Trauma Care in Germany

An Inclusive System

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Abstract

Background Development of trauma systems is a demanding process. The United States and Germany both have sophisticated trauma systems. This manuscript is a summary of political, economic, and medical changes that have led to the development of both trauma systems and the current high-quality standards.

Questions/purposes We specifically asked three questions: (1) What tasks are involved in developing a modern trauma system? (2) What is the approach to achieve this task? (3) Do these systems work?

Methods We conducted a systematic review of relevant articles by searching electronic databases (PubMed, Embase, Cochrane library) using the following search terms: “trauma system”, “polytrauma”, “trauma networks”, and “trauma registry”. Of 2573 retrieved manuscripts, the authors made a personal selection of studies. A personal

study selection from our experiences was added when their contribution to the topic was judged important.

Results Worldwide, similar tasks concerning trauma care have to be addressed. In most societies, traffic accidents and firearm-related injuries contribute to a high number of trauma victims. The German approach has been to decrease the number of accidents through injury prevention and to provide better care by establishing an emergency medical system. For in-hospital treatment, clinical care has constantly improved and a close interaction with members from the American Association for the Surgery of Trauma and the Orthopaedic Trauma Association has helped a great deal to achieve these improvements. The German health-care system was developed as a powerful healthcare tool covering patients from injury to rehabilitation. In addition, trauma and injury research has been strengthened to deal with various questions of trauma care.

Conclusions Organized injury prevention programs and systematized professional patient care can address the issues associated with the global burden of trauma. These trauma systems require constant monitoring and improvement.

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Introduction

Over the last five decades, care of the injured has become a demanding and complex worldwide public health issue [52, 62, 63]. Integration of the specific cultural, social, and historical background of a given country is key to appropriate care. Data from the WHO 2002 *Injury: A Leading Cause of the Global Burden of Disease* [63] showed young males are at highest risk for sustaining an injury-related death, with the incidence being lowest in Southeast Asia and highest in African countries. Low-income countries reportedly have higher numbers of trauma-related deaths

compared to high-income countries [62]. Established and nationwide available trauma systems might explain the lower death rates in the United States and some European countries.

In 1990, the American College of Surgeons Committee on Trauma (ACSCOT) [1] defined a number of criteria to improve the treatment of patients with multiple severe injuries. One of their key criteria implied optimal care for the seriously injured patient requires a systematic approach on the individual patient's level and a functional trauma system on the level of communities and countries. This was based on studies demonstrating an improved outcome when defined trauma systems were available. One of the most recognized summaries was the report from Orange County in 1984 [9]. Such dedicated systems necessarily imply the presence of specialized trauma centers to focus on the in-hospital care of the multiply injured patient. Improvement in individual education and networking between hospitals might be two of the major reasons for this fact [77]. An inclusive system was later defined to provide integrated and systematic structure of care to all injured patients from incident throughout rehabilitation until social and occupational reintegration. The inclusive system implies all healthcare facilities can provide at least basic trauma care, while severely injured patients are transferred to specialized facilities.

The development of a trauma care system in Germany was as follows. Based on historical developments in Switzerland, Germany, and Austria, there was a subspecialization of surgeons for the treatment of acutely injured patients [42, 52]. These surgeons are dedicated to provide care for most injuries, not just the extremity fractures. On the basis of this specialized education, the German Trauma System installed expert hospitals for the acutely injured for work-related injuries and for severe trauma. In 1970, a nationwide network of rescue helicopters was also installed to support this inclusive system. We describe the developments in the German system, closely approaching the inclusive system as defined by the ACSCOT.

Specifically, we focused on three questions: (1) What tasks are involved in developing a modern trauma system? (2) What is the approach to achieve this task? (3) Do these systems work?

