REVIEW

Strengthening neurotrauma care systems in low and middle income countries

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Abstract
Primary objective: To review basic elements to be considered in the development of effective neurotrauma care systems in low- and middle-income countries. Neurotrauma occurs more frequently in developing countries. The survival rate among neurotrauma patients depends in large part on the degree of sophistication of the trauma system.

Research design: A critical review of the literature was undertaken.

Results: In developing countries, there are difficulties in fully integrating the resources for care if the local and regional trauma systems are poorly structured. Factors like inadequate emergency and neurointensive care, low compensation compared with elective procedures or high medico-legal risks may result in a lack of interest from the few available neurosurgeons to be fully integrated in neurotrauma care. Appropriate structuring of trauma systems according to countries needs and their functionality is a key element that would facilitate the optimal use of resources for integral neurotrauma care.

Conclusions: In order to implement an efficient trauma system, organization of low cost resources such as trauma registries and quality control programmes are required. The participation of medical associations in legislative and government processes is also an important factor for the appropriate development and organization of an effective trauma system in under-privileged areas.

Keywords: Trauma systems, neurotrauma, trauma surgery, trauma registry, traumatic brain injury

Introduction
Trauma has increased significantly in the last several decades. Worldwide, ~16 000 people die every day as a result of some traumatic injury and for each one of these deaths many others are severely disabled [1]. The World Health Organization (WHO), through the Department of Violence and Injury Prevention and Disability (VIP), has begun to generate epidemiological data to identify tendencies in the different countries and thus generate preventive policies with the objective of minimizing trauma-related morbidity and mortality [1]. Motor vehicle-related collisions (MVC) are the second most common cause of death worldwide in the age range of 15–30 years and interpersonal violence is the sixth most common cause of death for 15–30 year-olds. Ninety per cent of the mortality and morbidity caused by trauma is concentrated in low- and middle-income countries

(70% of the global population) [1–3]. In these countries key factors such as diminished availability of healthcare resources, poor compliance to prevention policies and greater risk factors (social armed conflicts and diminished occupational health safety) are identified.

Traumatic brain injuries (TBI) represent one of the leading contributors to death and disability within these worldwide trauma statistics [1–3]. This constitutes a great challenge for the people in charge of providing neurotrauma care within a trauma system. Unfortunately, significant traumatic deaths and disability are found in low- and middle-income countries due to increased risk factors, including a lack of prevention programmes, low level of development of pre-hospital and hospital care for the patient with injuries and the lack of rehabilitative services. This review is focused on a detailed description of the ‘Trauma System’ concept and its application in low- and middle-income countries with an emphasis on neurotrauma aspects. The development of trauma systems in these countries could lead to an improvement in neurotrauma care with an optimal use of the resources.

**Trauma systems**

A Trauma System is a global concept that involves not only medical, but legal, administrative and social aspects. It is defined specifically as a comprehensive system of organized care for patients with traumatic injuries. It is structured within a geographic area and is integrated within the emergency medical system at local or regional levels. Its primary purpose is to improve the health of the community covered by the system by delivering and triaging patients to the appropriate and highest level of trauma care available. The system is multidisciplinary, with allocation of resources and expertise along the continuum of care and with the goal of maintaining continuity of care. The legal aspects are very important not only to manage the system but also to regulate the social and administrative issues.

An appropriately organized system should not encourage the improvisation of unstructured trauma care models [4, 5]. A solid structure of the system requires active participation from the medical scientific community (medical associations) as well as governmental representatives. For example, in Colombia, a low-middle income country, recent documents such as Decree 1011 of 2006 (obligatory health quality guarantee of the general social security system) and Resolution 1043 of 2006 (conditions for healthcare providers to qualify their services and to implement audit components for quality improvement) are important tools that begin to lay the foundations of a comprehensive health model (including trauma care). These documents are best generated with mutual participation and contribution of national scientific associations that are involved in trauma care [6, 7]. Commitment at all levels is necessary to ensure appropriate resources necessary for the delivery of optimal care. Documents like these should help in regulating the flow of patients within the healthcare facilities and throughout the system and concentrate the most critical patients in the more specialized institutions. This structure needs to take into account the real situation of the availability of local and regional resources. These documents should provide the basis for the foundation of the ‘Trauma Systems’ concept.

