SUNflower+6

Development and application of a footprint methodology for the SUNflower+6 countries

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Foreword

The number of road traffic crashes, fatalities, and casualties is decreasing in all European countries, as it is in other high-income and highly motorized countries in the world. Despite an ongoing increase of motorization, we manage to reduce the numbers of deaths and (seriously) injured by investing in the safety quality of the road traffic system. However, the toll of crashes on our roads is still considered to be unacceptably high. Almost all European countries are working with road safety targets, expressing their intentions to improve road safety. The European Commission itself is very ambitious indeed: it aims at halving the number of fatalities in the first decade of the 21st century.

The SUNflower concept can be considered as an important contribution to the goal of reducing the road crash toll on our roads. It is based on comparing road safety policies, programmes and road safety performances in different European countries. Building upon a methodology developed in the original SUNflower project, the policies in different countries are compared and trends are identified. The results are of potential value for the countries involved, for other countries, and for the European Union. SUNflower offers the possibility for countries to learn from each other and by doing so, to speed up road safety improvements.

As road safety is a complex problem, we need to understand the past as thoroughly as possible in order to learn from it and to even change the future. All who are familiar with this problem know that fast and easy solutions cannot improve road safety in a sustained way. Understanding the past in order to learn lessons for the future is the essence of SUNflower. The SUNflower methodology is data driven and knowledge based. Comparing policies and trends in different countries is of a very complex nature, never being sure of not overlooking an important factor, or one or two underlying forces. But surprisingly enough, the results are always astonishing, sometimes they confirm prejudices, often they are eye-openers, and sometimes they are groundbreaking.

SUNflower started in 1999 and reported its first result with *SUNflower: a comparative study of the development of road safety in Sweden, the United Kingdom and the Netherlands* in 2002. Based on this, SUNflower is considered as a strong brand, appreciated and trusted. An honest and powerful methodology is now available.

It was decided to extend this first result and to expand it to SUNflower+6. In this study three groups of countries were formed: the original SUN countries (Sweden, United Kingdom and the Netherlands), the Central group (Czech Republic, Hungary and Slovenia) and the Southern group (Greece, Portugal and Spain and Catalonia). In SUNflower+6, a first consideration is given to the impacts of regional road safety actions with the autonomous region of Catalonia being benchmarked alongside Spain and other countries.

A large number of researchers from different countries was involved: David Lynam, Barry Sexton (TRL, United Kingdom), Göran Nilsson (VTI, Sweden), Charles Goldenbeld, Peter Morsink, Siem Oppe, Martine Reurings, Divera Twisk, Willem Vlakveld (SWOV, the Netherlands), Vojtěch Eksler, Jaroslav Heinrich (CDV, Czech Republic), János Gyarmati, Peter Holló (KTI, Hungary), Bruno Bensa, Nina Bolko, David Krivec (OMEGAconsult, Slovenia), Simon Hayes, Susana Serrano (DSD, Catalonia/Spain), Laia Pages Giralt (SCT, Catalonia), Pilar Zori (DGT, Spain), Yannis Handanos, Dimitris Katsochis, Chryssanthi Lymperi (Trademco, Greece), António Lemonde de Macedo, João Lourenço Cardoso, Sandra Vieira Gomes (LNEC, Portugal).

The results are summarized in five documents:

- SUN	*An extended study of the development of road safety in Sweden, the United Kingdom, and the Netherlands*
- Central	*A comparative study of the development of road safety in the Czech Republic, Hungary, and Slovenia*
- South	*A comparative study of the development of road safety in Greece, Portugal, Spain, and Catalonia*
- Footprint study	*Development and application of a footprint methodology for the SUNflower+6 countries*
- Final report	*A comparative study of the development of road safety in the SUNflower+6 countries: Final report*

In the Foreword of the SUNflower report (2002), I expressed my wish that the study would be used as a model and would trigger off further comparable studies. We have gone from one study to five, in which nine countries and one autonomous region have participated. I am grateful for that result and I expect the same success as from the initial SUNflower study.

I would like to thank the whole SUNflower+6 team. Their task was a very challenging one and everybody worked hard to produce high-quality reports. I am grateful for the European Commission and all our other sponsors in the different participating countries to make this study possible. I do hope the results will find their way to further reduction of the number of casualties on our roads.

Fred Wegman

Content

Summary

Progress in traffic safety is the result of many efforts, starting with political decisions, the development of safety plans and safety actions and their implementation. This report explores ways of presenting information from the SUNflower+6 countries in such a way that it shows how the interaction between these factors leads to changes in the quality of the traffic system, and finally to differences in safety outcomes. Simple one-factor bar charts cannot be used to this effect. A method¬ology has been developed, which for each country results in a 'road safety footprint' showing the state of the art on road safety. The road safety footprint is based upon the different levels of 'the safety pyramid' which underpins the SUNflower methodology. As a result a footprint gives a representation of the road safety status and development over time in a country, which can be used for benchmarking. At this stage, the proposed methodology is considered as a first step in the definition of an overall methodology, which may eventually grow into a widespread tool for benchmarking road safety.

The contents of the footprint has been specified on the basis of existing knowledge of the state of the art of road safety in at least some of the SUNflower+6 countries. At a conceptual level this has resulted in what is called a best practice scheme, which is rather com¬prehensive. This best practice scheme has been worked out in two levels of footprint schemes: a detailed footprint scheme and a summary footprint scheme. The safety indicators of these schemes contain (disaggregate) fatality numbers (final out¬comes), indicators for the quality of the traffic system (safety performance indica¬tors) and safety measures and programmes (policy output). The indicators reflect important safety characteristics of road users, road types, and transport modes. Examples are given of how to use the schemes to compare a country to a reference safety level, to compare development over time within a country, and to compare the safety performance of one country to another. A prototype expert system has been devel¬oped to enable users to carry out chosen comparisons. To collect input for the expert system, a template has been developed to fill in the data that were available in the framework of this project.

Based on the available data, safety trends and disaggregate outcomes have been analysed for the SUNflower+6 countries, to get a deeper understanding of footprint outcomes. It was found that in the SUN countries the decline of safety risk started early and led to a low risk level per kilometre travelled. This fact is not new. However, it is also shown that the Central and Southern countries are closing the gap: seen over three time periods, from 1981-1983, 1991-1993 and 2001-2003, their initial arrears are diminishing in absolute terms. These recent positive developments in road safety are a reflection of the safety activities that have taken place in those countries. There is reason to believe that the more attention is given to road safety, the more this is translated in safety actions. And the more actions are taken in various areas of safety, the more safety is improving in the SUNflower+6 countries. Furthermore, large differences in fatality rates per transport mode were found between the countries. The Weighted Poisson Models technique made it possible to identify such differences.

The first applications of the footprint methodology turned out to be promising. However, it must not be considered a finished job. The theory and application can be made more robust by strengthening the causal relationships between indicators at the different pyramid levels. The method can be improved further by applying it

under practical conditions, and by using more high-quality data. Finally, it is recommended to keep track of new developments in road safety, and to incorporate these in the method. Such an ongoing process can eventually improve the quality of the footprint application. Moreover, and more importantly, it can give a better understanding of road safety developments, and form a solid basis for further improvements.

1. Introduction

Monitoring, comparing and understanding the safety status of a country with that of other countries requires a broad insight in the traffic system. For this purpose, one needs to be aware of key factors and indicators that meaningfully monitor past developments (trend analysis) and the current state of affairs, and that help to identify possible further improvements. This identification is an important goal of the SUNflower+6 project. Benchmarking of the safety status and developments of a country with a reference are then possible.
A challenging task in this benchmarking process is to assemble knowledge into a country's road safety profile, which is reasonably concise. In addition to traditional ways of monitoring and analysis, such a profile could for instance be used for international comparison of the road safety status at a general level, using meaningful references. Together, they can lead to recommendations for the individual SUNflower+6 countries, other countries and the European Commission. This kind of approach is common practice in the field of economics and ecology for instance; and in that context it is commonly referred to as a country's footprint on that matter (Worldbank, 2005).

One of the goals of the SUNflower+6 project, is to develop a methodological framework for a country's road safety footprint. Such a footprint would help to identify deviations and could help identify possibilities for further improvements. At this stage, the proposed methodology is considered an initial step in the definition of a comprehensive methodology, based on state-of-the-art knowledge. Eventually, it may grow into a widespread tool for benchmarking road safety.

A road safety footprint of a country can be described as a representation of the road safety status of a country. It is:

- *a multiple score of standardized key indicators,*
- *that can be compared with meaningful references,*
- *expressed as a snapshot in time, and as a past picture over time.*

It includes:

- *a full picture of all impacts of road crashes,*
- *and their most relevant underlying elements and processes for which causal relationships are understood.*

This report consists of two parts. The first part (Chapters 2 and 3) describes the development of the footprint structure, for which the hierarchy of road safety levels is the starting point (Koornstra et al., 2002). The second part of the report (Chapters 4 and 5) is directed towards a deeper understanding of footprint outcomes, for which known analytical techniques are the starting point.

In the first part of the report three steps are distinguished. First, the basis of the methodology is presented in Chapter 2. It is determined which elements can be part of a *footprint* for *best practice* and by which indicators these elements can be expressed. At each hierarchical level, a selection of (the most relevant) indicators is made. Subsequently, the application perspective of the method is briefly discussed.

The second step deals with the elaboration of the chosen footprint format into two levels of footprint schemes: a detailed and a summary scheme. State-of-the-art knowledge in road safety and differences in availability and quality of data and definitions among the countries are taken into account (Chapter 3). This process results in a thorough, although quite comprehensive footprint scheme, that describes the most important safety processes and tries to detect relations between them. This *detailed scheme* only contains elements that are available in at least one of the countries. However, it was known beforehand that not all countries can complete it to the same extent at this time. First applications of this footprint scheme are presented, based on only a part of the scheme, for which sufficient information is available in the SUNflower+6 countries. Examples are given of an individual country's footprint, its development over time, and comparisons between countries.

The third step gives a proposal for a structure of a more concise scheme. This *summary scheme* can be considered as the type of scheme that is a useful interface to for example policy makers to facilitate a first glance overview of the safety profile in a specific country and in comparison with other countries. In this sense, the summary scheme is an important part of the eventual end result of the footprint development process.