Search Strategy and Criteria

All three authors conducted a comprehensive systematic review of the citation databases PubMed, Embase, and Cochrane Library for relevant articles. Articles from 1960 to 2012 were searched using the terms: "trauma system", "polytrauma", "trauma networks", and "trauma register". The only limits applied to the electronic search were that

studies had to be in English or German. We identified 2573 articles. We excluded 2480 articles not specifically addressing severely injured patients or not addressing one of the trauma networks, rescue systems, or trauma registers. The remaining 93 articles were reviewed in several peer group meetings that occurred during a meeting of the German Society for Road Safety in Munich in April 2012, the Orthopaedic Trauma Association meeting in 2012, and the Aachen Polytrauma course in November 2012. If appropriate and not identified by the search strategy, we also added personal study selections, as all authors have been members of the German Trauma Register, the German Working Group on Polytrauma, and the Hannover and Aachen Shock Research Groups.

What Is the Task?

Today, the German system fulfills the key criteria of an inclusive system in a modern industrialized country. To understand the peculiarities of the German system in comparison with others, we provide a comparison with epidemiologic data from the United States. It is important to note in both countries more than 60% of deaths are listed as unknown. There appears to be a lack of documentation for work-related deaths in Germany. The documented incidence of penetrating injuries appears to be higher in the United States (Table 1) [11]. This may in part be due to the strict changes in the German law after World War II. Homicide continues to represent one of the leading causes of death in the United States in the third decade of life, followed by suicide [30]. According to a recent German Federal Health Monitoring report, most suicides are associated with blunt injury mechanisms (eg, jump from a height, suicide attempts by self-inflicted traffic accidents) [81, 82]. Only 0.09% of the German population has a firearm, while in the United States approximately 41% of the households own a registered firearm [79].

Traffic accidents continue to represent a public health problem in both countries. However, the results of the statistical evaluation of high-speed traffic accidents are surprising: the mortality rates are much lower in Germany than in the United States (Table 2). Historically, the absence of speed limits on the autobahn has received widespread attention worldwide [20]. Today, though, most well-populated areas in Germany have strict speed limits and automatic speed control cameras. German law has been changed to allow for vigorous fines and license withdrawal for inappropriate behavior on the autobahn, such as speeding and alcohol abuse. Based on the historical notion of unlimited speeds, the autobahn would appear to be a cornucopia for fatal crashes. However, 49 deaths per 1000 accidents occur on rural roads, while 37 deaths per 1000

Table 1. Death rates and distribution of unintentional deaths in Germany and United States (2010) [11, 21, 81]

Country	Death rate per 100,000 inhabitants				Unintentional deaths (%)		
	Transportation	Firearm	Falls	Work-related	Transportation	Work-related	Other*
Germany	4.9	NA	11.7	NA	32	3	65
United States	12.2	10.4	8.4	1.6	31	3	66

* Other includes household, in-hospital, unknown causes, and not available; NA = not available; Workers Compensation-related deaths are not listed separately.

Table 2. Road injury mortality in Germany and the United States per age group (2009) [11, 21, 81]

Country	Deaths per 100,000 population	
	Adults	Children < 10 years of age
Germany	5.0	2.0
United States	14.9	2.7

accidents occur on the autobahn [81, 82]. These findings from federal statistics can be explained by a broad spectrum of factors, such as risk of tree collision on rural roads, average number of passengers per car, rate of motorcycle involvement, so-called weekend party crashes, and speeding on small roads with limited passing zones [72].

What Is the Approach?

In Germany, several efforts were undertaken in recent decades to reduce the burden of road injury and death: (1) mandatory healthcare insurance; (2) injury prevention measures; (3) emergency medical system; (4) in-hospital care, quality management, and rehabilitation; and (5) trauma and injury research.

Mandatory Healthcare System

The development of a national insurance system started about 120 years ago [34]. Poor living conditions led to the development of several major healthcare insurance systems, initiated by the former German Chancellor Otto von Bismarck (1815–1898). Bismarck was responsible for a variety of innovations within the public social security system, including the implementation of a mandatory health insurance in 1883 (insuring cases not covered by the workers' liability insurance), an accident insurance in 1884, and a pension insurance in 1889 [90]. The mandatory general health insurance at that time covered all diseases and injuries within the whole population. In addition, workers' compensation insurance was instituted and covered all work-related injuries and diseases. Furthermore, a mandatory insurance for the care of the elderly and a pension fund for the whole population were established.