The evidence supporting the creation and development of regionalized trauma care has been widely published. Nathens and colleagues [8–10] demonstrated that high volume trauma centres (>650 cases per year) not only improve resource allocation but also diminish morbidity and mortality even in highly complex cases (15% of the total trauma population). Some regional hospitals in Colombia receive between 2000–10 000 trauma patients every year (similar to many other low- and middle-income settings). The incidence of TBI ranges from 20–40% of these admissions [11]. Improving the organization and planning for trauma care services in these facilities represents an affordable and sustainable method to improve outcome. Some hospitals have reported successful experiences including programmes for trauma audit and trauma registry management, with improvement in specific issues such as decreasing time delays for surgery [12, 13].

When comparing trauma systems from high-income countries to those in low- and middle-income countries, however, one must consider that, in low income settings, there is a greater volume of patients at some centres resulting from inappropriate distribution due to lack of regionalization. Even in many high income countries, there is a lack of regionalization and inappropriate coordination of transport and delivery of patients with severe injuries.

Patients with severe injuries arriving at centres that do not have enough resources diminish the possibility of survival. Furthermore, precious time is lost in trying to relocate these patients to other centres (not far from the initial one) that probably could have provided a higher level of care. This is a complex and difficult process. Even in the US where regulation concerning trauma regionalization was passed more than 30 years ago, only 50% of the country has regionalized trauma care [4]. Trauma care is still often disjointed and lacking in co-ordination. This last issue is more profound in low- and
Table 1. Requirements to consider for a neurotrauma centre to offer optimal care of the patient [14].

Minimum requirements for a reference neurotrauma care centre

<table>
<thead>
<tr>
<th>Requirement</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Computed Tomography available 24 hours a day.</td>
<td></td>
</tr>
<tr>
<td>2. Neurosurgeon available 24 hours a day (time of on call arrival less than 15 minutes).</td>
<td></td>
</tr>
<tr>
<td>3. Immediate availability of operating room.</td>
<td></td>
</tr>
<tr>
<td>4. Immediate availability of intensive care unit with an intensive care physician. *(Neuromonitoring is recommended)</td>
<td></td>
</tr>
<tr>
<td>5. Availability of other specialties for advanced care of trauma patient (general surgery, orthopaedic surgery, plastic surgery, etc.).</td>
<td></td>
</tr>
</tbody>
</table>

middle-income settings. For example, patients with head or spinal cord injury (SCI) often arrive to facilities that do not fulfil the minimum recommended requirements for the care of these patients (Table I) [14].

This often leads to a greater incidence of death or severe disability with higher costs for the system, family and society. In a recent study about the effect of the hospital designation level in outcome, DuBose et al. [15] analysed 16 037 patients with TBI in US trauma centres. Admission to a lower trauma designation level facility was an independent predictor of mortality ($p < 0.001$), complications ($p < 0.001$) and progression of neurological insult ($p < 0.001$). In a similar study, Macias et al. [16] analysed 4121 patients with SCI who were treated in 100 trauma centres and 601 non-trauma centres in the US. Paralysis was significantly lower at trauma centres ($p < 0.001$). Non-trauma centres with higher admission caseload were associated with worse outcome. Indeed, if these outcomes are coming from reasonably well-established trauma systems communities, it is likely that low- and middle-income countries without trauma systems would have even worse outcomes.