The second part of the report (Chapters 4 and 5) is directed towards a deeper understanding of footprint outcomes. To better understand benchmarking outcomes, more detailed analyses are performed on both aggregate (Chapter 4) and disaggregate (Chapter 5) safety outcomes. Furthermore, continuous time developments are investigated to understand the underlying trends. Part of this has been performed in the group reports for the SUN, Southern and Central countries (Lynam et al., 2005; Hayes et al., 2005; Eksler et al., 2005). These reports demonstrate the benefit of a '3 case benchmarking' approach, as a means of identifying recommendations for improvements in an individual country's performance. Here it will be extended to apply to all countries.

The main conclusions and recommendations are given in Chapters 6 and 7.

2. Methodology

2.1. Road safety hierarchy

The composition of a road safety footprint needs a fundamental understanding of road safety processes at different levels in the hierarchy of causes and effects that lead to casualties and costs for society. As for previous SUNflower tasks, the main reference is the safety pyramid model, which describes a target hierarchy of '*structure and culture*' towards *'social costs'* (Koornstra et al., 2002; LTSA, 2000). The pyramid serves as a comparison framework in three dimensions. Two of these dimensions are depicted in Figure 2.1, the third dimension being time.

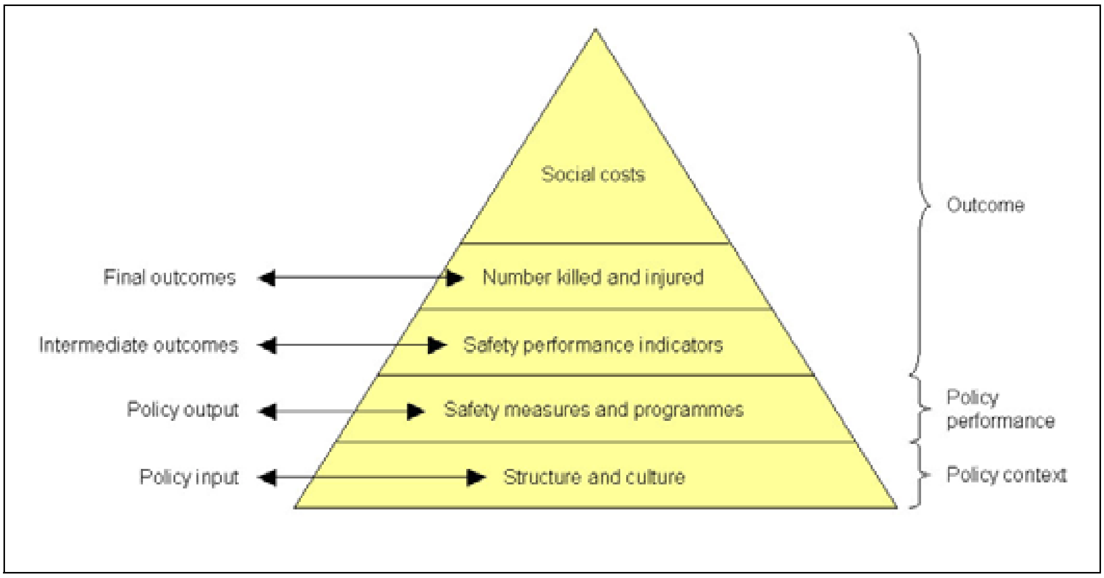


Figure 2.1. *A target hierarchy for road safety (Koornstra et al., 2002; LTSA 2000).*

The vertical dimension

The first (or vertical) dimension consists of the different levels of the pyramid. The most conventional way of describing the safety performance (*outcomes of the system*) is the *number of killed and injured*, indicated by *final outcomes*. On top of that are *social costs*, that can be related to the number of casualties and damage. Going down, *safety measures and programmes* reflect the *policy performance*, or the extent to which policy makers achieve to organize safety policy in goals, strategies and activities. This *policy output* should lead to an increase of the safety quality of the traffic system, which is reflected by better operational conditions (for example quality of roads, vehicles, behaviour). The indicators at this level are called *safety performance indicators* (SPIs), and are the *intermediate outcomes* between the policy output and the number of casualties. SPIs can predict safety levels before crashes have happened, assuming that causal relationships are known. At the bottom level, the *structure and culture* of a country describe the *policy context* such as public attitudes towards risk and safety, the organization of a country, and its history and cultural background. These matters should always be taken into account when trying to customize measures from one country to another.

In order to understand a country's road safety performance, one can move through the pyramid in both directions: bottom-up or top-down. For instance, from a sociological point of view, one can first describe public attitudes towards drinking or speeding (structure and culture) and climb the pyramid to identify measures (such as legal limits and enforcement activity) and consequently understand the extent of violation, and the related casualties and costs. From a cost-effectiveness point of view, one can take the opposite direction, by identifying which problems cause the highest costs and track those problems down to their origin and solve them in a cost-effective way. It is not necessary to start only at the bottom or top level, for instance when tracking the effects of implemented safety measures. Furthermore, some mechanisms are not bound by the sequence of pyramid levels. For instance, a change of casualty numbers or the occurrence of a severe crash with much publicity may directly affect public attitudes.

The horizontal and time dimensions

Each level of the pyramid contains a series of main problems, events or key safety topics. Rumar (1999) identified these at the three centre levels, as described in Appendix A. The performance of a country with respect to these problems is a reflection of its road safety performance. These problems can be disentangled into the components of the traffic system that constitute the structure of each level. This is called the *second (or horizontal) dimension*, which can be visualized by separated parts at each level of the pyramids. Road users, vehicles and infrastructure are the traditional components that can be subdivided into vehicle types, road types, user groups, age groups and typical behavioural aspects. Also differentiations in regions within a country, seasons within a year or types of casualties can be used here. The actual subdivision may differ between the different levels, but overlap and interaction is aimed at as much as possible, as will be described in the next section. Subsequently, developments of factors in both the horizontal dimension and the vertical dimension can be tracked over time*, the third dimension*.

2.2. Safety indicators

The road safety footprint of a country should be a composition of suitable indicators at all levels of the pyramid, and for all components. It can not be restricted to core data only, since countries that perform almost identically at a macroscopic level, can show much difference at a detailed level, such as the implementation of measures and risks for individual modes. This was concluded in the SUNflower study (Koornstra et al., 2002), in which a wide range of safety indicators was identified.

Continuing this approach, the comparative group studies in the SUNflower+6 project have addressed additional subjects and consequently introduced additional indicators (Lynam et al., 2005; Hayes et al., 2005; Eksler et al., 2005). Based on these reports, and other activities (ongoing or finished), such as the SafetyNet project (http://safetynet.swov.nl), an overview is given of possible safety indicators. The aim is to let this set of indicators be a coherent footprint, rather than only presenting a limited number of indicators at the different levels. This is why the causal relationships between the key safety topics at the different levels (transitions over pyramid levels) should be known, relying on state-of-the-art knowledge.

Furthermore, the distinction between indicators at the different levels should be clear. A recurrent issue is the quality of legislation and standards, the degree of compliance, and the actual effect on daily traffic. For example, speed limits and road design standards are policy output, since they are based on a policy decision. The same holds for the number of police fines for speeding, since it describes the level of enforcement activity, based on a policy decision, and it does not describe the actual effect on speed. It is not only the existence of legislation and enforcement that matters, the quality of the limits and standards, and the quality of their implementation are very important as well. They ask for dedicated indicators. When it comes to the actual traffic effect, described by SPIs, the compliance with the respective law or guideline is an important criterion. However, there will only be a positive effect if the legislation is of sufficient quality, since compliance with a low quality law or standard will not improve safety outcomes.

The overview presented in this chapter is based on state-of-the-art knowledge and current practices in the SUNflower+6 countries. It is therefore considered the best that can be achieved at the moment, and it provides a robust starting point to be complemented with new knowledge or better insights in due time. Due to its conceptual nature, the overview sometimes represents a rather ideal situation. It may not easily be achieved by countries in the short term, but it gives a reasonable target for monitoring road safety performances.

2.2.1. Social costs

The social costs of road crashes are placed at the top of the pyramid model. This can be justified, because rational decision-making of societies and policy makers starts with a comparison of the impact of road crashes with outcomes of other policy areas. The use of monetary costs allows for combining various consequences of road crashes such as the number of people killed and injured. The monetary costs of road crashes can be divided in a subset of costs as presented in Table 2.1, which is also used in the Rosebud project (Hakkert & Wesemann, 2005).

Type of costs	Description
Medical costs	Costs of medical care after a crash, such as hospital treatment, rehabilitation, medicine, and adaptations for the handicapped
Gross production loss	Costs due to loss of labour by road crash victims on account of absenteeism, death and disablement
Material costs	The costs of damage to vehicles, road side objects etc. from road crashes
Settlement costs	The costs of fire brigade, police, and courts as the result of a road crash
Traffic jam costs	The costs of traffic jams (loss of time) caused by road crashes
Human costs	These costs express the monetary loss of quality of life

Table 2.1. *Social costs divided in subsets.*

Each of these individual subsets of costs can function as a social costs indicator. However, there is a lack of uniformity in the methodologies used across EU countries, as they use different methods for cost assessment.

Wesemann (2000) made an assessment for the Netherlands. As a result, a Dutch fatality was valued at 6.6 million euro in 1997 (1997 prices). This relatively high value in comparison with the European average of 3.6 million euro, as estimated by ETSC (1997), can be explained by a higher productivity per capita and a smaller ratio of fatalities/injured.

If a country has made no estimates for itself, costs calculations from other countries can be used, assuming they are customized for a country's conditions. In this situation, the results of a study carried out by Elvik (2000) are helpful. He clearly shows that the costs of road crashes vary from 1.3% to 3.2% of GNP (with an average of 2.1%) in eight European countries. Excluding human costs, this amounted to 0.5% to 2.8% of GNP (an average of 1.3%). In international comparisons, the GDP in PPP (Purchasing Power Parities) is often used to equalize the purchasing power of different currencies.

2.2.2. Final outcomes

Final outcomes can be expressed by registered casualty numbers which are the traditional way to present the road safety status of a country. They comprise all types of casualties, but for international comparison it is most feasible to restrict final outcomes to fatalities, since differences in definitions and registration rates of injury crashes among the countries distort comparisons of even crashes with severe injuries. However, we must realize that such a restriction to fatalities leads to an underestimate of the real extent of the problem.

A fundamental factor when interpreting fatality numbers is the distribution over different modes of transport, as different modes have very different risk levels. Another important factor is the interaction between the different modes. Crash matrices are a way to present fatalities per transport mode and crash opponent, as shown in the SUNflower+6 group reports.

