



European Transport Safety Council

# **SOCIAL AND ECONOMIC CONSEQUENCES OF ROAD TRAFFIC INJURY IN EUROPE**

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Brussels 2007

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ETSC is grateful for the financial support provided by 3M, BP, Diageo, KeyMed, Shell International, Toyota and the Volvo Group. The contents of this publication are the sole responsibility of ETSC and do not necessarily reflect the view of sponsors or organisations to which research staff participating in the Working Party belong.

## The European Transport Safety Council

The European Transport Safety Council (ETSC) is an international non-governmental organisation which was formed in 1993 in response to the persistent and unacceptably high European road casualty toll and public concern about individual transport tragedies. Cutting across national and sectoral interests, ETSC provides an impartial source of advice on transport safety matters to the European Commission, the European Parliament and, where appropriate, to national governments and organisations concerned with safety throughout Europe.

The Council brings together experts of international reputation and representatives of a wide range of national and international organisations with transport safety interests to exchange experience and knowledge and to identify and promote research-based contributions to transport safety.

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# **Executive summary**

This report summarises current knowledge regarding the following socio-economic aspects of traffic injury in Europe:

1. The completeness and accuracy of official road accident statistics
2. Long-term impacts of traffic injury
3. Social disparities in road accident risk

## **1. The completeness and accuracy of official road accident statistics**

Official road accident statistics are incomplete and inaccurate in all countries. The level of reporting for injuries treated in hospitals is, on the average, less than 50%. Injuries are not always correctly classified by severity in police accident reports. The report makes the following recommendations for research and policy making to improve the quality of official road accident statistics.

### **Recommendations for research**

The following recommendations are made for research designed to estimate the true incidence and societal cost of traffic injury:

1. Studies designed to assess the level of reporting in official road accident statistics should be performed regularly.
2. Studies should address factors that influence the likelihood that an injury will be reported in official accident statistics and try to assess the amenability of these factors to interventions designed to improve the actual level of reporting.
3. Studies should be made to determine the extent to which injuries recorded by medical institutions can be geographically located correctly.
4. Studies should be made to determine the possibility of electronically merging police records and hospital records of traffic injury in ways that will not violate protection of privacy and personal integrity.
5. Guidelines based on research should be developed regarding the essential elements of a common approach to the estimation of the costs to society of traffic injury.

### **Recommendations for policy making**

The following recommendations are made regarding policy making and the administration of injury recording systems:

1. A simple injury scale should be developed for use by the police and other emergency services. Final classification of injuries according to severity should be performed by medical professionals.
2. Countries should provide training in the use of the AIS in order to make the use of this scale more common and thus make injury data more comparable between countries.
3. Countries should encourage electronic linkages between sources of injury data, like STRADA in Sweden or the CODES system of the United States.
4. Countries should regularly monitor the level and accuracy of reporting in official road accident statistics and make the results of studies available to other countries.
5. Countries should regularly provide a set of economic valuations of the benefits to society of preventing road accident deaths and injuries for use in cost-benefit analyses of road safety programmes.

## **2. Long-term impacts of traffic injury**

Long-term impacts of traffic injury are poorly documented in all countries. Little is known about these impacts. There are, however, reasons to believe that an increasing number of people live with lasting impairments as a result of traffic injury. The following recommendations are made for research and policy making.

## **Recommendations for research**

The following recommendations are proposed for research:

1. Studies should be made to assess the applicability of various quality-of-life scales for the purpose of describing systematically the long-term impacts of traffic injury.
2. Surveys of the general population should be made at regular intervals to determine the incidence and prevalence of lasting impairments as a result of traffic injury.
3. Studies should be made to assess the incidence of mild traumatic brain injury as well as its long-term socio-economic consequences.

## **Recommendations for policy making**

The following recommendations are made for policy making:

1. Countries are recommended to adopt a consensus-based prospective injury impairment scale based on the Abbreviated Injury Scale (AIS).
2. The number of people living with lasting impairments as a result of traffic injury is likely to be increasing. The EU and member states should therefore consider adopting targets for reducing not just deaths, but also serious injuries.
3. The EU should encourage member states to adopt a common definition of slight and serious injuries and of lasting impairments. Implementing common definitions of these concepts would make road accident statistics more comparable across countries than they are today.
4. Programmes designed to treat accident victims who suffer long-term impacts of injury, like post traumatic stress disorder, should be further developed and their effects evaluated.

## **3. Social disparities in road accident risk**

Social disparities in road accident risk are also not very well known. However, most studies show that individuals who have a low social status are more frequently involved in road accidents than individuals who have a high social status. This tendency applies to all groups of road users. The following recommendations are put forward with respect to social disparities in road accident risk.

## **Recommendations for research**

The following recommendations are made for research:

1. Countries that have not studied the association between social status and road accident risk are encouraged to do so.
2. Studies should be made to determine which variables are the strongest predictors of social disparities in road accident risk: education, income, quality and characteristics of residential area, or any combination of these variables.
3. Studies should be made to identify factors that may explain why road accident risk is associated with social status, in particular if differences in road user behaviour mediate this relationship.
4. Studies should be made to determine if social disparities in road accident risk vary according to injury severity or group of road user.

## **Recommendations for policy making**

The following recommendations are made for policy making:

1. Countries are encouraged to develop policies designed to reduce social disparities in road accident risk, to the extent that these are regarded as unjust.
2. A systematic use of traffic calming in residential areas for the purpose of reducing social disparities in road accident risk is encouraged.
3. Policies aimed at modifying unsafe road user behaviour associated with low social status should be developed.

# **1 Background and introduction**

According to the World Health Organisation (WHO, 2004), approximately 16,000 people die everyday worldwide from all types of injuries. Injuries represent about 12% of the global burden of disease, making injuries the third most important cause of overall mortality. Deaths from traffic injury are a very significant part of the problem accounting for 25% of all deaths from injury.

In 2004, the estimated annual costs, both direct and indirect, of traffic injury in the EU-15 countries exceeded 180 billion euros. The real costs in terms of deaths, injuries and social and economic consequences far exceed these estimates, however, for the reasons discussed in this report. Even using the lowest estimates with all the inherent problems of underreporting and misclassification, traffic injuries represent an enormous societal burden to the EU. In 2005, 41,600 people were killed in road traffic accidents in the EU and more than 1.5 million were injured in accidents recorded in official statistics (in this report, the term "official statistics" refers to accident statistics based on police reports). The true number of people injured in road accidents is unknown, but it is known that it is considerably higher than the officially recorded number.

This review gives an overview of the social and economic consequences of road traffic injury in Europe. It tries to answer the following questions:

- What is the true scope and long-term impacts of traffic injury in Europe?
- How well documented are the long-term impacts of traffic injury?
- What can be done to improve official statistics on traffic injury?
- How is the burden of injury distributed between groups of the population, in particular with respect to social status?

The objective of the review is to summarise current knowledge regarding the social and economic dimensions of road traffic injury in Europe and offer recommendations to researchers and policy makers concerning the scope of the problem and targets for its reduction.

## 2 The true scope and impacts of traffic injury

This chapter will try to estimate the true scope and impact of traffic injury in the European Union. First, a review of studies that have assessed the level of reporting in official road accident statistics will be presented. Next, problems related to the definition of injury severity will be discussed. Finally, the chapter will briefly discuss the estimation of the costs to society of traffic injury.

### 2.1 Official (police-reported) road accident statistics are incomplete, inaccurate and biased

In a review dealing with transport accident costs and the value of transport safety (ETSC 1997), the European Transport Safety Council developed estimates for the true number of injured road users in the European Union as of 1995 (15 member states). Figure 1 shows that the reported number of injuries, including deaths, in 1995 was 1,580,000, whilst the estimated true number was 3,500,000. Injured road users included all road users who sought medical treatment for an injury.

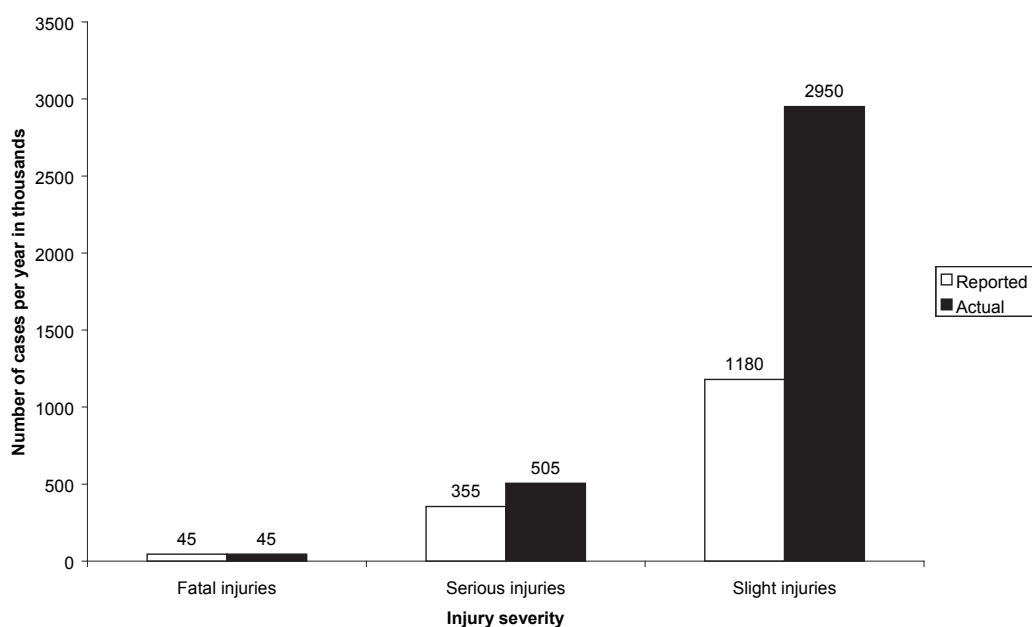


Figure 1 Estimated true number of traffic injuries in the European Union in 1995 (Source: ETSC 1997)

Since 1995, the European Union has been enlarged by ten new member states, and new studies have assessed the level of accident reporting in official statistics. The updated estimates presented here are based on a study by Elvik and Mysen (1999), whose main findings have also been reported by Elvik and Vaa (2004). This initial work has been updated by incorporating several additional studies (Amoros 2006, Binderup Larsen et al 2004, ETSC 2001, ETSC 2006, Hollo 2005, Plasencia 2000, Simpson 1996, Tecl 2006).

The results of multiple studies made in the same country have been combined by applying techniques of meta-analysis. Table 1 shows updated estimates of the level of accident reporting in official road accident statistics in a number of European countries.

<b>Country</b>	<b>Year of most recent study of accident reporting</b>	<b>Percent of injured road users reported in official statistics</b>
Czech Republic	2005	66
Denmark	2004	21
France	2006	42
Germany	1992	39
Great Britain	1996	56
Hungary	2005	76
Netherlands	1990	43
Norway	1995	37
Spain	2000	18
Sweden	1987	54
Switzerland	1990	25
Mean of listed countries		41

Table 1    Levels of accident reporting in official (police-reported) road accidents statistics in European countries

It can be seen that the percentage of injury accidents reported in official road accident statistics varies substantially between countries. In most countries, the level of reporting has been determined by comparing the number of injured road users treated in hospitals (including outpatients not staying in hospital overnight) to the number of injured road users recorded by the police. On average for the countries listed, it would seem that less than half of all injuries requiring treatment in hospital are reported in official accident statistics. For some of the new member states of the European Union (Poland, Slovakia, the Baltic states), the level of accident reporting in official statistics is not known.

The levels of reporting given in Table 1 are most likely not comparable between countries. The reporting level in Hungary, for example, was assessed by comparing the number of accident victims transported in ambulances to the number recorded by the police. An ambulance is more likely to be requested in cases of serious injury; many of the more slightly injured road users will be able to travel to hospital on their own. In one study in the Netherlands, the true number of injured road users was estimated on the basis of self-reported injuries, which apparently included very slight injuries, for which treatment by medical professionals was not sought. In another example from Denmark, a minor-to-moderate injury, for example a sprained ankle, may or may not be recorded as an injury even if the patient presents to hospital. If the patient receives no treatment, the event is simply recorded as a hospital visit, not an accident, and of course never appears in police records either. Finally, there are cases where police report road accident injuries, but the injured never present to hospital for treatment.

Table 2 show the reporting level in official accident statistics for injuries classified as serious and injuries classified as slight in some European countries.

<b>Country</b>	<b>Percent of serious injuries reported</b>	<b>Percent of slight injuries reported</b>	<b>Percent of all inju- ries reported</b>
Czech Republic	97	61	66
Denmark	57	14	16
France	39	18	18
Great Britain	38	60	56
Hungary	87	69	76
Netherlands	82	26	43
Norway	69	36	37
Switzerland	77	25	25

Table 2    Levels of road accident reporting in European countries by injury severity

The studies that serve as the basis for Table 2 are not in all cases identical to those used in Table 1; hence not all figures for the overall level of reporting will be identical to Table 1. Percent reported in columns 2 and 3 in Table 2 in general refers to the share of injuries recorded in hospitals that are also recorded in official road accident statistics. All injuries in column 4 refer to the total number of injured road users, i.e. both those who were slightly injured and those who were seriously injured.

Two studies from the UK further complicate the reporting of injuries by severity. A study by Simpson (1996) found that the police classified too few injuries as serious and too many as slight. When reporting was adjusted both for misclassification and for incompleteness, the effect of misclassification was greater than that of underreporting.

A more recent study in the UK (Morris et al 2003) showed the converse in terms of misclassification of injury severity. About one third of occupants classified as serious by the police had either no or minor injury according to the AIS. This misclassification in official injury statistics has profound implications for understanding the overall incidence of injuries and their severity as well as for assessing the cost of road casualties.

In 2001 in Spain, the number of serious victims in official road accident statistics represented only 68% of the victims admitted to hospitals, in spite of the fact that the "police definition" of a serious victim is a victim that requires admission to hospital (Plasencia, 2000; Pérez and Cirera, 2004). However, the reporting of serious injury was more complete than the overall level of reporting in Spain, which was only 18% (confer Table 1).

In Denmark, many hospitals record all significant injuries. However, in official statistics in 2002 the coverage in the uptake area for Odense University Hospital was 11% for AIS 1-injuries (slight), 45% for AIS 3-injuries (serious) and 100% for AIS 5 and 6-injuries (critical or fatal). The coverage for all bicycle accidents was 6% and for single bicycle accidents the coverage was as low as 1.5%. The level of reporting in official statistics appears to be declining. In 1992 the total coverage in the official statistics was 27%; in 2002 it was 16%.

One of the ways to address both the underreporting problem and misclassification of injury severity is to link accident and injury records. An example of an already widely used linked data system is the Swedish Traffic Accident Data Acquisition – STRADA – implemented by the Swedish Road Administration and developed in cooperation with the Swedish Police Authority, the Federation of Swedish County Councils, the National Board of Health and Welfare, the Swedish Association of Local Authorities and the Swedish Institute for Transport and Communications and Analysis (Sjölander, 2001) The Crash Outcome Data Evaluation System (CODES) in the USA offers another model of such a data linkage scheme.

