

Post-Impact Care

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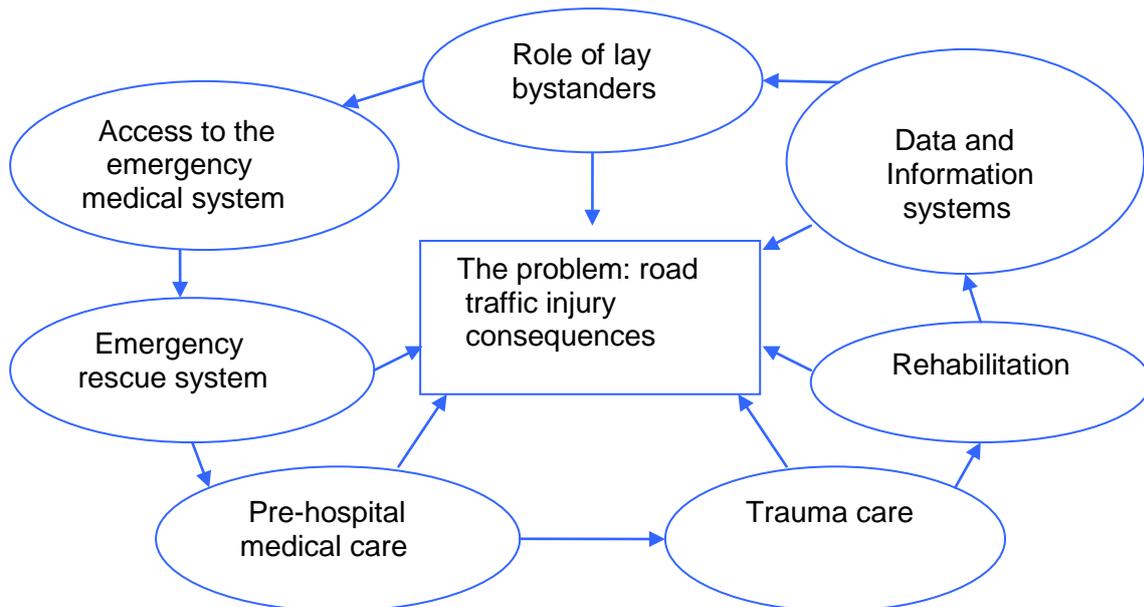


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1 Overview

Figure 1: The chain of help



Post-impact care is a strategy aimed at reducing the severity of injury consequences once a road traffic crash has occurred. For major injuries, clinical experts define the post-impact care needed as the chain of help starting with action taken by the victims themselves or more commonly by lay bystanders at the scene of the crash, access to the pre-hospital medical care system, emergency rescue, pre-hospital medical care, trauma care and helping road crash victims who have suffered debilitating injury to re-integrate into work and family life. See Figure 1. The effectiveness of such a chain depends upon the strength of each of its links (Buylaert, 1990). Minor injury patients will often need the help of a general practitioner and optimal medical and psychological follow-up care is important to alleviate pain and distress.

Despite the fact that the cost of years of life lost from road trauma is larger than from cancer or cardio-vascular diseases, the attention paid by health policymakers, by the medical community and by the road safety field to trauma-related care and research is disproportionately small. The Decade of Action announced by the United Nations and the related Global Plan 2011-2020 and its Pillar of Action on post-crash response holds promise of new attention to avert a growing global crisis of road traffic injury (UN, 2010; UN, 2011). The European Commission has stated that several thousands of lives could be saved in the EU by improving the response times of the emergency services and other elements of post-impact care in the event of road traffic crashes (CEC, 2003).

While post-impact care presents special challenges for low and middle-income countries as they motorise, improvements have been seen in many OECD countries over the last 40 years ranging from improvements in emergency medical response systems to advanced trauma care procedures to specific surgical intervention techniques. While studies analysing the relationship between the performance of the trauma management system and road crash outcomes are infrequent, research indicates that various improvements have contributed to better injury outcomes (Elvik & Vaa et al., 2009; Noland, 2004; Oestern et al., 2001; Noland & Quddus, 2004). In a review of 1970-1996 data in several OECD countries it was concluded that between 5% and 25% of the reductions in road crash fatalities may have been due to improvements in medical care and technology (including trauma and emergency response systems), (Noland, 2004).

The main sources of information for this outline comprise: in particular, a review of post-impact care by medical experts from across the European Union (Buylaert, 1999); a meta-analysis of studies by Elvik and Vaa et al. (2009); the World Health Organization's pre-hospital care guidelines (Sasser et al., 2005), essential care guidelines (Mock et al., 2004), World Report on Road Traffic Injury Prevention (Peden et al., 2004) and other WHO publications and a SafetyNet project report (Gitelman et al., 2008). The assistance provided by Dr Manjul Joshipura, World Health Organization in helping to identify clinical references is gratefully acknowledged.

2 The problem: road traffic injury consequences

2.1 Road traffic deaths and injuries

During 2010 there were around 31,000 road deaths in the European Union (European Federation of Road Traffic Victims, 1997) with over a threefold difference in highest and lowest death rates per 100,000 population (EC, 2011). Involvement in road crashes is one of the three leading causes of death and hospital admission for EU (12) inhabitants (together with cancer and coronary heart diseases), and it is the leading cause of death for EU citizens under 50 years old (ETSC, 2003). It was also been estimated that for EU (12) countries (Rumar, 1999):

- 1 in 3 citizens will need hospital treatment during their lifetime due to road crashes
- 1 in 20 citizens will be killed or impaired by road crashes
- 1 in 80 citizens will end their life 40 years too early due to road crashes
- Road crashes cause 6 months shorter life expectancy

2.2 Health of survivors and long-term disability

While information on road traffic deaths is available in most European countries, there is no systematic comparable information on the health of survivors. There are a variety of definitions of 'serious injury' although a new EU-wide definition is foreseen; many serious injuries are not reported (IRTAD, 2011); data on the long-term health consequences of road traffic injury is not collected on a systematic basis; and while rating systems have been devised and are in use, there are no international standards for describing and quantifying

the disabilities arising from traffic injuries, particularly those involving neurological trauma (IRCOBI, 2006, IRTAD, 2011).

In Europe it is estimated that for every death, there are an estimated 4 permanently disabling injuries such as to the brain or spinal cord, 10 serious injuries and 40 minor injuries (Mackay, 2005). Disability is usually defined as an individual's inability to carry out a normal range of daily activities due to physical and/or psychological consequences. Permanent disability, such as paraplegia, quadriplegia, loss of eyesight, or brain damage, can deprive an individual of the ability to achieve even minor goals and result in dependence on others for economic support and routine physical care. Less serious – but more common – injuries to ankles, knees and the cervical spine can result in chronic physical pain and limit an injured person's physical activity for long periods. Serious burns, contusions and lacerations can lead to emotional trauma associated with permanent disfigurement. Road crashes can also result in a variety of long-term psychiatric and psycho-social problems (Peden et al., 2004).

In-depth studies indicate that:

- Motor vehicle crashes are the leading cause of traumatic brain injury (Peden et al., 2004).
- The majority of whiplash injuries are sustained by car occupants in crashes, and around 50% of these are in rear impacts (Krafft, 1998).
- 22% of a sample of patients attending hospital with fractures to the upper or lower limb, or a soft tissue injury to their cervical spine ("whiplash") had some form of disability 4 years after the crash (Murray, 2001).
- Pedestrians and motorcyclists suffer the most severe injuries as a result of motor vehicle collisions, report more continuing medical problems and require more assistance, compared with other types of road user (Peden et al., 2004).