**Role of the scientific associations**

Scientific associations have begun to play a very important role in several aspects related to trauma care. For example, these associations have developed technical documents that can help governments in evaluation and quality control processes. Many scientific associations are also very active in injury prevention. These processes need to be conducted according to international standards but also need to take into account local issues. In North America, for example, for many years the Committee of Trauma of the American College of Surgeons (ACS) created Resources for the Optimal Care of Injured Patients [17]. This document is a model to evaluate trauma centres for accreditation, not only in the US, but also for international societies as well. In addition, the American Association of Neurological Surgeons (AANS)/Congress of Neurological Surgeons (CNS) Section of Neurotrauma and Critical Care and the Brain Trauma Foundation developed the Guidelines for the Management of Severe Traumatic Brain Injury and Paediatric Guidelines for the Management of Severe Traumatic Brain Injury [14, 18].

These documents are also clear examples of academic technical consensus acting as an instrument in the accreditation process of health institutions. Also, these aforementioned associations have actively participated advocacy for seatbelt and motorcycle helmet laws [19]. Another important example is the active participation of medical associations in broad collaborative meetings of the WHO. The International Association for Trauma Surgery and Intensive Care (IATSI) and the International Society of Surgery have participated in international meetings to develop standards for trauma care resources for countries at widely varying economic levels, including those of Africa, Asia, Latin America, as well as high-income countries. These guidelines were aimed to eliminate discrepancies in outcomes of trauma patients globally [20, 21].

For example, one study demonstrated that, for all persons with injury severity scores (ISS) greater than 9, mortality was proportional to the economic resources of the environment. Mortality declined from 63% in low income to 55% in middle-income to 35% in high-income settings. Looking specifically at mid-range injury severity (ISS 15–24) the discrepancies become even more pronounced, with 6-fold differences in mortality between low income and high-income countries [22]. These differences in mortality have led to the development of recommendations for the elaboration of trauma care guidelines according to different models of care based on local availability of resources.

Another role of medical associations is the active participation in political and governmental processes relating to the delivery of care. For example, in 2001, the AANS/CNS Section of Neurotrauma and Critical Care helped to unify the recommendations for hiring neurosurgeons that cover emergency rooms in trauma centers in the United States. The main aim was to improve the labor conditions and
diminish the possibility of occupational risk arising from the lack of institutional resources, benefiting both the neurosurgeon and the patient [23].

An appropriate data base: A basic element of a trauma system

Death after trauma is evaluated in several papers and is presented in bi-modal, tri-modal or tetra-modal distribution, according to the maturity of the trauma system [24–27]. As a common issue in all the distribution models, 50% of trauma deaths occur early in the first minutes of the event and are not amenable to treatment, even with a greater amount of resources available at the scene. Most of these early deaths are due to central nervous system injuries in both civilian and military scenarios [24–29]. Knowledge of such distributions of trauma deaths is key to being able to allocate trauma care resources effectively. Thus, adequate databases about trauma-related deaths are a key tool in trauma systems. Without the existence of reliable databases, the impact and the effectiveness of the system cannot be measured. Trauma centres in high income countries have the opportunity to constantly analyse their own databases and use this information to obtain funding for specific trauma care areas as well as targeted prevention programmes [28–33]. This is a fundamental reason supporting the need to begin building national trauma registries.

