

# Emergency medical systems in low- and middle-income countries: recommendations for action

Olive C. Kobusingye,<sup>1</sup> Adnan A. Hyder,<sup>2</sup> David Bishai,<sup>3</sup> Eduardo Romero Hicks,<sup>4</sup> Charles Mock,<sup>5</sup> & Manjul Joshipura<sup>6</sup>

**Abstract** Emergency medical care is not a luxury for rich countries or rich individuals in poor countries. This paper makes the point that emergency care can make an important contribution to reducing avoidable death and disability in low- and middle-income countries. But emergency care needs to be planned well and supported at all levels — at the national, provincial and community levels — and take into account the entire spectrum of care, from the occurrence of an acute medical event in the community to the provision of appropriate care at the hospital. The mix of personnel, materials, and health-system infrastructure can be tailored to optimize the provision of emergency care in settings with different levels of resource availability.

The misconception that emergency care cannot be cost effective in low-income settings is demonstrably inaccurate. Emergencies occur everywhere, and each day they consume resources regardless of whether there are systems capable of achieving good outcomes. With better planning, the ongoing costs of emergency care can result in better outcomes and better cost-effectiveness. Every country and community can and should provide emergency care regardless of their place in the ratings of developmental indices. We make the case for universal access to emergency care and lay out a research agenda to fill the gaps in knowledge in emergency care.

**Keywords** Emergency medical services/organization and administration; Emergency treatment/organization and administration; Triage; Transportation of patients; Allied health personnel/education; Cost-benefit analysis; Evidence-based medicine; Developing countries (*source: MeSH, NLM*).

**Mots clés** Service médical urgences/organisation et administration; Traitement urgence/organisation et administration; Orientation patients; Transport sanitaire; Personnel santé auxiliaire/enseignement; Analyse coût bénéfique; Médecine factuelle; Pays en développement (*source: MeSH, INSERM*).

**Palabras clave** Servicios médicos de urgencia/organización y administración; Tratamiento de urgencia/organización y administración; Triage; Transporte de pacientes; Técnicos medios en salud/educación; Análisis de costo-beneficio; Medicina basada en evidencia; Países en desarrollo (*fuentes: DeCS, BIREME*).

**الكلمات المفتاحية:** الخدمات الطبية في الطوارئ، إدارة وتنظيم الخدمات الطبية في الطوارئ، المعالجة في الطوارئ، إدارة وتنظيم المعالجة في الطوارئ، الفرز، نقل المرضى، العاملون الصحيون المساعدون، تثقيف العاملين الصحيين المساعدين، تحليل المردود والمنفعة، الطب المُستند بالبيانات، البلدان النامية (المصدر: رؤوس الموضوعات الطبية، المكتب الإقليمي لشرق المتوسط)

Bulletin of the World Health Organization 2005;83:626-631.

Voir page 630 le résumé en français. En la página 630 figura un resumen en español.

يمكن الاطلاع على الملخص بالعربية في صفحة 630.

## Introduction

The goal of an effective emergency medical system should be to provide universal emergency care — that is, emergency care should be available to all who need it. However, there are many unfounded myths about emergency medical care, and these are often used as a rationale for giving it a low priority in the health sector, especially in low- and middle-income countries. These myths include equating emergency care to ambulances and focusing on transport alone while neglecting the role of care that can be provided in the community and at a health-care facility. Perhaps most common is the perception that emergency

care is inherently expensive; this myth focuses attention on the high-technology end of clinical care as opposed to the strategies that are simple and effective. Efforts to improve emergency care, however, need not lead to increased costs.

Emergency medical systems address a diverse set of diseases that span the spectrum of communicable infections, noncommunicable conditions, obstetrics and injuries. Patients with all these conditions may present to the emergency medical system either in the acute stages (such as diabetic hypoglycaemia, septicaemia, premature labour or asthma) or may present with conditions that are acute in their natural presentation (such as myocardial infarction, acute haemorrhage or injuries).

<sup>1</sup> Regional Adviser, Disability, Injury Prevention and Rehabilitation, WHO Regional Office for Africa, PO Box 6, Brazzaville, Republic of the Congo (email: kobusingyeo@afro.who.int). Correspondence should be sent to this author.