For each of the components, described in Section 2.1, fatalities can be expressed in absolute numbers, as a percentage of all fatalities, or normalized with respect to population (mortality rate), number of vehicles (fatality rate), or number of motorized vehicle kilometres or person kilometres (fatality risk). The subdivision of the components is proposed in Table 2.2.

2.2.2.1. Transport modes

The modes with the highest fatality shares have been selected, based on the overview of crash matrices of all countries. Fatalities in Heavy Goods Vehicles (HGVs) are relatively rare and therefore HGVs are not listed as a separate component. However, they are taken into account as very relevant factor in the crash matrix and on the SPI level.

2.2.2.2. Road users

Age groups
The component 'road user' is strongly related to behavioural aspects. A first relevant way of addressing road user groups is by a subdivision in age groups. This allows for an identification of specific age-dependent behavioural aspects like driving experience, risk seeking, etc. The selection of age groups has been based on IRTAD definitions. It makes sense to monitor the involvement in fatal crashes rather than monitoring only fatalities within their own group. For young drivers this has already been done in Lynam et al. (2005) and this approach is recommended for all age groups in the future.

Components of the road traffic system		
Transport modes		Car occupant Pedestrian Cyclist Motorcyclist Mopedist
Road users	Age groups	0-14 15-17 18-24 25-64 65+
	Behavioural aspects	Alcohol and drugs use Speeding Wearing protection systems
Roads		Motorways A-level roads Other rural roads Urban roads

Table 2.2. *Subdivision of components of the road traffic system*.

Behavioural aspects

Behavioural aspects are interesting if they represent well-established risk factors. These factors can roughly be divided into two categories: not obeying legal traffic rules (legal limits for speed, alcohol usage, giving right of way, usage of protection systems, mobile phone use, red-light running etc.), and, secondly, the condition of the traffic participant (all kinds of impairments like alcohol and drugs, fatigue, cognitive and physical abilities, etc.). Ideally, behavioural aspects are used directly to quantify the occurrence of fatal crashes or fatalities. This has been tried, in the current state of the art, for speeding, alcohol usage and seatbelt or helmet wearing rates, but with varying success. Comparing countries turned out to be difficult due to a lack of standardized indicators and differences in registration practices.

Alcohol and drugs

Indicators reported in literature are 'the percentage of drivers over the limit in fatal crashes', and 'the percentage of fatal crashes registered with alcohol consumption as a main cause'. SafetyNet (SWOV, 2005) proposes the following indicator, which could become more suitable for international harmonization:

- the percentage of on-the-spot fatalities resulting from crashes involving at least one impaired active road user, with substance concentrations above predetermined impairment threshold, for a standard set of psychoactive substances.

In the current situation this will be restricted to violations of the legal BAC limit, although differences in legal BAC limits make comparisons difficult. Only on-the-spot fatal crashes are chosen to bypass the differences in definition of fatal crashes between countries, and possible insecure testing several days after the accident. Active road users are all road user categories except passengers (drivers, riders or pedestrians).

If this indicator is not feasible, the following indicator could be used as a substitute:

- the percentage of killed drivers under the influence of alcohol and/or drugs with respect to all killed drivers.

Speeding
An indicator reported in literature is 'the percentage of fatal accidents registered with speeding as main cause'. To make this assessment, a distinction should be made in road type, legal speed limit, and temporary conditions at the crash location (weather, traffic density, etc.). In fact one wishes to know if the speed has been appropriate, but this is difficult to determine. It may be easier to determine if the speed has been excessive, since this can be related to the legal speed limit. The following indicator may then result:

- the percentage of all fatalities in which excessive speed has been a major contributing factor.

Protection systems
For protection systems the following indicators can be defined:

- the percentage of all fatalities among car occupants for which not wearing a seatbelt or child restraint system (CRS) has been a major contributing factor,
- the percentage of all fatalities among riders of powered two-wheelers (PTWs) for which not wearing a helmet has been a major contributing factor.

In practice, it will be very difficult to assess if not wearing the protection system is the cause of the fatality. Therefore the following substitute indicators will just describe the wearing of the device:

- the percentage of fatally injured car occupants not wearing seatbelts or CRS,
- the percentage of fatally injured riders of PTWs not wearing a helmet.

2.2.2.3. Roads

For roads, a suitable indicator is the safety risk per road type. This can be further subdivided into the different transport modes on these roads. The fatality percentage per road type can only be used if it can be corrected for the traffic share per road type.

The most feasible way to make a selection of road types at this stage is to use the IRTAD definitions that distinguish four road types: motorways, A-level roads, other rural roads and urban roads. However, these types are not very specific for attributing safety features. Safety levels on these road types show large variations among countries. This is partly due to different definitions of road types or standards, which make it very difficult to have an uniform attribution of roads to these categories. Therefore, for future applications a better harmonized road classification system and well defined standards are recommended. Initiatives are being made in the SafetyNet project (SWOV, 2005), as described in Appendix B.

2.2.2.4. Overview

Table 2.3 gives an overview of indicators per component.

Vehicles/modes		
Collision matrix		
Per mode		
	Fatalities/km	
	Fatalities/vehicle	
	Fatalities/population	
Age groups		
Per age group		
	Per mode	
		Fatalities/km *or*
		Involvement in fatal crashes/km
	Per mode	
		Fatalities/licence
		Fatality percentage of all fatalities
	Fatalities/population (in that age group)	
	Fatality percentage of all fatalities	
	Fatalities/whole population	
Behavioural aspects		
Alcohol and drugs		
	Percentage of on-the-spot fatalities resulting from crashes involving at least one impaired active road user	
	Impaired killed drivers/all killed drivers	
Speeding		
	Percentage of fatalities due to excessive speeds	
Protection systems (helmets, seatbelts, CRS)		
	Percentage of fatalities of car occupants not wearing a seatbelt	
	Percentage of fatalities of riders of PTWs not wearing a safety helmet	
Roads		
Per road type		
	Per mode	
		Fatalities/km
	Fatalities/km	
	Fatality percentage of all fatalities	

Table 2.3. *Indicators for final outcomes per component*.

2.2.3. Intermediate outcomes

Intermediate outcomes describe the operational safety conditions of traffic, i.e., the actual traffic circumstances that influence, and predict crash and injury occurrence. They reflect the safety quality of the components roads, vehicles and road users. The SPIs involved, add valuable information to crash and injury records which do not necessarily reflect the full extent of the problem (for example due to registration practices and other causes or circumstances).

In the SafetyNet project a methodology is being developed to define SPIs and to specify their quality level (SWOV, 2005). The project uses the following definition of SPIs:

Safety performance indicators reflect those operational conditions of the road traffic system that influence safety performance, with the purpose:

- *to reflect the current safety conditions of a road traffic system,*
- *to measure the influence of various safety interventions,*
- *to compare between different road traffic systems (for example countries, regions).*

The causal relation is important between an SPI and the road safety problem it refers to. If this relation is not well-established, the SPI becomes detached from the problem. Two aspects are essential: the quality of the theoretical basis for the SPI and the quality of the data with which the SPI value is calculated. SPIs can be organized in seven key road safety domains (SWOV, 2005; ETSC, 2001), as specified in the following sections.

2.2.3.1. Alcohol and drugs

Drivers that are impaired by alcohol and drugs have a considerably higher crash rate than drivers that are not. Although more knowledge is needed about how substances, in what concentrations or doses, and in what combinations influence risks, there is no doubt that the crash rate increases with increasing blood alcohol concentration. This fact is illustrated by the much higher prevalence of alcohol among killed drivers than among the general driver population.

The most relevant indicator at this stage is:

- the percentage of the general road user population impaired by alcohol and/or drugs.

It can be made more specific by focussing on motorized vehicles, and by linking it to the legal limit.

2.2.3.2. Speeding

The relation between speed and road safety has a long history of research. Although an unambiguous quantification of speeding with respect to final outcomes has not yet been made, there have been several studies that addressed at least part of the problem quite well. The influence of two aspects of speeding on road safety in general and on speeding-related risk is generally acknowledged: the average speed and the speed variability on a specific road type (Aarts & Van Schagen, 2006; Nilsson, 2004; Elvik, Christensen & Amundsen, 2004). Both higher speeds and large speed differences, which are correlated, increase crash risks and the injury risk once a crash occurs. The underlying mechanisms are a reduction of available time for the driver to react to changes, a reduction of vehicle manoeuvrability, a longer stopping distance needed, and a higher level of impact energy to be dissipated by the crash partners.

Based on this reasoning, at least two types of speeding SPIs are proposed: a measure of the absolute speed level, and a measure related to the speed data dispersion. These indicators have to be attributed to different vehicle types and road types in which the speed limit serves as an important specification. When directly involving the speed limit, the following indicator can be used:
- the percentage of drivers over the limit.

Furthermore, the current state of the art proposes a series of indicators that can be derived from speed distributions. The two indicators that are mostly reported in literature, are:
- mean speed,
- standard deviation of speed.

2.2.3.3. Protection systems

Protective systems (seatbelts, airbags, child restraint systems and helmets) all aim to reduce the severity of injuries, once a crash has occurred. They have a significant demonstrated effect on injury severity rates. Availability and appropriate use of protective systems are therefore important safety issues.

A number of indicators concerning usage rates of protection systems is proposed. They are intended to give an overall picture on the wearing/usage rates in a country, and therefore aggregated values covering all road types and road user groups are preferred. Aggregation is based on weighing by exposure in traffic.

The SPIs concerning wearing rates of seatbelts are:
- seatbelt: front seats of all relevant motorized vehicles,
- seatbelt: rear seats of all relevant motorized vehicles,
- child restraint: front and rear seat of all relevant motorized vehicles.

The SPIs concerning usage rates of safety helmets are
- crash helmet: cyclists, mopedists, and motorcyclists.

These indicators are preferably observed in roadside surveys. Self-reported rates (questionnaires) and rates reported by the police are not as good.

2.2.3.4. Daytime Running Lights

Vehicle visibility in both day and night time is well known to affect road safety. Daytime Running Lights (DRL) for cars in all light conditions is intended to reduce the number of multi-party crashes by increasing the cars' visibility so that they are noticed more quickly. The idea for basing a SPI on DRL is the positive relation between the level of DRL use and safety.

The resulting SPI is:
- the percentage of vehicles using daytime running lights.

The general indicator is estimated for the whole sample of vehicles, which is available for a country. If enough data is available, a similar value can also be calculated for different road categories and for different types of vehicle (presuming identical measuring times).