The historical background is especially relevant with regard to the workers' liability insurance. Bismarck presented the first comprehensive social welfare legislation accident insurance act for workers in 1884 in an attempt to fight the upcoming socialist movement. One of the key components of this act was the requirement that every worker had to have insurance for sickness and old age. It was considered essential that this social security program be financed by the employers based on the notion that employers had a vital interest in preventing injuries and supporting rehabilitation of injured employees. If employers financed the treatment of injuries, they would also have a motivation to create safer work places and prevent injuries. Workers did not, and do not to date, depend on the employers when claims are made. Rather, an independent official judge is linked between parties. The insurance—paid for by the companies—covers all costs for emergency medical service and all hospital and rehabilitation costs, and the insured may even receive a long-term compensation or pension in case of disability. In consequence, the workers' liability insurance established dedicated trauma hospitals and rehabilitation units, all of them Level 1 trauma centers. Also, they developed a broad spectrum of quality standards in terms of hospital infrastructure, team education, and skills of accredited physicians.

In 1995, insurance for geriatric housing and care was added [88]. This insurance, as well as health insurance, worker's compensation, and pension insurance, is mandatory for every citizen. Currently, the total annual expenses for acute health care, prevention, rehabilitation, pension, compensation, and care of the elderly add up to USD 260 billion.

Injury Prevention Strategies

The German injury prevention system provides a broad spectrum of preventive measures, especially for industrial work sites. There are various prevention measures that have been successful in reducing the risk of injuries and mortality rates at work and in road traffic accidents [87].

(1) At every work place, an independent safety team investigates the potential risk for the worker on an annual

basis. The recommendations made by this team are mandatory for the company. Also, a certain time limit is set until the improvements (protective shields, etc) must be fulfilled. This applies especially for work places where sharp instruments or heavy loads are involved. The changes are controlled by these independent safety teams.

(2) In general, employees must wear and use protective devices such as gloves or steel-enforced shoes when they are at risk for injuries. Annual investigations by independent governmental audit control compliance with the respective federal laws and on-site safety guidelines. In case of noncompliance, fines and work restrictions can be imposed on companies and/or employers.

(3) A biannual technical investigation (brakes, condition of the suspension, etc) of almost every motor vehicle used in Germany is mandatory. The technical status is verified by an independent licensure institution. A license plate tag testifies the roadworthiness of every vehicle. These tags are frequently and randomly checked by the police. As a maximum penalty, vehicles with invalid tags can be withdrawn from road traffic without further notice followed by a substantial fine. A mandatory seat belt law for all car passengers was introduced in the 1970s. Around the same time, the German government began enforcing the mandatory helmet law for motorcyclists. Currently, the vast majority of motorcyclists on German roads wear a helmet. Moreover, a broad spectrum of research projects has been installed that deal with the documentation and evaluation of motor vehicle accidents. As an example, the four major automobile manufacturers (Audi, BMW, Mercedes Benz, and Volkswagen) are involved in multiple areas with experts in orthopaedic and trauma surgery. In addition, several university hospitals run large-scale interdisciplinary projects to provide in-depth crash data [64]. Funding for these projects is provided by federal institutions and other public donors. After data recruitment, the accident reports are analyzed by specialized Accident Research Unit teams. In 1974, the first investigation of its kind was founded by Harald Tscherne at Hannover Medical School [73]. The on-scene teams of the research units are organized to arrive at the crash scene shortly after an accident. Therefore, they operate special cars and are notified from police dispatchers.