2.3 Socio-economic costs and the value of prevention

In EU countries in 2002, a 38-fold difference was recorded in the valuation of the prevention of a road traffic death (ETSC, 2007). The average annual socio-economic cost (or the value of preventing fatalities and injuries in road traffic crashes) over the last decade has been estimated at around 2% of EU 27 countries' gross domestic product - around Euro 176 billion and twice the EU's annual budget (ETSC, 2003; ETSC, 2011).

However, the long-term impacts of transport-related injuries within the EU are to a large extent unknown (ETSC, 2007). Many national estimates do not take account of the cost of long-term disability resulting from road traffic crashes and associated intangible costs. Injuries reported as being minor at the time of crash can often lead to costly long-term disability. One British study (Murray et al., 2001), which contributed to subsequent national crash cost estimates, monitored the costs to the Health and Social Security services of treatment of patients with whiplash and fractures over a 4 year period. For fracture injuries, the largest single cost to the Health Service was in-patient treatment and for 'whiplash' patients physiotherapy was the largest single cost. Long-term disability also brings, however, many intangible costs to the patient and family. Work is urgently required to establish the

long-term impacts of serious health loss in road traffic crashes to inform policymaking in EU countries.

2.4 The costs and benefits of post-impact care

Surprisingly little work has been conducted on the costs of post-impact care versus the benefits for reducing trauma in road crashes.

However, studies have shown that improved organisation and planning for emergency care can be carried out at a reasonable cost and can lead to more appropriate use of resources, improved care, and better outcomes (White et al, 1996). In developing countries, most effective pre-hospital strategies are basic and inexpensive, and the lack of high-tech interventions should not deter efforts to provide good care. Even where resources allow them, the more-invasive procedures performed by physicians in some pre-hospital settings, such as intravenous access and fluid infusion or intubations, do not appear to improve outcomes, and evidence suggests that they may, in fact, be detrimental to outcomes (Kobusingye, et al., 2006). Information on the annual costs of aspects of post-impact care in Norway is presented in Table 1.

Studies show that significant reductions in preventable deaths can be achieved through improvements in the trauma care system. Panel reviews indicate an average reduction of 50% in medically preventable deaths and population-based studies and trauma registry studies show around a 15%-20% reduction in mortality as a result of improvements (Simons, et a, 1999), (Mann et al., 1999), (Brennan et al., 2002). The risk of death is significantly lower when care is provided in a trauma centre than in a non-trauma centre (MacKenzie et al., 2006). Costs per life saved and per life-year saved are very low compared with other comparable medical interventions (Durham et al., 2006), (Rotondo et al., 2006).

Table 1: Annual costs of post crash care in Norway

Measure	Costs NOK	Costs from year
9.1 Emergency medical services	-	-
9.2 Rescue helicopters (per mission)	180,000	1997
9.3 Automatic crash notification – investment infrastructure, per unit	240,000 – 400,000	2006
9.3 Automatic crash notification – training of personnel, per person	2,400 – 4,000	2006
9.3 Automatic crash notification – vehicle equipment, per vehicle	1,200 – 2,400	2006

Source: Elvik et al., 2009

Cost-benefit analyses in Norway of specific post-crash services (excluding emergency medical services are provided in Table 2. (Elvik et al., 2009).

Table 2: Benefit-cost ratios of post-impact care

Measure	Benefit-cost ratio
9.1 Provision of medical services	-
9.2 Rescue helicopters: Ambulance missions	5.9
8.3 Automatic crash notification (ACN)	0.23 – 1.65

Source: Elvik et al., 2009

2.5 Time between road crash and road death?

A study by medical experts in European high-income countries found that about 50% of deaths from road traffic crashes occurred within minutes, either at the scene or while in transit to hospital. For those patients taken to hospital, around 15% of deaths occurred within 1-4 hours after the crash, but around 35%, occurred after four hours (Buylaert, 1999). A more recent meta- analysis of studies found that the proportion of road deaths killed within the first minutes after a crash is between 37% and 50% (CEC, 2003). A comparative study of mortality among seriously injured patients across a range of countries found that for low-income and middle-income countries, the vast majority of deaths occurred in the pre-hospital phase (Hirsch & Eppinger, 1984). The World Health Organization has identified three phases of deaths from severe injury, as outlined in Box 1.

Box 1: Three phases of deaths from severe injury

Phase 1: Deaths occur immediately or occur quickly as a result of overwhelming injury;

Phase 2: Deaths occur during the intermediate or sub-acute phase. These deaths occur within several hours of the event and are frequently the result of treatable conditions;

Phase 3: Deaths are delayed. Deaths during this phase often occur days or weeks after the initial injury and are the result of infection, multisystem failure or other late complications of trauma.

Source: Sasser et al., 2005

As the World Report on Road Traffic Injury Prevention (Peden et al., 2004) underlined, there is not so much a “golden hour” (Lerner & Moscati, 2001) in which interventions have to take place as a chain of opportunities for intervening across a longer timescale.

2.6 Survivable and non-survivable road traffic injury?

The appropriate management of road casualties following a crash is a crucial determinant of the chance and quality of survival. The faster and the more effectively an injured person is treated medically, the greater are the chances of surviving and making a full recovery. A Swedish study into survivability in fatal road traffic crashes concluded that 48% of those who died sustained non-survivable injuries. Out of the group who sustained survivable injuries, 5% were not located in time to prevent death, 12% could have survived had they been transported more quickly to hospital and a further 32% could have survived if they had been transported quickly to an advanced trauma centre (Hendriksson et al., 2001). A UK study estimated that 12% of road crash victims with serious skeletal trauma went on to have significant preventable disability (McKibbin et al., 1992). A Spanish study found that reducing the time between crash occurrence and arrival of emergency services from 25 to 15 minutes reduces deaths by one third (Sánchez-Mangas et al., 2010). Trauma i.e. unspecific, extensive, and life-threatening injury is recommended to be treated within 10 minutes, and more extensive medical care should be provided within 1 hour, preferably at a specially equipped trauma centre (Champion, 2005). When not treated timely and adequately, trauma may lead to incapacitating injuries or death.

2.7 Post-impact care and road safety plans and targets

Post-impact care is now acknowledged globally as a key road safety strategy and fundamental to a *Safe System* approach (see ERSO [Road Safety Management](#) and [Work-related road safety](#) web texts). However, it is often neglected in national road safety strategies and programmes in European countries although Sweden plans to set a target for average time from injury to adequate rescue/medical care as one of its intermediate outcome targets. This may be because it is outside the direct responsibility of the lead agency for road safety which is typically the Ministry of Transport in European countries. Good inter-governmental coordination arrangements can ensure that attention is given to this key area in target-setting and plans. New Zealand's *Road Safety to 2010* strategy, for example, targeted a specific reduction in hospitalizations, the number of people hospitalized for more than one day and the number of people hospitalized for more than three days. Improving trauma management systems was one of the priorities of the strategy (LTSA, 2003).

Decade of Action - the Global Plan 2011-2020

Improving post-impact care is a key strategy promoted by the World Report on Road Traffic Injury Prevention (Peden et al., 2004) and is a Pillar of Action in the Global Plan for the Decade of Action (UNRSC, 2011), as shown in Box 2.