In addition to the obvious advantages of having a more complete "picture" of road accidents, a linked data system could provide numerous other opportunities. It could offer incentive for public sector (police, other public agencies) and private sector (hospitals and the trauma community) to work together in better understanding the overall traffic crash injury situation. It could provide information on the pre-crash, crash and post-crash phases. It could obviate the need for setting up new data collection systems or help improve current systems. It could provide a multipurpose database that could be used for different purposes at any time. For example, at the local level, information would be available on the types and severity of injuries, populations at risk and specific crash characteristics. At the national level, countermeasures such as the effectiveness of a seat belt law could be evaluated. At the EU level, a linked database would provide the basis for standards and directives and for setting injury reduction targets across the European Union.

A useful linked data system would involve the highway safety community (e.g., Departments of Transport / Motor Vehicles / Highways, Law Enforcement, other agencies responsible for traffic crashes), the medical/health community (e.g., emergency services, hospitals, medical researchers, rehabilitation facilities, public health professionals, nursing, professional trauma societies, medical examiners/coroners) and insurance and other stakeholders (public agencies responsible for welfare, vehicle/health insurance).

There are some obstacles that would have to be overcome with a linked data system. While police accident reports are generally considered public records, patient medical records are confidential.

However, adequate safeguards could be established to ensure patient anonymity under legislative or administrative policies whilst still allowing for access to necessary crash injury information.

The level of reporting for various categories of road users and types of accident in some European countries is shown in Table 3. Reporting is lowest for bicycle accidents, in particular those that do not involve other road users. Very few of these accidents are found in official accident statistics. Single vehicle accidents involving motorcycles also have a very low level of reporting.

The main points of current knowledge regarding the reporting of traffic injury in official road accident statistics in Europe can be summarised as follows:

1. Reporting of fatal injuries is complete, except for the small underreporting created by the use of the 30-day definition of a traffic death.
2. Reporting of medically treated injuries is incomplete in all countries.
3. The level of reporting varies greatly between countries. This means that official data on traffic injury are not comparable across countries.
4. The definitions of reportable injuries, and of injury severity, vary between countries and are not comparable.
5. If the definitions used by each country are taken as reference, it is found that:
  - a. Injuries are misclassified by severity.
  - b. There is a lower level of reporting for slight injuries than for serious injuries.
  - c. There is lower level of reporting for bicycle injuries than for injuries in other groups of road users.

To make official accident statistics more informative, and more comparable, there is a need to adopt standardised definitions of injuries and injury severity and to reduce the level of underreporting. This could create a firmer basis for setting policy objectives with respect to the reduction of injuries, not just deaths. While the number of deaths is declining in many countries, this is not always the case with respect to the number of permanent injuries, as evidenced in a Norwegian study (Lund and Bjerkedal 2001), showing an increasing number of disability pensioners. Forty-five percent of all disabilities were the result of traffic injury.

Country	Car occupants			Motorcycle riders			Bicyclists			Pedestrians		
	All	Drivers	Passengers	All	Collisions	Single	All	Collisions	Single	All	Collisions	Single
Czech Republic	90	91	90	85	31	53	16	10	31	3	39	62
Denmark	48											
France	42			47	30	15	10	10	34	2	44	
Germany	52			44			22					45
Great Britain	68	67	67	44				66	85	3	81	
Hungary	74			67	67			51			64	
Netherlands	63			56			24				49	
Norway	56	52	45	37			16	16	46	2	45	
Sweden	77	80	76	55	67	25	29	59	8	70		
Switzerland	44			22		8					38	

Table 3 *Level of reporting for various road user groups and types of accident*

## 2.2 Problems in defining and comparing levels of injury severity

In most countries, official road accident statistics make a distinction between three levels of injury severity: fatal, serious and slight. In most countries, fatal injuries include all those who die within 30 days of the accident as a result of injuries sustained in the accident. In the IRTAD database, correction factors have been developed and are applied to official statistics for countries that do not use the 30-day definition of a death. Official accident statistics often contain inaccuracies regarding the severity of the injuries and the severity of the crash. In the USA, 49% of the drivers coded by police as having incapacitating injuries actually had sustained no more than minor injuries, and 79% of the vehicles that crashed on roads posted at 60 mph or 96 km/h or higher experienced a delta-V (i.e. change in velocity) less than 25 mph or 40 km/h (Farmer, 2003). Safety studies depending on data from only police reports to establish injury or crash severity therefore could produce erroneous results.

Definitions of reportable injuries are often not very clear and not standardised. The definitions used in Norway are fairly typical and illustrate both the lack of clarity and the dilemmas faced in defining and classifying reportable injuries.

A reportable injury is defined as "an injury to a person, which is not inconsequential". No further details are given. In Norway, injuries are classified into four levels by severity: fatal, critical, serious and slight. A fatal injury is defined according to the usual 30-day rule. A critical injury is defined as follows: "Any injury that is, at some time, life-threatening, or that results in permanent impairment". No formal definitions are given of serious or slight injuries. Serious injuries are defined by listing examples of types of injury that are regarded as serious, such as "some damage to kidneys", or "fractures of arms or legs that need surgical treatment". Slight injuries are likewise defined by listing examples such as "uncomplicated fractures that do not need surgical treatment and will usually not require an overnight stay in hospital".

To apply these definitions at an accident scene is impossible since a police officer has no medical training to determine if an injury is life-threatening or will result in permanent impairment. Similarly, many life-threatening injuries such as injuries to abdominal organs cannot be observed at the scene and require clinical diagnosis in hospital.

In Norway, the police have almost ceased using the "critical" category. The definition of this level of injury severity illustrates the dilemma one faces in trying to define injury severity. Should injury severity be defined in terms of how life-threatening an injury is, or in terms of its lasting impact?

A more reasonable approach for police reporting systems would be to abandon using the highly-subjective categories of "critical", "serious" and "slight" injuries and adopt a simple injury scale (SIS) that is linked with the globally-accepted Abbreviated Injury Scale (AIS) used in trauma hospitals for assessing injury severity. An SIS would pre-assign a numerical severity ranking to anatomically-described injuries that are observable at the scene. While such a simple scale would not be able to capture injuries diagnosed in hospital, the severity assessment of the injuries that are observable in the field would be standardised across the police and would be linked to the currently most-used clinical trauma scale in the world. An SIS could also be adapted for use by first responders such as emergency service personnel and paramedics.

The Abbreviated Injury Scale (AIS) describes injuries on a 6-point numerical scale in terms of threat to life and tissue damage. Thus, an AIS 1 (minor) injury does not pose a threat to survival, whereas survival is highly uncertain in the case of an AIS 5 (critical) injury. Another injury scale, the Injury Severity Score (ISS) provides a numerical scale (from 1 to 75) that uses three injuries with the highest severity in three different body regions to measure the overall severity where a score of 75 is, for all intents and purposes, non survivable (Baker et al 1971). A New ISS has been proposed which uses three of the most severe injuries anywhere in the body to calculate an ISS score (NISS; Osler et al 1997).

Not all life-threatening injuries result in permanent impairment. A ruptured spleen, which is associated with heavy internal bleeding, will not result in any lasting impairment if treated successfully. A spinal cord injury, on the other hand, may leave a person in a wheelchair for life,

although the injury as such may not be life-threatening. The loss of part of a finger is also a permanent impairment, although the injury itself may be regarded as trivial (albeit painful).

Vision Zero is widely known and widely supported as an ideal for transport safety. According to Vision Zero, a safe transport system should not lead to fatal injuries or injuries that result in permanent impairment. If the definition of injury severity takes guidance from Vision Zero, both threat-to-life injuries and injuries that result in permanent impairment must be considered more serious than any injury that heals completely.

There are, however, two problems associated with defining injury severity in terms of the long-term impact of an injury. First, long-term impact cannot be observed at an accident scene or even at hospital admission in some cases; hence, final classification of injuries by severity may have to be postponed for a long time, at least several months. Second, a precise definition is needed of what constitutes a permanent impairment. Loss of limb or loss of function are impairments, but more subtle psychological impacts of accidents may not be so obvious. For example, are recurring nightmares or problems in concentration a permanent impairment? Careful attention needs to be paid to these issues in developing operational definitions of lasting impairment.

A different means to categorise injury would need to be devised in order to provide better linkage between crash and injury information. For example, an outcome scale such as the following might be useful: died, hospital admission, transported/treated in emergency department/released, slightly injured (not admitted but linked to an insurance claim), not injured (reported as either possible or no injury, but no link with any medical record). Such a scheme could be particularly effective in identifying the " uninjured" category. Obviously, adequate personnel would need to be trained at both national and EU levels to ensure competence in linking and managing the data system.

One of the most important outputs of a linked data system is to provide feedback especially to policy makers in both the public and private sectors who will ultimately decide on the efficacy of such a system and its continued funding. Providing policy makers with timely, valid, verifiable results on how the system is working and what it can offer to the highway safety community is fundamental.

The conclusion is that a national linked dataset of road traffic crash data should be produced from hospital admissions and police road traffic accidents data for use by policymakers, researchers, planners and practitioners.

## **2.3 Results of the ETSC Review on Accident Data in the enlarged EU**

At the beginning of 2006 the European Transport Safety Council presented its report: "Road Accident Data in the Enlarged European Union. Learning from each other". Its objective was "to evaluate existing methods for accident data collection and analysis" (ETSC, 2006). One of the main conclusions of the review was that gathering of accident data is not uniform throughout Europe and the corresponding recommendation was that regular studies of underreporting are needed. ETSC warns that when there is no information about the underreporting rates and their possible changes over time, it is impossible to interpret trends properly and decide, for example, whether a reduction in the number of accidents reported by the police represents a genuine safety improvement. For this reason, the improvement and standardisation of methodologies for tackling the underreporting issue of all types of traffic, including cyclists and pedestrians, should be the first priority.

The problem of underreporting has not been thoroughly investigated during the past few years. The EU 15, with the exception of France, Germany, Italy, the Netherlands, the United Kingdom, Belgium (not recently) and Spain, cannot assess the present level of accident data underreporting, due to a lack of recent relevant studies. According to ETSC, this is surprising, since most countries consider underreporting to be a serious limitation of accident data. As far as New Member States are concerned, Hungary is the only country where a study of underreporting has been made (during the mid 1990s). According to study-based estimates, the underreporting of deaths varies from 5% or 8% (Germany and Netherlands, based on national research reports) to 12% (France, based on an INRETS study for the region of Lyon) and 26% (Italy, based on a comparison of road deaths in the WHO-database of hospital reports of death per country with the Italian statistics

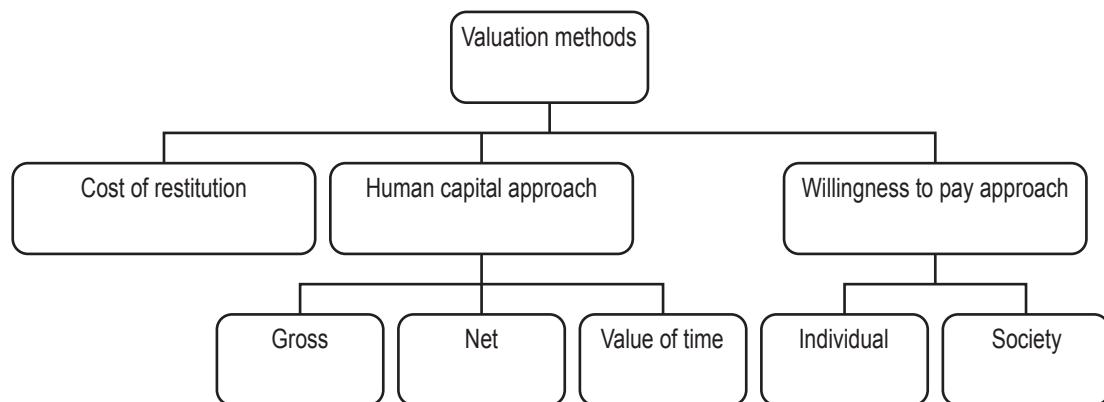
of police-reported road deaths). Underreporting of hospitalised casualties is estimated to vary between 30% and 60% (OECD-IRTAD, 1994).

Another issue regarding road accident data quality is data comparability and, in particular, the fact that injury severity cannot be considered comparable due to differences in the definition of the term "injured persons" (slightly, seriously). More specifically, based on the answers to questionnaires received from country experts in the frame of this ETSC's review, only eight countries (Belgium, Germany, Netherlands, France - since January 2005, Greece, Spain, Cyprus and Latvia) use the same definitions of injury severity: "seriously injured is an injured person who is hospitalised for at least 24 hours", while "slightly injured is each injured person who is not fatally or seriously injured".

Since road safety is increasingly studied in an international context, for example the EU target of halving the number of road accident deaths, ETSC states that it is desirable to move towards a common system for recording road accident data, and that this 'common system' should encompass all aspects, including the definitions of fatal, serious and slight injuries. The main advantage of this common system would be that data from different EU-countries could be compared on a consistent basis. Other suggestions for improving the road accident data collection systems are the linkage of databases, and the use of reliable Geographical Information Systems (GIS) as an aid in identifying the precise location of the accidents.

## 2.4 Costs to society of traffic injury

There have been several reviews of the costs to society of road traffic injury. A major review was presented in 1994 by the European Commission: "Socio-economic cost of road accidents, final report of action COST 313" (Alfaro, Chapuis and Fabre, 1994). This report is now more than 10 years old. A more recent survey was made as part of the ROSEBUD-project (de Blaeij et al 2004). This survey first considered methods used in estimating the costs to society of traffic injury, then presented recent cost estimates for selected countries. As far as methods for estimating costs are concerned, the typology shown in Figure 2 was developed in COST-313.



*Figure 2 Methods for estimating costs of traffic injury*

The costs of restitution are the direct costs generated by road accidents (for example, medical costs, property damage or administrative costs). Generally speaking, the human capital approach is used to estimate the value of lost productive capacity due to a traffic death, whereas the willingness-to-pay approach is used to estimate the value of lost quality of life. Two varieties of the willingness-to-pay approach are normally used: the individual willingness-to-pay approach and the social willingness-to-pay approach. According to the former approach, information about willingness-to-pay is obtained from individuals, either by studying behaviour in situations where reduced risk must be traded off against other commodities or by means of questionnaires. According to the latter approach, society's willingness-to-pay for reduced risk is inferred from the valuation implicit in public decisions like setting speed limits. More information on the different costing methods is given by Trawén et al. (2001), Wesemann (2000) and de Blaeij et al (2004).

At European Union level, the most frequently used "magic number" to put a value on the prevention of casualties is the "1 Million euro rule". This was introduced by the European Commission in its

Road Safety Programme 1997-2001 to help select traffic safety measures (European Commission, 1997). The 1 Million euro value is frequently used as a test of the effectiveness of traffic safety measures and implies that a measure can be considered for implementation when for every million euros spent on a road safety measure, at least one death is prevented. This amount takes into account the economic damage (although not the loss of human value) of a death, and also a certain proportion of the damage resulting from (serious) injuries and from accidents with only property damage. This is based on the statistical fact that, on average, for every prevented death there will also be a number of accidents with injuries and an even greater number of accidents with only property damage (Wesemann, 2000). This estimation, still in use, has not been updated since 1997.

