World J Surg (2015) 39:2161–2167
DOI 10.1007/s00268-015-2997-5

ORIGINAL SCIENTIFIC REPORT

Prehospital and Emergency Care: Updates from the Disease Control Priorities, Version 3

Renee Y. Hsia · Amardeep Thind · Ahmed Zakariah · Eduardo Romero Hicks · Charles Mock

Published online: 7 April 2015
© Société Internationale de Chirurgie 2015

Abstract

Background It is increasingly understood that emergency care systems can be cost-effective in low- and middle-income countries (LMICs). The development of such systems, however, is still a work in progress. This article updates previous work in providing the most recent estimates of the burden of disease sensitive to emergency care, the current state of knowledge on the feasibility of emergency care, effect on outcomes, and cost-effectiveness in LMICs, and future directions for research, policy, and implementation.

Methods We calculated the potential impact of prehospital and emergency care systems using updated and revised data based on the global burden of disease study. We then assessed the state of current knowledge and potential future directions for research and policy by conducting a review of the literature on current systems in LMICs.

Results According to these newest updates, 24 million deaths related to emergency medical conditions occur in LMICs annually, accounting for an estimated 932 million years of life lost. Evidence shows that multiple emergency care models can function in different local settings, depending on resources and urbanicity. Emergency care can significantly improve mortality rates from emergent conditions and be highly cost-effective. Further research is needed on implementation of emergency care systems as they become a necessary reality in developing nations worldwide.

Conclusions Emergency care implementation in LMICs presents both challenges and opportunities. Investment in evidence-based emergency care, research on implementation, and system coordination in LMICs could lead to a more cost- and outcome-effective emergency care system than exists in advanced economies.

R. Y. Hsia (✉)
UCSF Department of Emergency Medicine, San Francisco General Hospital, 1001 Potrero Avenue, 1E21, San Francisco, CA 94110, USA
e-mail: renee.hsia@emergency.ucsf.edu

A. Thind
Department of Epidemiology & Biostatistics, Schulich School of Medicine and Dentistry, Western University, Kresge Building, Room K201, London, ON N6A 5C1, Canada

A. Zakariah
Ghana National Ambulance Service, Ministries, P. O. Box M44, Accra, Ghana

E. R. Hicks
Director del Sistema de Urgencias del Estado de Guanajuato, Pastita 53-B, 36090 Guanajuato, GTO, Mexico

C. Mock
Department of Surgery, University of Washington, Harborview Injury Prevention & Research Center, 401 Broadway, 4th Floor, Seattle, WA 98104, USA

Introduction

Emergency medical systems encompass a spectrum of care, beginning with laypersons at the scene and ending in dedicated medical facilities. Connecting these two points are critical systems such as pre- and inter-hospital transport, health centers, and district hospitals. Reducing death and disability requires coordination of the emergency medical response at all stages, with effective facilities and systems management oriented to the needs of the critically ill.

Recently, there has been an increasing understanding that emergency care systems can be cost-effective in low- and middle-income countries (LMICs) [1]. This article presents the most recent available data on the burden of disease that can potentially be addressed by prehospital and emergency care in LMICs, and the current state of knowledge regarding feasibility, cost-effectiveness, and outcomes of emergency care systems in LMICs. It also provides recommendations regarding future directions for research and policy on health care prioritization in LMICs.

Burden of disease

The burden of disease that can potentially be addressed by prehospital and emergency care in LMICs was derived from the global burden of disease (GBD) study. Mortality and disability-adjusted life years (DALYs) data initially presented in the 2012 GBD Lancet papers [2, 3] were adjusted based on newer country and regional estimates from the Institute for Health Metrics and Evaluation website [4].

These updates show that 24 million lives are lost each year in LMICs due to conditions sensitive to prehospital and emergency care (Fig. 1). This translates into 1,023 million DALYs lost, or 932 million years of life lost (YLL) to premature mortality, and nearly 91 million years lived with disability (YLD).