(5) E-call systems and comparable electronic alert devices were introduced in 1982 and are expected to substantially reduce the prehospital time. Their key purpose is to detect kinematic crash parameters, analyze risk patterns, and most importantly, alert the closest emergency medical dispatcher. These systems use data generated by airbag, Electronic Stability Program ESP[®], and comparable sensors. The data to the dispatcher include the global positioning system (GPS)-based location of the crash scene [35, 38]. Major benefits are expected for unconscious drivers, undetected crash locations, and rural areas.

Emergency Medical Systems

There is a long and successful history of structured, organized rescue services in Germany. In the late 1920s, arguments arose as to how to develop an efficient and sustainable logistic framework. H. Kirschner from Heidelberg pioneered organized rescue in Germany and in 1938 insisted on the dogma that “the physician has to come to the injured patient, rather than the patient to the physician” [33].

His followers remembered Kirschner’s philosophy and tried to transfer professional prehospital care into civilian trauma. A major milestone occurred in 1957, when a physician-staffed bus was equipped as a mobile operating room in Heidelberg and Cologne [32]. In fact, various basic surgical procedures were performed on this vehicle; even splenectomies were reported [33]. However, this approach was not feasible due to the rapidly growing traffic density on German roads.

Between 1970 and 1980, major changes occurred in the German trauma system. It was then that Harald Tscherne was given the first university post in Hannover. Unlike many other ideas, the orthopaedic units began to deal with the management of the entire patient, including prehospital and early in-hospital care [85].

As far as rescue was concerned, more flexible systems were created with two complementary ground transportation systems. One is based on a large physician-staffed vehicle that can carry sufficient equipment and two paramedics to the scene [10]. The other system is called the rendezvous system [10]. It combines a small fast car for transportation of the emergency physician and a paramedic in a separate, large ambulance vehicle. The rendezvous system allows the physician to accompany the patient in the larger ambulance vehicle directly to a hospital. Both systems enable the emergency physician to “treat and run,” picking the best options out of the “scoop and run” or “stay and play” concepts [75]. Rapid transport and presence of an emergency physician to the crash scene reportedly increased the endotracheal intubation rate [13]. In this context, approximately 2/3 of patients in the TraumaRegister DGU[®], the trauma register of the German Trauma Society (Deutsche Gesellschaft für Unfallchirurgie [DGU]), received endotracheal intubation before hospital admission [13].

In addition, since the 1970s, a nationwide air-based rescue system has been developed. This is an excellent example of how war experiences can be successfully transferred into civilian trauma care and for the sake of the whole population. In fact, the German Trauma System learned a great deal from the American experience in Vietnam. Although a devastating event, the experiences in combat trauma rescue and hostile environments (96,000 injured soldiers transported within 35 minutes to mobile army surgical hospitals) provided the concepts for the

German emergency medical system. In the beginning, a network of physician-staffed helicopters for primary rescue was rolled out in Germany. To date, the 52 Helicopter Emergency Medical Service Systems provide nearly complete air rescue coverage throughout Germany [15].

In conclusion, three logistical rescue frameworks exist in Germany, all of which are dedicated to provide rapid and sufficient life-saving care: (1) the physician-staffed helicopter; (2) the physician-staffed, advanced life support unit; and (3) the paramedic-staffed ambulance vehicle system. Concurrent alarm of more than one of these three systems can occur. Nevertheless, decision making on how and where to transport the injured is among the responsibilities of the emergency physician on scene. In this context, it is important to know full insurance coverage of the costs, even in unnecessary alarms or transport, is provided to all rescue services/companies involved.

In-hospital Trauma Care, Quality Management, and Rehabilitation

The principles of Germany's in-hospital treatment structures also have been influenced by a historical background. The organization of a trauma center was adapted from the Austrian surgeon Lorenz Böhler, who has been called the father of trauma care in Europe [6]. Based on his experience with an extraordinary number of military injuries from World War I, he revolutionized fracture treatment using defined principles based on injury site, severity of the fracture, and soft tissue status [6]. According to Böhler's understanding, the trauma surgeon is responsible for the entire chain of care, from rescue to rehabilitation, including the treatment of fractures but also soft tissue injuries, such as vascular, abdominal, or pelvic organ injuries.