Box 2: Global Plan - Pillar 5: Post crash response

Increase responsiveness to post-crash emergencies and improve the ability of health and other systems to provide appropriate emergency treatment and longer term rehabilitation for crash victims.

Activity 1: Develop pre-hospital care systems, including the extraction of a victim from a vehicle after a crash, and implementation of a single nationwide telephone number for emergencies, through the implementation of existing good practices.

Activity 2: Develop hospital trauma care systems and evaluate the quality of care through the implementation of good practices on trauma care systems and quality assurance.

Activity 3: Provide early rehabilitation and support to injured patients and those bereaved by road traffic crashes, to minimize both physical and psychological trauma.

Activity 4: Encourage the establishment of appropriate road user insurance schemes to finance rehabilitation services for crash victims through:

- Introduction of mandatory third-party liability; and
- International mutual recognition of insurance, e.g. green card system.

Activity 5: Encourage a thorough investigation into the crash and the application of an effective legal response to road deaths and injuries and therefore encourage fair settlements and justice for the bereaved and injuries.

Activity 6: Provide encouragement and incentives for employers to hire and retain people with disabilities.

Activity 7: Encourage research and development into improving post crash response.

Source: UNRSC, 2011

In the road safety management system assessment framework used by the World Bank in road safety management capacity review, Checklist 5 highlights the need to assess jurisdictional post-impact care arrangements. Post-crash response and first aid, emergency preparedness and post crash recovery and rehabilitation is also cited as a key road traffic safety risk factor in the ISO 39001 road traffic safety management systems system for organisations (ISO, 2012).

Checklist 5: Recovery and rehabilitation of crash victims from the road network				
Questions	Yes	Partial	Pending	No
<ul style="list-style-type: none"> • Have comprehensive safety standards and rules and associated performance targets been set to govern the recovery and rehabilitation of crash victims from the road network to achieve the desired focus on results? • Pre-hospital? • Hospital? • Long-term care? 				
For each category of post-crash service (pre-hospital, hospital, and long-term care) are compliance regimes in place to ensure adherence to the specified safety standards and rules to achieve the desired focus on results?				
Do the specified safety standards and rules and related compliance regimes clearly address the safety priorities of high-risk road user groups to achieve the desired focus on results?				
Do the specified safety standards and rules and related compliance regimes compare favourably with international good practice?				

Source: Bliss and Breen, 2009.

Improved emergency and post-injury services are included as a pillar in the European Commission’s proposals for action on road safety to 2020 (EC, 2011). The Commission aims to develop the elements of a global strategy concerning road injuries and first aid, with the help of a Task Force bringing together the relevant actors, representatives of international and non-governmental organisations, government experts and the Commission. The development of a new EU *Injuries Strategy* is underway.(EC, 2012).

3 The role of lay bystanders

3.1 The first link in the chain of help

The chain of help begins, according to the World Health Organization, with those who are present or who arrive first at the scene of a crash. Lay bystanders can play an important role in various ways, including:



- Contacting the emergency services, or calling for other forms of help
- Helping to put out any fire
- Taking action to secure the scene (e.g. preventing further crashes, preventing harm to rescuers and bystanders, controlling the crowd gathered at the scene)
- First aid e.g. unblocking airway obstruction. One of the most common causes of death for road crash victims is anoxia – a lack of oxygen supply – caused by blocked airways which take, on average less than 4 minutes, to prove fatal according to the British Red Cross.

3.2 Do commercial and public transport drivers need first aid training?

While basic first-aid training for commercial and public transport drivers and trained community first responders in rural and remote locations is recommended by the World Health Organization (Sasser et al., 2005), it has not been scientifically established whether such a measure would decrease pre-hospital mortality.

EC Directive 2000/56 provides for the requirement of first aid training and refresher courses for professional drivers.

Before the introduction of a national ambulance system, a study in Ghana established that commercial taxi and minibus drivers trained in first aid in Ghana could provide one effective means of providing pre-hospital care (Mock et al., 2002). See Box 3.

Box 3: First aid training of professional drivers in Ghana

Improving Trauma Care in the Absence of a Formal Ambulance System

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

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

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

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

Component of first aid	Before (percent)	After (percent)
Crash scene management	7	35
Airway management	2	35
Bleeding control	4	42
Splint application	1	18
Triage	7	21

Conclusions: Even in the absence of a formal EMS, improvements in the process of prehospital trauma care are possible by building on existing, although informal, prehospital transportation.

Source: Mock and others 2002.

Source: Kobusingye et al., 2006

3.3 Would first aid training for the general public help?

For EU countries, EC Directive 2000/56 provides for Member States to take measures to ensure that: applicants for driving licences know how to behave in the event of a crash; they can assess road crash victims including emergency action such as evacuation of passengers and basic knowledge of first aid. When obtaining a driving licence it is in many countries mandatory to take a first-aid course and e.g. in Germany all drivers are obliged to provide first aid when arriving at a crash scene (CEC, 2003).

The World Health Organization holds the view that training of specially selected community volunteers and other lay professionals could be valuable but does not recommend requiring first aid training for drivers in general (Sasser et al., 2005). There is no strong evidence that basic first aid training by drivers and members of the public would decrease pre-hospital mortality. There is, also, concern that unless there is in-depth knowledge of basic life support techniques, more harm might be done than good. At the same time, the level of cost to provide the necessary in-depth training supplemented with regular refresher courses for all road users would need to be balanced by evidence of substantial benefit. There is no evidence that provision of first aid kits in cars would help (Bull, 1985).

4 Access to the emergency medical system

4.1 Telephone notification

A national emergency number speeds up the process and guarantees that all relevant agencies are warned and involved. In high-income countries, access to the emergency medical system is almost always made by telephone, but the coverage and reliability of the telephone link varies between countries. The growth in the use of mobile telephones is having a helpful effect on crash notification (Mock et al., 1993).

The emergency notification number for the European Union is 112 which allows European citizens in distress to contact the emergency services in all Member States. It was established by Council Decision of 29 July 1991 and reinforced through the Directive 98/10/EC and now to be found in the Universal Service Directive. According to the European Commission it has now been implemented in all EU countries, although the number is little known by EU citizens according to European Commission monitoring. No information is available about the time taken to answer this emergency call number and no EU standard exists for call receipt.

4.2 In-vehicle emergency notification systems

Automatic Crash Notification (eCall) which is available in several car models today aims to provide emergency responders with data that indicates the severity of the crash and the nature of injuries sustained. It is estimated more than 765.000 vehicles fitted with eCall have been sold in 11 European countries (Chauvel & Haviotte, 2011). The aim of eCall is to reduce the time between the crash and arrival of the emergency services. eCall is a system which can be triggered manually or automatically. The aim is to send an in-vehicle message



through a GPS system to an emergency call centre in the event of vehicle involvement in a crash. The minimum set of data contains information about the incident including time, precise location, vehicle identification, eCall status (as a minimum, indication if eCall has been manually or automatically triggered) and information about a possible service provider (CEC, 2003).

Legislation for this technology is currently under discussion within the European Commission and is expected to be fully defined for 2012. Instead of a manual call on the part of the passenger or bystander at a crash scene, the aim is for the in-vehicle eCall system to send an automatic message in a European standardised format usually to the nearest 112 Public Safety Answering Point, PSAP (fire brigade, police or emergency call centre) where the appropriate response to the alert is determined. The Public Safety Answering Points have still to be established and equipped to receive the message in the European standardized format in all European Countries.