Figure 1 lists the burden of disease—clustered into communicable and maternal conditions, chronic conditions, and injuries—that can potentially be addressed by prehospital and emergency care in LMICs. While ischemic heart disease and cerebrovascular disease contribute the largest number of deaths, unintentional injuries are the

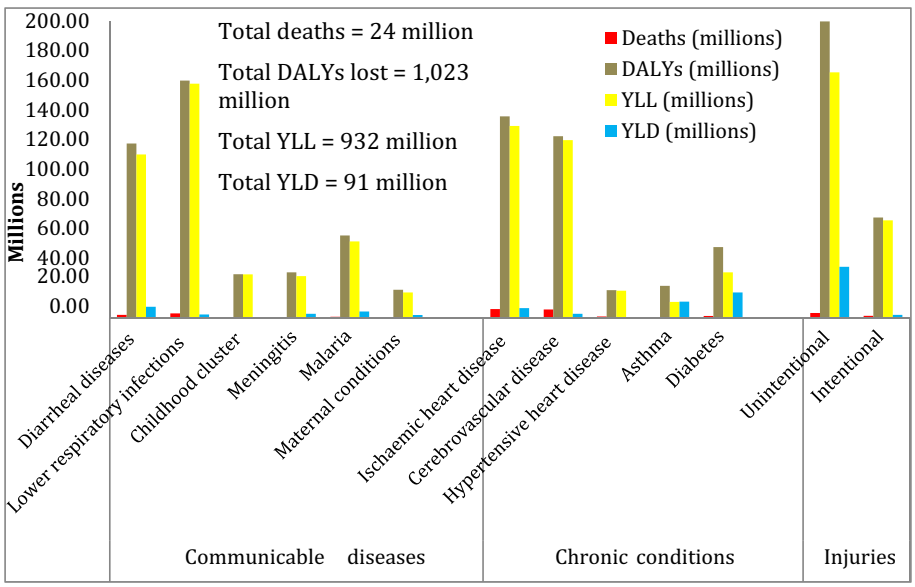

Fig. 1 Burden of disease potentially addressable by emergency medical systems in low-and middle-income countries (LMICs) Caption: The figure shows deaths, disability-adjusted life years (DALYs), years of life lost (YLL), and years lived with disability (YLD) that can be addressed by emergency medical care in low-income countries, stratified into three major categories of burden of disease—communicable diseases, chronic conditions, and injuries. The communicable disease group includes diarrheal diseases (cholera, other salmonella infections, shigellosis, E coli, campylobacter, amoebiasis, cryptosporidiosis, rotavirus, typhoid, and paratyphoid fevers), lower respiratory infections (influenza, pneumococcal pneumonia, haemophilus influenza pneumonia, respiratory syncytial virus pneumonia, other lower respiratory infections), childhood conditions (diphtheria, whooping cough, tetanus, measles), meningitis, malaria, and maternal conditions (hemorrhage, sepsis, hypertensive disorders of pregnancy, obstructed labor, abortion). Chronic conditions potentially amenable include ischemic heart disease, cerebrovascular disease, hypertension, asthma, and diabetes. Injuries include both intentional (self-harm, interpersonal violence, force of nature, war, and legal intervention) and unintentional (transport and non-transport injuries)