Based on a review made by Sælensminde (2001) and the review of de Blaeij et al (2004), Figure 3 shows the official monetary valuation of a road accident death in a number of countries.

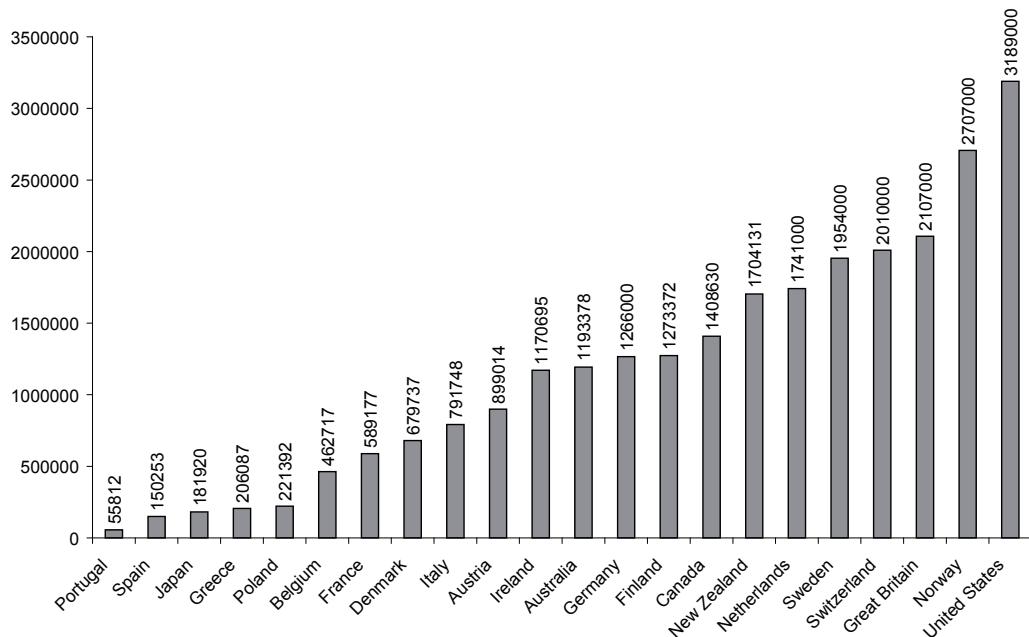


Figure 3 Official monetary valuation of a road accident death in selected countries (Euro in 2002-prices)

The valuations vary substantially. An interesting pattern is that some of the countries that have a good safety record, such as Norway, Great Britain, Sweden and the Netherlands, assign a high monetary value to the prevention of a traffic death. Some countries with a rather bad road safety record, like Portugal, Spain and Greece, assign a low monetary value to the prevention of a death.

The values are determined by two main factors: (1) The method used for estimating them. Values based on the willingness-to-pay approach tend to be about twice as high as values not based on the willingness-to-pay approach. (2) The level of real income in a country. Generally speaking, lower values are found in countries that have a relatively low gross domestic product per capita, higher values are found in the richer countries.

The following conclusions can be drawn:

- Between different members of the European Union there was in 2002 a 38-fold difference in the valuation of the prevention of a traffic death. In some countries figures vary even among different bodies of government because no common set of values has been agreed upon.
- There is no common updated approach at the European level to conduct cost-benefit analysis of road safety measures based on a universally accepted method for valuing deaths and injuries.

### **3 Long-term impacts of traffic injury**

This chapter focuses on injury outcomes from several dimensions. First, it describes the various scales available to characterise impairment, disability and diminished quality of life. Second, it discusses the psychological consequences of road accident injuries as well as injuries to specific body regions or organs. Third, the second-order impacts on employment, on families and on uninjured drivers involved in road accidents are considered.

#### **3.1 The long-term impacts of traffic injury: a white spot on the map**

Accidents happen in a fraction of a second but their consequences may last for days, months, years or the rest of life. A large number of road users involved in traffic crashes recover from their injuries, but some of them never recover fully and suffer from some kind of permanent disability. In Spain, according to a recent study, 15% of those who survive a road crash must be treated in hospitals as in-patients, while 32% are forced to take a sick leave from work of between one and three months and another 29% have to remain away from work for more than three months (Rodriguez, 2005).

In addition to loss of life or reduced quality of life, road accidents carry many other consequences to the survivors such as legal implications, economic burden, home and vehicle adaptations as well as psychological consequences.

According to the Oxford English Dictionary, outcome is defined as a visible or practical result. In the trauma setting outcome is in most studies expressed as mortality within 30 days after the event causing the injuries. Even if death can be considered a rather clearly defined outcome, this standard of reporting does not take into account the victims dying in a later phase.

When it comes to describing the long-term consequences of injuries the situation is less clear. The reasons for this are partially the lack of ideal scales for measurement of outcome and also different opinions regarding how long-term impacts should be expressed (in monetary or non-monetary terms).

A large number of scales have been developed over the years. These can broadly be divided into those measuring the doctor's assessment and those measuring the patient's own assessment of their problems. Whereas the former are usually used by physicians comparing results of specific treatment modalities for specific injuries, the latter (often referred to as health status, functional status or quality of life measures) are more often used by health economists, managers and politicians.

When discussing the long-term effects or outcome of injuries it is also appropriate to consider the definitions given by WHO regarding impairment, disability and handicap. Impairment is defined as a demonstrable anatomical loss or damage (e.g. restricted movement of a joint). Disability is the functional limitation caused by this impairment, interfering with something the person wishes to achieve. Handicap depends on the environment, where different adjustments or adjuncts can reduce or overcome the disability (WHO, 1986).

Different injuries may cause similar impairments. Restriction of movement may result from injuries to the musculoskeletal system, but neurological injuries may cause exactly the same result. Persistent pain or psychological sequelae may cause various difficulties in living a normal life, which are not easily quantified. It is therefore difficult to find a single scale or score that adequately describes health (or the loss of it) and fits all possible conditions.

An ideal instrument should include both objective and subjective assessments and still be simple, quick, reliable, reproducible and cost-effective. In general such an instrument does not exist, although many measures have come into general use.

The same injury can have a very different outcome depending on the patient's work and social status. For example, a severely sprained ankle can result in long-term problems so that if a person's job requires considerable walking throughout the day, continuation in that job may not

be possible. The same injury for a person spending most of his or her working hours sitting behind an office desk will not have the same impact. Socially, the injury is much more severe for the first person than for the second.

### **3.2 Universal outcome scales**

Two different examples of outcome scales are the Functional Independence Measure (FIM) and the Functional Capacity Index (FCI). The FIM is an 18-item scale frequently used to measure improvement during rehabilitation. The FCI is related to the Abbreviated Injury Scale, and assigns the outcome one year after injury. The FCI score is a consensus-derived prospective score which primarily identifies level of reduced functional capacity or functional limitations as opposed to levels of either impairment or disability. The FCI is an index of physical and cognitive limitations only. Currently, it does not capture psychosocial consequences.

A large number of Quality Of Life scales (QOL) are in use. They span from a Global Quality of Life score, which describes the general life situation in one single measure, to different health-related Quality of Life scales. In the latter scales the intention is to describe the quality of life by means of a multidimensional profile, usually addressing this by the use of questionnaires. Several examples are the following: EQ-5D (EuroQoL Group) measures health outcome. It is applicable to a wide range of health conditions and treatments; it provides a simple descriptive profile and a single index value for health status, based mainly on activities of daily living. The WHOQoL-100 is a consensus scale that reflects the views of a group of scientific specialists as well as lay persons as to what constitutes quality of life. The dimensions included in the scale range from physical and psychological aspects to religious and personal beliefs. The SF-36 (36-Item Short Form Health Survey) combines eight separate scale scores resulting in two summary measures, a physical component score and a mental component score. The developers of the SF-36 felt that it was not appropriate to try and devise one overall score for measuring quality of life. The SF-36 has undergone at least two revisions in the last 10 years to make it better suited for both large population surveys and for more focused clinical trials, for example.

### **3.3 Organ-related outcome scores**

A large number of organ-related or disease-related Quality of Life tools have been developed. In general these are developed to compare therapies for certain diseases or injuries. An example of a frequently-used and generally-accepted outcome measure following head injuries is the Glasgow Outcome Scale (GOS). This scale assesses survival, social integration and level of care for daily living using 5 exclusive levels, rather than looking specifically at impairment, disability or handicap. The Disability Rating Scale (DRS) also scores the outcome following head injury, but on a 30-point scale (Rappaport et al, 1982). The DRS was not surprisingly found to be more sensitive as compared to the GOS, which was due to the more extensive questionnaire (Hall et al, 1985). Its use is therefore more time consuming. Other examples of assessment tools following head injury are the European Brain Injury Questionnaire, Quality of Life after Brain Injury and Rivermead post-concussion questionnaire. Confounding factors in measuring outcome after head injury are, apart from age, also central nervous system (CNS) disorders present before the injury as well as the timing of assessment after injury. Assessments are usually performed 1 year after injury, but motor skills and cognitive skills can continue to improve for years after injury (Prigatano et al 1984). Also the method of gathering data can influence the recorded functional outcome. Neurological outcome scores all rely on assessing social function/handicap rather than scoring impairment and disability in detail.

Regarding outcome measures related to other organ systems (thoracic, abdominal, musculoskeletal), a number of different scales are in use. However, in general these are more related to diseases, rather than injuries. Some of the scales more relevant to injuries will be presented in more detail below.

### **3.4 Problems and pitfalls**

The problem of underreporting has been addressed in chapter 2. In summary, injuries that are regarded as severe/life-threatening in the acute phase are more likely to be reported in official statistics than less severe injuries. However, injuries that in the acute phase are considered to be "slight" or "minor" can have a huge impact on the individual's future health. WAD ("Whiplash-associated disorders") is a typical example of such a condition. WAD gets the lowest score in the Abbreviated Injury Scale (AIS 1), but is by far the single most expensive condition from the insurance companies' perspective – at least in certain EU countries. Some of the patients seeking compensation for WAD did not consider the condition to be serious enough to warrant medical examination immediately after the injury. The pain and discomfort associated with the injury only became apparent later.

The same applies to psychosocial conditions, such as PTSD (post traumatic stress disorder). As groups, patients such as those described above are much less likely to be included in different registries kept by the police or at the trauma centres. Thus, to describe the total long-term impact or consequences following transport-related injuries within the EU, neither hospital-based trauma registries nor police records alone are likely to be effective means for collecting data.

Also, once the population of interest is identified the method and timing of data acquisition can influence the result.

### **3.5 Burden of injury**

When describing the total long-term effect of transport-related injuries on society it is difficult to use multidimensional profiles. Instead, single-value tools such as the Sickness Impact Profile (SIP) or the EQ-5D are preferred, or converting the multidimensional profiles gained by the quality of life tools given above into a single value. This value/index on health status can then be used in economic calculations. The other method is to study people's preferences of health status using for example Visual Analogue Scales, Time Trade off or Willingness to pay methods.

The term quality-adjusted life-year (QALY) is frequently used. It is the product of the quality of life (expressed as a value between 0 and 100) for the remaining life-years multiplied with life expectancy. Disability adjusted life years (DALY) combines the time lived with disability and the time lost due to premature death in a population. The measurement thus represents the gap between the situation in the population and an ideal situation where everyone lives into old age free of disease and disability.

No country keeps any statistics showing how quality of life is affected for victims of traffic injury. At best, some very crude indirect indicators can be extracted from official statistics.

In a few countries, studies have been made in which samples of traffic injury victims have reported in detail on their quality of life and the long-term impact of their injury. In a study conducted in Norway some years ago (Haukeland 1996), the investigators found that rather few reported that the injury had affected their ability to perform tasks of daily life, like cooking meals, dressing and undressing, doing housework or going to the shop. A far higher proportion reported that they had become more afraid in traffic, had lost concentration, had a poorer memory, or needed more time to think. Impacts like these can be serious in occupations that require concentration and mental processing, as more and more occupations do today.

A study that shows how information concerning permanent impairments can be extracted from official statistics (or, more precisely, official records that are kept, but not necessarily processed to produce statistics) was reported by Lund and Bjerkedal (2001). Using records from the Norwegian social security administration, the study estimated that during the years 1992-1997, 3,309 persons became disability pensioners in Norway as a result of traffic injury. Becoming a disability pensioner must certainly be considered as a case of permanent impairment. It may result in a significant loss of income, in addition to the loss of social network and support that is often associated with leaving the labour force. During the same period, the officially-recorded number of critically-injured traffic accident victims in Norway was 1,035. Critically-injured victims include those who

have life-threatening injuries or who get permanent impairments. It therefore seems clear that the incidence of permanent impairment is underreported in official Norwegian road accident statistics.

In Spain, where approximately 5,000 persons die every year as a consequence of road crashes, there are around 90,000 disabled men and women as a result of traffic crashes, according to the National Disabilities, Functioning and Health Survey (INE, 2000). In this context, the term functioning refers to all body functions, activities and participation while disability is similarly an umbrella term for impairments, activity limitations and participation restrictions, as defined by the World Health Organisation (WHO, 2002). Figure 4 shows the types of functioning disabilities in the nationwide representative sample of this household survey.

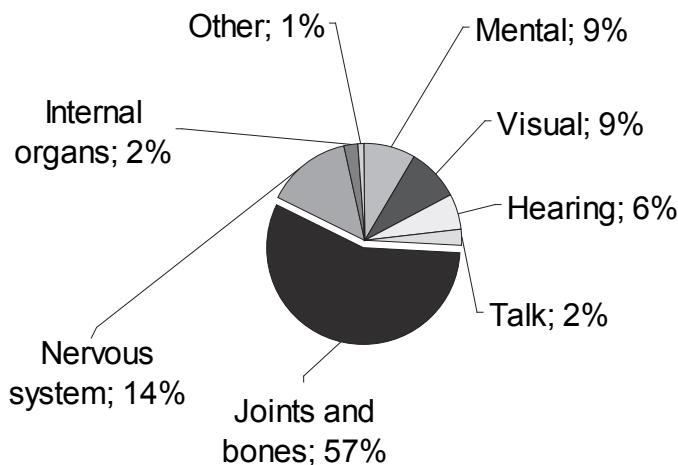


Figure 4 Distribution of impairments resulting from traffic injury in Spain in 1999

The impacts on accident victims are numerous and diverse: health (both physical and mental), job absences and disabilities, need of care from a third person, need to adapt their homes or vehicles. In Spain, out of those seriously injured road accident victims (those with an ISS greater than 25), 22.4% suffer from some kind of job-limitations, 2.6% need a third person to take care of their daily needs, 1.4% require some modifications in their homes and 0.2 percent need adaptations of their vehicles (Rodriguez, 2005).

### **3.6 Psychological consequences of traffic accidents and economic impact on society**

A proportion of persons being involved in transport-related incidents develop psychological symptoms. In its most severe form this is described as PTSD (post-traumatic stress disorder) and can cause a high grade of impairment in everyday life for those affected. The incidence does not seem to be correlated with the severity of the actual injury, but rather with the perceived subjective threat to life.