For the interpretation of DRL rates it must be noted that there are large differences in legislation among countries. In some countries DRL is obligatory, although sometimes only for certain periods of the year, for certain vehicle categories, and for certain road categories. In other countries, headlights are switched on automatically.

2.2.3.5. Passive vehicle safety

The level of protection in a crash depends on the safety quality of a vehicle, on characteristics of the crash (speed, angle), and on characteristics of involved crash opponents. Vehicles should protect their own occupants, but they should also be compatible with other vehicles. This means that vehicle constructions (together with protections systems) should be able to dissipate enough impact energy and absorb a proportional share of it, to reduce injury risks for all road users involved in the crash (car passengers and other road users). For this purpose indicators can be identified based on crashworthiness scores of vehicle types and composition of the vehicle fleet.

Crashworthiness
The EuroNCAP star rating is a widely used measure of the level of passive safety of passenger cars. It gives a comparative safety rating of a car in its class, based on crash tests (front, side, pole, pedestrian). It is generally recognized that cars, designed to meet EuroNCAP test procedures, offer better protection to vehicle occupants than vehicles that were designed before the EuroNCAP test programme. A passive safety rating of the passenger car fleet can thus be achieved by aggregating the EuroNCAP scores per car type over the whole fleet. In a step-by-step manner the following indicator can be defined, assuming all types of car are tested:

- multiply the EuroNCAP score per car type with the number of cars of this particular type,
- summarize the outcomes of all types,
- divide this number by the size of the car fleet.

This will produce a final SPI value giving each country a score for the protection offered by EuroNCAP tested cars. Similar programmes for other vehicle types may result in a comparable indicator.

If not all the test outcomes per type are available, the following indicator can be used as a substitute:

- the percentage of vehicles in the fleet that is tested according to EuroNCAP.

Fleet age
If not all types are tested, the percentage of older and newer vehicles in the fleet can be used for adjusting the outcome of the previous indicator (SWOV, 2005). Fleet age can also be used as a substitute indicator in itself. Since newer vehicles are more equipped with state-of-the-art safety technology, and contain a higher level of structural crashworthiness, they offer more protection than older vehicles. So the overall age of the fleet gives a general indication of the safety of the fleet. To increase the validity of the indicator, the exposure of groups of vehicles of different

age should be taken into account. On average, the exposure of new cars is higher than that of older cars.

Fleet composition
The vehicle fleet composition, especially the share of the 'aggressive' vehicle types such as heavy goods vehicles (HGVs) and light trucks, gives an indication of the safety of a fleet, since vehicle-to-vehicle compatibility has a well-recognized effect on injury outcomes in crashes. In general, compatibility relates to differences in weight, external geometry, and body stiffness. For example, a high percentage of heavy goods vehicles in the fleet, is likely to increase the number of car-against-HGV crashes, which will increase the number of severe injuries. Also, a high percentage of high-risk vehicles, such as motorized two-wheelers gives an indication of crash and injury exposure. A subdivision in vehicle types, starting with vehicle weight, is recommended. Based on this weight classification, the following indicator can be defined:

- compatibility ratio based on the weight distribution of the vehicle fleet.

The score of this ratio will be 1 in the theoretical case that all vehicles have the same weight. More deviating scores will be obtained when weight differences increase.

2.2.3.6. Roads

The safety performance of the road transport system is the result of the (right) combination of the functionality, homogeneity, and predictability of the network, the road environment, and the traffic involved (Wegman et al., 2005). Therefore, safety problems related to infrastructure are best organized at a minimum of two levels: the road network layout and individual road design. To define suitable SPIs, quantitative relations between the network layout, road design elements and standards, and road safety have to be known sufficiently well. Although knowledge is still lacking, it is known that conflicts and related crashes can be prevented and the consequences of crashes can be mitigated by choosing the right elements or facilities in the road network or on individual roads. Based on these elements and facilities, SPIs are proposed in SafetyNet (SWOV, 2005).

Road types can be classified according to functional road categories (flow, distributor, access) as described in Appendix B. Based on the distribution of road types of a network, one can assess the structure of the network from a functional point of view (i.e., have the right roads been positioned at the right place, or what is the percentage of road types in the road network hierarchy).

At the *road network level,* the following SPIs apply:

- road length percentage of different road types,
- share of intersection types (grade separated, roundabout, at level signalized, not signalized),
- intersection density.

At the *road design level*, one can assess if the physical appearance and characteristics of a road comply with its functionality. This should have been made concrete by specific design features. When taking into account four frequently occurring crash types (run-off-the-road, head-on, intersection, and crashes involving vulnerable road users), the following SPIs have been derived (per road type):

- percentage of roads with a wide median or median barrier,

- percentage of roads with a wide obstacle-free zone or roadside barrier,
- percentage of road length with facilities for separation of slow vulnerable traffic and other, motorized traffic.

It should be noted that information about traffic volume and speed is very useful to improve the interpretation of safety outcomes. The first two SPIs are mainly applicable to motorways and main arteries with relatively high speed limits in rural areas or urban areas, or roads in a specific geographical setting (for example along an abyss). The third SPI mainly applies to lower level roads in the rural and urban network. The listed items are addressed in the European Road Assessment Programme project (Lynam, 2003) as well, and progress in this project should be monitored for future updates of indicators and available data.

To meet current practices in a country, the SPI should be related to the prevailing road design standards. This can be indicated by the percentage of roads fitting into the design standards. However, standards and assessment protocols may vary significantly among countries.

2.2.3.7. Trauma management

Good emergency services increase the chances of survival and, on survival, the quality of life in case of severe injuries. Therefore, high-quality post-crash care relates to a high road safety level. ETSC (2001) proposes the following SPIs:

- arrival time of emergency services at the place of the crash,
- the quality of medical treatment.

SafetyNet gives a more detailed specification (SWOV, 2005).

2.2.3.8. Overview

An overview of SPIs is presented in Table 2.4.

Vehicles/modes		
Per mode		
	Crashworthiness (EuroNCAP scores for passenger cars)	
	Fleet composition (share within the whole fleet)	
	Compatibility ratio	
	Fleet age	
Behaviour		
Drinking & Driving		
Percentage of road user population impaired by alcohol and/or drugs		
Percentage of road user population over the legal limit		
Speed		
Per road type		
	Per vehicle type	
		Mean speed
		Standard deviation
Protective systems usage rates		
Seatbelts: • seatbelt in front seats; all relevant motorized vehicles • seatbelt in rear seats; all relevant motorized vehicles • child restraint systems in front and rear seat; all relevant motorized vehicles		
Helmets: • crash helmet; cyclists, mopedists, motorcyclists		
Daytime running lights (DRL)		
• DRL rate per road type and vehicle type • DRL rate, total		
Roads		
	Road network • Percentage length of road types • Percentage of intersection types • Intersection density	
Per road type		
	Road design • Percentage of road length with a wide median or median barrier • Percentage of road length with a wide obstacle-free zone or roadside barrier • Percentage of road length with facilities for separation of slow vulnerable traffic and other, motorized traffic	
	The percentage of roads that meets the design standard	
Trauma management		
Arrival time of emergency services at the place of the crash		
The quality of medical treatment		

Table 2.4. *Indicators for intermediate outcomes per component*.

2.2.4. Policy output

Policy output refers to the nature and content of national road safety plans, action programmes, and safety related standards and legislation. This level can describe how road safety policy and activities are organized, the road safety programmes themselves, and the associated targets and measures.

First, at a general level, the following indicators can be used:

- the existence of specific safety organizations,
- the existence of safety programmes,
- the existence of quantitative targets,
- types and number of measures that have been taken (for example regarding: drinking & driving, seatbelts and helmets, speed, vehicle fleet characteristics, infrastructure, young drivers, vulnerable road users).

In Chapter 4 this will be elaborated further.

At a more detailed level, two types of indicators can be distinguished referring to:

- the quality of the policy documents,
- the quality of the implementation of these documents.

Table 2.5 gives a listing of evaluation items for policy documents (Wegman, 2004). At this stage, the judgement of policy documents resulting in a score, is based on expert opinions.
Wegman (2004) also lists circumstances that influence the implementation quality of the policy documents and that are useful for monitoring progress (Table 2.6).

Evaluation items for policy documents
The political support of the document
The precision of the definition of goals/objects/targets
The use of valid causal theory (problem – solution)
The available means (implementation + monitoring)
The reduced necessity of inter-organizational decisions
The sanctions/incentives for co-producers and target audience
The implementation priority for all stakeholders
The active support of stakeholders

Table 2.5. *Evaluation items to measure the quality of policy documents (Wegman, 2004)*.

Factors which influence the implementation quality of policy documents
The economical/social/political environment
The public support (see SARTRE project)
The progress of the implementation of the policy documents
The support of key stakeholders
The quality of the 'delivery mechanisms'

Table 2.6. *Influence factors for the implementation of policy documents (Wegman, 2004)*.

The likelihood of countries implementing effective safety policies in specific areas may be assessed by scoring the evidence of national government support and funding for safety measures and the existence of strong linkages between central and local government and of local partnerships between delivery agents (Lynam et al., 2005).

The legal background of participation in traffic and enforcement are important issues at this level. Indicators for enforcement policy should reflect the interactive effect of the law, the enforcement level, the system of sanctions and their application, and the attitudes of the public towards enforcement of the issue.
In the current situation, policy implementation indicators, as listed in Table 2.7, have been identified.

Vehicles
• Existence and quality of periodic vehicle inspection • Percentage of cars completely equipped with seatbelts • Percentage of bicycles with side reflectors/lighting
Behaviour/enforcement
The legal BAC limit
The speed limit system (limits per road type)
The chance of getting caught (violations/population) for • Driving with too high a BAC • Not wearing a seatbelt • Speeding
The penalty level of[1] • BAC violation • Seatbelt/helmet violation • Speed violation • Red light violation
Percentage of paid fines
Behaviour/education
Driver training programmes and the access age
The existence and quality of an annual test (for example an eye test) for drivers older than 59
The quality of the education for powered two-wheelers (PTWs)
The existence and type of driver's licence for PTWs
Roads
The quality of the road design standards
The percentage of all residential areas designed as a 30 km/h zone
Traffic calming progress

Table 2.7. *Policy implementation indicators*.

[1] This can be expressed with respect to Purchasing Power Parity.

2.2.5. Structure and culture

The context for policy makers is strongly influenced by overall characteristics of society defined by for instance the economical environment, the way a country is organized and governed (for example the relation between central and local governments), cultural aspects and (more or less temporary) emotions and attitudes among the public (e.g. how to respond to laws).