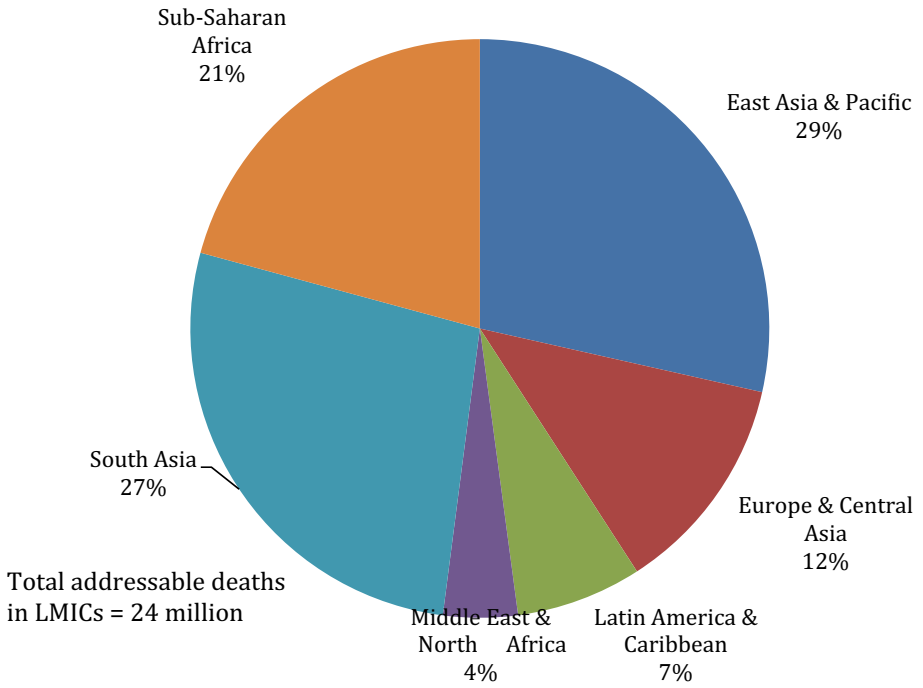

Fig. 2 Regional distribution of deaths addressable by emergency medical systems in low- and middle-income countries (LMICs), data from WHO 2013

single largest contributor to DALYs lost. The largest contributors to YLL are unintentional injuries, lower respiratory infections, and ischemic heart disease.

Figure 2 depicts the regional variations in mortality. Given their large populations, South Asia, East Asia, and the Pacific account for 56 % of the addressable deaths.

Current state of knowledge

Feasibility

Laypeople trained in first aid have been shown to effectively respond to emergencies in communities with high trauma burdens [5]. Individuals who frequently encounter injury and are informally called upon to transport patients—for example, taxi drivers in Ghana—are well-positioned to provide prehospital care and are effectively able to do so with first aid training [6, 7]. In Madagascar, trainings on prehospital services for taxi drivers were successful in empowering the participants and providing basic knowledge and awareness about prehospital emergency care [8]. A recent study from northern Iraq has also shown a mortality benefit of first responder training [9], and a study of midwives and traditional birth attendants in rural Cambodia found that a prehospital training course could improve obstetric emergency care [10].

Trained paramedical personnel are also available to render prehospital care throughout most middle-income countries and in some cities in low-income countries. They are often paid ambulance personnel (or sometimes specially designated cohorts of fire or police personnel who desire more medical skills) who receive between 100 and 400 h of professional training [11]. These personnel fall largely into two tiers: basic providers who are proficient in scene management, rescue, stabilization, and transport of injured patients, and advanced providers who offer more complicated services (e.g., invasive airway techniques) and generally involve systems including regional call management centers and integrated communication networks [11].

In most of Sub-Saharan Africa and Asia, commercial ambulances may not be available for prehospital transport, resulting in a range of alternate options including private vehicles [12, 13] and bicycles [14]. For example, non-ambulance arrivals, either by private cars or public transportation, constituted about 77 % of total arrivals to the emergency center in the Ashanti region of Ghana [15]. Though often limited to transferring patients between health facilities, rudimentary ambulances have been successfully established in these regions, even in low-resource settings such as Niger [16].

In middle-income countries, ambulances play a major role in emergency care systems and can significantly reduce the interval between recognition of an emergency and arrival at the hospital, improving patients' likelihood of survival [1]. For a response time of 4–6 min, the suggested

ratio is one unit per 50,000 people [17]. Numerous middle-income cities have shown strong response times; Monterrey, Mexico achieved an average 10-min response time with one unit per 100,000 people, and Hanoi, Vietnam averages a response time of 30 min with one unit per 3 million people [1]. Confounding factors such as distribution of dispatch sites, population density, and infrastructure may affect results.