Even though most quality of life scales take into account social relationships and psychological well-being, specific scales to describe psychosocial outcome as well as scales describing the influence of a certain event to the well-being of an affected individual have been developed. The *Impact of event scale* (IES) is one example of such a scale.

Post-traumatic stress disorder (PTSD), described in DSM-IV (Diagnostic and statistical manual of mental disorders), is characterised by intrusive thoughts and memories, avoidance and hyperarousal after exposure to a life-threatening situation or a severe life event. Several studies have shown that traffic accidents are a common cause of post-traumatic stress disorder (PTSD). Ursano et al, (1999) and Bryant et al (2004) found a prevalence of 25% PTSD three months and 18% six months after the traffic accident. PTSD seems to be an important psychological consequence of accidents with motorised vehicles. Most studies involve populations of patients selected according to the

kind of injury caused by the accident, e.g. an orthopaedic trauma (Starr et al, 2004), a spinal cord trauma (Nielsen 2003) or a brain trauma (Harvey 2000).

The severity of the trauma, the perceived threat and dissociation during the accident are, according to Ehlers et al (1998), related to the development of chronic PTSD. The authors found that women, people with previous emotional problems and people who were involved, were more likely to develop chronic PTSD. According to Ehlers and her colleagues, negative interpretations of intrusions, continuing medical problems and rumination three months after the trauma are the most important predictors of PTSD after one year.

A previous trauma does not seem to be a risk factor (Ursano et al, 1999), although a previous episode of PTSD does. Richmond et al (2000) identified four variables that were important in the prediction of psychological distress after a serious injury, namely increased levels of psychological distress during hospitalisation, a positive screen for drugs and alcohol at the time of the injury, young age and the lack of anticipation of possible problems that can occur with when resuming normal activities. Zatzick et al (2002) examined 101 surgical inpatients and found that 73% perceived a high level of psychological stress and/or were positive for intoxication with stimulants. One, four and twelve months after the injury, 30 to 40% of the patients reported symptoms of PTSD. Severe symptoms in the beginning were the strongest predictor of continuing PTSD-symptoms during the following year. This suggests that one can assess predictors of PTSD from the moment of hospitalisation and thus allow early assessment for referral into psychiatric care.

Little is known about the economic impact of PTSD following a traffic accident. Matthews (2005) followed 46 individuals eight months after a traffic accident. The participants with PTSD had significantly more problems to return to work than those without PTSD, including higher levels of depression, reduced time-management ability and an excessive concern or anxiety related to physical injuries. The individuals with PTSD reported also a significantly higher extrinsic motivation to work than those without PTSD. According to the author, this can indicate a need for financial stability and therefore a potential for therapeutic value in return to work post-trauma.

In summary, the majority of studies on psychosocial residual states following traffic accidents are retrospective. Most studies concern individuals who have sought treatment following traffic accidents. As a result of this, knowledge regarding the incidence and severity of psychosocial residual states is scarce when it comes to individuals with mild somatic injuries or no injuries. A large portion of the literature discusses psychological residual states in the form of PTSD, but studies of social consequences are few.

### **3.7 Injuries to specific organs**

#### **Brain injuries**

Brain injuries can cause many kinds of physical, cognitive and behavioural/emotional impairments that may be either temporary or permanent. Impairment may range from subtle to severe. Brain injury may also result in seizure disorders. According to the International Brain Injury Association, in the European Union brain injury accounts for one million hospital admissions per year. Motor vehicle crashes account for 50% of all traumatic brain injury and are the leading cause of this type of injury among persons under the age of 65 years (IBIA, 2006).

Recovery from a head injury may require long periods of time, and in some instance full recovery is never achieved. According to a survey of victims and their relatives conducted in 1995 by the European Federation of Road Traffic Victims, only 37% of the victims who had suffered head injuries thought that they had fully recovered within the first 3 years and only a further 19% recovered after that period (Haegi and Chaudhry, 1995). The other 44% suffered from permanent neurological or brain damage. This is particularly striking as head injuries represent about half of all road crash injuries. The European Federation of Road Traffic Victims points out that the effects of head injury are often not recognised because they are not always apparent, yet they may cost victims their jobs or educational qualifications, with serious economic consequences for society as a whole.

A symposium on brain injury organised in Spain in 1984 concluded that every year approximately 12,000 new cases of brain trauma are diagnosed in Spain. This figure includes only those cases with some kind of permanent disability. Between 50% and 70% of all serious brain injuries are caused by road accidents (AESLEME, 2000; Ministerio de Educación y Ciencia, 2004). The seriousness of neurological disabilities vary: 6% consist of deep coma, 32% involve severe disabilities (the victim needs permanent care and is not able to regain his/her normal occupation), and 63% suffer from moderate disability (partial independence, but not full mental and social recovery) (FEDACE, 2003).

### **Spinal cord injuries**

According to the Parliamentary Assembly of the Council of Europe, advances in health care have resulted in increasing numbers of people with spinal cord injury surviving and living relatively successfully in the community with their disability, often in a wheelchair and for a near normal lifespan. About half of these injuries are the result of road accidents and, even more relevant, occur at a young age (Parliamentary Assembly, 2002). The International Campaign for Cures of Spinal Cord Injury Paralysis - ICCP, an organisation working to fund research into cures for paralysis caused by spinal cord injury estimated the average annual incidence of spinal cord injuries to be 22 persons per million inhabitants in the western and developing world (ICCP, 2005). The ICCP reports the following overall incidence rates in a series of European countries: 12 spinal cord victims per million inhabitants in the U.K., 18.5 per million in Germany and 27.4 in the Netherlands. On average, more than 50% of spinal cord injuries occur in motor vehicle crashes. With an EU-25 population of approximately 456 million inhabitants and an annual incidence rate of 22 victims per million (half of them related to road accidents), each year road accidents would account for about 5,000 cases of spinal cord injury in the EU. In the U.K. and the Netherlands, an estimated number of about 47,000 persons live with a spinal cord injury. Given the fact that the average age at injury is 33.4 years and the fact that life expectancy is reduced by an average of less than 10%, it is clear that the population of victims living with spinal cord injuries is steadily increasing around the world.

In Spain 1,179 cases of spinal cord damage were reported in 1991. Between 60% and 70% of those injuries have a traumatic origin and road traffic accidents account for two out of every three spinal cord injuries (AESLEME, 2000; Ministerio de Educación y Ciencia, 2004).

### **Lower extremity injuries**

Research has shown that physical impairment from severe lower limb fractures sustained primarily in motor vehicle crashes is frequent and can cause permanent disability (Kuppa et al, 2001; MacKenzie et al, 1993). In side impacts, lower extremities are the most frequent site of moderate to serious injuries to survivors (Thomas and Frampton, 1999) and the second most common site of moderate to fatal injuries for belted occupants (Morgan et al, 1991). Foot and ankle injuries accounted for 8-12% of all moderate to serious injuries sustained by motor vehicle occupants involved in frontal crashes (Crandall et al, 1998). In economic terms, lower extremity trauma is associated with high costs (MacKenzie et al, 1988) and the frequency and economic impact is increasing (Martin et al, 1997).

Epidemiological data indicate the seriousness of this problem. Data from the National Automotive Sampling System (NASS) in the United States indicate that 27.8% of the annual 1.5 million injuries are lower limb injuries (Luchter, 1995). The societal costs associated with these injuries were second only to head and brain trauma (Miller et al, 1995). Using the Functional Capacity Index (FCI) to gauge the loss of productivity and quality of life, Luchter found that injuries to this region accounted for 41% of all "life-years" lost (Luchter, 1995). AIS 2+ lower limb injuries each represent an average loss of 11.8 years of perfect health. Ore et al (1993) found that injuries to the lower limbs accounted for 41% of work days lost, with 15% attributed to the ankle alone. By comparison, the head/brain represented 23% and the chest region 24% of lost workdays.

In a multiyear study conducted in the USA, more than 300 patients with lower limb injuries were followed prospectively at 3, 6 and 12 months after injury. Patients were queried at each follow-up about their work status and completed the Sickness Impact Profile (SIP), a widely-used and well-validated measure of general health status (Bergner et al, 1976). The 204 patients who had not recovered by 12 months were contacted again at 30 months and asked to complete an interview

and the SIP. At 30 months, 17% had mild disability, 12% had moderate disability and 7% had severe disability; one-fifth had not yet returned to work. Whether the disability was due entirely to the lower extremity fractures or other psychosocial aspects were involved as well is not fully understood. However, it is obvious that, at least at 12 months, a significant amount of disability is still present in patients with serious lower limb fractures. A scale to better assess these types of injuries would help to determine what factors are involved in residual impairment and functional limitations (MacKenzie et. al. 1993).

In a European study, Morris et al found that lower extremity injuries are by far the most costly injuries and account for some 43% of injury costs in front and side impacts (Morris et al, 2006). In terms of injury frequency, pelvis and lower extremity injuries account for 26% of AIS 2+ (moderate to fatal) injuries in frontal crashes in vehicles manufactured after 1998 and 21% of injuries in side impacts for the same type of vehicles.

### **3.8 Job loss associated with long leaves**

Road accidents induce costs in terms of both human costs and socio-economic costs. Socioeconomic costs include, for example, hospitalisation, long-term care, material damage, police and rescue service, production loss, and welfare loss. From a welfare point of view, investigating loss in disposable income due to road injuries is of interest.

The Danish Institute of Local Government Studies investigated whether traffic injuries are associated with a permanent reduction in disposable income and employment (Møller Danø, 2004). The data were taken from a random 10% sample of the adult population of Denmark for the years 1981-2000. For this large representative panel full records on demographics, work status, income, and detailed information on traffic injuries were available.

The overall result is that traffic injuries are associated with significant differences in the labour-market outcomes between injured persons and matched controls. Further investigation shows that the effect of traffic injuries on disposable income varies by age. In the long run, after 6 years, young injured persons do not seem to have a lower disposable income than non-injured persons. This is in contrast to older persons who have significantly lower earnings than older non-injured persons.

The average employment rate declines sharply for men in the year of the road accident and it does not approach the level of the matched controls within a 6-year period, indicating a clear effect in the long run. The employment rate is around 10 per cent lower for the injured men. With respect to women, the picture is a bit different, as significant effects were found only 3-6 years after the injury. The difference between the injured and their matched controls is around 8 percent 6 years after the injury. This difference seems to be due the fact that some disabled women exit the labour force and receive disability pensions.

Average earnings are reduced for both men and women, but at the 10% significance level, only effects for men were found. Six years after the accidents, earnings were 10 per cent lower for men than they would have been had they not been involved in the accident.

In Spain, 3.4% of people involved in accidents have been reported to sustain some kind of disability (Rodriguez, 2005). For those with an ISS above 25, the percentage is 22.4%; 3% of victims with an ISS greater than 25 never go back to work, another 6% need to be retrained to a different type of work, and 13.4% are partially disabled, but may be able to work reduced hours. While the ISS is not a direct measure of disability or impairment, it can be an indicator for certain body regions such as the head or spine.

### **3.9 Impact on families**

The burden of crashes is borne not only by those directly involved in traffic accidents but also by their families. A study conducted by the European Federation of Road Victims in 1993 found that 90% of the families of dead victims and 85% of the families of disabled victims declared

a significant, and in half the cases even dramatic, permanent decline in quality of life and/or standard of living (Federation of European Road Traffic Victims, 1993).

This survey was extended in 1995 using a questionnaire that was answered by 1,364 relatives of dead victims and relatives of disabled victims (Haegi and Chaudhry, 1995). This second phase study found that a large proportion of the relatives of dead and disabled victims, as well as the disabled themselves, suffer psychological disorders, including anxiety attacks (46%) and suicidal feelings (37%). Even after 3 years, these symptoms continued in most of the cases, indicating long-term and in certain cases even permanent suffering. With the exception of suicidal feelings, the relatives of disabled victims present a similar pattern to that of the relatives of dead victims.

In fact, the traditional view that it is normal to recover rapidly from the sudden, unexpected loss of a spouse or child was refuted as early as in 1987 based on interviews of 39 individuals who had lost a spouse and 41 parents who had lost a child 4 to 7 years before in road accidents (Lehman et al, 1987).

Bryant et al (2004) also took the consequences for the relatives into account in cases where a child was involved in a traffic accident: 84% of the mothers reported re-experiencing, 81% reported hyperarousal and 16% met all criteria for acute stress disorder in the first interview that took place two weeks after the accident. Mothers who had been involved or who had witnessed the accident showed significantly higher levels of acute stress: 13% had PTSD after six months.

Merlevede et al (2004) collected data from UZ Ghent on 74 relatives of 53 deceased individuals. In this study several useful recommendations were offered to improve the psychological care of the bereaved relatives, including the need for a straightforward communication about the accident and its consequences as well as the offer of psycho-education about mourning.

With regard to impacts on the participation in the labour force of the relatives of accident victims, about 60% of the relatives of dead victims, 80% of the relatives of disabled victims and 70% of the disabled themselves who changed occupation did so because they were forced to by the circumstances. Among those who lost their jobs about 65%, 33% and 33%, respectively, did so for psychological reasons, the others for physical reasons (Haegi and Chaudhry, 1995).

One of the main recommendations of the European Federation of Road Traffic Victims is the creation of free assistance centres for victims, where victims would receive assistance/advice in the fields of law, medicine and psychology. In support of road accident victims an innovative project was proposed in 2005 by the Spanish NGO organisation "STOP Accidentes" to the Ministry of Health and Consumer Protection. The project, titled "Road Violence Victims Care", foresees a two-stage intervention and three different actions designed both for "direct" victims and for "indirect" ones (mainly relatives and close friends). The first proposed intervention stage would take place immediately after the accident while the second would imply a longer term treatment of psychological consequences resulting from the accident. The three actions that give shape to this proposal are: the creation of a traffic victim supporter network (based mainly on social workers and psychologists), the organisation of training activities on psychological support for victim supporters and hospital workers and, in the third place, the design of a "victim support protocol" including the definition of a (quiet) physical environment in hospitals to receive the "indirect victims", a written guide for victims, as well as other psychological, social and legal matters.

A research team of the university hospital of Ghent (Verhaeghe et al, 2004) studied the literature about stress and coping in families of patients with a brain trauma. They concluded that the level of stress was such that professional support was appropriate, even after 10 to 15 years. The nature of the injuries of the victim determines the level of perceived stress by the relatives, not the severity of the injury. The personal problems of the victim, behavioural problems, emotional and intellectual problems strongly correlate with perceived pressure, anxiety and depression of the relatives. Partners experience more stress than parents and children. Young families with little social support, financial, psychiatric and/or medical problems are the most vulnerable. Support from professionals reduces the stress being experienced and encourages people to cope effectively. According to the authors every attempt should be made to develop models of long term support and care that alleviate sources of burden on relatives.