For example, it makes a big difference if there is a high sense of urgency about the reduction of road safety toll. In order to achieve this, it is necessary to make people aware of the problem by relevant statistics and to convince them that traffic fatalities can indeed be prevented (by proposing a safety policy), instead of just accepting a high number of road fatalities as 'a fact of life'. Furthermore, the social acceptance of unwanted behaviour in both 'shame and guilt cultures' such as drinking & driving and speeding have a clear effect on the observed frequency of this type of behaviour.

The 'structure and culture' level should be developed further, before incorporating it into this footprint methodology.

2.3. Application aspects

Footprint based benchmarking is mainly meant to show deviations from a reference point for a country. This especially concerns those deviations that indicate a worse performance than the reference point. It is not meant to completely explain all observations regarding the road safety of a specific country, but it can highlight items that need improvement, and that should be investigated in more detail. This section discusses some relevant aspects for the application of the footprint methodology.

2.3.1. Meaningful references

The type of reference that is interesting for benchmarking differs per country and may change over time. Some examples of meaningful references are given below.

References for individual countries:
- countries that perform better; incentive to the 'best-in-class' approach,
- the average of a wide range of countries: to put the own situation into perspective, and determine one's position within a group of countries,
- road safety targets; to provide insight for making the right choices to reach the targets.

References for the European Commission:
- determine which countries lag behind on the average, and on which topics,
- determine which improvement efforts are efficient for reaching targets (2010 target for example).

2.3.2. Developments over time

The indicators that have been identified in the previous section can be used to assemble an ideal footprint for a country. It can reflect the country's situation at a particular moment in time, but a footprint should also give insight in developments over time. This can be achieved in two complementary ways. First, footprint schemes can be designed for different time periods, giving a discrete representation of the performance. Furthermore, time trends will show continuous developments over time, for a limited number of general safety indicators. The following trend lines are proposed to be part of the footprint:

- mortality (fatalities per unit of population),
- fatality risk (fatalities per unit of motor vehicle kilometres),
- fatality rate (fatalities per unit of motor vehicle fleet).

The reason to restrict the risks and rates to motor vehicles is based on the availability of data on this mode only in many countries.

2.3.3. Validity considerations

2.3.3.1. General methodology

It should in the end be possible to track a specific road safety aspect through all levels of the pyramid. For example it should be possible to track high social costs of a particular safety aspect down to casualty numbers, via operational conditions of traffic, to a measure that has or has not yet been taken, and the social, political and cultural environment that it originates from. The other way around is a valid option as well. For instance, a country that has implemented many safety measures, should perform relatively well on at least the safety aspects that are related to these measures. Or, if this is not the case, the reasons should be clear and reflected in the indicators as well. For example, it might be expected that the percentage of drivers under the influence of alcohol is high and can be related to a high percentage of fatal crashes in a country where a rather high BAC is permitted or where the police doesn't perform alcohol controls very often. The quality of the safety indicators and the quality (science based) of causal relationships between indicators at different pyramid layers are the success factors for this goal. With particular regard to these items, it is important to realize that the development of the methodology is an ongoing process which should adapt to new insights and new developments in the road safety working field.

2.3.3.2. Comparing countries

Transport background
When comparing road safety performances of countries, one should be aware of the fact that countries differ with respect to their transport background. This may be due to the geographical features of a country (flat, mountains), the climate, the light conditions and demographic characteristics. Also traffic volumes on different road types and factors like population density, the road network, motorization etc. can help explain differences.

These items have not been addressed by disentangling the road safety system into components and hierarchical levels. To compensate, it is recommended to add a section of transport background features according to the 'Fundamental Data list' in Koornstra et al. (2002) to the footprint format.

Motorization rate
The road safety development in countries is influenced by motorization rate (known as 'Smeeds' law). It is known that countries with a low motorization rate have a relatively poor performance in road safety (traffic risk expressed by a high fatality risk and/or a high fatality rate) and a relatively good performance in personal safety

(personal risk expressed by low mortality). With increasing motorization, the road safety performance became better and the mortality rate increased initially, but decreases again after a certain motorization rate has been reached (Trinca et al., 1988). This is depicted in Figure 2.2, which shows the traffic risk against the personal risk. Moving along the curve in the direction of the arrow represents an increasing motorization rate.

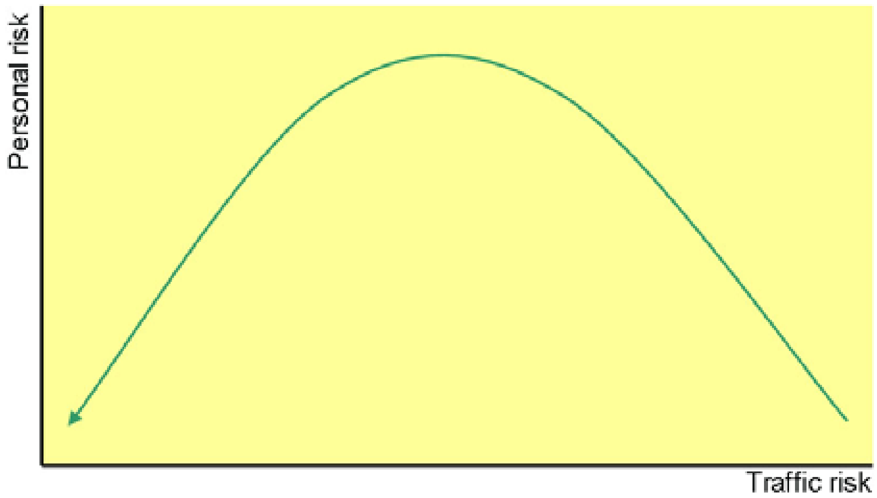


Figure 2.2. *Personal safety against traffic safety, related to increasing motorization rate (from right to left).*

For comparing countries, this mechanism should be taken into account. We have experienced that benchmarking is easier to interpret for countries that are grouped relatively close in this graph. The explanation of differences between countries that are grouped at significantly different levels of this graph may easily be supported by the observation that there is a big difference in the overall development of the transport system. In Chapter 4 the position of the SUNflower+6 countries in this conceptual graph will be illustrated.

3. Footprint schemes

This chapter describes the first steps that are necessary to make the methodology outlined in Chapter 2 operational. The first step addresses data aspects, and especially limitations in data availability and quality (Section 3.1). A lack of indicators and data availability, and the innovative character of the method, have already made clear that at this stage not all levels of the pyramid can be represented to the same extent. The three middle layers of Figure 2.1 are the most specific for road safety. The lower layer 'structure and culture' gives a general impression of characteristics of society, while the upper layer 'social costs' directly relates to the overall economic situation. Although these two layers are of major importance for viewing road safety in an overall perspective, it has been decided to initially focus on the layers specific for road safety.

The methodological framework is further concretized and visualized in two different types of schemes. The first (Section 3.2) is directly deducted from the methodological overview, while, driven by current practice and state of the art, some practical/sensible choices have been made. The second scheme (Section 3.3) is more concise and therefore easier to interpret as a first glance overview of a country's safety profile. This summary scheme can be considered as a further step in the development of the methodology, which is worth describing due to its promising character for future use. Based on these schemes, examples of possible application are presented. To prevent a far too wide listing of results, a selection of countries and graphs has been made.

3.1. Sources and quality of data

A complicating factor for application of the footprint method, on the relatively short term, are the differences in the availability and quality of data and the differences in definitions between countries. This can only partly be overcome by using the internationally harmonized data, that is currently available. Therefore the main data sources are the SUNflower+6 group reports, supplemented with data from the international IRTAD and CARE databases.

Incidentally some data has been obtained from reports dedicated to a specific topic, such as the European Road Statistics ERF (ERF, 2005), OECD benchmark reports (ATSB, 2002; ATSB, 2003), the Impact Assessment Road Safety Action Programme (Ecorys, 2005; Brüde, 2005) or additional data supplied by national representatives in the project.

For building up a complete footprint according to the description in Chapter 2, it is clear that current sources are not sufficient in availability and quality of data. Major shortcomings are data limitations because of lack of registration or varying registration efforts and practices, and data definitions. See for instance Appendix D of the Central group report, describing data reliability and comparability (Eksler et al., 2005). Below, some relevant aspects of current data sources and data acquisition processes will be discussed.

There are several international information and data sources on road crashes, which originate from different needs and demands. They have different information structures, different scopes of information, and different ways of collecting, processing and publishing data. Therefore this data needs to be accessed with caution and awareness of their specific features. An important problem is the definition of the basic terms, i.e., to have an internationally accepted common definition of crash features and characteristics for data comparison on the international level. A typical example is the definition of traffic fatalities. Some countries define traffic fatalities as only persons killed at the place of the crash. In other countries, persons that die within 24 hours after the accident, after 3, 6, 7 or 30 days, or even after one year, are registered as a fatality. It is obvious that common definitions are a prerequisite for international comparisons. Fortunately, for the example of fatalities, many countries provide standardized data and apply a common 30-days fatality definition: traffic fatalities comprise those persons that die within 30 days of the crash and as a result of the crash. And for other fatality definitions, transformation rules exist to make the data comply with the international definition.

Another example is the crash and injury definition. A problem is to define in which category a crash should be registered. The number of injury crashes, and especially those with fatal injury are more important than those with material damage only. Moreover, the injury level is often hard to compare, because of different definitions of severe or slight injuries. A common international definition does not yet exist.

Databases often differ by the level of data disaggregation, i.e., a distribution according to road user type, age, sex, road type etc. This is strongly determined by their original purpose and the type of operator. Crash databases can exist on a inter-governmental, non-governmental, or only on a national basis. They can have different modes of operation and access. Well-known international road traffic crash databases, for example, differ in the following aspects:

- needs and purpose,
- information structure,
- scope of the information,
- way of data collection,
- data processing,
- publishing and availability,
- regional coverage.

Individual countries may have problems with gathering consistent datasets over a longer time period. This can be due to the fact that the crash database was not developed well before a certain time, or due to a change in methodology which makes it difficult to compare different time frames. For instance in Portugal, the crash database was developed in 1989. For previous years, no disaggregate data but only general indicators (for example total number of crashes and casualties) are available. In Spain and Catalonia there was a change in methodology in 1982 and 1993.

Table 3.1 gives a specification of international road traffic crash databases. Appendix C gives a further description.