Since 2010, Euro NCAP's Advanced rewards has recognized car manufacturers who make available new safety technologies which demonstrate a scientifically proven safety benefit for consumers and society. Several car models have received rewards points for fitting eCall Euro NCAP.

The European Commission believes that a pan-European eCall has the potential to save up to 2500 fatalities annually in EU-25 when fully deployed (COM(2005) 431 of 14.9.2005: Bringing eCall to Citizens). While no empirical studies of the effects of injury outcomes have been found, some prospective studies have estimated likely effects on fatalities and serious injuries. An overview of the results from these studies is given in Table 3. The results are shown as intervals of the estimated likely upper and lower limits of the possible reductions of fatalities and severe injuries. Studies that do not provide a comprehensible description of the methods are not included in the overview (Elvik et al., 2009).

Table 3: Effects on numbers of fatalities and serious injuries of automatic crash notification

Crash severity	Types of crashes affected	Number of fatalities / injuries in the study	Percentage change in the number of fatalities
Clark & Cushing, 2002 (USA)	All crashes	30,875	(-1.5; -6)
Evanco, 1999 (USA)	Accidents in rural areas	25,761	(-7; -12)
Virtanen, 2005 (Finland)	All crashes	919	(-3;-8)

Source: Elvik et al., 2009.

The studies assumed that all vehicles were equipped with the eCall terminal and that each terminal would function properly. They were unable to evaluate the impact of the precise location information given by eCall on the swifter arrival of rescue units at the accident site in evaluating decreases in road traffic deaths nor the overall impact of the system which involves additional players.

A recent French study (Chauvel & Haviotte, 2011) looked at the effectiveness of eCall in 202 crashes in France and found a 2.8 % reduction in fatalities. A global assessment of studies carried out to date presented in the report is shown in Table 4.

Table 4: Effectiveness of eCall

Study referencies	Effectiveness (number of death reduced)	Countries studied
E-Merge [3] [13]	5 – 10%	European Union 15
AINO Study [4] [13]	4 – 8%	Finland
eImpact [5] [13]	3.6% < 5.8% < 7.3%	European Union 25
SEISS [6] [13]	5 – 15%	European Union 25
TRACE [7] [13]	10.80%	Australia
SBD [8] [13]	3%	UK
Erie County ACN field test [9] [13]	20%	USA – New York
Czech eCall study [10] [13]	3 – 9%	Czech Republic
Swedish eCall study [11] [13]	2 – 4%	Sweden
Dutch eCall study [12] [13]	1 – 2%	Netherlands
CEESAR-LAB (“ <i>a priori</i> ” methodology) [1]	5.1%	France
CEESAR-LAB (“ <i>a posteriori</i> ” methodology)	2%	France

Source: Chauvel and Haviotte, 2011

A cost benefit study based on Norwegian data (see Table 5) indicated that the benefits are larger than the costs only under the assumption of high benefits (8% fatality reduction). Under the assumption of medium or low benefits, the costs exceed the benefits, independent of the costs. These figures are similar to the results from (Virtanen et al., 2006), according to which the cost-benefit ratio is 0.55 under the assumption of small benefits and high costs, and 2.32 under the assumption of large benefits and low costs.

Table 5: Cost-benefit ratios of automatic crash notification under different cost and benefit assumptions

	High benefit (-8% fatalities)	Medium benefit (-4% fatalities)	Low benefit (-1.5% fatalities)
High costs	1.22	0.61	0.23
Low costs	1.65	0.82	0.31

See ERSO eSafety web text for further information.

4.3 Telephone answering by the emergency services

An efficient call receiving system is essential to avoid wasted time. A variety of models exist but have not been studied. In some Member States, calls are answered by the ambulance services or the emergency medical services, in others by other emergency services - police and fire service – and then appropriate calls are transferred to the emergency medical system. A priori direct contact over indirect contact is to be preferred (Buylaert, 1999). It is not known whether all countries have standards for call receipt, although several countries have developed call receipt performance indicators.

4.4 Emergency Medical Dispatch

In Europe, calls received by the Emergency Medical System either result in:
Automatic dispatch of an emergency ambulance requiring the call taker to give accurate identification of the location of the incident and to mobilize the emergency crew;
Selective dispatch depending on the perceived nature and urgency of the incident and the process of doing this is known as Emergency Medical Dispatch.

The functions of the Emergency Dispatch System are:

- Prioritization by level of urgency (triage) to determine the speed of response
- Prioritization by level of need to determine type of response
- Provision of pre-ambulance arrival instructions in first aid and scene management
- Communication with those on the scene and in the receiving hospital.

Clinical experts across Europe believe that all calls to the Emergency Medical System in Europe should be transferred as soon as possible to a trained dispatcher able to make a layered response using an appropriate Emergency Dispatch System (Buylaert, 1999).

A computerized system which promotes the call taker, records responses, supports decision-making and provides information for audit and quality assurance is considered essential (Nicholl, 1997). There are various ways of operating emergency medical dispatch systems: the essential elements which have been identified are the use of a standard protocol, the need for medical supervision, audit of operations and the training of dispatchers (Buylaert, 1999).

5 Emergency rescue systems

5.1 Coordination between emergency services

Emergency rescue requires effective coordination between all the emergency services. The objective is to ensure speedy first aid and transport to an appropriate treatment centre. There needs to be close professional cooperation at the scene between fire-fighters, coastguards and police (who may arrive first at the scene) and the emergency medical service personnel.

5.2 Training of emergency personnel

Emergency medical technicians staffing an ambulance and carrying out basic pre-hospital care techniques can save lives and limit disability. At the same time, there is no evidence for the effectiveness of training pre-hospital care paramedical personnel in advanced life-saving skills (Kobusingye et al., 2006). Research shows that the level of training and the degree of professionalism involved varies (Chamberlain, 1998, Huemer et al., 1994). The important status of the emergency medical technician is often not well recognized, is seen as an accessory for the fire department, or is even left to volunteers. The establishment of minimum standards at European Union level has been recommended by clinical experts in Europe (Buylaert, 1999). Non-medical emergency services need to be trained in basic life support in order to provide immediate first aid. There also needs to be cooperation between the fire-fighting services and medical personnel when victims are not readily accessible and special training is organized in many Member States to this effect. Evaluation has shown that by a 3-day cross-sectoral team training course, the extrication and on scene-time may be reduced by as much as 40-50% which is important not least in extreme weather conditions Ersson et al, 1999. One issue, in particular, is the need for safe extrication of victims and awareness of the rescue services of special hazards such as undeployed airbags.

5.3 The availability and response times of ambulances

Land ambulances are used in the majority of attendance at the scene of road collisions in Europe. The standardization of equipment in ambulances in Europe has been recommended, together with the development of appropriate vehicle and driver safety standards, given the considerable number of crashes involving ambulances (Buylaert, 1999).

A research overview (Elvik et al., 2009) indicates that the faster a road casualty can gain access to expert first aid, the greater the chance of survival and full recovery. Research shows that:

In general, road traffic deaths increase with increasing ambulance response time which is strongly related to population density.

The proportion of fatal crashes is lowest where ambulance availability is best and highest where ambulance availability is poor.