### **3.10 Impacts of being prosecuted for manslaughter as a result of an accident**

Drivers who are involved in accidents may suffer a number of adverse consequences even if they are not injured. For example, a driver may be prosecuted for negligence or even manslaughter as a result of an accident. Although very limited attention has been devoted to this topic, some authors have recently reported studies on it.

A recently published Swedish study examined the consequences of road crashes on drivers charged with involuntary manslaughter, based upon a retrospective study of 14 trials held in Swedish appeal courts and district courts (Lundälv, 2005). During the 1994-2004 period, 1,290 persons pleaded guilty to the charge of involuntary manslaughter in Sweden (this crime is defined as a killing resulting from the commission of a traffic violation, or as the result of negligence, such as reckless or careless driving, in which there is no intention to kill). At the EU level, there may be several thousands of drivers who are prosecuted every year. The study concluded that many individuals complained of having reactions such as negative stress, a sense of guilt, victim blaming and having to take sick-leave after the accident. Imprisonment and other penalties as a result of road traffic crimes, also represent an additional burden to the society as a whole, often neglected when considering the impact of road accidents.

This study indicates a need for adequate psychological and social counselling (social support) for individuals convicted of the crime of involuntary manslaughter in road deaths. Lundälv suggests, from the social work perspective, that resources for crisis intervention and social support from hospital workers should be available at an early stage to individuals suspected of this type of crime. From a socio-economic point of view, involuntary manslaughter in road deaths affects more frequently (at least in the Nordic countries) individuals with a poor socio-economic position. Involuntary manslaughter is strongly related to other crimes such as alcohol and drug crimes and reckless driving.

### **3.11 Summary and conclusions**

The long-term consequences of transport-related injuries within the EU are to a large extent unknown. Mortality rates are fairly well known in the different member states. Statistics on survivors are much less reliable, especially for slight injuries. These patients are usually only to a small extent included in the trauma registries or police records, even though the long-term consequences of injury might be severe. Questionnaires to samples of the population seem to be the only feasible way to obtain data on the magnitude of the problem, especially regarding psychosocial consequences.

To describe the long-term outcome following injuries a large number of scales have been developed. An ideal instrument to evaluate the outcome should include both objective and subjective assessments and still be simple, quick, reliable, reproducible and cost-effective. Such an instrument does not exist; consequently there is no agreement on the best scale or score that adequately describes health (or the loss of it) and fits all possible conditions. Cost calculations as well as other methods of describing the burden of injury on society all have their flaws. Thus it seems reasonable to use several measures in combination to provide relevant information on the different perspectives following injury.

## 4 Socio-economic dimensions of traffic injury

This chapter summarises the main findings of a number of studies on the relationship between socio-economic status and involvement in road accidents in six countries.

### 4.1 France

A study among employees and former employees of the French companies Gaz de France and Électricité de France (Lenguerrand et al 2006) assessed the rate of accident involvement for three groups of employees: (1) Managers, (2) Skilled workers and (3) Unskilled workers. Managers had the highest social status of these groups; unskilled workers the lowest. The study relied on individual data and controlled for a number of confounding factors, the most important of which was annual driving distance. Table 4 presents some key findings of the study.

Social status	Crude relative risks		Adjusted relative risks	
	Men	Women	Men	Women
Managers	1.28	1.47	1.13	1.36
Skilled workers	1.09	1.12	1.08	1.12
Unskilled workers	1.00	1.00	1.00	1.00

Table 4 *Relative risk of road accident involvement for employees and pensioners of Gaz de France and Électricité de France (Source: Lenguerrand et al 2006)*

The relative risks of road accident involvement have been adjusted for the potentially confounding effects of socio-demographic factors, life events (divorce, death of family member, etc.), health state, annual driving distance and a number of driver behaviour variables.

It is seen that managers – the group with the highest social status – have the highest accident rates. Unskilled workers have the lowest accident rates. Adjusting for potentially confounding factors weakens this relationship, but does not eliminate it. It should be noted, however, that none of the adjusted relative risks differ from the reference value of 1.00.

### 4.2 Great Britain

Abdalla, Barker and Raeside (1997) investigated the relationship between the level of deprivation in the residential area of road accident casualties in the Lothian region of Scotland and casualty rate, stated as the number of killed or injured road users per 10,000 inhabitants. An excerpt of their findings is shown in Table 5. It compares injury rates per 10,000 inhabitants for the 15% most deprived areas (the poorest areas) and the 15% most affluent areas in the Lothian region. The injury rates in areas representing the middle 70% according to deprivation score are not shown.

Type of casualty	Injured road users per 10,000 inhabitants		Incidence rate ratio
	15% most deprived areas	15% most affluent areas	
All casualties	54.1	29.2	1.85
Pedestrian	19.9	5.1	3.90
Non-pedestrian	34.3	24.1	1.42

Table 5 *Road accident injury rates per 10,000 inhabitants for deprived and affluent areas in the Lothian region of Scotland (Source: Abdalla et al, 1997)*

It is seen that the road accident injury rate is almost twice as high in the 15% most deprived areas as in the 15% most affluent areas. The difference in the injury incidence rate is particularly large with respect to pedestrian injury.

As estimated in this study, injury rate does not account for exposure to traffic risk, or for differences in the road system. The comparison is therefore very crude. To the extent that the affluent travel more than the poor, one would, all else equal, expect them to be more often involved in road accidents. On the other hand, affluent areas may benefit from an inherently safer road system than deprived areas, which implies that the affluent would be less at risk for a given amount of travel. Based on the data provided, it is impossible to know which of these sources of uncertainty is the more important.

A considerably more sophisticated study was reported by Graham, Glaister and Anderson (2005). They studied the number of pedestrian accidents in English wards in 1999 and 2000. They developed a negative binomial regression model to explain the number of pedestrian accidents in 8,414 wards. The model included such explanatory variables as deprivation score, size of population, employment, length and type of road network and variables describing weather. Graham, Glaister and Anderson found that the incidence of child pedestrian casualties (children defined as 0-15 years of age) in the most deprived ward was 4.07 times higher than in the least deprived ward. For adult pedestrian casualties, the corresponding incidence rate ratio was 2.28. For pedestrian accidents in which the pedestrian was killed or seriously injured, the incidence rate ratio between the most and least deprived ward was 4.4 for children and 2.5 for adults.

Thus, the risk of pedestrian accidents increases substantially in deprived areas. The study reported by Graham and colleagues is important because it was well-controlled, meaning that the effect attributed to deprivation is less likely to be confounded by other variables than in less well-controlled studies.

### **4.3 Norway**

Studies of the relationship between socio-economic status and traffic injury have not been reported in Norway. There are, however, two sets of easily available data that can be used to explore the relationship. Neither data set permits a well-controlled study, but may at least give an indication of whether there is any relationship between socio-economic status and the incidence of traffic injury in Norway.

The first data set, covering the period 1996-1998, refers to districts in the city of Oslo. There were at that time 25 districts, plus the central business district (the number has since been reduced to 15). For each district, data were available on the total number of injury accidents, pedestrian accidents, vehicle kilometres of travel, population and mean annual income per household. Leaving out the central business district, which is very atypical in terms of the size of the resident population and the use of the road system (e.g. a vastly higher number of pedestrians than the other districts), Figure 5 shows the relationship between mean household income and the injury accident rate in the 25 districts. Injury accident rate is stated as the number of injury accidents per million vehicle kilometres of travel.

The open white squares refer to inner city districts. The black dots refer to suburban districts. There is no relationship between household income and injury accident rate. This applies both to inner city districts and suburban districts. Figure 6 shows a similar relationship for pedestrian accidents. Again, there is no relationship between household income and the rate of pedestrian accidents.

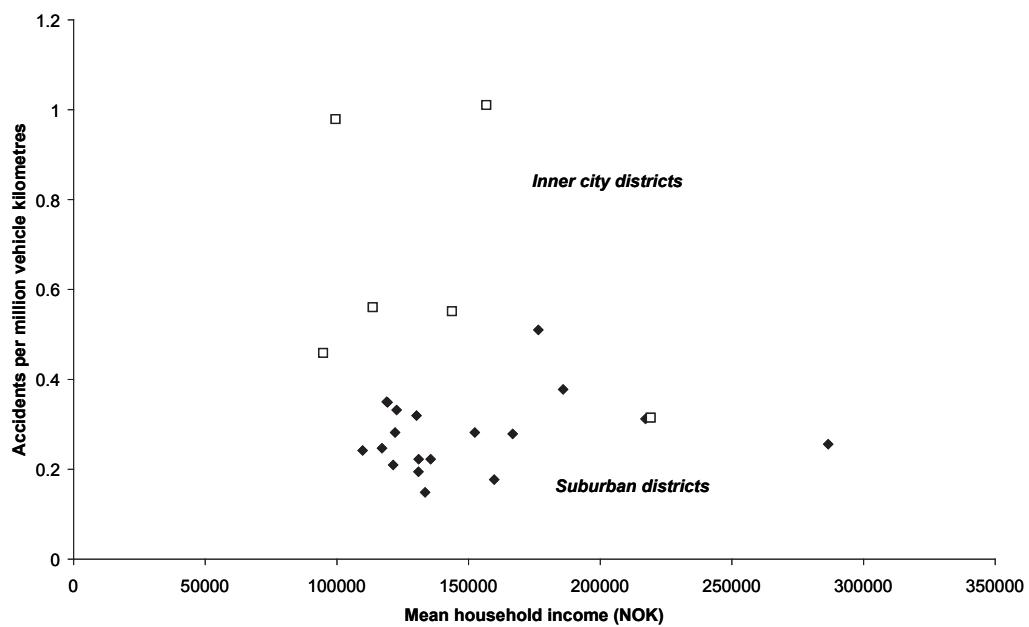


Figure 5 Relationship between mean annual household income and traffic risk for 25 districts in Oslo, Norway

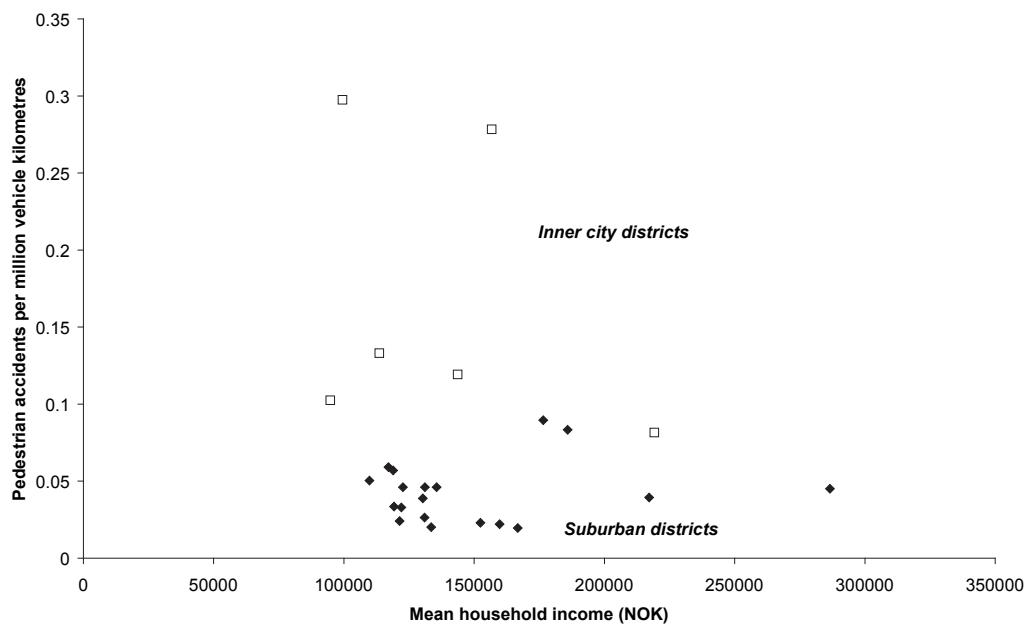


Figure 6 Relationship between mean annual household income and risk of pedestrian accidents in 25 districts in Oslo, Norway

There are clearly very many potentially confounding factors that this simple analysis does not account for. When risk was stated as population risk, i.e. the number of injury accidents per 1,000 inhabitants, findings were very similar to those in Figures 5 and 6. Thus, the definition of risk did not influence results in this case.

In general, however, one may expect the choice of measure of risk to influence the relationship between variables describing social status and the risk of traffic injury. The reason for this is that those with low social status are not similarly exposed to road accident risk as those with high social status. Those who have a high social status tend to travel more than those who have a low social status.

The second data set from Norway is well suited to illustrate this. Table 6 shows the mean daily travel distance for individuals belonging to households in different income categories in Norway, estimated on the basis of the national travel survey (Denstadli and Hjorthol, 2002). Based on detailed information about the means of transport used, and the death risk associated with each means of transport, it is possible to estimate an expected number of fatal accidents for each income group. Table 6 shows the result of the estimate.

It can be seen that the individuals who belong to high-income households travel more than twice as many kilometres per day as individuals who belong to low-income households (around 50 km/day versus 22 km/day). All else equal, one would expect this higher level of exposure to transport risk to result in a higher number of accidents per individual. On the other hand, it is possible that individuals from high-income households may be able to compensate for their greater exposure by choosing safer means of transport. This, however, does not appear to be the case. The relative death risk per kilometre of travel, as estimated according to the mix of transport modes used by each income group, is almost the same for all income groups. Thus, those with a high income do not walk or cycle less than those with a low income. In fact, the rich travel more by means of every type of transport than the poor, except for travel by bus, tram or train – all of which are comparatively safe modes of transport.

Household income (NOK; 1 NOK = 0.12 €)	Mean daily travel distance (km)	Relative death risk per km	Relative death risk per individual
Less than 150,000	22.4	1.00	1.00
150,000-299,000	31.5	1.04	1.47
300,000-449,000	37.9	1.17	1.99
450,000-599,000	42.8	1.11	2.12
600,000-749,000	50.5	1.07	2.41
750,000 or more	48.1	0.97	2.08

Table 6 Travel and expected relative risk of fatal injury for different income groups in Norway

The steepest income gradient is found for car driving. It is likely that the rich drive safer cars than the poor, but available data did not allow for an adjustment for this. However, the exposure of the rich as car drivers is so much greater than the exposure of the poor that their cars would have to be very much safer than those used by the poor in order to offset the impact of the difference in exposure.

The net result is that when relative death risk is estimated using the size of the population as denominator, i.e. not adjusting for differences in exposure between income groups, the rich are estimated to have more than twice as high risk as the poor. It is important to stress the fact that this is an estimate only; it is based on travel behaviour data and mean values for risk. It is not an observed level of risk. Still, the example is interesting because it suggests that when population risk (i.e. risk estimated with the size of the population as indicator of exposure) is found to vary inversely according to social status, it suggests that those who have a high social status are able to compensate for the adverse effects of their greater exposure in a number of ways.

#### 4.4 Sweden

A series of studies reported by researchers from the Karolinska Institute in Sweden have probed the relationship between socio-economic variables and the incidence of traffic injury in Sweden.