Database	Countries	Time covered	Transport data	Exposure data	Crash data	SPI data
IRTAD (OECD)	29	From 1989	Yes	Yes	Aggregated	Yes
CARE (DG-TREN)	25	From 1993	Limited	No	Disaggregated	No
ECMT	38		Limited	Limited	Aggregated	No
UN ECE			No			No
EUROSTAT	25		Yes	Yes	Aggregated	No
WHO	world		No	No		No
IRF	185	From 1995	No	Yes	Aggregated	No

Table 3.1. *Specification of international road traffic crash databases.*

As a very recent initiative, the SafetyNet project aims to develop a road safety observatory, in which data acquisition and indicator definition are important goals. Workpackage 3 describes the required collection and quality demands for data to calculate SPI values (SWOV, 2005). This may eventually fill in many of the gaps between necessary and available data for SPIs.

Appendix D describes the process and results of gathering data on a series of SPIs (seatbelts, protection devices, alcohol, and speed) for the SUNflower+6 countries.

3.2. Detailed footprint scheme

3.2.1. Structure

The detailed footprint scheme can be considered a summary of Chapter 2, translated into a kind of template or fact sheet, as depicted in Table 3.2. The new item *transport background* has been added to give a first impression of the country's settings. Then, successively, *final outcomes, safety performance indicators,* and *policy output* are included. The subdivision in components of the traffic system according to Table 2.2, is used as much as possible, in order to facilitate the identification of interactions between the pyramid layers. The scheme purposely displays indicators of varying quality levels (for final outcomes and SPIs) in order to facilitate countries that have relatively high data acquisition standards, and to provide a comparison basis for countries with lower standards. For policy output, a less fixed format is used, due to the strong variation in the type of available data per country, and the lack of indicators with proven applicability. In the following sections, examples of the application of this scheme are presented.

<table>
<tr><th colspan="2">Transport background</th></tr>
<tr><td>Road traffic fatalities
Population
Area
Public paved road length
Motorway length
Number of motor vehicles
Motor vehicle kilometres
Motor vehicle kilometres on motorways</td><td>Percentage of vehicle kilometres per road type</td></tr>
</table>

<table>
<tr><th colspan="61">Final outcomes - fatalities</th></tr>
<tr><td colspan="61">Collision matrix</td></tr>
<tr><td>Modes</td><td colspan="20">Fat./km (pkm and vkm)</td><td colspan="20">Fat./veh.</td><td colspan="20">Fat./pop.</td></tr>
<tr><td rowspan="4">Age groups</td><td colspan="12">0-14
Fat./km
per mode</td><td colspan="12">15-17
idem</td><td colspan="12">18-24
idem</td><td colspan="12">25-64
idem</td><td colspan="12">65+
idem</td></tr>
<tr><td colspan="30">Fat./population per age group</td><td colspan="30">% Fatalities per age group</td></tr>
<tr><td colspan="12">0-14
% Fatalities
per mode</td><td colspan="12">15-17
idem</td><td colspan="12">18-24
idem</td><td colspan="12">25-64
idem</td><td colspan="12">65+
idem</td></tr>
<tr></tr>
<tr><td>Behaviour</td><td colspan="60">• Percentage of on-the-spot fatalities resulting from crashes involving at least one impaired active road user
• Impaired killed drivers/all killed drivers
• Percentage of fatalities due to excessive speeds
• Percentage of fatalities due to car occupants not wearing a seatbelt
• Percentage of fatalities of riders of powered two-wheelers not wearing a safety helmet</td></tr>
<tr><td rowspan="2">Roads</td><td colspan="15">Motorways
Fat./vkm
per mode</td><td colspan="15">A-level roads
idem</td><td colspan="15">Other rural roads
idem</td><td colspan="15">Urban roads
idem</td></tr>
<tr><td colspan="30">Fat./vkm per road type</td><td colspan="30">% Fatalities per road type</td></tr>
</table>

<table>
<tr><th colspan="62">Safety Performance Indicators</th></tr>
<tr><td colspan="2">Modes</td><td colspan="20">Crashworthiness</td><td colspan="20">• Compatibility ratio
• Fleet composition</td><td colspan="20">• Fleet age</td></tr>
<tr><td rowspan="5">Behaviour</td><td rowspan="2">Speeding</td><td colspan="15">Motorways
Drivers
over the limit</td><td colspan="15">A-level roads
idem</td><td colspan="15">Other rural roads
idem</td><td colspan="15">Urban roads
idem</td></tr>
<tr><td colspan="60">Mean speed and standard deviation per road type</td></tr>
<tr><td rowspan="2">Daytime running lights (DRL)</td><td colspan="15">Motorways
DRL rate per
vehicle type</td><td colspan="15">A-level roads
idem</td><td colspan="15">Other rural roads
idem</td><td colspan="15">Urban roads
idem</td></tr>
<tr><td colspan="60">DRL rate per road type</td></tr>
<tr><td>Other</td><td colspan="60">• Percentage of impaired road user population
• Seatbelt wearing rates (front, rear, child restraint systems)
• Helmet wearing rates (motorcycles, mopeds)</td></tr>
<tr><td colspan="2" rowspan="2">Roads</td><td colspan="60">Percentage length of road types</td></tr>
<tr><td colspan="60">Per road type:
• Percentage of intersection types
• Intersection density
• Percentage of road length with a wide median or median barrier
• Percentage of road length with a wide obstacle-free zone or roadside barrier
• Percentage of road length with facilities to separate vulnerable road users from motorized traffic</td></tr>
<tr><td colspan="2">Trauma management</td><td colspan="60">• Arrival time of emergency services
• Quality of medical treatment</td></tr>
</table>

Fat. = fatalities; pop. = population; veh. = vehicles; pkm = person kilometres; vkm = vehicle kilometres.

Table 3.2. *Detailed footprint scheme*.

Policy output		
Types and number of measures		Types and number of measures that have been taken (e.g. regarding drinking & driving, seatbelts and helmets, speed, vehicle fleet characteristics, infrastructure, young drivers, vulnerable road users)
National road safety policy documents		• The political support of the document • The precision of the definition of goals/objects/targets • The use of valid causal theory (problem – solution) • The available means (implementation + monitoring) • The reduced necessity of inter-organizational decisions • The sanctions/incentives for co-producers and target audience • The implementation priority for all stakeholders • The active support of stakeholders
Implemen-tation	Organization	• National government support and funding • Linkages between central and local government
	Modes	• Existence and quality of periodical vehicle inspection • Percentage of cars completely equipped with seatbelts • Percentage of bicycles with side reflectors/lighting
	Behaviour/ enforcement	• The legal BAC limit • The speed limit system (limits per road type) • The chance of getting caught (violations/population); too high BAC, not wearing a seatbelt/helmet, speeding • The penalty level; violation of BAC, seatbelt/helmet, speed • Attitude/awareness of the public
	Behaviour/ education	• Training programmes and access age per mode • Existence/quality annual test (e.g. an eye test) for elderly drivers • The quality of the education for powered two-wheelers • The type of driver's licence for powered two-wheelers
	Roads	• The quality of road design standards • The percentage of all residential areas designed as a '30 km/h zone' • Traffic calming schemes application

Fat. = fatalities; pop. = population; veh. = vehicles; pkm = person kilometres; vkm = vehicle kilometres.

Table 3.2 (continued). *Detailed footprint scheme*.

3.2.2. Graph configuration

The footprint scheme contains several graphs, mainly at the levels of final outcomes and SPIs. Two types have been used, depending on the contents: bar graphs and star-shaped graphs.

The *star-shaped graph* is only used in cases where the size of the area inside the star is related to a safety performance. For example, if the star-shaped graph is used to visualize the usage rates of passive protection systems (for example seatbelts), then a larger area corresponds to higher usage rates. So, if in this graph the area for one country is larger than the area for another country, the first country performs better when it comes to passive protection systems. It is not always possible to conclude something from the area inside the star. If for example a graph shows the percentage of fatalities per age group, then the area is equal for all countries, namely 100%. In these cases the *bar graph* is used.

Star-shaped graphs are not very common. Therefore an explanation is necessary why this graph type is chosen instead of another type of area graph. In general, area graphs are an efficient way for visualization, since they allow for a quick identification of deviating results in benchmarking. Furthermore, they fit within the footprint philosophy since the shape of such a graph resembles the shape of a footprint. The first idea was to use simple *spider web* figures. This type of figure is also used in footprints for other policy areas (for example economy, ecology), and therefore can be considered as a trade mark of the footprint methodology. However, a disadvantage is that the order of the axes influences the area shown in the spider web. If for example there are four axes, two with very high values and two with relatively low values, putting the high valued axes next to each other gives a much larger area than putting the low valued axis in between them. To overcome this disadvantage the star-shaped graph was developed, which actually is an extended spider web figure. However, neighbouring axes are not connected to each other, but to a new axis in between them with the value zero. By setting the minimum value of all axes to a negative value, the star-shape is derived. As a result the area is independent of the order of the axes.

For each star-shaped graph, one of the subjects (for example country 1, country 2, reference, or time frame 1, 2 etc.) is chosen to be put on top. To prevent an underlying value from becoming invisible, its contours are shining through. In case of identical values, only the top colour can be seen, since the underlying contour coincides with the upper contour. Zero values indicate that information on that topic was not available.

3.2.3. Application

The scheme can be used for:

- monitoring individual countries, for example with respect to a common reference,
- monitoring a country's performance over time, for example with respect to specific targets for that country,
- comparison of countries, bilaterally, or with respect to a common reference.

For this purpose, the complete scheme can be filled in for different countries and time periods, but this is too extensive to report here. Therefore a selection of examples and a selection of graphs for each example has been made, and will be shown in the following sections. These examples are meant to illustrate the application of a part of the method, and to provide a reference for further exercises. For the selected figures within the examples presented, not always the preferred indicators are used, since they were not available for every country. In these cases substitute indicators are presented. The time trends that are part of the footprint as discussed in Section 2.3.2 are not presented here, but will be discussed in Chapter 4. Not all observations can be explained, since this requires further analysis for which the footprint has identified the necessity.

All data from the SUNflower+6 countries that has been used for these examples has been gathered in an Excel footprint data file, and has been made accessible through an Excel macro application.

3.2.4. An individual country's most recent footprint

A country's most recent footprint is useful to monitor the current safety status and to understand the interaction of safety processes. It also monitors the contribution of different components of the traffic system to safety for all pyramid levels. Preferably the performance is benchmarked with respect to a norm, for example the European average (or a country specific target). For now, this European average is represented by the SUNflower+6 average: based on values of those countries for which information on that topic is available. As a result, each graph will then display values of a country against the SUNflower+6 average.