Response times depend amongst other things upon the distance to the nearest hospital, the availability of ambulances and ambulance personnel, road and traffic conditions and the accurateness of the descriptions of the crash location (Elvik et al., 2009).

Shorter pre-hospital times, in general, are considered an important parameter of the quality of pre-hospital care. These times have the following components:

Notification time is the time elapsed from occurrence of injury or recognition of severe illness until the EMS system is notified.

Response time is the time elapsed from notification until arrival of an ambulance to the site of the ill or injured person.

Scene time is the time taken by pre-hospital providers from arrival at until departure from the scene.

Transport time is the time elapsed from leaving the scene until arrival at the hospital or other treatment facility (Kobusingye et al., 2006).

5.4 Is helicopter rescue effective?

Helicopters are used widely throughout Europe as emergency ambulances in a primary responder role in post-impact care and have been used in this role in Germany since the early 1970s. They are thought to be useful in improving response times and removal times to and from the scene, giving a more appropriate level of response, particularly in rural areas and providing access to more appropriate hospitals. Research shows that using helicopters to transport patients does not influence greatly their probability of survival, they are costly (between around 0.5 million – 1.5 million euro annually to operate) and not without significant crash risk (Elvik et al., 2009; Buylaert, 1999). A cost-benefit analysis of the national air ambulance helicopter service (Elvik, 1996) concluded that the current service in Norway carried out by these helicopters had a benefit-cost ratio of around 5.4. Rescue helicopters carry out both search and rescue missions and ambulance transport. For the search and rescue missions, the benefit-cost ratio of current services is around 4.9. For ambulance services, the benefit-cost ratio was calculated to be around 5.9.

If helicopters are operated, the evidence suggests that it should be on a regional basis in a secondary responder role in which they are called out at the request of emergency personnel at the scene or at a primary receiving hospital (Buylaert, 1999).

6 Pre-hospital medical care

6.1 What type of treatment?

While the old method of ‘scoop and run’ without any treatment is no longer practiced in high-income countries in Europe, to ‘stay and play’ at the scene may also be detrimental for the prognosis of the patient (Buylaert, 1999). A recent survey of pre-hospital literature found only 24 randomized controlled trials and concluded there was insufficient data to provide a strong evidence base for the effectiveness of many common pre-hospital interventions (Bunn et al., 2001). The World Health Organization (Sasser et al., 2005) distinguishes between *basic* and *advanced* systems of pre-hospital care.

Basic Life Support (BLS): Consists of emergency medical care to restore or sustain vital functions (airway, respiration, circulation) without specialized medical equipment and to limit further damage in the period preceding the arrival of specialized, advanced emergency medical care.

Advanced Life Support (ALS): Medical care given by medical doctors and nurses trained in critical care medicine with the use of specialized technical equipment, infusion of fluids and drugs aimed to stabilize or restore vital functions. Advanced life support is an integral part of a system of emergency medical services that needs adequate medical supervision.

While advanced systems are impressive and undoubtedly benefit some patients, the WHO states that there is little evidence that they are inherently superior to systems that offer basic pre-hospital care. They may also hinder the overall provision of pre-hospital care if they lead system planners to divert scarce resources from basic interventions that benefit large numbers of patients to interventions that benefit fewer patients. With few exceptions (such as early defibrillation for victims of cardiac arrest), most advanced interventions have not been scientifically proven to be effective because the necessary randomized trials have not been conducted. In contrast, improved outcomes have been documented after bystanders and health-care providers have been educated to provide the fundamental elements of trauma care (Sasser et al., 2005).

Scientific knowledge about the efficacy of pre-hospital medical care techniques is, thus, still evolving. The optimal approach needs to be determined for different types of trauma patients and well-controlled studies need to be carried out to address this question further. It is clear, however, that only essential treatment should be given so there is no unnecessary waste of time. Measures to protect the victim from further injury, basic life support measures such as providing a free airway and techniques used to aid breathing are considered essential. Mouth to mouth resuscitation and mask bag valve ventilation and decompression are also essential techniques. Measure to reduce circulatory failure and manoeuvres started for immobilizing possible fractures to prevent further damage are also considered to be essential treatments (Buylaert, 1999).

6.2 Who should deliver the pre-hospital care?

Those who provide basic pre-hospital trauma care have had formal training in pre-hospital care, scene management, rescue, stabilization and transport (World Health Organization, 2005). Essential basic pre-hospital care techniques can be delivered by emergency medical technicians staffing ambulances. Advanced techniques can only be provided by:

- Paramedics (emergency medical technicians who have received further training) e.g. in the UK
- Nurses specialized in critical care e.g. in the Netherlands
- Physicians in mobile intensive care units which is a system widely used in Europe e.g. in Belgium, Germany, France, Italy.

In order to make the best use of resources, a two-tier system has been set up in some European countries comprising emergency medical technicians as the first tier and mobile intensive care units as a second tier.

6.3 Which hospital? The importance of field triage

Different factor needs to be taken into account in the decision about the appropriate hospital for the road crash victim such as type of injuries, services available at the hospital, comparative distances and times to reach hospitals, and regulations concerning the transport of injured people.

Triage is the term applied to the process of classifying patients at the scene according to the severity of their injuries to determine how quickly they need care. Careful triage is needed to ensure that resources available in a community are properly matched to each victim's needs. Formal algorithms or protocols need to be developed for both the pre-hospital and hospital setting to ensure that community resources are used properly to care for trauma patients. Failure to develop protocols may lead to over-triage or under-triage. Over-triage occurs when non-critical patients are sent to facilities offering the highest level of care. Under-triage occurs when critically injured patients are treated at the local level or sent to facilities that are not properly equipped to meet their needs. This may result in increased morbidity and mortality among patients with otherwise treatable injuries (Sasser et al., 2005).

6.4 Medical control and direction of pre-hospital care

Physician input is needed throughout the planning, implementation, evaluation and audit of the Emergency Medical System. Medical control and direction of pre-hospital care is essential and at the local level, a knowledgeable and committed health-care professional should be identified to serve as the medical director. In urban areas, an experienced hospital-based physician trained in accident and emergency medicine, anaesthesiology or critical care, or trauma surgery, and ideally trained or experienced in pre-hospital care, may be best suited to this role. In rural communities where a physician may not be available, the most experienced nurse or paramedical professional should fill this role. It is important that qualified individuals be assigned responsibility for assuring the availability and quality of pre-

hospital care in their community, whether it is delivered through paid health-care providers or local volunteers (Sasser et al., 2005).

6.5 Planning and care in multiple casualty crashes?

Major road crashes involving multiple casualties: Contributory factors include fog and excess speed (Buylaert, 1999). Large numbers of injured persons may also result from collisions involving buses or lorries carrying explosive, toxic or inflammable chemical products. A disaster planning document is needed to strengthen the capacity of local and regional governments, health-care providers and public health organisations to react to such events (Sasser et al., 2005). Best practice indicates that a region-wide trauma team is the optimal means of dealing with such events utilizing such a disaster plan. Post-impact care is coordinated by hospital-based medical teams who are trained in disaster management and in collaboration with the ambulance, police and the fire service. Efficient rescue involves on-site triage and immediate care, evacuation and hospital admission (Buylaert, 1999).

6.6 Legislative framework for pre-hospital care

Establishing a legislative framework for pre-hospital care standards and their compliance forms the basis of a national system.