<sup>2</sup> Assistant Professor and Leon Robertson Faculty Development Chair, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD, USA.

<sup>3</sup> Associate Professor, Department of Population and Family Health Sciences, Johns Hopkins Bloomberg School of Public Health, Baltimore, MD, USA.

<sup>4</sup> Director, Sistema de Urgencias del Estado de Guanajuato, Centro de Capacitación de Tecnología en Emergencias Médicas (CECATEM), Guanajuato, Mexico.

<sup>5</sup> Associate Professor of Surgery, Harborview Injury Prevention and Research Center, Harborview Medical Center, Seattle, WA, USA.

<sup>6</sup> Director, Academy of Traumatology, Ahmedabad, India.

Ref. No. 04-020412

(Submitted: 18 December 2004 – Final revised version received: 13 April 2005 – Accepted: 16 April 2005)

It is thus challenging to define the burden of disease addressed by emergency medical systems. For example, injuries alone accounted for 14% of the burden of disease among adults in 2002 (1). Both unintentional and intentional injuries are acute events by their definition, therefore nearly all require emergency care. Since more than 80% of all deaths resulting from injury occur in low- and middle- income countries, injuries are a significant contributor to the disease burden that is amenable to emergency care.

This paper presents a rationale for deliberate planning and institutionalization of emergency medical systems in low- and middle-income countries because a significant proportion of disease burden cannot be addressed without the use of adequate emergency services. It highlights the need for investment in emergency medical services in the developing world and makes recommendations for action and research.

## Components of emergency medical systems

An emergency medical system must be appreciated as a system of care with linked and interdependent components: pre-hospital care (including transportation) and care at the hospital. All components must work together to make a lasting impact on the health of a population. The organization and operation of pre-hospital care will vary from country to country but should be linked to health facilities. When pre-hospital transportation is poor or absent, deaths that could have been prevented — even by inexpensive procedures — occur (2). The majority of obstetric deaths may fall into this category. When the quality of care at hospitals is poor and leads to death, communities may be discouraged from promptly taking patients to such facilities even when the capacity exists to transport patients there (3, 4). Skilled and motivated personnel, appropriate supplies, pharmaceuticals, equipment, and coordination and management that are oriented towards the needs of the critically ill all contribute to making emergency care effective in reducing death and disability.

### Pre-hospital care

Pre-hospital care is the care provided in the community (at home, school, work or recreation area) until the patient arrives at a formal health-care facility capable of providing definitive care. Pre-hospital care should comprise basic strategies with proven effectiveness, such as accessible and rapid transportation and the deployment of personnel with basic life-support skills. Triage, the process of screening patients to determine their relative priority for treatment and transfer, is important in successfully linking the two components of care. Even where resources allow, it appears that invasive procedures (such as establishing intravenous access and infusing fluids or intubating a patient) performed by physicians in some pre-hospital settings do not necessarily improve outcomes, and there is evidence that some may in fact be detrimental (5–8). The majority of the world's population does not have access to formal pre-hospital care.

Since resource availability varies greatly between and within countries, different tiers of care exist. Where no formal pre-hospital system exists, the first tier of care may consist of laypeople in the community who have been taught basic first-aid techniques (known as first responders). Recruiting and training particularly motivated citizens who are more likely to confront emergency situations (such as public transportation drivers) to function as pre-hospital care providers can add to this resource (9). The second tier comprises paramedical

personnel using dedicated ambulances and equipment. The implementation of a second tier may not always be feasible in low-income countries, where trained personnel are few and where high running costs make round-the-clock coverage difficult. Although providing universal access to paramedical personnel and ambulances may be beneficial, adopting this policy would be premature for populations lacking more basic interventions, such as laypeople to act as first responders and accessible transportation (10).

### Personnel

There is little published literature on the impact of first responders. One study in northern Iraq and Cambodia evaluated a programme designed to train a core group of paramedics; these paramedics then trained thousands of laypeople to act as first responders. The study demonstrated a significant reduction in mortality from injury among populations with a high prevalence of injury (11, 12). There are no studies comparing the effectiveness of lay responders with that of trained paramedics. In Ghana, it was demonstrated that commercial taxi and minibus drivers trained in first aid could provide effective pre-hospital care (9).