The example has been worked out for the Netherlands. In Appendix E the whole scheme has been completed as far as is possible at this stage. In Table 3.3, a selection of graphs has been displayed for final outcomes and SPIs. The selection is meant to show examples of effects of indicators at the different pyramid levels and for different components. The following graphs are presented in the table:

Final outcomes:
- fatality risk,
- mortality per age group,
- fatality risk per road type,
- the part of the crash matrix that shows crash opponents with highest shares in fatal crash involvement (in percent).

Safety Performance Indicators:
- fleet composition,
- wearing rates of protection devices.

Transport background:
- vehicle kilometre share (percentage) per road type.

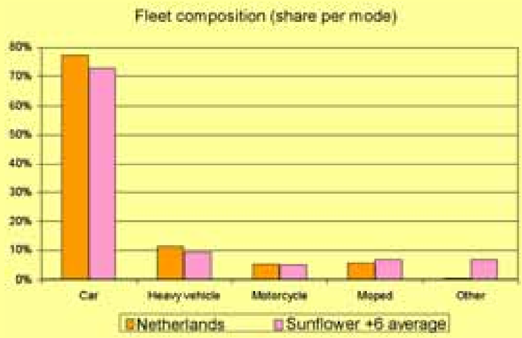
The fatality risk graph shows that risks for car occupants in the Netherlands are somewhat lower than the SUNflower+6 average. This could be caused by a relatively high vehicle kilometre percentage on motorways, which is the road type with the lowest fatality risk. And besides that, fatality risks on Dutch motorways are significantly lower than the SUNflower+6 average. Furthermore, Dutch car occupants are somewhat better protected than average, as is explained by seatbelt wearing rates that are a little above (and never below) the average. Combined with the relatively high percentage of cars within the motorized vehicle fleet, this adds up to the positive Dutch result.

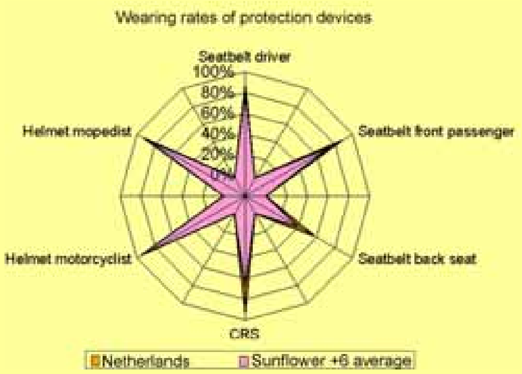
The fatality risk for bicycles is clearly lower than the average. This is not reflected in the graph displaying the fatality risk per road type. Dutch urban roads appear to perform average. However this graph only uses motor vehicle kilometres in the denominator. The exposure of cyclists in the Netherlands is known to be high; there are many bicycles and they are frequently used. This, together with frequently applied bicycle facilities (segregated bicycle paths), explains the relatively good Dutch results, expressed in terms of risk per bicycle kilometre (see also Table 5.4).

The percentage of lorry involvement in fatal crashes almost equals the SUNflower+6 average. The same holds for percentage of heavy vehicles in the fleet. It should be noted that the percentages of crash opponents do not add up to 100%, since the category 'Other' is not represented.

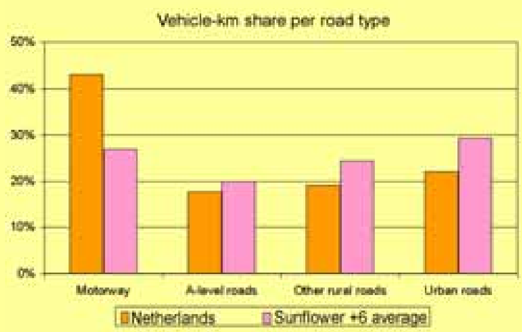
The fleet percentage of mopeds and motorcycles is close to average, but the fatality risk is higher for both modes, despite relatively high usage rates for safety helmets. For mopeds this relates to a close to average mortality for the 15-17 group, whereas most other age groups are well below the average.

Safety Performance Indicators

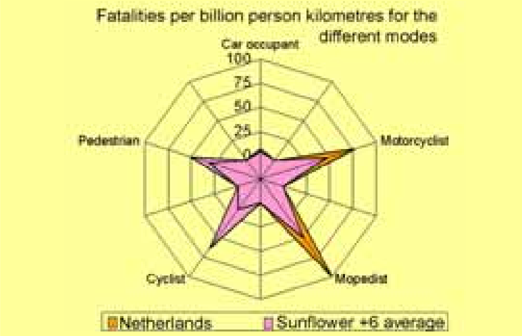


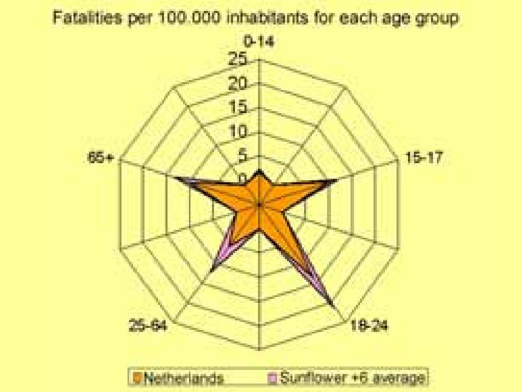


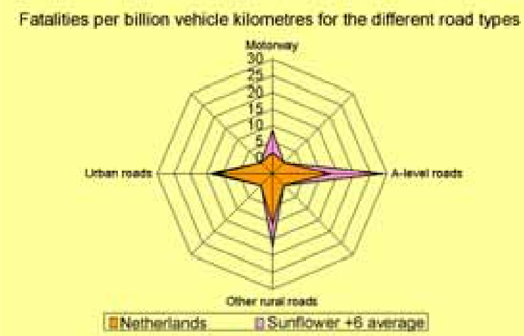
Transport background



Final outcomes







Percentage of crash opponents in fatal crashes (2003)

Country	Single vehicle	Passenger car	Lorry	Bus	Motorcycle	Moped/Cycle
Netherlands	34.9	39.4	13.5	2.0	1.0	2.5
SUNflower+6 average*	32.7	38.1	13.4	2.6	1.4	0.7

* Excluding the Czech Republic and Hungary.

Table 3.3. *Safety Performance Indicators and final outcomes for the Netherlands compared with the SUNflower+6 average for the period 2001-2003*.

3.2.5. Development over time of an individual country's footprint

Monitoring a country's performance over time increases the understanding of developments. For this purpose, average values over three successive years are used to overcome data fluctuations, and three time frames have been selected to identify changes over time; 1981-1983, 1991-1993, and 2001-2003. Each graph will then display values of the three time frames. The selection of graphs in Table 3.4 is in accord with that in the previous section, and again the example for the Netherlands has been worked out.

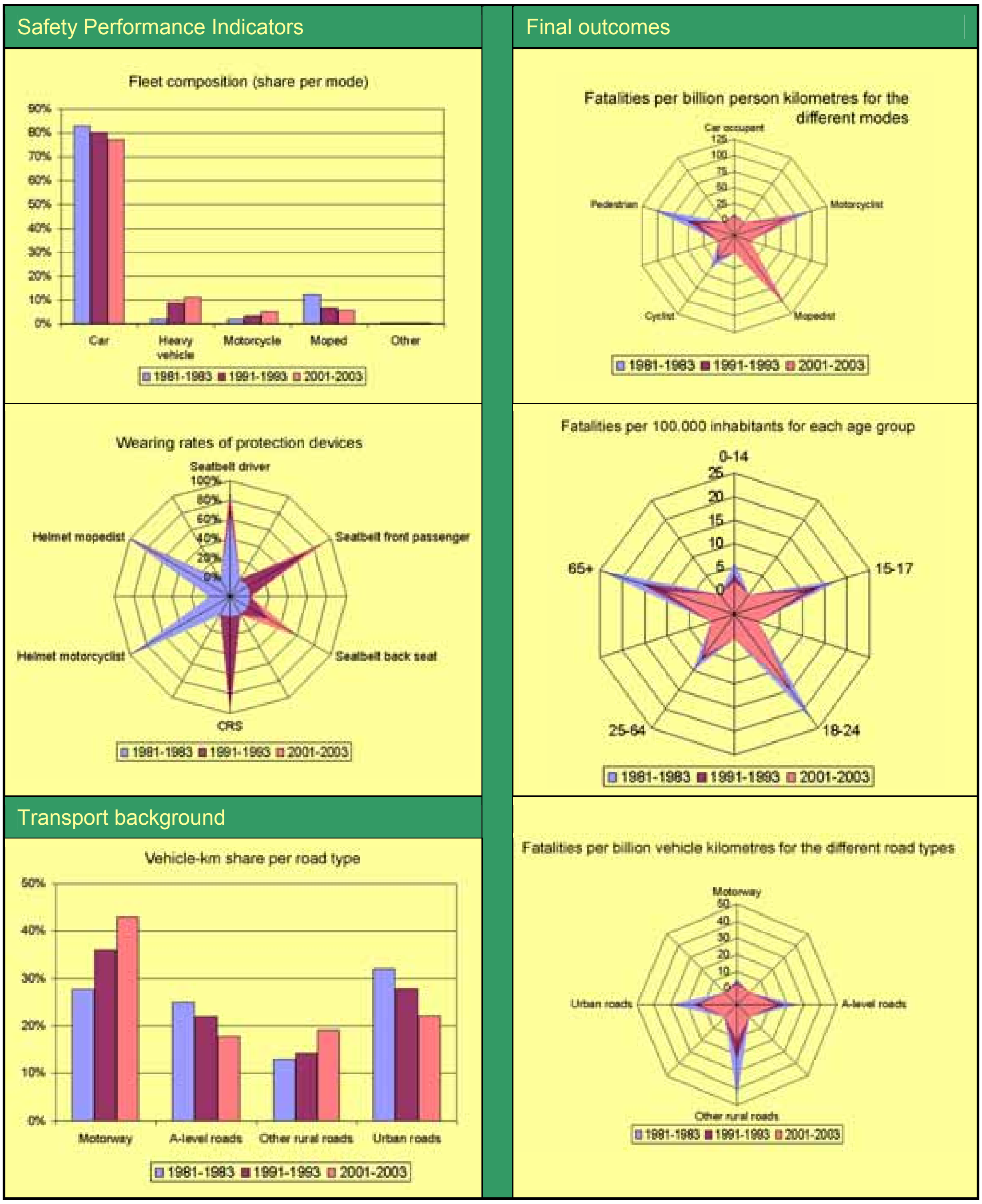


Table 3.4. *Safety Performance Indicators and final outcomes for the Netherlands compared over three time frames 1981-1983, 1991-1993, and 2001-2003*.