Availability of statistical information is vital to the process of applying for governmental and non-governmental funds, be it for research or quality improvement activities. The increase in survival rates, the impact of morbidity and mortality and the possibility of evaluation of prevention policies are some of the elements that one can test through such databases. Unfortunately, in the worldwide evaluation of trauma care models and systems, one great failure in low- and middle-income countries has been the deficiency of databases and the resultant lack of information and true understanding of the basic details surrounding trauma in these regions. In a recent evaluation, the WHO demonstrated that appropriate health databases are used in only 29 of the 115 countries that are reporting data to the organization. This represents real data from only 13% of the global population. For example, some countries report only 10% of the major health events managed by their systems [34]. If nearly 90% of the trauma victims are concentrated in low and middle-income countries, it is easy to see that most countries do not have adequate information sources with which to make informed decisions. This situation does not allow an appropriate analysis of the real behaviour of the trauma system. These small amounts of data are those that annually arrive at the governmental organizations to determine adjustments in budgets and programmes of impact in healthcare. Due to the lack of data, important but unfortunately uneducated decisions may be made in many low- and middle-income countries based on data that do not represent an accurate assessment of the healthcare offered by the system. The Pan American Health Organization (PAHO) reviewed injury data from their 35 member states, focusing on countries with a minimum population of 10 million [35]. The research group obtained information of 11 countries (88% of the total population of the region) included in the WHO Statistical Information System (WHOSIS). In the 11 countries examined, during 2000, the cumulative potential productive years of life lost (PPYLL) from injuries exceeded the burden of infectious diseases, diseases of the circulatory system or malignant neoplasm combined (Figure 1). However, the budgetary allocation for infectious diseases in the 2006–2007 periods for the same region was USD$107 million and injury, violence and disabilities programmes received only USD$2 million.

Resource allocation most of the time is based on analysis of available data. Trauma systems can generate appropriate data to justify resource allocation and also developing of trauma quality improvement programmes, providing information on public health, assessment and quality of care. These programmes allow generating appropriate interventions based on real data such as reducing unnecessary delays in the care processes [36]. This entire process helps to avoid audit errors minimizing time in discussion with insurance companies (private and governmental offices) and other resource allocation issues.

The National Trauma Data Bank of the American College of Surgeons (ACS), the National Traumatic Coma Data Bank of the AANS and the ‘Common Data Elements for TBI Project’ are examples of databases that can rapidly provide detailed information for analysis of academic and administrative processes [37–40]. This information can immediately benefit the affiliated institutions. These are also powerful tools in the evaluation of quality improvement programmes, as well as the impact of the center on the regional or local public health. This information is useful to identify risk factors and high risk groups in the community. As an example, a database allows clear identification of the severity of the traumatic brain injuries in motorcycle riders for certain regions where there is still not an implementation of obligatory helmet use [41]. This lack of implementation is often due to a lack of knowledge of statistics among the general public and little involvement of health organizations and scientific
medical associations in aggressive campaigns of prevention. One aspect of this is highlighted, although the need for continued prospective collection of data is not only to assess changes in incidence or characteristics of trauma but also to make real improvements in prevention and care.

Characteristics of a trauma care health facility

A trauma centre most often is developed in a hospital of medium-to-high complexity level. Nearly 15% of the general trauma patient population will benefit from acute care at this kind of centre [4, 5]. This centre must be a leader in the development of specialized care programmes, protocols and algorithms and must have an internal evaluation programme for quality improvement that measures adherence to guidelines by members of the care teams.

This also includes the availability of a certain level of trauma care capability 24 hours a day, 365 days a year. These centres also must promote continued educational programmes for the multidisciplinary team as well as prevention programmes within the community. Lastly a trauma centre should have an appropriate database to help research processes in trauma care. Programmes for quality improvement in trauma care need to focus on monitoring all the levels of care. From the pre-hospital phase throughout the evaluation and treatment and the rehabilitation process, errors in process and quality must be identified and solutions created. This specialized care must be offered in a sequential manner, planned with a real connection between the guidelines and institutional protocols [4–6].