In most middle-income countries, and some cities in low-income countries, trained paramedics render pre-hospital care (2, 13). In most of sub-Saharan Africa and Asia, paramedical personnel (and ambulances) are used only to transfer patients between health facilities and not from the scenes of injury or from their homes (14). In middle-income countries, though, they are a major component of emergency medical systems (15). The level of training of paramedical personnel should be appropriate to the provider. Some evidence has shown that training paramedics in basic life-saving skills improves patients' outcomes (15–18). There is no evidence to support training paramedics in advanced life-saving skills (19).

Where paramedical personnel already exist as part of the emergency medical system, their numbers and organization (location, training, deployment and supervision) should be enhanced to improve response times and, hence, patients' outcomes. Effectiveness has been demonstrated for well placed dispatch sites in urban populations where vehicles and personnel can be deployed most efficiently (15). The recommended ratio of 1 team to 50 000 people suggested by McSwain results in response times as low as 4–6 minutes (20). Traffic congestion, poor maps, poor road signs and limited road access may all increase response times in cities with poor infrastructure. (Response time is measured from the time a call activates the emergency medical system until the team arrives on the scene.) In Monterrey, Mexico, an area with a ratio of 1 team per 100 000 people, the average response time was 10 minutes, while in Hanoi, Viet Nam, five teams dispatched from one station that are expected to serve 3 million people (1 team per 600 000 people) have recorded an average response time of 30 minutes (2). In the time since these data were collected, Hanoi has introduced satellite ambulance stations which have the potential to reduce the interval even further.

### Equipment and communication

In keeping with the tenets of the Hippocratic oath to do no harm, equipment and supplies should match the knowledge and skills of the personnel available to use them. Even teams with the fewest resources should have protective clothing, especially gloves and aprons. Other necessities include a stretcher,

pressure dressings (bandages — elastic if possible — and cotton or gauze dressings), splints (in various sizes and made out of locally available materials), and a radio, phone or other mode of rapid communication.

Nowhere is the demand for efficient communication and rapid transportation more critical than in emergency medical systems. The best teams equipped with state-of-the-art technology and supplies will be wasted if they cannot reach patients quickly or if they have no contact with the hospitals where their patients are to be taken. The majority of the world's population lives in areas with weak telecommunications infrastructure. In 1999, Brazil had an average of 15 main telephone lines and 89 cellular mobile phones per 100 inhabitants. Comparative figures for Azerbaijan were 9 telephone lines per 100 inhabitants and 23 cellular mobile phones per 100 inhabitants. In Cambodia there were essentially no telephone lines and 7 cellular mobile phones per 100 inhabitants (21). Innovations are needed to provide efficient emergency communication in such settings in order to enable these populations to gain access to the emergency care interventions that already exist. Equipping traditional birth attendants and remote health units with radio receiver sets linked to local hospitals is one method that has been used to shorten response times and thus reduce maternal deaths (22). Cellular mobile phones may offer communities that are isolated from standard communication services an opportunity to leap into a more modern and efficient mode, if the infrastructure for cellular mobile phones exists.

### Transportation

Transporting a patient from the location of an acute event to a hospital is a critical element of pre-hospital care, since a lack of transportation is often the major barrier preventing patients from accessing emergency care (14, 22–24). In devising a pre-hospital transportation system, locally available resources and the range of viable alternative means of transportation should be considered. For example, seriously ill and injured patients may be brought to medical facilities by commercial vehicles, the police or relatives using private motorized or non-motorized transportation (14, 25, 26). Emergency transportation should be accessible at short notice; a vehicle with a stretcher is ideal but almost any mode of transportation that gets a patient to a facility where definitive care can be obtained is acceptable. A bicycle ambulance in Malawi that was set up to improve emergency obstetric care was actually used more often for patients who had been injured and for medical emergencies (23).

A study of a decision to develop an emergency medical system in Kuala Lumpur (which has a population of 1.1 million people and is spread over 243 km<sup>2</sup>) estimated that it would require the purchase and staffing of 48 ambulances at a cost of US\$ 53 000 each per year, thus totalling US\$ 2.5 million per year (10). The study also found that ambulances were unable to locate the patient in 20% of calls in Kuala Lumpur as a result of problems with maps and signage (10). The authors noted that despite the paucity of ambulances, severely injured or ill patients did get to hospital with only minor delays by using taxis, family transportation or by calling the police. A study conducted in Turkey found that vehicle costs were the leading component of ambulance capital costs. The cost per trip was US\$ 163.00, and the cost per patient transported was US\$ 180.50, amounts that the authors thought were beyond the means of private individuals (27). A trip by state-run ambulance services in New Delhi, India, costs about US\$ 40.00.