Urban centers posit a density of hospitals and benefit from established telecommunications, transportation infrastructures, and coordinating capacity among community, hospital, and civic emergency services, making them a more conducive setting for professional paramedic personnel. Strategically placed dispatch sites with stationed paramedical personnel and vehicles can optimize emergency response times and resources in cities, while keeping costs sustainable. Effective prehospital emergency care should be integrated into the larger emergency response system through centralized dispatch with a well-known direct line from the community to request services, alliances with fire and police department emergency services, and protocols for communicating with receiving hospitals. Such systems must be evaluated with both metrics assessing availability of services (e.g., number of units on duty), and in terms of their cost-effectiveness.

In geographically dispersed regions, a tiered system may improve response time, where a relatively larger number of trained layperson first responders with a wider geographic distribution supplement a smaller number of centrally located, more highly trained paramedical personnel [18]. This system may benefit from centralized dispatch with paramedical personnel and laypersons managed by the same organizational unit.

Finally, provision of appropriate supplies is essential. Previous studies have shown that educational interventions for paramedics are less effective if equipment availability limits their ability to implement their knowledge [19]. Financial and supply-chain barriers often hinder the ability to adopt intervention strategies and provide quality emergency care [20].

Cost-effectiveness

There is a paucity of literature delineating the costs of providing prehospital and emergency care in LMICs. While some studies examine costs of specific components of this system, none evaluate the cost of the entire system.

Perhaps the best exercise to date in estimating the system-level costs of emergency care is by Kobusingye et al. in their chapter 'Emergency Medical Services' for the Disease Control Priorities in Developing Countries, second edition [21]. Researchers modeled system costs of establishing and running two types of prehospital and emergency care systems in which (a) trained laypersons and paramedics provide prehospital emergency care and (b) staffed community ambulances provide such care. For a population of 1 million, they assumed that the first system would require 7,500 lay responders, with 2,500 trained on a rolling basis, and 50 trained paramedics annually. System costs included training and first aid kits. Trained laypersons and paramedics would volunteer their services after training. Given these assumptions, their best cost estimate was USD $62,923 (range $30,254–$126,475), amounting to $170 per death averted, and $7 per life year gained for a population of 1 million.

Jayaraman et al. built upon this framework to estimate the costs of scaling up their layperson first aid training pilot to cover Kampala [7]. Using Kobusingye et al.'s cost assumptions, their base case scenario (training 9,000 trainees over 3 years) resulted in an annual cost of $47,854 ($0.12 per capita); these costs increased to $143,854 annually ($0.36 per capita) when first aid kits ($16 each) were factored in [7]. As a result, mortality reductions were assumed to be 15 % [22], resulting in a cost of $598 per death averted, and $25 per life year saved. A more conservative estimate (7.5 % mortality reduction plus supply costs of $32) raised the cost to $3,596 per death averted and $150 per life year saved [7].

For a system reliant on ambulances, Kobusingye et al. assumed that an ambulance unit with seven paramedic drivers serves 30,000 people, with supervisors overseeing three ambulance units per year. Ambulances can be purchased and retrofitted locally; they are assumed to last nine years if 20,000 km are driven each year. Under these assumptions, they estimated annual costs for such a system in an urban area to be approximately USD $1.27 million (range $0.79–$2.15 million), with rural systems costing three times more [21].

However, certain caveats should be kept in mind. The Kobusingye et al. analysis based inputs on 2001 data and the results are reported in 2001 USD, which may not be reflective of today's economic environment. For example, the widespread availability and low costs of cellular phones have revolutionized communications in many developing countries, decreasing the need of dedicated communications equipment for emergency care. Kobusingye et al. also assumed that trained laypersons and paramedics would volunteer their services. Both studies applied the outcome on a global basis without taking regional variations, systemic costs, or the additional burden to the health care system from increased visits into account. The Kobusingye et al. analysis assumed that the ambulance system would have the same effectiveness in rural and urban areas, and the authors caution that "substantial uncertainty remains over actual effectiveness of the interventions in emergency medicine" [21].