The first study (Laflamme and Engström, 2002) investigated accidents among children (ages 0-19). Risk was stated as the number of injured children per 100,000 children. Children whose parents were unskilled workers (rated as having the lowest social status) had a risk which was between 1.1 and 2.3 times higher than children whose parents were employees with intermediate or high salaries (rated as having the highest social status), depending on child age and road user role. A

distinction was made between the following road user roles: pedestrian, cyclist, motor vehicle passenger and motor vehicle driver.

A second study (Hasselberg and Laflamme, 2005) was concerned with injury repetitions among car drivers aged 18-26. The study found that the risk of repeated injuries was substantially higher among those with only basic education than among those who had higher education (university degrees). The socio-economic groups used in the study were broad and not too precisely defined. If the category labelled "others" (which included students, the unemployed and people on disability pension) is taken to have the lowest ranking, the risk of one injury was 2.02 times higher in this group than in the highest ranked group. The risk of two injuries was 3.11 times higher in the lowest ranking group compared to the highest ranking group.

A third study investigated the social background of impaired drivers involved in accidents (Vaez and Laflamme, 2005). This study included the same sample of drivers used in the second study (quoted above). Drivers in the lowest ranked group in terms of social status were 1.24 times more often involved in injury accidents when impaired (i.e. influenced by alcohol or other drugs) than drivers in the highest ranked group.

In a fourth study, social background characteristics of drivers involved in different types of accident, and in accidents of different levels of severity, were studied (Hasselberg, Vaez and Laflamme, 2005). The sample used was the same as in studies 2 and 3, quoted above. It consisted of drivers who were between 18 and 26 years old. Risk was stated as the number of accidents per 100,000 person years. The incidence of accidents in the lowest ranked group was 1.58 times higher than in the highest ranked group. The incidence rate ratio was 1.51 for accidents that resulted in no or only minor injury and 2.14 for accidents resulting in serious or fatal injury.

Finally, a fifth study (Zambon and Hasselberg, 2006) compared accident rates as a motorcyclist per 100,000 inhabitants aged 18-26. Relative risk was found to be 1.60 in the lowest ranked group, using a reference value of 1.00 for the highest ranked group.

All these studies indicate that the incidence of traffic injury, using the size of the population as denominator, is higher in low-status groups than in high-status groups. The differences are, however, rather small. The gradient of risk with respect to social status seems to be steeper in Great Britain than in Sweden. In general, the Swedish studies do not control very well for potentially confounding factors. There are, for example, no data on actual exposure to traffic risk.

In a study reported by VTI (the Swedish Road- and Transport Research Institute), the accident rate for immigrants was compared to that of ethnic Swedes (Yahya, 2001). Accident rate was stated as the number of police-reported accidents per 1,000 licence holders. This rate was 3.8 for ethnic Swedes and 6.7 for immigrants. Thus, the accident rate ratio was 1.76. Immigrants from the Middle East and North Africa and from Sub-Saharan Africa had the highest accident rates.

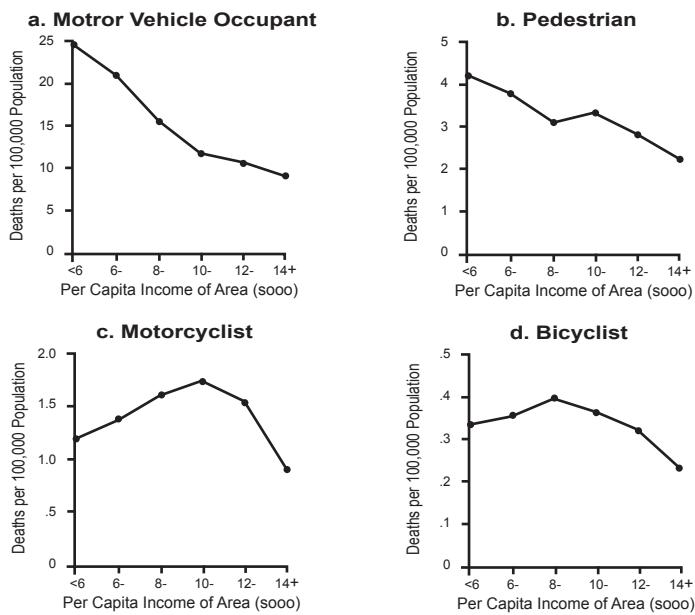
## 4.5 Canada

Given the paucity of studies in this area, it is of interest to quote a study of child (ages 0-17) pedestrian accident rates in two cities in Canada (Bagley, 1992). Accident rate was stated as injuries per 100,000 children. In Montreal, the incidence rate ratio between the lowest and highest income group was 5.73. In Calgary, the corresponding rate ratio was 4.24. The study was a simple comparative study, not controlling for any confounding factors.

## 4.6 The United States of America

Two studies of the relationship between social status and involvement in road accidents from the United States are worth mentioning. The first study is reported in *The Injury Fact Book* (Baker et al, 1992). This is a comprehensive text presenting facts about all types of unintentional injury, not just road accidents. Figure 7 taken from this reference shows the number of traffic deaths per 100,000 inhabitants as a function of the per capita income of the area of residence.

Motor vehicle occupant death rates decline sharply as income per capita increases. In the poorest areas, the rate is about 2.5 times higher than in the richest areas. For pedestrian deaths, the rate ratio between the poorest and richest areas is about 2. The patterns found for motorcyclist and cyclist deaths are less clear. While death rates for these groups of road users are lowest in the richest areas, they are not highest in the poorest areas, but in areas with a middle-level income.



Note: Vertical scales differ

Figure 7 Death rates in the United States as a function of per capita income in residential area (Source: Baker et al 1992, Figure 16-10)

The second American study worth quoting is a study by Braver (2003). She compared motor vehicle occupant death rate per million vehicle kilometres of driving by race and socio-economic status. Socio-economic status was measured in terms of education. Three levels were used: less than high school (lowest), high school (middle) and more than high school (highest). Table 7 shows some of the findings of the study.

Education	Relative death rate		Seat belts worn (%)		BAC above 0.1 (%)	
	Men	Women	Men	Women	Men	Women
Less than high school	3.52	2.79	19%	36%	60%	42%
High school	2.57	1.81	23%	43%	55%	32%
More than high school	1.00	1.00	42%	54%	40%	22%

Table 7 US motor vehicle occupant death rates per million vehicle kilometres of travel by education  
(Source: Braver 2003, tables 1 and 4)

Among men, those with the least education had a 3.5 times higher death rate than those with the highest education. Among women, the corresponding risk ratio was about 2.8.

A particularly interesting finding of the study reported by Braver is that the differences in death rate appear to be partly explicable in terms of differences in driver behaviour. Thus, 42% of men

with the highest level of education wore seat belts, compared to just 19% of men with the lowest level of education. A similar difference in seat belt wearing was found among women. Drinking and driving also appears to be more widespread among those with low education than among the more highly educated.

## **4.7 Can anything be done to reduce the effect of social status on accident risk?**

The evidence provided by the study of Braver (2003) suggests that social disparities in risk are not immutable, but may be reduced by means of appropriate treatment. Thus, if men with a low level of education wore seat belts as often as those with a high level of education, their death rate would be reduced – perhaps not to the same level as for highly educated drivers, but at least the difference would be reduced.

In a similar vein, Jones et al (2005) have studied the effects of traffic calming on inequalities in child pedestrian risk. In city A, the child pedestrian injury rate ratio (injured children per 1,000) between the most deprived and the most affluent part of the city was 3.21 before traffic calming. Traffic calming was introduced, and the most deprived part of the city benefited from 4.80 times as many traffic calming features (speed humps, etc.) as the most affluent part. Following traffic calming, the injury rate ratio was reduced to 2.01.

In city B, the child pedestrian injury rate ratio of most deprived area to most affluent area was 4.27 before traffic calming. After traffic calming, it was reduced to 3.96. In city B, however, the most deprived area received only 1.88 as many traffic calming features as the most affluent area.

The study suggests that: (1) Social disparities in child pedestrian risk can be reduced by means of traffic calming, and (2) The more strongly traffic calming is concentrated in the deprived areas, the greater is the reduction of the social disparities in risk.

## **4.8 Summary of knowledge regarding social disparities in risk**

Studies of the relationship between various indicators of social status and involvement in road accidents have come to diverse findings. A French study found that individuals with a high social status are more often involved in road accidents than individuals with a low social status. Data referring to city districts of Oslo, Norway, are inconclusive: basically these data show no relationship between per capita income of a district and road accident risk in that district.

All other studies have found that low social status – no matter how that is measured – is associated with a higher rate of involvement in road traffic accidents. This has been found consistently in studies made in Great Britain, Sweden, Canada and the United States of America. Thus, the preponderance of evidence suggests that low social status is associated with a higher risk of becoming involved in road accidents than high social status.

The quality of the studies is somewhat variable; it cannot be ruled out that lack of control for potential confounding factors may have influenced the results of some studies. However, if taken at face value, the studies suggest that the following conclusions can be drawn:

1. It is more likely than not the case that individuals with a low social status, irrespective of how social status is defined, are more often involved in road accidents than individuals with a high social status.
2. Some studies suggest that the status gradient for accident involvement is steeper for pedestrian accidents than for other road accidents.
3. Some studies suggest that the status gradient is steeper for fatal and serious injury accidents than for slight injury accidents. Again, however, not all studies have found this.
4. Few studies provide any explanation of why individuals with a low social status are more often involved in accidents than individuals with a high social status, but an American study suggests that differences in road user behaviour could partly explain the differences in accident rate.

5. To the extent that social disparities in road accident risk are associated with characteristics of residential areas, a British study shows that a selective application of traffic calming may reduce the social disparities.

## **4.9 Other issues related to socio-economic factors and road accidents**

### **Interventions for preventing injuries in problem drinkers**

Injuries and death due to motor vehicle crashes and other causes such as falls and drowning, that are caused by alcohol consumption are well known problems. An important issue is whether interventions for problem drinking can prevent the subsequent risk of injuries.

A Cochrane review (Dinh-Zarr et al, 1999) examined the literature and concluded that interventions for problem drinking appear to reduce injuries and their antecedents (e.g. falls, motor vehicle crashes, and suicide attempts). Brief counselling in the clinical setting was the most commonly evaluated intervention.

Other second-order effects related to drinking and motor vehicle crashes should be considered. The presence of high blood-alcohol concentration (BAC) makes injuries more severe. In a study of more than one million drivers in the USA (Waller et al, 1986), 21,000 had a measured BAC of 0.10% or higher. After controlling for variables such as seat belt wearing, vehicle deformation, vehicle speed, driver age and vehicle weight, the study found that the injury rate for the group 0.15-0.19% BAC was slightly lower than that for the 0.10-0.14% BAC but that the injury rate was much higher for the 0.20% and higher BAC group. While further research on this category of impaired driver could elucidate this point, it is clear that high BACs exacerbate injury severity.

A number of earlier clinical studies failed to show a harmful effect of alcohol on patient outcome (Huth et al, 1983; Thal et al, 1985). However, it should be noted that these clinical studies have certain limitations that bias their results. For example, deaths at the scene which may be directly related to elevated BAC are not included. Two of the studies included in Dinh-Zarr's review pooled patients with blunt and penetrating trauma. These two populations are quite different not only with regard to injury aetiology but also resuscitation and stabilisation. Finally, these clinical studies did not control for impact severity (i.e. change in velocity), which is a fundamental parameter for assessing injury severity.

While these clinical studies have some limitations, they do offer insight into other second-order problems in patients with high levels of alcohol. The diagnosis of severe brain injury can be compromised by alcohol intoxication. Brain injury is worsened by the presence of alcohol which is known to cause edema leading to prolonged or fatal head injury. A study of motorcyclists with severe head injury resulting in death underscores the inability to adequately resuscitate patients with acute alcohol intoxication (Luna et al, 1984).

### **Emergency medical services drivers**

Frontline emergency medical services (EMS)-vehicles are at high risk of serious road accidents. Studies show an up to 50 fold increased collision risk, a collision rate of 2 to 5 per 10,000 ambulance responses and collision rates as high as 1 per 50,000 km (Auerbach et al, 1987; Saunders and Heye 1994; Pirrallo and Swor 1994; Biggers et al, 1996; Calle et al, 1999; Custelow and Gravitz, 2000). These figures stress the need for the modification of the risk taking behaviour of EMS-drivers and the selection of the best suitable vehicle and national standards for safe EMS-responses (Calle et al, 1999; NAEMSP, 1994; Ossmann et al, 1997).

There are data indicating the risk-reducing effect of installing a black box combined with well defined guidelines and a close monitoring system (DeGraeve, 2003; Levick, 2005).

### **Professional drivers**

According to a TRL study from 1998, company drivers were found to have an accident involvement rate between 29 and 50 per cent higher than private drivers who were otherwise similar in terms

of age, sex and annual mileage. This research relied on questionnaire surveys of self-reported accidents, which are inevitably dominated by damage-only accidents (Lynn and Lockwood, 1998). Further research also at TRL concentrated on injury accidents: based on 6,168 questionnaires returned, it was concluded that car drivers with a high proportion of work-related mileage have a much greater risk of injury accidents than other drivers of similar age, sex, annual mileage and percentage of mileage done on motorways (Broughton et al, 2003). This study also found that drivers who drove more than 80 per cent of their annual mileage on work-related journeys had about 53% more injury accidents than otherwise similar drivers who did no work-related trips; drivers whose work-related journeys accounted for 1-80 per cent of their total mileage had, on average, about 13% more accidents than non-work drives.

The TRL survey from 2003 was not able to provide direct evidence linking the excess risk of work-related driving to particular attitudes and behaviours of company drivers, or to the situation in which they drive. However, there was much indirect evidence, as the authors indicate, on the risk-related aspects of company driving. In particular, the highest risk drivers drove more often:

- in situations known to make drivers susceptible to fatigue and drowsiness (for instance, driving on journeys longer than 80 kilometres after a full day of work);
- when under time-pressure to reach a destination;
- when conducting potentially distracting in-car tasks such as mobile phone conversations, eating and drinking.

The solution pointed out by Broughton and colleagues relies on the companies themselves and is to change the conditions under which their employees drive, so that time pressure and fatigue are reduced, and attention-demanding in-car tasks like mobile phone conversations are strongly discouraged.

## **5 Conclusions and recommendations**

This chapter presents a summary of the main findings of the study and a set of recommendations. Two sets of recommendations are proposed: one set for research, designed to help in improving knowledge regarding the socio-economic aspects of traffic injury, and one set for policy making, intended to help policy makers develop road safety policies that will reduce the impacts of traffic injury and the social disparities of these impacts. The main findings and recommendations will first be presented for incomplete and inaccurate accident reporting, then for long-term impacts of traffic injury and finally for socio-economic dimensions of traffic injury.

### **5.1 Incomplete and inaccurate accident reporting**

#### **Summary of main findings**

The number of traffic injury survivors is under-reported and misclassified in all countries. The true number of traffic injury survivors in Europe is at least twice the number stated in official statistics. Classification of injury survivors by severity is inaccurate and based on the very crude scales used in official accident statistics.

In view of Vision Zero, a serious injury ought to be defined in terms of the permanent impairment associated with it; the more extensive the impairment, the more serious the injury. However, the extent of impairment can often only be determined a long time after the accident, making a definition of serious injury in terms of impairment difficult to implement in practice.