Yet 1 in 3 of the ambulances served only as a means of transportation, having no paramedical staff on board (28). A review of civilian helicopter ambulance programmes in the United States concluded that the primary factor in reducing mortality from trauma was not the speed of the transportation but the administration of life-saving care by the helicopter's medical crew at the scene or at the outlying hospital (29). Helicopter ambulances may have some benefit in low- and middle-income countries (30) but this benefit may not be distributed equitably. In low-income countries, for example, for the few that benefit from such an expensive intervention, there are hundreds of thousands of people who cannot gain access to care using even the most basic means. These issues should be considered in low- and middle-income countries when they are making decisions about what kind of pre-hospital care is appropriate given their existing resources and communities' needs.

### Health facilities

The capabilities of formal health facilities vary immensely between and within countries. In some low-income countries, emergency medical care may be effectively delivered at a health centre staffed by non-doctor clinicians (e.g., for acute diarrhoea or severe malaria). However, such a facility will be grossly inadequate for the management of a severe multiple injuries or obstructed labour. Similarly, using a tertiary facility to provide basic services will create inefficiencies in the emergency medical system and in the health system overall. The triage process in the pre-hospital subsystem should determine which patients get transported to which facility instead of merely taking patients to the nearest facility. Time and lives are lost because patients are taken to facilities where the desired definitive care is not available. Chronic problems resulting from inappropriate triage underscore the need to emphasize the "systems" aspect of emergency medical care. Putting the emphasis on the systems ensures that proper communication is given to first responders so they know where and when to refer patients and can receive feedback about cases that they have managed well or poorly. The WHO *Guidelines for essential trauma care* lists comprehensively the most appropriate resources for various levels of health-care facilities (31).

### Interventions for strengthening systems

Since the goal of an effective emergency medical system is to provide universal emergency care, the following sections review the evidence base for selected inputs at different care levels.

### Training

Husum et al. have demonstrated that laypeople trained in first aid can effectively respond to emergencies in a community with a high trauma burden (11, 12). In hospitals, most in-service training for emergency care professionals is designed to address particular problems, such as severe injuries, paediatric emergencies or obstetric emergencies. Yet because of the resource constraints of low-income countries, the same personnel will be confronted with all of these conditions. Unfortunately, few courses in emergency care have been rigorously evaluated (19, 32). The Advanced Trauma Life Support course, a meticulously controlled training course in clinical skills for doctors that was devised by the American College of Surgeons, has improved patients' outcomes in some settings, although it may be too expensive for most low- and middle-income countries, and it

is clearly inappropriate for settings where most patients are not seen by doctors. In a tertiary hospital in Trinidad and Tobago, mortality from injury fell by 50% after doctors attended this course (33). Training in life-saving obstetric skills was found to contribute towards reducing maternal deaths in Kebbi state, Nigeria, and in other sites where the intervention was implemented (4, 34).

Emergency Triage Assessment and Treatment (ETAT) training, part of WHO's Integrated Management of Childhood Illnesses strategy, has been used in many countries to improve paediatric emergency care (35). Other examples of training courses are Primary Trauma Care (36), devised by the World Federation of Societies of Anaesthesiologists, and Advanced Life Support in Obstetrics, devised by the American Academy of Family Physicians (37). The above courses are used to standardize protocol-based emergency care but evaluations of their outcomes are still awaited. The National Trauma Management Course in India (14) costs US\$ 50.00 per trainee and is taught by local trainers. This course has now become a national training standard for immediate trauma care in India. The courses described above are all examples used to show that even in the absence of ambulances it is possible to improve emergency medical systems. Low-income countries need to identify training models that are appropriate for their emergency care personnel, who may need to take on a variety of roles, especially those working at middle-level facilities, who respond to different types of emergencies.

### Organization and financing

Emergency medical systems can only be put in place with careful planning and implementation, and the various components that make up the system 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 a community or district. The coordinator should work with a committee that has representatives from key sectors: hospitals and health facilities in the area, transportation, local administration and the community.