Advantages of trauma care health facilities

Development of trauma care centres could lead to a significant minimization of the number of preventable deaths after trauma. Preventable deaths by definition are deaths that could be avoided by an appropriate management scheme according to the available resources and the training of the care team. These often arise due to a failure in the management process (inappropriate use of the resources or medical failures in the management). These situations usually involve patients with more than one significant injury and, for this reason the management process involves many resources and also interdisciplinary participation of more than one specialty. A failure in the interdisciplinary trauma care team ‘harmony’ is often found in the quality care evaluations of non-specialized health care centres. Survival rates of patients with severe injuries (ISS > 24) are near 50% in specialized trauma centres [4, 5]. Mortality rates in severe TBI (head AIS > 3 or GCS < 9) in high-income countries trauma centres range between 15–40% [15, 30–32, 40]. Mortality rates higher than these values lead to specific questions about the appropriate organization of a healthcare facility and its ability to manage this kind of patient. Trauma centres usually have some minimum amount of errors in the management of a patient with multi-trauma and also a few failures in the monitoring process [24, 42]. Most studies have shown a 15–20% reduction in mortality for trauma centres vs non-specialized healthcare centres [4, 5]. Celso et al. [43], in a systematic review comparing outcome of patients with severe injuries treated in trauma centres following the establishment of trauma systems, found an overall 15% lower mortality following trauma system implementation. Thus, the organization and

![Figure 1](https://example.com/figure1.png)

Figure 1 Injuries are the main cause of potentially productive years of life lost in the American region including Canada, the US, Cuba, Argentina, Brazil, Chile, Colombia, Mexico, Venezuela, Ecuador and Guatemala. This figure was originally published in Fraade-Blanar et al. [35].
planning that go into establishing a trauma centre have been well demonstrated to improve patient outcome.

The neurosurgeon’s role in the trauma care team

One of the major differences between models of trauma care in low, middle and high income countries is the presence and role of the neurosurgeon in the trauma team. Because of the relatively small number of neurosurgeons relative to population need, only a small proportion are available in some areas of the world, especially in low- and middle-income countries [44]. In many of these countries, the few neurosurgeons are concentrated in main cities, without appropriate coverage in rural zones and intermediate suburban cities that also have a significant population nearby. Some European countries and areas of North America currently have the same problem, although in smaller proportions. The true significance of this paucity of neurosurgeons in low- and middle-income countries is uncertain, but it is likely a contributor to the higher rates of death from trauma in these countries [45, 46].

Additionally, secondary transport to the trauma centres in health systems of high income countries is generally by air and the total transport time is not more than 1 hour; after this transfer, a neurosurgeon and a neuro ICU bed is almost always available for this patient [33, 47]. Ambulance ground transfers of trauma patients (including severe TBI) in countries of low and middle income can take several hours without appropriate transport management, especially when they come from rural areas and finally when they arrive to receive appropriate definitive care sometimes the neurosurgeon is not available and/or an ICU bed is not immediately available.

In order to have an idea of the availability of neurosurgeons and their distribution throughout different world zones, recently the AANS/CNS Section of Neurotrauma and Critical Care published a review of global statistics on this topic (Table II). According to the worldwide directory of neurosurgeons, there are 23,940 neurosurgeons for a total population of more than 6 billion people, ~1 for each 230,000 inhabitants. Half (50%) of these neurosurgeons are concentrated in countries of high and medium-high income, covering ~30–40% of the world’s population, whereas in the countries of low and middle income, a much smaller percentage of neurosurgeons cover ~60–70% of the exposed population to trauma emergencies [44].

Esposito et al. [47, 48] and Valadka et al. [49], in the US, showed that nearly 20% of neurosurgeons who are in charge of initial management of neurotrauma cases would prefer not to do it, due to issues of financial reimbursement, medical liability and impact on elective practice. This tendency is increasing in several countries forced by multiple situations such as medico-legal risks, differences in reimbursement between emergency vs elective neurosurgical procedures (oncology, vascular and spine surgery) and the lack of appropriate processes of institutional contracts. Some of these contract models do not provide any benefit or incentive to encourage neurosurgeons to choose a practice with acute emergency care neurosurgery rather than a more lucrative elective practice. These factors have a direct impact on how patients are identified for long-term follow-up. In some hospitals of low income areas, follow-up with a neurosurgeon is limited to only those who underwent craniotomy; other patients with moderate and severe injuries that were under medical management are lost to follow-up. Long-term care is sometimes assumed by other specialties without a multidisciplinary trauma team approach [12]. Furthermore, the lack of participation of neurosurgeons is frequent and has led to the training of other disciplines such as anaesthesiologists, critical care physicians, trauma surgeons and