This unique understanding led to the development of a specific resident and other educational programs for trauma physicians, resulting in an independent subspecialty of accident and trauma surgery (Unfallchirurgie). The success of this concept was soon known across the border of Austria, and in 1970, the first German university chair for this subspecialty was given to the Austrian Harald Tscherne. He was educated and trained according to the ideas of Böhler in Austria under Maurice E. Müller at Graz. Over the following decades and to this day, he has profoundly influenced the German trauma care system and many of his trainees have become leading figures in European trauma care.

Today, trauma surgeons all over Germany are involved in primary rescue and as trauma leaders in emergency rooms. This includes diagnostic procedures, such as abdominal ultrasound and emergency surgical procedures in abdominal, chest, and limb injuries. The latter are usually treated as the sole responsibility of a trauma surgeon. This part of the daily

work is comparable to that of trauma surgeons in the United States. However, each surgical specialization focuses on special fields. In case of severe body cavity injuries, many hospitals favor an interdisciplinary approach, with general surgeons, maxillofacial surgeon, and neurosurgeons. Nevertheless, the trauma surgeon remains the trauma leader and is therefore responsible for the organization of clinical care. In addition, intensive care is performed by the trauma surgery department in several large trauma centers. The responsibility of these centers regularly includes rehabilitation, outpatient followup, diagnosis and treatment of complications, and subsequent medical expertise when compensations or pensions are concerned.

It was the achievement of Tscherne [84–86] to further develop Böhler's ideas, which finally resulted in the implementation of a system where the patient is seen by the same physician from injury through to rehabilitation. This is especially important in severely injured patients, where high-level team communication and crew resource management are required. The underlying rationale is to substantially reduce the number of underdiagnosed/missed injuries [58]. In the same context, mandatory reevaluations of all patients in the intensive care unit and on the regular ward have been installed [85]. Apart from this, his globally published concepts of the staged treatment of patients with polytrauma according to the clinical status are still widely accepted [60, 83, 85, 86].

A number of rehabilitation facilities are available for the requirements of patients with trauma. For patients with work-related injuries, the insurance owns rehabilitation centers to host all patients in a uniform manner. The range of treatment usually includes orthopaedic and neurologic rehabilitation. For patients after private accidents, a variety of specialized facilities are available. The decision as to where a patient is transferred is based on medical needs and made by the trauma surgeon or modified according to the patient's and the relative's wishes. The rehabilitative measure is completely covered by the insurance.

The classification of the severity of posttraumatic sequelae is also judged by a certified trauma surgeon. To provide high-quality in- and outpatient care, a network of formally qualified physicians in the evaluation of post-trauma conditions is spread all over Germany. The grading and classification of the sequelae are performed according to standardized guidelines. The system foresees that these physicians are independent and their evaluation results are not associated with any financial benefit.

Trauma Research Laboratories

The development of a dedicated trauma research team also guided research groups that developed all over Germany. Under his guidance, Otmar Trentz developed such a

laboratory in Homburg, and his school opened another one in Frankfurt under the guidance of Ingo Marzi. The Ulm research group has been active for many years, and most recently, in Aachen, the Harald Tscherne Laboratory for Trauma Research was opened and helped in the development of this manuscript.

What Are the Results of This System?

The development of such a trauma system as that described above has many effects. When analyzing the results, there are, on the one hand, the direct effects to patient care and, on the other hand, the disciplines encouraged by the direct patient care such as the research sector. When compared with the past decades, trauma mortality in Germany has dropped from about 40% to less than 15% [65] and one important factor was the enlarged research capacity.