The following areas are commonly addressed by law or by administrative regulation (Sasser et al., 2005):

- Training, certification and licensure of providers of pre-hospital emergency medical care
- Services, including minimum skills requirements and provisions for disciplinary actions
- Scope of practice (allowable skills) of pre-hospital providers and the conditions under which they may use these skills
- Scope and authority of medical direction, including protocols determining a patient's destination, triage guidelines and protocols for inter-facility transfer
- Licensure or authorization of emergency medical services, including medical direction and training, and vehicles, including equipment, communications etc.
- Complaint investigation procedures
- Quality improvement
- Financing
- Designation of medical facilities as specialty care centers if appropriate
- Data collection, reporting and confidentiality
- Accreditation of education programmes
- Liability protection of providers and physicians, if needed
- Communications requirements
- Access to the emergency medical care system, including a nationwide emergency telephone number
- Emergency medical service catchments areas and mutual aid requirements; disaster response.

A case study on establishing a legislative and compliance framework for Emergency Medical Services compiled from information published by the World Health Organization is presented in Box 4.

Box 4: Establishing a legislative framework for EMS in Romania – a case study

Between 1990 and 2000, Romania made progress in its provision of emergency medical services (EMS). A network of governmental ambulance services had existed in the country before 1990, and fire departments in some areas had also started running ambulance services. At the same time, several hospitals throughout the country had been upgrading and improving the organisation of their emergency departments. Despite these important improvements in trauma and emergency care, Romania's EMS system remained extremely fragmented. The quality and availability of EMS depended on local county resources and motivation, both for pre-hospital ambulance services and hospital emergency care.

In 2006 *Health System Reform Law* was introduced which defined emergency care as a duty of the state, distinguishing it from other aspects of health care. A major implication of this is that emergency care for all is paid for by the state, whereas all other medical care is paid for by insurance or other means. The Ministry of Health was assisted by an expert Consultative Committee for Emergency and Disaster Medicine, which addressed both pre-hospital and hospital-based components of EMS.

Under this legislation, the criteria and definitions for different levels of hospital emergency departments in terms of staffing, physical resources and financing were outlined. The Consultative Committee also established standards for ambulances, detailing the resources required for each ambulance in terms of medications, materials and staffing. Further decrees were issued in conjunction with other governmental departments to establish the criteria for several types of ambulance vehicle, ranging from first response vehicles to mobile intensive care unit vehicles. The competencies of ambulance personnel were defined and the limits of what each level of personnel could perform in the field were established. Logistical and safety regulations were created and a partnership established with the police force responsible for enforcing these standards through spot checks. Several decrees followed which established standards for different levels of hospital critical care capabilities (including intensive care units) and for different levels of hospital emergency departments, including human resources, equipment, drugs and infrastructure.

In 2007, the Ministry of Health created a Ministerial position – the Under-Secretary of State for Emergency and Disaster Medicines - specifically responsible for the administration of EMS and for implementation of the provisions of the EMS section of the Health System Reform Law. This position has autonomous decision-making power and has enabled documented advances in the organisation, administration, enforcement, monitoring and performance of Romania's EMS.

Source: WHO, 2010



7 Trauma care

7.1 What is trauma care?

This involves the provision of appropriate care at a medical establishment to road crash victims with major and minor injuries.

Minor injury: Injuries are treated by the patients themselves, a general practitioner or the accident and emergency department. Correct treatment of injuries such as head and neck trauma and adequate follow up care is important to limit pain and prevent adverse consequences.

Major injury: A trauma care systems needs to be put in place by every hospital receiving patients with major trauma.

7.2 Are trauma services effective?

Evidence of the effectiveness of improvements in trauma services comes from panel reviews of preventable deaths, hospital trauma registry studies and population-based studies (Mock et al., 2004). Panel reviews indicate an average reduction of 50% in medically preventable deaths and population-based studies and trauma registry studies show around a 15%-20% reduction in mortality as a result of improvements in the trauma care system (Simons et al., 1999; Mann et al., 1999; Brennan et al., 2002). A comprehensive population based study examined the effects of planning of system for trauma management in all 50 states of the United States and found an 8% reduction in overall trauma mortality (including deaths at the scene and having adjusted for various confounding variables) due to improvements. The study found that the effect of the system of trauma managements was not usually evident until 10 years after its implementation and reached a maximum at 16 years (Nathens et al., 2000a, 2000b). A study in the US confirmed that the risk of death is significantly lower when care is provided in a trauma centre than in a non-trauma centre (MacKenzie et al., 1996)

7.3 Establishing a national trauma system

A prerequisite for high-quality trauma care in hospital emergency departments is the existence of a strategy for the planning, organisation and provision of a national trauma system. The strategy for the organisation of a national trauma care system needs to be formulated by health policymakers with input from medical professionals to provide research-based guidelines, standards and general advice about the treatment of trauma victims. Trauma centres in several European Countries have protocols for the pre-hospital and hospital phase. National guidelines need to be formulated in consultation with national, scientific medical societies on trauma centres and their organisation.

Each trauma system must be defined by local needs and assessments of capacity and developed with due regard for local culture, legislation, infrastructure, health-system capacity, economic considerations and administrative resources. International essential



trauma care guidelines have recently been established by the World Health Organization (Mock et al., 2004).

There is considerable potential worldwide and in Europe to upgrade arrangements for trauma care and improve training in trauma care at the primary health care level, in district hospitals and in tertiary care hospitals (Peden et al., 2004), (Buylaert, 1999), (Coats & Davies, 2002). The US vision of a national trauma system is set out in Box 5 and Box 6 (NHTSA, 2006). The latest detailed requirements for trauma centre capability were set out in 2006 by the American College of Surgeons (ACSTC, 2006) See Boxes 5 and 6.

Box 5: The US Vision of a Trauma System for the Future

Trauma systems, when fully implemented throughout the U.S., will enhance community health through an organized system of injury prevention, acute care and rehabilitation that is fully integrated with the public health system in a community. Trauma systems will possess the distinct ability to identify risk factors and related interventions to prevent injuries in a community, and will maximize the integrated delivery of optimal resources for patients who ultimately need acute trauma care. Trauma systems will address the daily demands of trauma care and form the basis for disaster preparedness. The resources required for each component of a trauma system will be clearly identified, deployed and studied to ensure that all injured patients gain access to the appropriate level of care in a timely, coordinated and cost-effective manner.

Box 6: Comprehensive Trauma Care System: Key Infrastructure Elements

The infrastructure of a trauma care system includes eight key elements:

- Leadership
- Professional resources
- Education and advocacy
- Information
- Finances
- Research
- Technology
- Disaster preparedness and response

In a model system, these elements are integrated and coordinated to provide cost-efficient and appropriate services across the continuum of care

7.4 Regional trauma care plans

Regionalisation of care to specialist trauma centres reduces mortality by 25% and length of stay by 4 days (Mackenzie et al., 2006). Clinical experts recommend that each region should have a major trauma plan which defines the pathway of care for severely injured patients, identifies the location and capability of each trust/hospital within the trauma system and outlines ambulance bypass protocols and thresholds for transferring patients to more specialist units. Within each geographical region there should be a network of units geared to treat trauma patients ranging from those with life threatening conditions, to those with less complex injuries. This 'trauma system' would need to integrate pre-hospital care (i.e. the care delivered by paramedics at the scene of the injury), the initial journey to a suitable unit, inter-hospital transfer (where required for patients in need of more specialist treatment), definitive hospital treatment and rehabilitation (Royal College of Surgeons of England Orthopaedic Association, 2000, 2007).