<table>
<thead>
<tr>
<th>Area population</th>
<th>Population</th>
<th>Number of neurosurgeons</th>
<th>Neurosurgeons per inhabitant</th>
</tr>
</thead>
<tbody>
<tr>
<td>World</td>
<td>&gt;6 Billion</td>
<td>23,940</td>
<td>1/230,000</td>
</tr>
<tr>
<td>Africa</td>
<td>700 Million</td>
<td>565</td>
<td>1/238,000</td>
</tr>
<tr>
<td>Subtropical Africa</td>
<td>600 Million</td>
<td>79</td>
<td>1/360,000</td>
</tr>
<tr>
<td>Latin America</td>
<td>305.7 Million</td>
<td>2489</td>
<td>1/123,000</td>
</tr>
<tr>
<td>Mexico</td>
<td>107 Million</td>
<td>280</td>
<td>1/377,000</td>
</tr>
<tr>
<td>Asia</td>
<td>3.253 Billion</td>
<td>9618</td>
<td>1/336,000</td>
</tr>
<tr>
<td>Japan</td>
<td>120 Million</td>
<td>7987</td>
<td>1/122,000</td>
</tr>
<tr>
<td>India</td>
<td>1.12 Billion</td>
<td>800</td>
<td>1/140,000</td>
</tr>
<tr>
<td>North America</td>
<td>370.8 Million</td>
<td>4583</td>
<td>1/81,000</td>
</tr>
<tr>
<td>European Union</td>
<td>799 Million</td>
<td>6594</td>
<td>1/121,000</td>
</tr>
<tr>
<td>Australia</td>
<td>21.1 Million</td>
<td>103</td>
<td>1/205,000</td>
</tr>
</tbody>
</table>
developed the Guidelines for Essential Trauma Care [2, 54]. This defined 11 core essential trauma care services that every injured person in the world should realistically be able to receive. To assure the availability of these services, the Guidelines delineate 260 items of human resources (skills, training, staffing) and physical resources (equipment, supplies) that should be in place as a spectrum of healthcare facilities globally, as described in Tables III and IV.

For each cell within the matrix delineated above, the authors recommend those resources (vertical axis) that should be available at a specific level of the healthcare system (horizontal axis). In the development of national trauma plans, countries may very appropriately decide to convert some of the items in the desirable category to essential.

The priority of each item was given a designation according to the following criteria [2]:

- **‘Essential’ (E) resources**: The designated item should be assured at the stated level of the healthcare system in all cases. As this Essential Trauma Care Project covers the spectrum of facilities across the world, the E designation represents the ‘least common denominator’ of trauma care common to all regions, including even those where access to resources is most severely restricted. It is felt that these services could and should be provided to patients with injuries at the level of health facility concerned, even in countries whose ministries of health have a total budget of only $3–4 per capita per year. Essential items could be provided, primarily through improvements in organization and planning, with a minimal increase in expenditure.

- **‘Desirable’ (D) resources**: The designated item represents a capability that increases the probability of a successful outcome of trauma care. It also adds cost. Such items are not likely to be cost-effective for all facilities of a given level in environments with the poorest access to resources. Hence, they are not listed as essential. However, for countries with greater resource availability, such items may ultimately be designated essential in their own national plans. Likewise, there are some services for which only low-cost physical resources would be required and for which training of healthcare personnel at the level in question would be feasible. However, in order for this training to be considered essential, mechanisms would need to be in place to ensure that it is provided for all health care workers at the level in question, within the time constraints of all else for which they must be trained. In cases where it did not seem reasonable to assure such training nationwide, such services have been designated as desirable. Individual countries may

The essential trauma care project of the world health organization: A tool for trauma and neurotrauma care system organization

In order to promote improved organization and planning for trauma systems worldwide, the World Health Organization with other partners worldwide
wish to upgrade these to essential, either at all such facilities or at a sub-set of those with high trauma volume.