An emergency medical system must be sensitive to and meet the needs of the poor. Issues of access to the system become critical because a lack of money often deters people from using emergency services. The poor in every country confront barriers to access when they must pay directly for the costs for transportation, medical treatment and pharmaceuticals. As a result, emergencies often lead to financial ruin for poor families, and the implementation of some sort of financial protection for emergency health care has not received adequate attention. Such protection would ensure that those with limited finances are not deterred from using emergency services and that they do not get tipped into extreme poverty by having to meet costs entirely out of their own pocket. Different means of achieving this financial protection need to be explored, including community financing (24, 38). Community loan funds to cover transportation and other requirements for emergencies, especially for obstetrics, have been used in various settings, especially in Africa (39, 40). Early experience indicates that these approaches may overcome some of the barriers to accessing emergency medical services and should be investigated further.

Having lower paid jobs, differences between social classes, a person's ethnicity and other affiliations may make already vulnerable poor people susceptible to receiving poor quality care in an emergency medical system. The toughest decisions that need to be made concern how much to invest in the emergency-care capacity of secondary and primary care centres as opposed to providing support for referral and transportation networks to feed tertiary care centres. These decisions are both highly variable and too system specific to yield to a uniform policy prescription. Local data on costs, capacities and outcomes, and a process for developing an emergency care system, will inform such decision-making at the national level.

### Research and development for emergency services

As a neglected topic, emergency medical systems are part of the 10/90 gap in health research whereby less than 10% of global research investment is spent on problems affecting 90% of the world's population (41). A review of the evidence on emergency medical systems as applicable to low- and middle-income countries reveals many gaps in global knowledge. There is a need to better understand the epidemiology of conditions that may be addressed by emergency systems in these countries and to better understand which interventions may address them adequately. Intervention trials in low- and middle-income countries are a research priority in the field of emergency medical systems. Well designed, locally appropriate studies that establish effectiveness are urgently needed, and they should include both those interventions that may be available in high-income countries and newer interventions. Economic analysis is another area where research is needed, especially in places where cost and cost-effectiveness information from low- and middle-income countries is scant (42). These gaps reflect the need for a more systematic analysis of the areas towards which research investments should be directed in order that systems can be based on credible evidence.

### Conclusion

Emergency medical systems are a critical component of national health systems in low- and middle-income countries. Governments and ministries of health in these countries need to pay specific attention to developing emergency systems and ensuring that the evolution of any emergency system is both evidence-based and appropriate to their country's needs. More importantly, the context and implementation of the emergency system should help increase health equity and not exacerbate existing health disparities. In promoting the systematic development of an evidence-based emergency medical system, low- and middle-income countries could help define more effective and cost-effective emergency systems than exist in high-income countries. This opportunity should not be lost either as a result of political inattention or a lack of funds; international and national stakeholders must move to stem the preventable loss of life that arises from the lack of an organized emergency medical system. ■

**Competing interests:** none declared.

## Résumé

**Recommandations en vue d'une intervention pour améliorer les systèmes d'urgences médicales des pays à revenus faibles et moyens**

Les urgences médicales ne sont pas un luxe pour pays riches ou pour habitants privilégiés d'un pays pauvre. Le présent article fait observer que les soins d'urgence peuvent contribuer de manière importante à la réduction du nombre de décès et de cas d'invalidité évitables dans les pays à revenus faibles et moyens. Les soins d'urgence exigent cependant une planification rigoureuse et un soutien à tous les niveaux, que ce soit celui du pays, de la province ou de la communauté. Ils doivent également offrir une gamme complète de services, allant de la prise en charge d'un événement médical aigu survenant dans la communauté à l'apport de soins appropriés dans le cadre hospitalier. Il est possible d'ajuster le dosage des moyens en termes de personnel, de matériel et d'infrastructures sanitaires de façon à optimiser la délivrance des soins d'urgences dans des pays disposant de différents niveaux de ressources.