7.5 The trauma team

The creation of a multi-disciplinary trauma team and the appointment of a trauma team leader is required by the in-hospital trauma service. The multi-specialist trauma team comprises anaesthesiologists, surgeons, radiologists, emergency physicians etc. and provides care for every major trauma patient admitted to hospital. A minimum threshold of clinical capabilities needs to be established for each trauma centre. A review by the World Health Organization of studies on the effectiveness of trauma teams found that organized trauma teams have been shown to improve the process and outcome of trauma care in high-income countries (Bunn et al., 2001). For example, in one study on trauma resuscitations, resuscitation time was halved in the presence of an organized trauma team (Driscoll & Vincent, 1992).

7.6 The trauma team leader

In Europe, trauma team leaders tend to be either emergency physicians, surgeons (orthopaedic surgeons, neurosurgeons, general surgeons) or anaesthesiologists and specialists in intensive care. The leader is well trained in trauma care and is available on a 24 hour basis. The functions are to interpret, apply and decide about the priorities for the primary and secondary survey of pol trauma as well as team training. Studies have shown that the presence of a trauma team leader improved resuscitation time (Hoff et al., 1997), (Sugrue et al., 1995).

7.7 Education, training and audit

Team leader training: The global standard for trauma team leader training is the ATLS course of the American College of Surgeons. Good practice indicates that the leader's previous experience in trauma care should include a period sufficient to have been involved in the treatment of at least 50 trauma patients in a level I/II trauma centre emergency Department (in Europe such a department would be expected to admit more that 150-180 major trauma cases each year) (Buylaert, 1999).

Education and training of trauma team: Each trauma centre is responsible for the training of the trauma team and this is usually organized by a committee of trauma team leaders. In Germany, for example, team trauma training is aligned to pre-hospital and hospital phase protocols.

Audit: Together with the trauma co-ordinator, the group of trauma team leaders takes responsibility for the audit of the care and outcomes of all major trauma. This entails setting up a trauma registry and recording patient details by means of various scores, ratings and injury scales. (See 9: Data and Information systems).

Greater attention is needed worldwide to define and optimize the training of doctors and nurses in trauma care (both in basic education and post-graduate settings. A range of available courses are listed in the Guidelines for Essential Care (Mock et al., 2004).

8 Rehabilitation

8.1 Returning the patient to the community

The last link of the trauma system care chain is to return the injured individual to his or her place in the community. This involves the integration of initial 'high tech' medicine and rehabilitation services and attention to the psychological needs of the patient. Training is required for staff caring for patients as well as those supporting relatives. Long lasting psychological and social suffering of relatives may result from the way they are approached by emergency care givers (EFRTV, 1997).

Patients who have sustained traumatic brain injury (TBI) will require additional specialized attention on the part of neuropsychologists and psychologists. Research shows that even relatively 'mild TBI' is followed by prolonged disability in a high percentage of cases. In hospital trauma care a neuropsychologist should take part in the acute rehabilitation phase. Psychologists should be involved in the 'discharge planning' of all patients with TBI and be consulted whenever there is concern about the re-integration of a patient into the community. Post-traumatic stress disorder is recognized as a major obstacle to full recovery after injury. It is probable that early assessment and early referral for rehabilitation will improve long-term outcome and speed up the recovery process.

Other injuries e.g. of the spine and the upper and lower limbs can also be debilitating and rehabilitation of these patients should receive the necessary attention.

9 Data and information systems

9.1 Documenting information

The collection and documentation of data on road traffic injury consequences and the different phases of post-impact care are essential to identify priority areas, monitor progress and check that investments are being appropriately directed. Detailed information on injury severity and health outcomes is needed in EU countries for a better understanding of the



scope for savings through post-crash care. The recording of injury severity in hospitals; the measurement of road crash survivor outcomes; and post injury measures of disability (at least on discharge from hospital or at 30 days post impact), to be included in routine hospital statistics linked to national crash data (Buylaert, 1999). Data should be collected by all Member States of the EU for auditing the performance of the Emergency Medical Services. The need for regulations for performing post-mortems or radiological investigations in all road traffic deaths has also been indentified (Buylaert, 1999).

9.2 Monitoring pre-hospital care

A range of data is necessary to support the ongoing evaluation of pre-hospital care systems. The patient care record should be based on the International Classification of External Causes of Injury (Ware & Gandek, 1998) and the WHO Injury Surveillance Guidelines. These should include at minimum sufficient information to answer the following questions:

- Who was injured and who provided care?
- What caused the injury and what was done to treat it?
- When did it occur?
- Where did the injury occur?
- How did the patient respond to treatment (outcome)?

The medical director or field supervisor has several simple but effective ways of ensuring the quality of pre-hospital care by listening in on radio or other communications, direct observation, report review, critical incident review, outcome studies, continuing education and maintaining discipline.

Different indicators can be defined to measure the quality of the Emergency Medical System system. Different indices can be used to measure the quality of treatment provided by permanent medical facilities, or to characterize the whole trauma care system.

A review of evaluation parameters in use by Hakkert et al., 2007 and Gitelman et al., 2008 included:

- At the EMS Level (Mock et al, 1993), (Nathens et al., 2004)
Type of training that EMS teams receive: BLS (Basic Life Support) versus ALS (Advanced Life Support)
- Type of evacuation to trauma centre: self, regular ambulance, MICU, helicopter
- Time values (Smith et al., 1990): arrival at scene, treatment in the field, arrival for definitive treatment in hospital (are they within "the golden hour" rule?) See example from Victoria in Table
- Type of field treatment
- Treatment implementation according to protocols, to the extent that protocols exist.

Table 5: Performance Measurement of Ambulance Emergency Services – Victoria		
Timeliness	2003-04 Expected	2004-05 Outcome
Emergency response time (code 1) in 50 per cent of cases -metro minutes	9	8
Emergency response time (code 1) in 90 per cent of cases -metro minutes	14	13
Emergency response time (code 1) in 50 per cent of cases -statewide minutes	9	9
Emergency response time (code 1) in 90 per cent of cases -statewide minutes	15	15

Accounting for the limitations of data available in the countries, a core set of performance indicators has been recommended for emergency medical response (Gitelman et al., 2008).

This core set of safety performance indicators includes:

- The number of EMS stations per area,
- The number of EMS transportation units per road length,
- The number of EMS transportation units per citizens,
- Percent of physicians and paramedics out of the total EMS staff,
- Percentage of highly-equipped transportation units out of the total,
- The demand for response time,
- Average response time of EMS,
- Percentage of EMS responses meeting the demand,
- The number of trauma care beds per citizens

9.3 Monitoring hospital trauma care

Trauma Registries (based on hospital recruitment areas) are used and provide an important tool to change legislation, to promote trauma prevention, to assess the management of patient care, and to evaluate trauma system effectiveness (Cameron et al., 2005). They contain detailed information on trauma care. Trauma registries, however, are not common in Europe (Hakkert et al., 2007). (Gitelman et al., 2008).

EuroTARN The Trauma Audit & Research Network: The EuroTARN initiative consists of a regular participation of trauma centre professionals in 14 European countries and support from many others who have come together to develop an effective system to review the standards of trauma care across Europe and develop an effective method for future data collection.