The problem of under-reporting and misclassification of injuries is probably best solved by improving injury recording at hospitals and other medical institutions. This is more realistic than trying to make the police attend to more traffic accidents than they do today. It is, for example, not realistic to expect the police to report single vehicle bicycle accidents involving children to a far greater extent than now. Indeed, neither parents nor children will usually know that such accidents are reportable, and when a child is injured, the first thing parents think of is to get a doctor, not call the police.

In the past, the lack of precise information concerning the place of the accident has limited the usefulness of hospital injury records for the planning of road safety measures. Today, however, digital maps are rapidly being developed and becoming available at reasonable prices. By downloading such maps in PCs, locating accidents precisely can be done with minimum effort. In most cases, the patient will be able to locate the accident by sitting down at the PC and studying the map. If the patient is unable to do this, as might be the case for seriously injured patients, then often another family member can help, or the accident will have been reported to the police, who are able to locate it.

By merging hospital records and police records, accident statistics can be greatly improved and the problem of under-reporting and misclassification reduced substantially. There will still be under-reporting, but far less than today.

#### **Recommendations for research**

The following recommendations are made for research designed to estimate the true incidence and societal cost of traffic injury:

1. Studies designed to assess the level of reporting in official road accident statistics should be performed regularly.
2. Studies should address factors that influence the likelihood that an injury will be reported in official accident statistics and try to assess the amenability of these factors to interventions designed to improve reporting.
3. Studies should be made to determine the extent to which injuries recorded by medical institutions can be geographically located correctly.

4. Studies should be made to determine the possibility of electronically merging police records and hospital records of traffic injury in ways that will not violate protection of privacy and personal integrity.
5. Guidelines based on research should be developed regarding the essential elements of a common approach to the estimation of the costs to society of traffic injury.

### **Recommendations for policy making – administration of injury recording**

The following recommendations are made regarding policy making and the administration of injury recording systems:

1. A simple injury scale should be developed for use by the police and other emergency services. Final classification of injuries according to severity should be performed by medical professionals.
2. Countries should provide training in the use of the AIS in order to make the use of this scale more common and thus make injury data more comparable between countries.
3. Countries should encourage electronic linkages between sources of injury data, like STRADA in Sweden or the CODES system of the United States.
4. Countries should regularly monitor the level and accuracy of reporting in official road accident statistics and make the results of studies available to other countries.
5. Countries should regularly provide a set of economic valuations of the benefits to society of preventing road accident deaths and injuries for use in cost-benefit analyses of road safety programmes.

## **5.2 Long-term impacts of traffic injury**

### **Summary of main findings**

The long-term impacts of transport-related injuries within the EU are to a large extent unknown. Mortality rates are fairly well known in the different member states. Statistics on survivors are much less reliable, especially for slight injuries. These patients are usually only to a small extent included in the trauma registries or police records, even though the long-term impacts of some injuries that are classified as slight can be serious (whiplash injury is a case in point). Questionnaires to samples of the population seem to be the only feasible way to collect data on the nature of long-term impacts and the prevalence of such impacts in the general population.

Case mortality in road accidents, i.e. the proportion of all those involved in road accidents who are killed, has been declining in many countries for a long time. For example, in Sweden around 5% of those reported as killed or injured in 1970 were killed. By 2005, the percentage killed was less than 2%. Part of the decline in case mortality is probably attributable to medical progress. This implies that some of those who would have died of their injuries 35 years ago survive today, but very often with lasting impairments. It is known, for example, that the number of people living with spinal cord injuries is increasing. It is therefore highly likely that the number of people living with lasting impairment as a result of traffic injury is steadily increasing.

Most of the current knowledge about brain injuries relate to those that result in serious neurological damage. But not all brain injuries result in immediate, obvious impairment and therefore are likely underrepresented in all statistics on traumatic brain injury (TBI).

To describe the long-term impacts of injury a large number of scales have been developed. Some of these are generic, i.e. intended to measure the overall quality of life. Other scales are specific to certain diagnoses. An ideal instrument designed to measure quality of life should include both objective and subjective assessments and still be simple, quick, reliable, reproducible and cost-effective. In general such an instrument does not exist. Consequently there is no agreement on the best scale or score that adequately describes health (or the loss of it) and fits all possible conditions. Cost calculations as well as other methods of describing the burden of injury on society all have their flaws.

Thus it seems reasonable to use several measures in combination to provide relevant information on the different perspectives following injury. Setting up a recording system for long-term impacts of traffic injury is difficult. Many countries conduct periodic surveys of activities and conditions of

daily life. As part of such surveys, questions concerning permanent impairments and their cause can be asked. This can then serve as the basis for estimating the number of permanently impaired road accident survivors.

### **Recommendations for research**

The following recommendations are proposed for research:

1. Studies should be made to assess the applicability of various quality-of-life scales for the purpose of describing systematically the long-term impacts of traffic injury.
2. Surveys of the general population should be made at regular intervals to determine the incidence and prevalence of lasting impairments as a result of traffic injury.
3. Studies should be made to assess the incidence of mild traumatic brain injury as well as its long-term socio-economic consequences.

### **Recommendations for policy making**

The following recommendations are made for policy making:

1. Countries are recommended to adopt a consensus-based prospective injury impairment scale based on the Abbreviated Injury Scale (AIS).
2. The number of people living with lasting impairments as a result of traffic injury is likely to be increasing. The EU and member states should therefore consider adopting targets for reducing not just deaths, but also serious injuries.
3. The EU should encourage member states to adopt a common definition of slight and serious injuries and of lasting impairments. Implementing common definitions of these concepts would make road accident statistics more comparable across countries than they are today.
4. Programmes designed to treat accident victims who suffer long-term impacts of injury, like post traumatic stress disorder, should be further developed and their effects evaluated.

## **5.3 Socio-economic dimensions of traffic injury**

### **Summary of main findings**

Little is known about the socio-economic dimensions of traffic injury. However, the preponderance of evidence suggests that traffic injury is associated with social status. Those who are low in social status sustain traffic injury more often than those who are high in social status. Social disparities in risk appear to apply to all groups of road users and all levels of injury severity. This means that those groups of the population who are disadvantaged in terms of income, education or quality of their residential areas are also disadvantaged as users of the road transport system by sustaining injury more often than the more advantaged segments of the population. There is thus a significant element of social injustice with respect to traffic injury.

It should be noted, however, that not all studies are perfectly consistent in their findings. Some studies show an opposite pattern – that those who have a high social status are more frequently involved in road accidents than those who have a low social status. Moreover, not all studies have controlled adequately for potentially confounding factors. Despite this, it is more likely that social disparities in road accident risk put those with a low social status at a disadvantage than that the opposite is the case.

Social disparities in road accident risk can be reduced. In particular, traffic calming in residential areas has been found to reduce these disparities.

### **Recommendations for research**

The following recommendations are made for research:

1. Countries that have not studied the association between social status and road accident risk are encouraged to do so.

2. Studies should be made to determine which variables are the strongest predictors of social disparities in road accident risk: education, income, quality and characteristics of residential area, or any combination of these variables.
3. Studies should be made to identify factors that may explain why road accident risk is associated with social status, in particular if differences in road user behaviour mediate this relationship.
4. Studies should be made to determine if social disparities in road accident risk vary according to injury severity or group of road user.

### **Recommendations for policy making**

The following recommendations are made for policy making:

1. Countries are encouraged to develop policies designed to reduce social disparities in road accident risk, to the extent that these are regarded as unjust.
2. A systematic use of traffic calming in residential areas for the purpose of reducing social disparities in road accident risk is encouraged.
3. Policies aimed at modifying unsafe road user behaviour associated with low social status should be developed.



## References

- Abdalla, I. M., Barker, D., Raeside, R. (1997) Road accident characteristics and socio-economic deprivation. *Traffic Engineering and Control*, December, 672-676.
- AESLEME (2000) Accidentes de Tráfico. Guía práctica de prevención. Asociación para el Estudio de la Lesión Medular Espinal. Madrid, Editorial Santillana Profesional.
- Alfaro, J. L., Chapuis, M. and Fabre, F. (1994) Socio-economic cost of road accidents: final report of action COST 313. Brussels, Commission of the European Community.
- Amoros, E., Martin, J. L., Laumon, B. (2006) Under-reporting of road crash casualties in France. *Accident Analysis and Prevention*, 38, 627-635.
- Auerbach, P. S., Morris, J. A., Phillips, J. B., Redlinger, S. R., Vaughn, W. K. (1987) An analysis of ambulance accidents in Tennessee. *Journal of the American Medical Association*, 258: 1487-1490
- Bagley, C. (1992) The urban setting of juvenile pedestrian injuries: a study of behavioural ecology and social disadvantage. *Accident Analysis and Prevention*, 24, 673-678.
- Baker, S. P., O'Neill, B., Haddon, W., Long, W. B. (1971) The Injury Severity Score: A method for describing patients with multiple injuries and evaluating emergency care. *Journal of Trauma* 14:187-196.
- Baker, S. P., O'Neill, B., Ginsburg, M. J., Li, G. (1992) The injury fact book. Second edition. New York, Oxford University Press.
- Bergner, M. et al (1976) The Sickness Impact Profile: Conceptual form and methodology for the development of health status measurement. *International Journal of Health Sciences*, 6, 393.
- Biggers, W. A. Jr, Zachariah, B. S., Pepe, P. E. (1996) Emergency medical vehicle collisions in an urban system. *Prehospital Disaster Medicine* 11: 195-201
- Binderup Larsen, L., Schultz Larsen, M., Lauritsen, J. M. (2004) Ulykker 2003. Tilskadekomne registreret på skadestuen, Odense Universitetshospital. Ulykkes Analyse Gruppen, Odense.
- Blaeij, A. de., Koetse, M., Tseng, Y-Y., Rietveld, P., Verhoef, E. (2004) Valuation of safety, time, air pollution, climate change and noise; methods and estimates for various countries. Report prepared for ROSEBUD. Department of Spatial Economics, Vrije Universiteit, Amsterdam.
- Braver, E. R. (2003) Race, Hispanic origin, and socioeconomic status in relation to motor vehicle occupant death rates and risk factors among adults. *Accident Analysis and Prevention*, 35, 295-309.
- Brewin, C. R. (2001) Cognitive and emotional reactions to traumatic events: implications for short-term intervention. *Advances in Mind-Body Medicine*, 17 (3), 163.
- Broughton, J., Baughan, C., Pearce, L., Smith, L., and Buckle, G. (2003) Work-related road accidents. TRL Report TRL582. Crowthorne: TRL Limited.
- Bryant, R. A., Marossey, J. E., Crooks, J., Gurka, J. A. (2000) Posttraumatic stress disorder after severe traumatic brain injury. *American Journal of Psychiatry*, 157, 629-631.
- Bryant, B., Mayou, R., Wiggs, L., Ehlers, A., Stores, G. (2004) Psychological consequences of road traffic accidents for children and their mothers. *Psychological Medicine*, 34, 335-346.
- Calle P., Fonck, K., Buylaert, W. (1999) Collisions involving mobile intensive care unit vehicles in Flanders, Belgium. *European Journal of Emergency Medicine*, 6: 349-353

Crandall, J. R., Martin, P. G., Sieveka, E. M., Pilkey, W. D., Dischinger, P. C., Burgess, A. R., O'Quinn, T. D. and Schmidhauser, C. B. (1998) Lower limb response and injury in frontal crashes. *Accident Analysis and Prevention*, 30, 667-677.

Cryer, P. C., Westrup, S., Cook, A. C., Ashwell, V., Bridger, P. and Clarke, C. (2001) Investigation of bias after data linkage of hospital admissions data to police road traffic crash reports. *Injury Prevention* 7, 234-241.

Custalow, C. B., Gravitz, C. S. (2000) Emergency medical vehicle crashes: identifying driver and crash characteristics amenable to preventative intervention. *Academic Emergency Medicine* 7: 482

DeGraeve, K., Deroo, K., Calle, P., Vanhaute, O., Buylaert, W. (2003) How to modify the risk taking behaviour of emergency medical services-drivers? *European Journal of Emergency Medicine* 10: 111-116

Denstadli, J. M., Hjorthol, R. (2002) RVU 2001. Den nasjonale reisevaneundersøkelsen. Nøkkelerapport. Rapport 588. Oslo, Transportøkonomisk institutt.

Dinh-Zarr, T., Goss, C., Heitman, E., Roberts, I., DiGuiseppi, C. (1999) Interventions for preventing injuries in problem drinkers. *The Cochrane Database of Systematic Reviews*.

Ehlers, A., Mayou, R. A., Bryant, B. (1998) Psychological predictors of chronic posttraumatic stress disorder after motor vehicle accidents. *Journal of abnormal psychology* 107, (3) 508-519.

Ehlers, A., Clark, D. (2003) Early psychological interventions for adult survivors of trauma: a review. *Biological Psychiatry*, 53 (9), 817-826.

Ehlers, A., Clark, D. M., Hackmann, A., McManus, F., Fennell, M. (2005) Cognitive therapy for posttraumatic stress disorder: development and evaluation, 43, 413-431.

Elvik, R., Mysen, A. B. (1999) Incomplete accident reporting. Meta-analysis of studies made in 13 countries. *Transportation Research Record*, 1665, 133-140.

Elvik, R., Vaa, T. (2004) *The Handbook of Road Safety Measures*. Oxford, Elsevier Science.

European Commission (1997) Promoting road safety in the EU: The Programme for 1997-2001. Commission of the European Communities.

European Commission (2003) Proposal for a Directive of the European Parliament and of the Council Amending Directive 1999/62/EC on the Charging of Heavy Goods Vehicles for the Use of Certain Infrastructure. Annex III (Cost Calculation and Allocation), COM (2003) 448 final, Brussels, 23.07.2003.

European Transport Safety Council (ETSC) (1997) Transport accident costs and the value of safety, Brussels.

European Transport Safety Council (ETSC) (2001) EU transport accident, incident and casualty databases: current status and future needs, Brussels.

European Transport Safety Council (ETSC) (2003) Cost Effective EU Transport Safety Measures, Brussels.

European Transport Safety Council (ETSC) (2006) Road accident data in the enlarged European Union: learning from each other, Brussels.

Farmer, C. M. (2003) Reliability of Police-Reported Information for Determining Crash and Injury Severity. *Traffic Injury Prevention* 4, 38-44.

FEDACE (2003) Conclusiones generales del II Congreso de Daño Cerebral Adquirido. Federación Española de Daño Cerebral, Madrid (general conclusions available online at [www.fedace.org](http://www.fedace.org) as of 05/01/2004).

Federation of European Road Traffic Victims (1993) Study of the physical, psychological and material secondary damage inflicted on the victims and their families by road crashes, Geneva.

Gennarelli, T. A. and Wodzin, E., Eds. (2005) Abbreviated Injury Scale 2005, Association for the Advancement of Automotive Medicine, Des Plaines IL, USA.

Graham, D., Glaister, S., Anderson, R. (2005) The effects of area deprivation on the incidence of child and adult pedestrian casualties in England. *Accident Analysis and Prevention*, 37, 125-135.