L'article parvient à démontrer l'inexactitude d'une conception répandue selon laquelle les services d'urgences des pays à faibles revenus ne peuvent être efficaces sur le plan économique. Des situations d'urgence interviennent partout et sont chaque jour consommatrices de ressources, indépendamment de la capacité des systèmes à obtenir de bons résultats. Moyennant une planification plus stricte, les coûts actuels des soins d'urgence pourraient permettre d'atteindre de meilleurs résultats et une plus grande efficacité sur le plan économique. Chaque pays ou communauté pourrait et devrait dispenser des soins d'urgence indépendamment de son degré de développement. L'article plaide en faveur d'un accès universel aux soins d'urgence et présente un programme de recherche visant à combler les lacunes de connaissances dans le domaine des soins d'urgence.

## Resumen

**Las urgencias médicas en los países de ingresos bajos y medios: recomendaciones para la acción**

La atención médica de urgencia no es un lujo para los países ricos o las personas ricas de los países pobres. Antes bien, como se señala en este artículo, la atención de urgencia puede contribuir considerablemente a reducir las discapacidades y las defunciones evitables en los países de ingresos bajos y medios. Pero la atención de urgencia se ha de planificar bien, tiene que contar con apoyo a todos los niveles -nacional, provincial y comunitario-, y debe tener en cuenta todo el espectro asistencial, desde la aparición de un evento médico agudo en la comunidad hasta la prestación de la atención apropiada en el hospital. La combinación de personal, material e infraestructura sanitaria puede adaptarse para optimizar la dispensación de atención de urgencia en entornos con distintos niveles de disponibilidad de recursos.

La idea de que la atención de urgencia no puede ser costoeficaz en los entornos de bajos ingresos es, como puede demostrarse, errónea. Se producen urgencias en todas partes, y esas urgencias consumen cada día recursos haya o no haya sistemas capaces de conseguir buenos resultados. Con una mejor planificación, los costos de la atención de urgencia pueden traducirse en mejores resultados y en una mayor costoeficacia. Cada país y cada comunidad puede y debe proporcionar atención de urgencia independientemente de cuál sea su índice de desarrollo. Ofrecemos argumentos a favor del acceso universal a la atención de urgencia y presentamos una agenda de investigaciones para llenar los vacíos existentes en los conocimientos sobre ese tipo de atención.

## ملخص

**نُظْم الطوارئ الطبية في البلدان المنخفضة والمتوسطة الدخل: توصيات عملية**

ومن الخطأ الاعتقاد بأن الرعاية في الطوارئ سيئة المردود في المواقع المنخفضة الدخل، فالطوارئ يمكن أن تحدث في كل مكان وهي تستهلك كل يوم الموارد بغض النظر عما إذا كانت تلك النظم قادرة على الوصول إلى حصائل جيدة أم لا. إلا أن التخطيط الجيد سيؤدي إلى حصائل جيدة للرعاية في الطوارئ رغم إنفاق نفس التكاليف الحالية، مع مردودية مرتفعة. وينبغي على كل بلد وعلى كل مجتمع تقديم الرعاية في الطوارئ بغض النظر عن موقعها في السَّامِب والمُؤشرات التنموية. وقد عملنا على الدعوة إلى الإتاحة الشاملة للرعاية في الطوارئ مع إعداد جدول أعمال للبحوث يضمن ملء الفجوة في المعارف حول الرعاية في الطوارئ.

لا تعد الرعاية الطبية رفاهية تقتصر على البلدان الغنية أو على الأغنياء في البلدان الفقيرة. وتؤكد هذه الورقة على ما يمكن للرعاية في الطوارئ أن تحقِّقه من مساهمات هامة في تخفيض حالات الوفيات والعجز التي يمكن توقيها في البلدان المنخفضة والمتوسطة الدخل. ولا بد من التخطيط الجيد وتقديم الدعم على كافة المستويات الوطنية والمجتمعية وعلى مستوى المقاطعات، مع الأخذ بالحسبان كامل طيف الرعاية بدءاً من حدوث طارئة طبية في المجتمع إلى تقديم الرعاية الملائمة في المستشفيات. إذ يمكن موازنة مجموع العاملين والأدوات والبنية الأساسية للنظم الصحية للحصول على أفضل النتائج من إتياء الرعاية الصحية في الطوارئ في مواقع يتفاوت فيها مستوى توافر الموارد.