- **'Possibly required' (PR) resources**: In environments with poorer access to resources, some trauma treatment capabilities might need to be shifted to lower levels of the healthcare system in order to increase their availability. Such services usually represent only minimal increased cost, relative to the provision of such services only at higher levels of the healthcare system. Shifting to a lower level in the healthcare system would usually imply that a provider with less advanced trauma-related training and skills would be performing procedures that might otherwise be performed by more highly trained personnel. Hence, it is to be emphasized that the 'PR' designation is different from the 'desirable' designation. PR represents a potential necessity to increase availability of trauma care services in environments with poorer access to resources. It is anticipated that the PR designation will apply primarily to low income countries, but not to middle-income.

- **'Irrelevant' (I) resources**: This implies that one would not ordinarily expect this capability at the given level of the healthcare system, even with full availability of resources.

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Table III. Guidelines for Essential Trauma Care. Resources Matrix for TBI management according to the different facility level [2].

<table>
<thead>
<tr>
<th>Resources</th>
<th>Basic Facility</th>
<th>General Physician Facility</th>
<th>Specialist Facility</th>
<th>Tertiary Facility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recognize altered consciousness; lateralizing signs, pupils</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
</tr>
<tr>
<td>Full compliance with AANS guidelines for head injury</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
</tr>
<tr>
<td>Maintain normotension and oxygenation to prevent secondary brain injury</td>
<td>D</td>
<td>E</td>
<td>E</td>
<td>E</td>
</tr>
<tr>
<td>Avoid over-hydration in the presence of raised ICP (with normal BP)</td>
<td>D</td>
<td>E</td>
<td>E</td>
<td>E</td>
</tr>
<tr>
<td>Monitoring and treatment of raised ICP</td>
<td>I</td>
<td>I</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>CT Scans</td>
<td>I</td>
<td>D</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>Burr holes (skills plus drill or other suitable equipment)</td>
<td>I</td>
<td>PR</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>More advanced neurosurgical procedures</td>
<td>I</td>
<td>I</td>
<td>PR</td>
<td>D</td>
</tr>
<tr>
<td>Surgical treatment of open depress skull fractures</td>
<td>I</td>
<td>PR</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>Surgical treatment of closed depress skull fractures</td>
<td>I</td>
<td>I</td>
<td>PR</td>
<td>D</td>
</tr>
<tr>
<td>Maintenance of requirements for protein and calories</td>
<td>I</td>
<td>E</td>
<td>E</td>
<td>E</td>
</tr>
</tbody>
</table>

AANS, American Association of Neurological Surgeons; ICP, Intracranial Pressure; CT, Computed tomography; BP, blood pressure; MRI, Magnetic resonance image; E, essential; D, desirable; PR, possibly required; I, Irrelevant.

Full definitions of designations Essential, Desirable, Possibly Required and Irrelevant are given in the text under the section: 'The Essential Trauma Care Project of the World Health Organization: A tool for trauma and neurotrauma care system organization'.

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Table IV. Guidelines for Essential Trauma Care. Resources Matrix for SCI management according to the different facility level [2].