Table 6: Participating countries in EuroTARN

Belgium	Norway
Croatia	Portugal
Germany	Spain
Denmark	Sweden
Greece	Switzerland
Ireland	The Netherlands
Italy	United Kingdom
Bosnia-Herzegovina	Slovakia
Macedonia	Austria

The aims and objectives of this European Collaboration are:

- To promote high standards of care for trauma victims in Europe and, thereby, reduce the associated burden of death and disability
- In the short term to establish a common international data set so that management strategies and their consequences can be compared
- In the longer term to use the database to promote the development of clinical guidelines and associated performance indicators
- To study the epidemiology of trauma and thereby promote a rational approach to injury prevention.

EuroTARN has concluded that it is possible to collect and collate outcome data from established trauma registries across Europe with minimal additional infrastructure using a web-based system. Initial analysis of the results reveals significant international variations. The network has potential as a source of data for epidemiological and clinical research and for optimal trauma system design across Europe.

Hospital inspection: A review of hospital inspection requirements is provided in the World Health Organization's), essential care guidelines (Mock et al., 2004).

Performance indicators: A review of evaluation parameters in use by Gitelman et al, 2009, included:

At the Hospital Level:

- Level of coverage: to what extent do critical patients arrive at trauma centres and not at hospitals of other levels?
- Outcome according to Severity of injuries (ISS) and according to part of body injured and nature of injury (Barell Matrix), with emphasis on head, chest and abdomen injuries
- Performance of specific surgical procedures and evaluation of outcome, comparisons of treatment in specific procedures
- Speed of treatment in the hospital, speed of arrival to Emergency Rooms, extent of work according to protocols.

-
- the percentage of beds in trauma centres and trauma departments of hospitals out of the total trauma care beds
 - the number of total trauma care beds per 10,000 citizens

For outcomes:

- Death rate
- Hospitalization in Intensive Care Unit
- Total length of hospitalization.

9.4 Impairment, disability and loss of function scales and scores

A variety of injury and health loss scores are used in post-impact care. These are used for assessing injury severity, the probability of survival and long-term loss of health. They are used in the field for determining the appropriate hospital for the crash victim, evaluating trauma system performance and for research purposes.

Anatomical scoring systems

The Abbreviated Injury Scale (AIS), first published in 1971 (Committee on Medical Aspects of Automotive Safety 1971), is the most widely used scheme internationally for injury severity assessment. Currently in its sixth revision, the AIS (2005) is a dictionary of approximately 2,000 descriptions of individual injuries, mainly anatomically-based, written in currently acceptable medical terminology. While many of the injury descriptions are clinically-specific and require some knowledge of contemporary trauma language, the AIS is so structured that it can equally accommodate less detailed information, thus fostering compatibility across different data needs and uses. The bedrock of the AIS is its 6-point numerical severity ranking system (AIS 1=minor injury; AIS 6=injury currently untreatable) that has remained virtually unchanged for three decades. By its nature, the AIS can be used by both medical and non-medical researchers (IRCOBI, 2006). The AIS does not reflect the combined effects of multiple injuries but can give some indication of an overall severity score when used as part of ISS.

The Injury Severity Score (ISS) is an anatomical scoring system that provides an overall score for patients with multiple injuries. It is used to assess penetrating injuries, falls, crush-type injuries as well as road crash injuries. AIS is the basis for the Injury Severity Score (ISS). Its limitations are its inability to account for multiple injuries to the same body region and it limits the total number of contributing injuries to only 3. However, the NISS (new injury severity score) accounts for multiple injuries in the same body region.

International Classification of Disease, Tenth edition (ICD 10) The ICD has become the international standard diagnostic classification for all general epidemiological and many health management purposes. Compared to AIS, its limitation is the absence of severity score.

Physiological response scales and scores

The Glasgow Coma Scale is used as a standard assessment of levels of consciousness following or when suspecting a head injury - this is used by paramedics and throughout the hospitals and is widely accepted in UK, Europe, US, Australia etc.

The Revised Trauma Score is a physiological scoring system, with high inter-rater reliability and demonstrated accuracy in predicting death. It is scored from the first set of data obtained on the patient, and consists of the Glasgow Coma Scale, Systolic Blood Pressure and Respiratory Rate. The revised trauma score is used to rapidly assess patients at the scene of a crash and to facilitate pre-hospital triage decisions and evaluation ((Champion, 1989) .

Both are used widely although use is limited when a patient is intubated, chemically paralysed or under the influence of alcohol and drugs.

Probability of survival scales and scores

Trauma Score - Injury Severity Score: TRISS This widely used score is designed to determine the probability of survival of a patient based on patient characteristics and was designed to evaluate trauma care and outcomes from different trauma centers (Boyd et al, 1987.

Outcome scores

More recently, the development of an injury outcome scale has become a priority. While the topic is not new – scales date back to the 1980s (Hirsch & Eppinger, 1984; Gustafsson et al., 1985; Bull, 1985) – there is still significant disparity on what criteria to use, although there seems to be agreement that any future impairment scale should be directly linked to the AIS.

Injury Impairment Scale (IIS) (AAAM, 1994). It was fashioned directly on the AIS severity code and assigned a value between 1 and 6 to each injury descriptor that was adjudged to have some residual impairment one year post injury. Several years later, the Functional Capacity Index (FCI) (Mackenzie et al., 1996) was proposed.

The Glasgow Outcome Scale has also been used in which a crude 5 point scale of functioning is made at the time of hospital discharge.

The Functional Capacity Index (FCI) was developed through a large collaborative effort in the US (Mackenzie et al., 1996). It assigns a score (between 0 and 1) to each injury descriptor in the AIS in all body regions. The FCI, also directly linked to the AIS, has been validated on one patient population in the US and some revisions to the Index were subsequently proposed. It is anticipated that the FCI will be integrated into the AIS dictionary thus offering substantial opportunities to validate it as a research tool to assess the probability and severity of injury-related impairment (IRCOBI, 2006). Validation for the Functional Capacity Index in Europe may be required (EuroTarn, 2007).

Functional Independence Measure: The Functional Independence Measure (FIM) scale assesses physical and cognitive disability and focuses on the burden of care.

A study comparing the responsiveness of the Glasgow Outcome Scale (GOS), GOS-Extended (GOSE), Functional Independence Measure (FIM), and modified FIM in major trauma patients, with and without significant head injuries found that the GOSE was the instrument with greatest responsiveness and the lowest ceiling effect in a major trauma population with and without significant head injuries and is recommended for use by the authors by trauma registries for monitoring functional outcomes and benchmarking care (Williamson et al, 2011) .

Health loss scales

The EQ-5D scale assesses changes in health states in 5 domains; mobility, self care, usual activity, pain, and anxiety and depression. Each domain has 3 levels of assessment and the scores can be combined to derive a composite outcome measure and used to calculate Quality Years of life lost (Qalys). Population measures are available so that the distributions of an injured sample can be compared (EuroQuol Group, 1990).

The SF-36v2 assesses health across 8 dimensions namely, general health, physical role and functioning, social functioning, bodily pain, mental health, vitality and emotional role. The assessment incorporates the previous 4 weeks and not just a one off assessment. Scores are generated for each dimension ranging between 0-100 which are then used to generate two component scores, namely the physical component and mental component scores (PCS and MCS respectively). These can be compared with standard values for specific populations to assess trends over time and absolute changes in health (Ware & Gandek, 1998).

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