Outcomes

A growing body of literature exists on the effectiveness of first responders and paramedics in LMICs. Although a prehospital and emergency care system can respond to a wide range of conditions, a majority of these studies focus on trauma outcomes, with increasing evidence supporting the benefits of a well-functioning prehospital care system.

Literature from high-income countries suggest that trauma system implementation can significantly reduce preventable trauma deaths [23]. For example, the implementation and expansion of trauma systems in North and Central Iraq (consisting of trained laypersons, paramedics, and two trauma referral centers) reduced the trauma mortality rate from 17 to 4 % over 10 years [24]. Work done in Cambodia and Northern Iraq demonstrates a 9 % reduction in mortality among trauma victims after instituting a system of first responders and trained paramedics [5]. A review of studies on prehospital care in developing countries found a 25 % reduction in risk of mortality due to injury with the implementation of a prehospital system, with treatment effects enhanced in rural settings [25].

For an ambulance-based system, Kobusingye et al. modeled that such a system can potentially save 700 lives annually (200 from ischemic heart disease, 200 from obstetric emergencies, and 300 from trauma) when covering a population of 1 million [21].

Providing basic life support (BLS) training to ambulance personnel can reduce trauma mortality, as evidenced by a decrease in mortality (15.7–10.6 %) in Trinidad when such a system was established [26]. However, some LMICs are gravitating toward providing advanced life support (ALS) training to these personnel instead, partly due to evidence from high-income countries that attribute trauma mortality reduction to ALS training [27]. A meta-analysis of 18 studies found that provision of ALS care to non-traumatic cardiac arrest patients could increase their survival, but found no difference in survival in trauma patients who had received ALS versus those receiving BLS [28]. Similarly, a Cochrane review did not find any differences in mortality among trauma victims cared for by BLS-trained versus ALS-trained personnel [29]. On the contrary, some evidence suggests that care provided by ALS-trained personnel might have resulted in worse outcomes [30].

This evidence suggests that the development of an advanced prehospital emergency care system should never be 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 and whose prehospital treatment might be less cost-effective. Some experts recommend delaying the development of these more advanced systems until they demonstrate improved outcomes [19]. Another disadvantage of ALS training for laypersons is poor retention of advanced skills [19].

Future directions

As LMICs develop their prehospital and emergency systems, concurrent efforts are necessary to develop, investigate, and implement evidence-based policy for continued progress in achieving cost-effective emergency care in these regions. There are several considerations relevant for all phases.

First, the emergency medical system must be organized so that its various components, from prehospital intervention onward, are fully integrated and inclusive of all necessary services [31]. A systems administrator should be appointed to coordinate emergency care activities to ensure that the system functions cohesively. The budget for every emergency medical system must account for the costs of coordination, such as the systems administrator's salary.

Second, to promote community buy-in and better represent the needs of the population, the systems administrator should chair a committee of representatives from the various emergency medical care components and affected communities. This form of stakeholder governance has been successful; in a township outside Cape Town, South Africa, the community governing board tailored the content of the first aid training course to specific needs, including penetrating injuries and drug overdoses, which enhanced the system's integration into the community [32]. The systems administrator also needs to monitor the activities of emergency medical systems to improve quality of care. Simple steps such as periodic audits may be useful in responding to opportunities and shortcomings.

Third, resource-constrained regions must not serve the interests of the privileged few at the expense of the majority. The cost of elite technologies and specialists cannot be justified as essential according to the prevailing burden of disease. Balancing investment into expanding the capacity and practice scope of primary and secondary health facilities with funding for tertiary care referral and transportation networks poses considerable challenges, the resolution of which will be particular to each health system.