## References

- World Health Organization. *The world health report 2003: shaping the future*. Geneva: WHO; 2003.
- Mock CN, Jurkovich GJ, nii-Amon-Kotei D, Arreola-Risa C, Maier RV. Trauma mortality patterns in three nations at different economic levels: implications for global trauma system development. *Journal of Trauma* 1998;44:804-12.
- Leigh B, Kandeh HBS, Kanu MS, Kuteh M, Palmer IS, Daoh KS, et al. Improving emergency obstetric care at a district hospital, Makeni, Sierra Leone. *International Journal of Gynaecology and Obstetrics* 1997;59 Suppl 2:S55-65.
- Prevention of Maternal Mortality Network. Situation analysis of emergency obstetric care: examples from eleven operations research projects in West Africa. *Social Science and Medicine* 1995;40:657-67.
- Lieberman M, Mulder D, Lavoie A, Denis R, Sampalis JS. Multicenter Canadian study of prehospital trauma care. *Annals of Surgery* 2003;237:153-60. (Comment in: *Annals of Surgery* 2003;237:161-2.)
- Sampalis JS, Tamim H, Denis R, Boukas S, Ruest SA, Nikolis A, et al. Ineffectiveness of on-site intravenous lines: is prehospital time the culprit? *Journal of Trauma* 1997;43:608-17.
- Sampalis JS, Boukas S, Lavoie A, Nikolis A, Frechette P, Brown R, et al. Preventable death evaluation of the appropriateness of the on-site trauma care provided by Urgences-Santé physicians. *Journal of Trauma* 1995;39:1027-35.
- Sampalis JS, Lavoie A, Salas M, Nikolis A, Williams JI. Determinants of on-scene time in injured patients treated by physicians at the site. *Prehospital and Disaster Medicine* 1994;9:178-89.
- Mock NC, Tiska M, Adu-Ampofo M, Boakye G. Improvements in prehospital trauma care in an African country with no formal emergency medical services. *Journal of Trauma* 2002 ;53:90-7.
- Hauswald M, Yeoh E. Designing a prehospital system for a developing country: estimated cost and benefits. *American Journal of Emergency Medicine* 1997;15:600-3.
- Husum H, Gilbert M, Wisborg T. Training pre-hospital trauma care in low-income countries: the 'Village University' experience. *Medical Teacher* 2003;25:142-8.
- Husum H, Gilbert M, Wisborg T, Van Heng Y, Murad M. Rural pre-hospital trauma systems improve trauma outcome in low-income countries: a prospective study from North Iraq and Cambodia. *Journal of Trauma* 2003;54:1188-96.
- Tannebaum RD, Arnold JL, De Negri Filho A, Spadoni VS. Emergency medicine in Southern Brazil. *Annals of Emergency Medicine* 2001;37:223-8.
- Joshiyura MK, Shah HS, Patel PR, Divatia PA, Desai PM. Trauma care systems in India. *Injury* 2003;34:686-92.
- Arreola-Risa C, Mock CN, Lojero-Wheatly L, de la Cruz O, Garcia C, Canavati-Ayub F, et al. Low-cost improvements in prehospital trauma care in a Latin American city. *Journal of Trauma* 2000;48:119-24.
- Ornato JP, Craren EJ, Nelson NM, Kimball KF. Impact of improved emergency medical services and emergency trauma care on the reduction in mortality from trauma. *Journal of Trauma* 1985;25:575-9.
- Ali J, Adam R, Josa D, Pierre I, Bedsaysie H, West U, et al. Effect of basic prehospital trauma life support program on cognitive and trauma management skills. *World Journal of Surgery* 1998;22:1192-6.
- Ali J, Adam RU, Gana TJ, Williams JI. Trauma patient outcome after the Prehospital Trauma Life Support program. *Journal of Trauma* 1997;42:1018-22.
- Sethi D, Kwan I, Kelly AM, Roberts I, Bunn F. Advanced trauma life support training for ambulance crews. *Issue 2. Oxford: Update Software; 2003* (Cochrane Review).
- McSwain NE. Prehospital emergency medical systems and cardiopulmonary resuscitation. In: Moore EE, Mattox KL, Feliciano DV, editors. *Trauma*. 2nd ed. Norwalk, CT: Appleton and Lange; 1991. p. 99-107.
- Alaadini P, Marcotullio P. *Urban implications of information technology: new electronics for developing countries*, United Nations University Institute of Advanced Studies, UNU/IAS Working Paper, 2003. Available from <http://www.ias.unu.edu/binaries/IASWorkingPaper99.pdf>