Haegi, M. and Chaudhry, B. (1995) Impact of Road Death and Injury. Research into the principal causes of the decline in quality of life and living standard suffered by road crash victims and victim families. European Federation of Road Traffic Victims.

Hall, K., Cope, D. N., Rappaport, M. (1985) Glasgow outcome scale and disability rating scale: comparative usefulness in following recovery in traumatic head injury. *Archives of Physiotherapy and Rehabilitation*, 66, 35-37.

Harvey, A. G., Bryant, R. A. (2000) Two-year prospective evaluation of the relationship between acute stress disorder and posttraumatic stress disorder following mild traumatic brain injury. *American Journal of Psychiatry*, 157, 626-628.

Hasselberg, M., Laflamme, L. (2005) The social patterning of injury repetitions among young car drivers in Sweden. *Accident Analysis and Prevention*, 37, 163-168.

Hasselberg, M., Vaez, M., Laflamme, L. (2005) Socioeconomic aspects of the circumstances and consequences of car crashes among young adults. *Social Science and Medicine*, 60, 287-295.

Haukeland, J. V. (1996) Welfare consequences of injuries due to traffic accidents. *Accident Analysis and Prevention*, 28, 63-72.

Hollo, P. (2005) Estimation of the real number of road casualties. Unpublished paper. Budapest, Institute for Transport Sciences (KTI).

Huth, J. F., Maier, R. V., Simonowitz, D. A. et al (1983) Effect of acute ethanolism on the hospital course and outcome of injured automobile drivers. *Journal of Trauma* 23(3): 494-498.

IBIA (2006) Brain Injury Facts. International Brain Injury Association. Document available online at [www.internationalbrain.org](http://www.internationalbrain.org) as of 7<sup>th</sup> September 2006.

ICCP (2005) International Campaign for Cures of Spinal Cord Injury Paralysis (ICCP). Information Package. Version 7.0, April 2005 (available online at [www.campaignforcure.org](http://www.campaignforcure.org) on August 27, 2006).

IMPACT (2005) IMPACT. ICR Measure of Participation and ACTivities. Flyer produced by the iRv Institute for Rehabilitation Research and TNO Quality of Life.

Inghelbrecht, E., Willems, B., Bernheim, J. (2005) De impact van whiplash ten gevolge van een verkeersongeval op de kwaliteit van het leven. Steunpunt voor verkeersveiligheid.

Instituto Nacional de Estadísticas (INE) (2000) Encuesta sobre Discapacidades, Deficiencias y Estado de Saludo, Madrid.

Jones, S. R., Lyons, R. A., John, A., Palmer, S. R. (2005) Traffic calming policy can reduce inequalities in child pedestrian injuries: database study. *Injury Prevention*, 11, 152-156.

Kuppa, S., Wang, J., Haffner, M. and Eppinger, R. (2001) Lower extremity injuries and associated injury criteria. International Technical Conference on the Enhanced Safety of Vehicles, Amsterdam.

Laflamme, L., Engström, K. (2002) Socioeconomic differences in Swedish children and adolescents injured in road traffic accidents: cross sectional survey. *British Medical Journal*, 324, 396-397.

Lehman, D. R., Wortman, C. B. and Williams, A. F. (1987) Long-Term Effects of Losing a Spouse or Child in Motor Vehicle Crash. *Journal of Personality and Social Psychology*, 52, 218-231.

Lenguerrand, E., Martin, J. L., Chiron, M., Laumon, B. (2006) Road crash involvement and professional status: a prospective study of the French GAZEL cohort. Paper submitted to Accident Analysis and Prevention.

Levick, N. R. (2005) An optimal solution for enhancing ambulance safety: implementing a driver performance feedback and monitoring device in ground emergency medical service vehicles. Abstract in "49th annual proceedings of the association for the advancement of automotive medicine", September 12-14, 2005.

Luchter, S. (1995) Long Term Consequences of Lower Extremity Injuries, Proceedings of the International Conference on Pelvic and Lower Extremity Injuries, December 1995, Washington, D.C.

Luna, G. K. et al (1984) The influence of ethanol intoxication on outcome of injured motorcyclists. *Journal of Trauma* 24(4): 695-700.

Lund, J., Bjerkedal, T. (2001) Permanent impairments, disabilities and disability pensions related to accidents in Norway. *Accident Analysis and Prevention*, 33, 19-30.

Lundälv, J. (2005) Involuntary manslaughter in Nordic road fatalities: frequency, long-term consequences, social work interventions, and social support in the Nordic welfare states. Paper presented at the Conference Road Safety on Four Continents, Warsaw, Poland, October 2005.

Lynn, P. and Lockwood, C. (1998) The accident liability of company car drivers. TRL Report TRL317. Crowthorne: TRL Limited.

MacKenzie, E. J., Siegel, J. H., Shapiro, S., Moody, M. and Smith, R. T. (1988) Functional Recovery and Medical Costs of Trauma: an analysis by type and severity of injury. *Journal of Trauma*, 28, 281-297.

MacKenzie, E. J., Cushing, B. M., Jurkovich, G. J., Morris, J. A. Jr., Burgess, A. R., deLateur, B. J., McAndrew, M. P. and Swionkowski, M. F. (1993) Physical impairment and functional outcomes six months after severe lower extremity fractures. *Journal of Trauma*. April 34 (4).

Martin, P. G., Crandall, J. R., Pilkey, W. D. and Miller, T. R. (1997) Passenger Car Drivers: Annual Injury Incidence and Costs Projected to 2005, 41<sup>st</sup> Association for the Advancement of Automotive Medicine Conference.

Martin, A. (2006) Factor Influencing Pedestrian Safety: A Literature Review. Unpublished Project Report UPR SE/199/05. TRL Limited.

Matthews, L. R. (2005) Work potential of road accident survivors with post-traumatic stress disorder. *Behaviour Research and Therapy* 43, 475-483.

McNally, R., Bryant, R. A., Ehlers, A. (2003) Does early psychological intervention promote recovery from posttraumatic stress? *Psychological science in the public interest*, 4 (2) November 2003.

Merlevede, E., Spooren, D., Henderick, H., Portzky, G., Buylaert, W., Jannes, C., Calle, P., Van Staey, M., De Rock, C., Smeesters, L., Michem, N., van Heeringen, C. (2004) Perceptions, needs and mourning reactions of bereaved relatives confronted with a sudden unexpected death. *Resuscitation* 61, 341-348.

Miller, T., Martin, P., and Crandall, J. (1995) Costs of Lower Limb Injuries in Highway Crashes. Proceedings of the International Conference on Pelvic and Lower Extremity Injuries, December 1995, Washington, D.C.

Ministerio de Educación y Ciencia (2004) Cuaderno Didáctico sobre Educación Vial y Salud, Madrid.

Morgan, R. M., Eppinger, R. H. and Hennessey, B. C. (1991) Ankle Joint Injury Mechanism for Adults in Frontal Automotive Impact, 35<sup>th</sup> Stapp Car Crash Conference, San Diego, California, USA.

Morris, A., Mackay, A., Wodzin, E., Barnes, J. (2003) Some injury scaling issues in UK crash research. IRCOBI Proceedings, pp. 283-292, September 2003, Lisbon.

Morris, A., Welsh, R., Barnes J. and Frampton, R. (2006) The nature, type and consequences of lower extremity injuries in front and side impacts in pre- and post-regulatory passenger cars. Paper presented at 2006 IRCOBI conference, Madrid.

Møller Danø, A. (2004) Road Injuries and Long-Run Effects on Income and Employment. Institute of Local Government Studies, Denmark.

National Association of Emergency Medical Services Physicians (NAEMSP) and the National Association of State EMS Directors (NASEMSD) (1994) Use of warning lights and siren in emergency medical vehicle response and patient transport. Prehospital Disaster Medicine 9: 133-136.

Nielsen, M. S. (2003) Prevalence of posttraumatic stress disorder in persons with spinal cord injuries: the mediating effect of social support. Rehabilitation Psychology 48 (4), 289-295.

OECD-IRTAD (1994) Underreporting of road traffic accidents recorded by the Police, at the international level, Special Report of the OECD – Road Transport Research Programme and Public Roads Administration of Norway, Paris/Oslo.

Ore, L., Tanner, B., and States, J. (1993) Accident Investigation and Impairment Study of Lower Extremity Injury. SAE Technical Paper No. 930096.

Osler, T., Baker, S. P., Long, W. (1997) A modification of the injury severity score that both improves accuracy and simplifies scoring. The Journal of Trauma: Injury, Infection, and Critical Care, 43, 922-926.

Ossmann, E. W., Bartkus, E. A., Olinger, M. L. (1997) Pitfall: use of lights and siren. Emergency Medicine Clinics North America 15: 291-293

Parliamentary Assembly (2002) Towards concerted efforts for treating and curing spinal cord injury. Doc. 9401, 27 March 2002. Report. Social, Health and Family Affairs Committee.

Patterson, D. R., Questad, K. A., Boltwood, M. D., Covey, M. H., de Lateur, B. J., Dutcher, K. A., Heimbach, D. M., Marvin, J. A. (1987) Patient self-reports three months after sustaining a major burn. Journal of Burn Care and Rehabilitation 8: 274-279.

Perez, C., Cirera, E. (2004) Estudio de la Mortalidad a 30 días por Accidente de Tráfico (EMAT-30). Plasencia, A. (coordinator). Ministerio de Sanidad y Consumo, Madrid.

Pirrallo, R. G., Swor, R. A. (1994) Characteristics of fatal ambulance crashes during emergency and non-emergency operation. Prehospital Disaster Medicine 9: 125-132.

Plasencia, A. (2000) Epidemiología de las lesiones de tráfico en España. In Programa sobre accidentes de tráfico: prevención y asistencia. Álvarez, F. J., Blanco, E., Guisan, C., García, E., coordinadores, ed. Madrid: EMISA-SEMERGEN, 2000, pp.: 1.1-1.10.

Prigatano, G. P., Wright, E. C., Levin, D. (1984) Quality of life and its predictors in patients with mild hypoxemia and chronic obstructive pulmonary disease. Archives of Internal Medicine, 144, 1613-1619.

Rappaport, M., Hall, K. M., Hopkins, K., Belleza, T., Cope, D. N. (1982) Disability rating scale for severe head trauma: coma to community. Archives of Physiotherapy and Rehabilitation, 63, 118-123.

Richmond, T. S., Kauder, D. (2000) Predictors of psychological distress following serious injury. Journal of traumatic stress, 13 (4) 681-692.

Rodríguez, J. I. (2005) El reto de sobrevivir. Article published in Trafico Magazine (magazine of the Spanish Directorate General for Traffic), November-December 2005 issue, Madrid.

Saunders, C. E., Heye, C. J. (1994) Ambulance collisions in an urban environment. *Prehospital Disaster Medicine* 9: 118-124

SCT (2003) Accidents de trànsit a l'entorn laboral. Servei Català del Trànsit. Generalitat de Catalunya, Barcelona.

Simpson, H. F. (1996) Comparison of hospital and police casualty data: a national study. TRL report 173. Crowthorne: TRL Limited.

Sjölinder, K. (2001) STRADA – National information system concerning injuries and accidents within the road transport system. *Traffic Safety in Three Continents Conference*, Moscow.

Starr, A. J., Smith, W. R., Frawley, W. H., Borer, D. S., Morgan, S. J., Reinert, C. M., Mendoza-Welch, M. (2004) Symptoms of posttraumatic stress disorder after orthopaedic trauma. *The Journal of Bone and Joint Surgery*, 86 (6) 1115-1120.

Sælensminde, K. (2001) Verdsetting av trafikksikkerhet i ulike lands nytte-kostnadsanalyser. Arbeidsdokument SM/1352/2001, Oslo, Transportøkonomisk institutt.

Taylor, S. T., Koch, W. J., Fecteau, G. F., Fedoroff, I. C., Thorarson, D. S., Nicki, R. M. (2001) Posttraumatic stress disorder arising after road traffic collisions: patterns of response to cognitive-behavior therapy. *Journal of consulting and clinical psychology* 69 (3) 541-551.

Tecl, J. (2006) Estimation of the real number of road accident casualties. National study of underreporting – Czechia. Unpublished manuscript, Brno, CDV.

Tecl, J., Konarek Z., (2006) Socio-economic costs of road accidents in Czechia in 2005. Unpublished manuscript, Brno, CDV.

Thal, E. R., Bost, R. O., Anderson, R. J. (1985) Effects of alcohol and other drugs on traumatized patients. *Archives of Surgery* 120, 708-712.

Thomas, P. and Frampton, R. (1999) Injury patterns in side collisions - a new look with reference to current test methods and injury criteria, 43<sup>rd</sup> Stapp Car Crash Conference Proceedings, San Diego, CA.

Trawén, A., Maraste, P. and Persson, U. (2001) Methods for estimating road accident costs – A comparison of costs for a fatal casualty in different countries. Paper to *Traffic Safety on Three Continents*, International Conference in Moscow, 19-21 September, 2001.

Ursano, R. J., Fullerton, C. S., Epstein, R. S., Crowley, B., Vance, K., Kao, T.-C., Baum, A. (1999) Peritraumatic dissociation and posttraumatic stress disorder following motor vehicle accidents. *American Journal of Psychiatry* 156, 1808-1810.

Vaez, M., Laflamme, L. (2005) Impaired driving and motor vehicle crashes among Swedish youth: an investigation into drivers' sociodemographic characteristics. *Accident Analysis and Prevention*, 37, 605-611.

Verhaeghe, S., Defloor, T., Grypdonck, M. (2004) Stress and coping among families of patients with traumatic brain injury: a review of the literature. *Journal of clinical nursing*, 14, 1004-1012.

Waller, P. A. et al (1986) The potentiating effects of alcohol on driver injury. *Journal of the American Medical Association* 256(11): 1461-1466.

Wesemann, P. (2000) Economic evaluation of road safety measures. Contribution to the 117<sup>th</sup> Round Table, 26 and 27 October 2000, Paris. SWOV Publication D-2000-16E. SWOV Institute for Road Safety Research, The Netherlands.

World Health Organization (1986) International Classification of Impairments, Disabilities and Handicaps, Geneva.

World Health Organization. (2002) Towards a Common Language for Functioning, Disability and Health, ICF, World Health Organization, Geneva.

World Health Organization (2004) World report on road traffic injury prevention, Geneva.

Yahya, M.-R. (2001) Invandrare och trafiksäkerhet. Förstudie. VTI meddelande 907, Linköping, Väg- och transportforskningsinstitutet.

Zambon, F., Hasselberg, M. (2006) Socioeconomic differences and motorcycle injuries: age at risk and injury severity among young drivers – a Swedish cohort study. Accident Analysis and Prevention, 38, 1183-1189.

Zatzick, D. F., Kang, S. M., Müller, H. G., Russo, J. E., Rivara, F. P., Katon, W., Jurkovich, G. J., Roy-Byrne, P. (2002) Predicting posttraumatic distress in hospitalized trauma survivors with acute injuries. American journal of psychiatry, 159, 941-946.



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