Fourth, lack of funds presents a formidable barrier to access for many individuals. In some cases, payment for transportation and treatment precludes their use, while in other cases, perceived future costs and fear of financial ruin constrain how the poor interact with emergency medical systems. However, there is evidence that when a service such as ambulance transport is provided, families are willing to pay. Various financing schemes, such as

community financing or loan funds, may alleviate this impediment to emergency care use [33, 34].

Finally, governments play a pivotal role in the provision of emergency care. Public health officials, legal experts, and policymakers must work together to draft legislation regulating health facilities, protect trained and lay providers, and ensure quality and availability of emergency care for the critically ill regardless of personal characteristics or ability to pay.

Conclusions

Emergency medical systems are an essential but largely underdeveloped component of health care for resource-constrained regions and their implementation in LMICs presents both challenges and opportunities. Systematic development of emergency medical care that is evidence-based and appropriate to local needs could define a more cost- and outcome-effective emergency medical system than exists in advanced economies. When internally coherent and properly integrated, emergency medical systems can deliver acute care to the critically ill, thereby reducing health disparities and preventable deaths. Investing in emergency medical systems can help achieve this end for many LMICs.

Acknowledgments This article was prepared as a contribution to the Disease Control Priorities, third edition, which is sponsored by a grant from the Bill & Melinda Gates Foundation to the University of Washington. The sponsor had no role in the study design; in the collection, analysis, and interpretation of data; in the writing of the report; or in the decision to submit the paper for publication.

Conflict of interest Charles Mock is an associate editor for WJS. He will be recusing himself from handling this manuscript for the journal so as to avoid any potential conflicts of interest. We have no financial interests or conflicts to report.

References

1. Kobusingye OC, Hyder AA, Bishai D et al (2005) Emergency medical systems in low- and middle-income countries: recommendations for action. Bull World Health Organ 83:626–631
2. Lozano R, Naghavi M, Foreman K et al (2012) Global and regional mortality from 235 causes of death for 20 age groups in 1990 and 2010: a systematic analysis for the global burden of disease study 2010. Lancet 380:2095–2128
3. Murray CJ, Vos T, Lozano R et al (2012) Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990–2010: a systematic analysis for the global burden of disease study 2010. Lancet 380:2197–2223
4. Institute for Health Metrics and Evaluation (2010) Global burden of disease study 2010 (GBD 2010) data downloads. http://ghdx.healthmetricsandevaluation.org/global-burden-disease-study-2010-gbd-2010-data-downloads. Accessed 28 Feb 2014
5. Husum H, Gilbert M, Wisborg T et al (2003) Rural prehospital trauma systems improve trauma outcome in low-income countries: a prospective study from North Iraq and Cambodia. J Trauma 54:1188–1196
6. Mock CN, Tiska M, Adu-Ampofo M et al (2002) Improvements in prehospital trauma care in an African country with no formal emergency medical services. J Trauma 53:90–97
7. Jayaraman S, Mabweijano JR, Lipnick MS et al (2009) First things first: effectiveness and scalability of a basic prehospital trauma care program for lay first-responders in Kampala. Uganda PLOS ONE 4:e6955
8. Geduld H, Wallis L (2011) Taxi driver training in Madagascar: the first step in developing a functioning prehospital emergency care system. Emerg Med J 28:794–796
9. Murad MK, Husum H (2010) Trained lay first responders reduce trauma mortality: a controlled study of rural trauma in Iraq. Prehosp Disaster Med 25:533–539
10. Chandy H, Steinholt M, Husum H (2007) Delivery life support: a preliminary report on the chain of survival for complicated deliveries in rural Cambodia. Nurs Health Sci 9:263–269
11. Sasser S, Varghese M, Kellermann A et al (2005) Prehospital trauma care systems. World Health Organization, Geneva
12. Joshipura MK, Shah HS, Patel PR et al (2003) Trauma care systems in India. Injury 34:686–692
13. Kobusingye OC, Guwatudde D, Owor G et al (2002) Citywide trauma experience in Kampala, Uganda: a call for intervention. Inj Prev 8:133–136
14. Lungu K, Kamfose V, Hussein J et al (2001) Are bicycle ambulances and community transport plans effective in strengthening obstetric referral systems in southern Malawi? Malawi Med J 12:16–18
15. Mould-Millman CNK, Rominski S, Oteng R (2014) Ambulance or taxi? High acuity prehospital transports in the Ashanti region of Ghana. AJEM 4:8–13
16. Bossyns P, Abache R, Abdoulaye MS et al (2005) Unaffordable or cost-effective?: introducing an emergency referral system in rural Niger. Trop Med Int Health 10:879–887
17. McSwain NE (1991) Prehospital Emergency Medical Systems and Cardiopulmonary Resuscitation. In: Moore EE, Mattox KL, Feliciano DV (eds) Trauma, 2nd ed, Appleton and Lange, Norwalk, p. 99–107
18. Mould-Millman CNK, Naidoo R, de Vries S et al (2014) AFEM Consensus Conference, 2013. AFEM Out-of-Hospital Emergency Care Workgroup Consensus Paper: Advancing Out-of-Hospital Emergency Care in Africa-Advocacy and Development. AJEM 4:90–95
19. Arreola-Risa C, Vargas J, Contreras I et al (2007) Effect of emergency medical technician certification for all prehospital personnel in a Latin American city. J Trauma 63:914–919
20. Osei KM, Hamilton B, Freeman FB et al (2014) Essentials for emergency care: lessons from an inventory assessment of an emergency centre in Sub-Saharan Africa. AJEM 4:174–177
21. Jamison DT, Breman JG, Measham AR et al (eds) (2006) Disease control priorities in developing countries, 2nd edn. Oxford University Press, New York
22. Husum H, Gilbert M, Wisborg T (2003) Training pre-hospital trauma care in low-income countries: the'Village University'experience. Med Teach 25:142–148
23. Mullins RJ, Veum-Stone J, Helfand M et al (1994) Outcome of hospitalized injured patients after institution of a trauma system in an urban area. JAMA 271:1919–1924
24. Murad MK, Larsen S, Husum H (2012) Prehospital trauma care reduces mortality. Ten-year results from a time-cohort and trauma audit study in Iraq. Scand J Trauma Resusc Emerg Med 20:13
25. Henry JA, Reingold AL (2012) Prehospital trauma systems reduce mortality in developing countries: a systematic review and meta-analysis. J Trauma 73:261–268