Effects of Clinical and Experimental Research on In-hospital Care

The injury distribution of patients with blunt polytrauma in Germany can be derived from the German trauma registry. From 1993, it was started in five hospitals to collect the data of severely injured patients to compare treatment and set up benchmarks for diagnostic and treatment modalities [18, 91]. More hospitals joined in and at this point more than 500 hospitals are involved with the database, which includes all patients initially treated for shock. The database currently oversees approximately 100,000 severely injured patients, 2/3 of whom were affected by a road traffic crash. The average patient has a mean of 6.7 injuries and four fractures (Fig. 1). Data from the TraumaRegister DGU[®] have been used for epidemiologic observations and for the development of scoring systems for blunt trauma, some of which are used for close monitoring of quality indicators in trauma care [2, 76].

The evolution of the traditional trauma surgeon to the trauma leader and to the clinical expert who oversees the treatment of all injuries and their systemic effects, including shock-related disease, created widespread research activities. As an example, trauma surgeons began to investigate the special care of single injuries [8, 89] but especially interaction of these injuries and their systemic effects on the circulatory and immune system [24, 68, 69]. Therefore, interdisciplinary shock research groups have been created at several trauma centers, fostering interdisciplinary, joint efforts by trauma surgeons and basic scientists [25, 57]. Two major research fields were addressed: (1) the clinical impact of surgical procedures on shock and on the development of multiorgan failure (MOF) and (2) studies on rehabilitation.

A variety of studies have been undertaken to determine the consequences of posttraumatic immunologic alterations on the development of complications. In studies on the intestinal permeability defects in patients with MOF and combined hyperactivation of the immune system, the importance of the gut-liver axis was demonstrated [47, 55]. In addition, certain injury profiles were identified that are especially prone to develop such complications (borderline patient) [43]. Also, certain surgical procedures were reportedly associated with defined risks [44, 48, 53]. Depending on the type of surgery, the presence of specific comorbidities can be associated with a predictable increase in inflammatory markers [45, 46, 54, 59, 61]. In addition, to gain a systematic understanding of MOF and systemic inflammatory response syndrome [22, 56], various animal models were developed. Among these, a large-animal model of MOF in sheep is available [16, 17, 49, 67]. Also, several models were used [40] that can be expanded toward a two-hit model allowing the use of knockout animals [3].

Further investigations have focused on the general outcome of severely and multiply injured patients and were undertaken using the TraumaRegister DGU[®]. On the basis of this registry, an outcome scoring system was developed using data of 2-year followup examinations from 254 patients with blunt trauma. The scoring system includes established rehabilitation instruments and the results of a medical examination [80]. As a pertinent key finding, the greatest functional impairment was found in patients suffering from lower limb injury, especially in injuries below the knee. This occurs despite a comparable injury severity in the upper extremities, pelvis, and abdomen. This objective finding is in agreement with the subjective evaluation indicating moderate to severe restrictions in 41% of patients with lower extremity injuries but in only 16% of patients with upper extremity injuries [92]. In patients with a very high Injury Severity Score, it appears systemic interactions aside from the initial injury can heavily affect subsequent function [23]. A 5-year followup of 50 MOF survivors revealed considerable deficits in the ROM of the ankle, knee, hip, and elbow [51]. These patients had long intensive care stays in common and approximately 1/3 were reported to suffer from a decreased ROM in initially uninjured joints. This was in part due to heterotopic ossification [51]. Moreover, the importance of injuries below the knee for long-term outcome was confirmed in previous studies [36, 70, 78]. Another study found about 80% of such a study sample were reintegrated into work, but about 20% had to undergo a program to find an adequate work/profession different from the previous one [66].

The German system has undergone a quality improvement strategy over the last decade. It resulted in a standardized evaluation process. It is a strict system where the documentation of work-related injuries is now being examined, as well

Fig. 1 The frequency of injuries (AIS 2–6) per injury mechanism and body region from the Trauma-Register DGU® is shown. Modified and reprinted with permission by the DGU from Deutsche Gesellschaft für Unfallchirurgie. Jahresbericht 2009 [Annual Report 2009]. Available at: http://www.traumaregister.de/index.php?option=com_content&view=article&id=49&Itemid=55&lang=de.

as that for all trauma cases in the German Trauma Register, participation in which is mandatory for every center that wants to be involved. These efforts are in addition to confirmation of protocols, documentation of night shifts, and assessment of the emergency rescue plans. One result of this process is the generation of trauma networks.

