. J. Kuna. 1997. "Mobilizing Transport for Obstetric Emergencies in Northwestern Nigeria. The Sokoto PMM Team." *International Journal of Gynaecology and Obstetrics* 59 (Suppl 2): S173–80.

Solagberu, B. A., C. K. Ofoegbu, L. O. Abdur-Rahman, A. O. Adekanye, U. S. Udoffa, and others. 2009. "Pre-hospital Care in Nigeria: A Country without Emergency Medical Services." *Nigerian Journal of Clinical Practice* 12 (1): 29–33.

Stiell, I. G., L. P. Nesbitt, W. Pickett, D. Munkley, D. W. Spaite, and others. 2008. "The OPALS Major Trauma Study: Impact of Advanced Life-Support on Survival and Morbidity." *Canadian Medical Association Journal* 178 (9): 1141–52. doi:10.1503/cmaj.071154.

Sun, J. H., R. Shing, M. Twomey, and L. A. Wallis. 2012. "A Strategy to Implement and Support Pre-hospital Emergency Medical Systems in Developing, Resource-Constrained Areas of South Africa." *Injury* 45 (1): 31–38.

Sun, J. H., M. Twomey, J. Tran, and L. A. Wallis. 2012. "The Need for a Usable Assessment Tool to Analyse the Efficacy of Emergency Care Systems in Developing Countries: Proposal to Use the TEWS Methodology." *Emergency Medicine* 29 (11): 882–86.

Sun, J. H., and L. Wallis. 2011. "The Psychological Effects of Widespread Emergencies and a First Responder Training Course on a Violent, Developing Community." *African Journal of Emergency Medicine* 1 (4): 166–73.

Tannebaum, R. D., J. L. Arnold, A. De Negri Filho, and V. S. Spadoni. 2001. "Emergency Medicine in Southern Brazil." *Annals of Emergency Medicine* 37 (2): 223–28.

Tiska, M. A., M. Adu-Ampofo, G. Boakye, L. Tuuli, and C. N. Mock. 2004. "A Model of Prehospital Trauma Training for Lay Persons Devised in Africa." *Emergency Medicine* 21 (2): 237–39.

Varghese, M., and P. Mohan. 1998. *When Someone Is Hurt: A First Aid Guide for Laypersons and Community Workers.* New Delhi: The Other Media Communications.

WHO (World Health Organization). 2010. *Strengthening Care for the Injured: Success Stories and Lessons Learned from around the World*. Geneva: WHO.

———. 2013. "Global Health Estimates for Deaths by Cause, Age, and Sex for Years 2000–2011." WHO, Geneva. http://www.who.int/healthinfo/global_burden_disease/en/.

WHO and UNICEF (United Nations International Children's Emergency Fund). 2000. *Management of the Child with a Serious Infection or Severe Malnutrition: Guidelines for Care at the First-Referral Level in Developing Countries*. Geneva: WHO.

Wilkinson, D., and M. Skinner. 2000. *Primary Trauma Care Manual: A Manual for Trauma Management in District and Remote Locations*. Oxford: Primary Trauma Care Foundation. http://www.primarytraumacare.org/wp-content/uploads/2011/09/PTC_ENG.pdf.

Wisborg, T., M. K. Murad, O. Edvardsen, and B. S. Brinchmann. 2008. "Life or Death: The Social Impact of Paramedics and First Responders in Landmine-Infested Villages in Northern Iraq." *Rural and Remote Health* 8 (1): 816.

Wisborg, T., M. K. Murad, O. Edvardsen, and H. Husum. 2008. "Prehospital Trauma System in a Low-Income Country: System Maturation and Adaptation During 8 Years." *Journal of Trauma* 64 (5): 1342–48.