26. Ali J, Adam RU, Gana TJ et al (1997) Trauma patient outcome after the prehospital trauma life support program. J Trauma 42:1018–1021
27. Reines HD, Bartlett RL, Chudy NE et al (1988) Is advanced life support appropriate for victims of motor vehicle accidents: the South Carolina Highway Trauma Project. J Trauma 28:563–570
28. Bakalos G, Mamali M, Komninos C et al (2011) Advanced life support versus basic life support in the pre-hospital setting: a meta-analysis. Resuscitation 82:1130–1137
29. Jayaraman S, Sethi D (2010) Advanced trauma life support training for ambulance crews. Cochrane Database Syst Rev 1:CD003109
30. Stiell IG, Nesbitt LP, Pickett W et al (2008) The OPALS major trauma study: impact of advanced life-support on survival and morbidity. Can Med Assoc J 178:1141–1152
31. Hardcastle TC, Finlayson M, van Heerden M et al (2013) The prehospital burden of disease due to trauma in KwaZulu-Natal: the need for Afrocentric trauma systems. WJS 37:1513–1525
32. Sun JH, Shing R, Twomey M et al (2012) A strategy to implement and support pre-hospital emergency medical systems in developing, resource-constrained areas of South Africa. Injury 45:31–38
33. Macintyre K, Hotchkiss DR (1999) Referral revisited: community financing schemes and emergency transport in rural Africa. Soc Sci Med 49:1473–1487
34. Essien E, Ifenne D, Sabitu K et al (1997) Community loan funds and transport services for obstetric emergencies in northern Nigeria. Int J Gynaecol Obstet 59:S237–S244