The Development of Trauma Networks

Since 2004, attempts have been made to connect individual trauma centers in regional trauma networks to secure equal process and structural quality of trauma care all over Germany [39]. In 2006, the German Trauma Society developed and published respective standards, algorithms, and guidelines in a dedicated white book [14]. The guidelines recommended that the proposed quality indicators should be independently evaluated, audited, and certified, aiming at a sustainable and reliable development toward a nationwide homogenization of care quality in Germany. Based on criteria from the white book, independent auditing and certification visits were established in hundreds of German trauma hospitals. These trauma centers were then graded according to their different levels of care. Next, all successfully audited hospitals within a region could cooperate and become a certified trauma network (Trauma-Netzwerk DGU®). Currently, there are about 35 trauma networks with approximately 600 trauma centers (Fig. 2) [13]. In 2014, Germany will be completely covered with an expected 55 trauma networks and 900 trauma centers, allowing overlapping coverage of helicopters and trauma networks (Fig. 2).

One of the main goals is to provide a rapid interhospital transfer of severely injured patients since many polytraumatized patients are in need of immediate initial stabilization at the nearest hospital with subsequent transport to a higher care level facility. Therefore, the trauma network system has been established to provide structures for interhospital communication, for adequate and rapidly available transportation, and to reveal the capabilities of different hospitals. This network is frequently considered the backbone of the German inclusive trauma system [15].

While the system provides reliable and high-quality trauma care to the whole population, the development and maintenance of such an elaborate system creates a financial burden [21]. This includes access to professional trauma care irrespective of health insurance status, income, age, or other variables. A tight network of rescue systems secures immediate emergency care by physicians experienced in trauma care. In addition, the achievements of rehabilitation provide evidence for the effectiveness of this system. Such improvements demand substantial and ongoing public expenses. It will therefore be the task for the upcoming trauma surgeons to achieve better financing by politicians and hospital administrators.

Currently, Germany is facing substantial structural changes in its healthcare system, such as the implementation of a German diagnosis-related group system. In this context, numerous clinical studies have targeted the costs of the initial clinical course for the multiply injured. Some researchers have focused on the total hospitals costs, an approach that mandates meticulous documentation of hundreds of variables [32, 41], while others have addressed the reduction of intensive care unit charges [12] or investigated whether the amount of clinical tests can be reduced [74].

However, these costs are negligible when compared to the real socioeconomic impact of trauma in terms of social costs and/or productivity loss. Official cost analyses show the socioeconomic impact of trauma is highly underestimated [50]. Trauma continues to represent the major cause of disability in individuals during their productive work life [81, 82]. In addition, trauma-related deaths have a higher loss of productive life years than other diseases, such as malignancies or cardiovascular diseases [32, 71].

Discussion

The purpose of this review was to highlight the process of trauma system development in Germany as an example of an inclusive system. Severely injured patients are in need of specialized care, and structural preconditions must reflect the

Fig. 2 The TraumaNetzwerk DGU[®] consists of regional networks with local (green), regional (blue), and supraregional (red) trauma centers. Yellow (= audited hospitals) and gray hospitals (= registered hospitals) are awaiting certification in the upcoming 12 months. Modified and reprinted with permission by the DGU from <http://map.telekooperation-tnw.de/maps/index.html>.

trauma load expected. The implementation of such a developed system is affected by multiple factors. We tried to underline the specific circumstances influencing such a process by answering the following questions: (1) What tasks are involved in developing a modern trauma system? (2) What is the approach to achieve this task? (3) Do these systems work?