- Samai O, Sengeh P. Facilitating emergency obstetric care through transportation and communication, Bo, Sierra Leone. *International Journal of Gynaecology and Obstetrics* 1997;59 Suppl 2:S157-64.
- Lungu K, Kamfose V, Hussein J, Ashwood-Smith H. Are bicycle ambulances and community transport plans effective in strengthening obstetric referral systems in southern Malawi? *Malawi Medical Journal* 2001;12:16-8.
- Macintyre K, Hotchkiss D. Referral revised: community financing schemes and emergency transport in rural Africa. *Social Science and Medicine* 1999;49:1473-87.
- Andrews CN, Kobusingye OC, Lett RR. Road traffic accident injuries in Kampala. *East African Medical Journal* 1999;76:189-94.
- Kobusingye O, Guwatudde D, Owor G, Lett R. Citywide trauma experience in Kampala, Uganda: a call for intervention. *Injury Prevention* 2002;8:133-6.
- Altintas KH, Bilir N, Tuleylioglu M. 1999. Costing of an ambulance system in a developing country, Turkey: costs of Ankara Emergency Aid and Rescue Services' (EARS) ambulance system. *European Journal of Emergency Medicine* 1999;6:355-62.
- Government of Delhi, India. *Report of evaluation study on CATS*. New Delhi: Evaluation Unit, Planning Department; 2001.
- Moylan JA. Impact of helicopters on trauma care and clinical results. *Annals of Surgery* 1988;208:673-8.
- Buntman AJ, Yeomans KA. The effect of air medical transport on survival after trauma in Johannesburg, South Africa. *South African Medical Journal* 2002;92:807-11.
- Mock C, Lormand JD, Goosen J, Joshipura M, Peden M. *Guidelines for essential trauma care*. Geneva: World Health Organization; 2004.
- Black RS, Brocklehurst P. A systematic review of training in acute obstetric emergencies. *International Journal of Gynaecology and Obstetrics* 2003;110:837-41.
- Ali J, Adam R, Butler AK, Chang H, Howard M, Gonsalves D, et al. Trauma outcome improves following Advanced Trauma Life Support (ATLS) program in a developing country. *Journal of Trauma* 1993;34:890-9.
- Oyesola R, Shehu D, Ikeh AT, Maru I. Improving emergency obstetric care at a state referral hospital, Kebbi state, Nigeria. *International Journal of Gynaecology and Obstetrics* 1997;59 Suppl 2:S75-81.
- World Health Organization. *Management of the child with a serious infection or severe malnutrition: guidelines for care at the first-referral level in developing countries*. Geneva: WHO, Department of Child and Adolescent Health and Development; 2000.
- Wilkinson DA, Skinner MW. *Primary trauma care manual: a manual for trauma management in district and remote locations*. Oxford: Primary Trauma Care Foundation; 2000.
- American Academy of Family Physicians CME Center. *Advanced life support in obstetrics*, 2000. Available from: <http://www.aafp.org/also>
- Ande B, Chiwuzie J, Akpala W, Oronsaye A, Okojie O, Okolocha C, et al. Improving obstetric care at the district hospital, Ekpoma, Nigeria. *International Journal of Gynaecology and Obstetrics* 1997;59 Suppl 2:S47-53.
- Essien E, Ifenne D, Sabitu K, Musa A, Alti-Mu'azu M, Adidu V, et al. Community loan funds and transport services for obstetric emergencies in northern Nigeria. *International Journal of Gynaecology and Obstetrics* 1997;59 Suppl 2:S237-44.
- Shehu D, Ikeh AT, Kuna MJ. Mobilising transport for obstetric emergencies in northwestern Nigeria. *International Journal of Gynaecology and Obstetrics* 1997;59 Suppl 2:S173-80.
- Global Forum for Health Research. *10/90 report on health research 2002*. Geneva: Global Forum for Health Research; 2002.
- Waters H, Hyder AA, Phillips T. Economic evaluation of interventions for road traffic injuries – application to low middle income countries. *Asia Pacific Journal of Public Health* 2004;16:23-31