<table>
<thead>
<tr>
<th>Resources</th>
<th>Basic Facility</th>
<th>General Physician Facility</th>
<th>Specialist Facility</th>
<th>Tertiary Facility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Assessment—recognition of presence of risk of spinal injury</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
</tr>
<tr>
<td>Immobilization: C-Collar, backboard</td>
<td>D</td>
<td>E</td>
<td>E</td>
<td>E</td>
</tr>
<tr>
<td>Monitoring of neurological function</td>
<td>E</td>
<td>E</td>
<td>E</td>
<td>E</td>
</tr>
<tr>
<td>Assessment by International classification system</td>
<td>I</td>
<td>I</td>
<td>D</td>
<td>E</td>
</tr>
<tr>
<td>Maintain normotension and oxygenation to prevent secondary neurological injury</td>
<td>D</td>
<td>E</td>
<td>E</td>
<td>E</td>
</tr>
<tr>
<td>Holistic approach to prevention of complications, especially pressure sores and urinary retention/infection</td>
<td>D</td>
<td>E</td>
<td>E</td>
<td>E</td>
</tr>
<tr>
<td>CT scan</td>
<td>I</td>
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<td>MRI</td>
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<tr>
<td>Full compliance with AANS guidelines</td>
<td>I</td>
<td>I</td>
<td>D</td>
<td>D</td>
</tr>
<tr>
<td>Non-surgical management of spinal injury (as indicated)</td>
<td>I</td>
<td>PR</td>
<td>E</td>
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<tr>
<td>Surgical treatment of spinal injury</td>
<td>I</td>
<td>I</td>
<td>PR</td>
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<tr>
<td>Surgical treatment of neurological deterioration in the presence of spinal cord compression</td>
<td>I</td>
<td>I</td>
<td>PR</td>
<td>E</td>
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</tbody>
</table>

AANS, American Association of Neurological Surgeons; ICP, Intracranial Pressure; CT, Computed tomography; BP, blood pressure; MRI, Magnetic resonance image; E, essential; D, desirable; PR, possibly required; I, Irrelevant.

Full definitions of designations Essential, Desirable, Possibly Required and Irrelevant are given in the text under the section: 'The Essential Trauma Care Project of the World Health Organization: A tool for trauma and neurotrauma care system organization'.
The World Health Assembly Resolution 60–21 on Trauma and Emergency Care was released in March 2007. Since then few countries have started a formal process for policy development in order to improve trauma and emergency care. This is an important document that all the medical specialties need to promote and take into account for build capacity in countries without a formal trauma system [55]. A brief comment of this resolution related to the care of TBI patients is supported by the International Brain Injury Association (IBIA) on their website [56]. This is linked with the patient safety culture that has been promoted from WHO. A recent publication of Haynes et al. [57], of the WHO Safe Surgery Saves Lives Study Group, shows that implementation of simple elements like checklists for surgical procedures could minimize the death rate and clinical complications. The study was developed in a variety of health facilities, with different economic circumstances and diversity of the patient population. The essential trauma care checklists are also great tools in quality improvement programmes at a global level. Recently the WHO has been piloting a trauma care check list project in 12 hospitals in different countries as a safety patient instrument for trauma care [58].

Conclusion

In low- and middle-income income areas, where the emergency care systems do not have all of the resources for the appropriate coverage of the entire population, it is important for countries to organize their care systems according to the incidence of their own emergency conditions. Neurotrauma is one of the conditions that cause significant morbidity and mortality worldwide and the availability of neurosurgeons is not enough, especially in areas of the lowest income that are also the areas with high risk. The implementation of a data collection system and careful analysis of these data are an important initial step to generate statistics that allow for supporting appropriate decision-making processes based on facts and not on suppositions, particularly in the development of a regionalized trauma/neurotrauma system. This is a fundamental step to organize the limited resources that already are available.

Scientific associations or professional societies dedicated to trauma and neurotrauma patient care must also get involved and support the processes of policy-making and healthcare planning for trauma care system development. Trauma healthcare facilities must share the philosophy of optimal care of the patient. The human resources in these centres must be appropriately valued by the health systems. There needs to be a real commitment from the administrators that should reflect appropriate contracting models that specifically support and encourage participation in trauma care initiatives by providing incentives and benefits for those being in charge of acute emergency care. Neurosurgeons are an important resource for the patient who is multiply injured and particularly those with severe TBI. Neurosurgeons have a definitive role in these trauma teams and must be allocated appropriately.

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