Our review is subject to a number of limitations. First, our literature review was not comprehensive. We selected literature based on our experience and mostly specific for the German and US trauma sector. The topic of the development of trauma systems and their impact on patient care can be conducted from many perspectives. Our search was focused on the historical development in Germany. Other searches might find different results based on their literature selection. Second, to underline their personal impact, some

important participators are mentioned personally in this study. The authors acknowledge that many colleagues dedicated themselves to develop and maintain the German trauma systems. However, not all of them could be named and we are sure their importance is not impaired by highlighting others. Third, the comparison between different countries is difficult. Implied in the development process is that enough financial capacities are available. This was and is an ongoing burden for countries such as Germany or the United States. Countries with less financial power might struggle to follow this way because of lack of resources. However, the point of exporting the structural process to other countries might be worthy of future studies.

The tasks that a trauma system is faced with were outlined above for the German trauma system and in

comparison to the US trauma system. The majority of trauma cases are due to traffic road accidents. For Ireland, Bedford et al. [5] demonstrated alcohol abuse was a major contributory factor for fatal traffic accidents. In about 1/4 of all pedestrian deaths (2003–2005), alcohol consumption was a contributory factor in that study. These data are confirmed for the region of South Australia where Holubowycz et al. [28] found a substantial blood alcohol level in more than 1/3 of all killed drivers. In Pakistan, Mir et al. [37] reported a 5-year road crash history in 11% of their cohort with alcohol consumption being a 2.2-fold risk for crashes. Therefore, motor vehicle accidents are a worldwide task for the trauma specialist.

One specific approach the German trauma system took was the implementation of a physician-operated emergency medical service. With this system, the mortality could be reduced, and if mandatory procedures were required (eg, intubation), there was a substantial time reduction as substantiated by findings from other countries [7, 26]. Iirola et al. [29] reviewed the importance of physician-staffed helicopter emergency services and found a more extensive treatment by the physician-staffed services without increasing scene time. This was substantiated by Garner et al. [19] who also found a substantially lower mortality. In 1987, Baxt and Moody [4] had already reported a decreased mortality rate through the concept of bringing the physician to the trauma scene.

The results of the implementation of an inclusive trauma system in Germany were a substantially reduced trauma mortality rate, a sector of research newly derived from all the clinical questions induced by the special patient care, and for the system itself an upgraded networking with the organization of trauma networks, spreading all over Germany. This networking idea might be appropriate for other countries. Carr et al. [10] found different standards of rescue times at a national level, regarding the scene of trauma. Especially in rural areas, greater time is needed for bringing patients to the right hospital. A study on patients with traumatic brain injuries in an area without a standardized trauma system showed a substantially longer time for patient arrival in the hospital for definitive treatment when those patients had to be transferred first [31]. Hardcastle et al. [27] reported for an African country the prehospital trauma service was below nationally accepted time norms because of the lack of an appropriate trauma system. These studies suggest a potential benefit of the development of trauma systems adapted to every country's requirements. Future studies might substantiate this need and might clarify whether the German system can partially serve as a prototype for such a development.

Trauma is a neglected epidemic with an enormous burden for the national health systems in both industrialized and developing countries, a fact that has not yet gained adequate public and political attention. In consequence, professional

care of the injured and injury prevention are the most important “cure” for the global disease called trauma.

Acknowledgments This article is dedicated to Harald Tscherne MD who held the first University Chair for Trauma Surgery (Unfallchirurgie) in Germany starting in 1970. His influence vividly stimulated the development of trauma and orthopaedic surgery in Germany. He resigned in October 2000, having fulfilled 30 years of trauma leadership in Europe. He continues to be a mentor in the ongoing discussion about optimal trauma care. The authors thank Prof. Tscherne who provided them with their training in trauma care. The article is based on the 2000 Fitt's Lecture of the American Association for the Surgery of Trauma given by Johannes A. Sturm MD at the Annual Meeting of the Association in San Antonio, TX, USA. Dr. Sturm is currently the chief executive officer of the Akademie der Unfallchirurgie (AUC), an organization that runs the German Trauma Registry, and has coinitiated the German Trauma Network.

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