Among all modes, fatality risks for cyclists and pedestrians have decreased most during the last two decades. This is related to the implementation of road design standards based on the Sustainable Safety vision. For example, 50% of all urban access roads belong to a 30 km/h zone nowadays, which has contributed to reduced risks on urban roads.

Mortality has decreased to the same extent for all age groups. For the age group 15-17 this may be surprising, when noticing that the moped fatality risk has not decreased. It can be explained by the fact that the percentage of mopeds in the (motorized) fleet has decreased, as well as the number of kilometres per moped.

Car occupant fatality risks have decreased a little. This relates to a slight increase of seatbelt wearing rates for drivers and front passengers, and a (more significant) increase of the use of restraint systems in the rear seat. Furthermore, the percentage of vehicle kilometres on motorways is still increasing. Although these roads were already relatively safe in the early 1980s, the risk is considerably lower in comparison with the other road types. This results in a safety effect for the total risk of car occupants if the vehicle kilometre percentage on motorways increases. Behavioural aspects such as driving under the influence of alcohol or speeding could not be taken into account, since sufficiently harmonized indicators were not yet available for this footprint. However, the high level of speeding fines may indicate the importance of speeding in slowing down the decrease of the fatality risk, even though in Chapter 2 it became clear that more suitable indicators on speeding should be made operational. Furthermore, it is clear that there are still opportunities to lower the alcohol usage in traffic.

3.2.6. Comparisons of country footprints

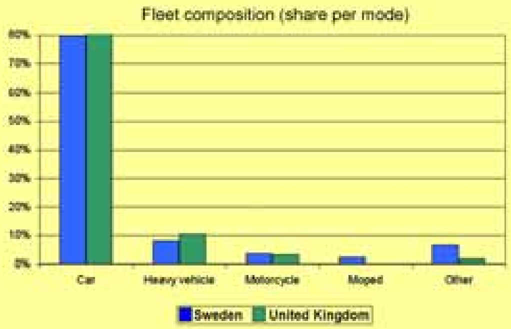
A comparison of two or more countries can be made by displaying values of those countries in each graph. This is done best for a single time frame, and can be repeated for others. Here, the most recent time frame, 2001-2003, is used. One example has been described per geographical group, one in-between the groups, and one comparing a country and a region. The selection of countries for each example is done in such a manner that all countries are represented.

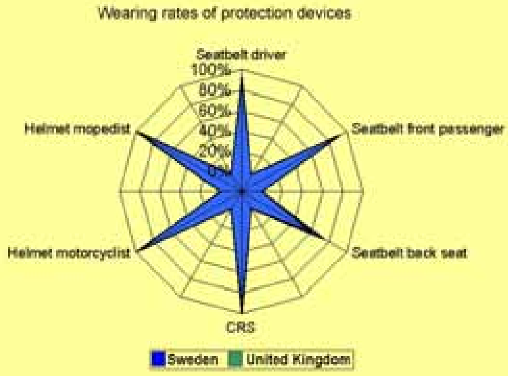
3.2.6.1. SUN countries: United Kingdom and Sweden

The same kinds of graph as in Table 3.3 are displayed in Table 3.5 for the UK and Sweden.

In many respects the indicator values for Sweden and United Kingdom are very similar. The main differences are in the fatality risk for individual user groups where pedestrian, bicycle, moped and motorcycle rates are all higher in United Kingdom. This is largely caused by the different road network and traffic volumes in the two countries, as is discussed in detail in the Group report (Lynam et al., 2005). The indicators in Table 3.5 show this both in terms of the lower percentage of traffic on motorways and A-level roads in Sweden, and the high percentage of single vehicle crashes in the Swedish crash matrix. The percentage of passenger cars for the United Kingdom includes crashes involving three or more vehicles.

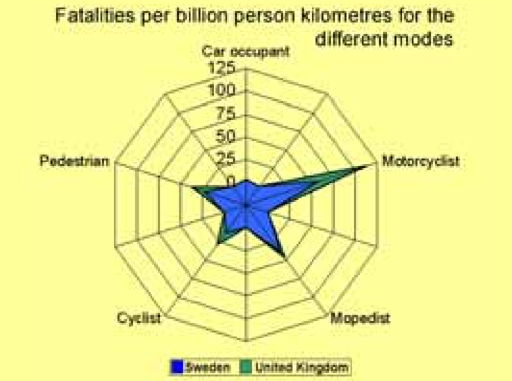
Safety Performance Indicators

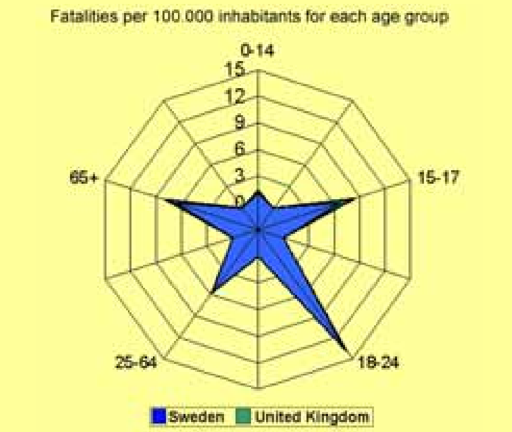


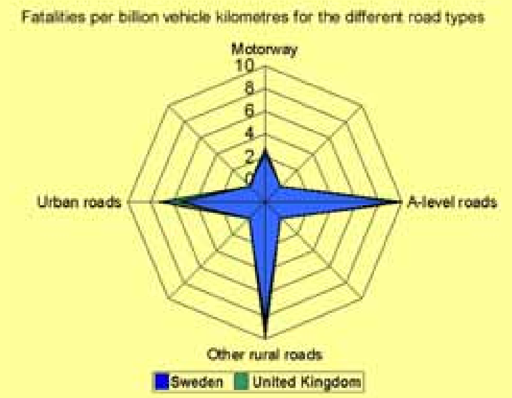


Transport background

Final outcomes







Percentage of crash opponents in fatal crashes (2003)

Country	Single vehicle	Passenger car	Lorry	Bus	Motorcycle	Moped/Cycle
Sweden	35	38.9	18.3	3.6	0.6	0.2
United Kingdom	24.4	40.0	14.4	2.7	1.3	0.2

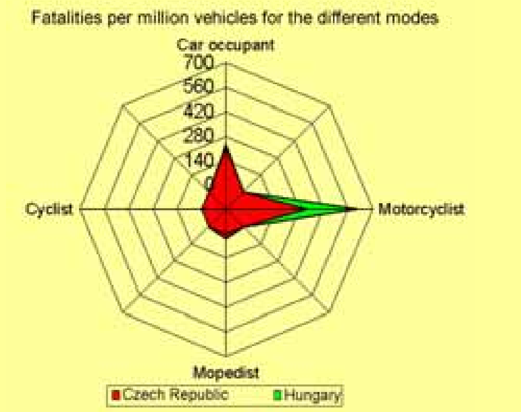
Table 3.5. *Safety Performance Indicators and final outcomes for Sweden and the United Kingdom for the period 2001-2003.*

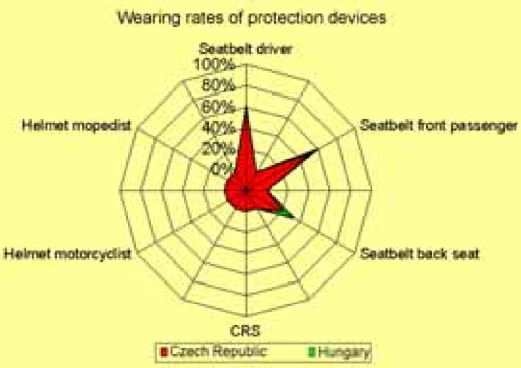
3.2.6.2. Central countries: Czech Republic and Hungary

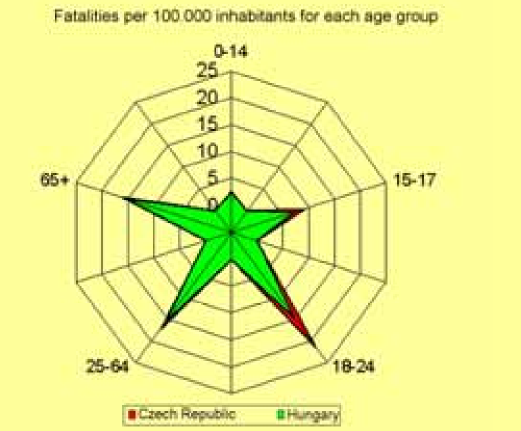
The same kinds of graph as in Table 3.3 are displayed in Table 3.6 for the Czech Republic and Hungary, except for the graph showing vehicle kilometres per road type (data not available). This graph has been replaced by a graph showing the road length percentage (share) of road types. The crash matrix part has been left out, since only limited information was available for the Czech Republic.

There are no significant differences in the distribution of road fatalities between the Czech Republic and Hungary. The observed differences for motorcyclists is correlated with the differences in motorcycle ownership.

Safety Performance Indicators	Final outcomes







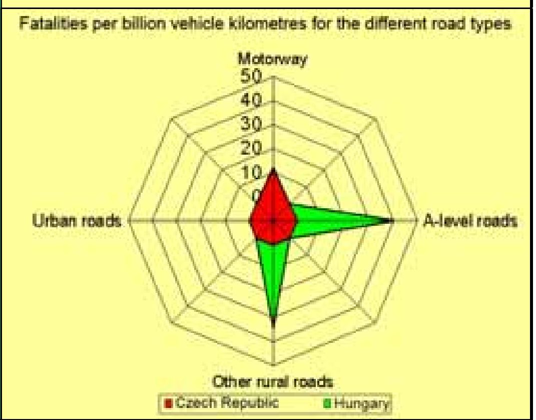


Table 3.6. *Safety Performance Indicators and final outcomes for the Czech Republic and Hungary for the period 2001-2003*.

The observed differences in road mortality for different age groups of road users are most significant for the 18-24 age group. The Central report (Eksler et al., 2005) explained this by relatively higher exposure of Czech youth in traffic, on the one hand, and the existence of a strict young drivers licensing scheme in Hungary, on the other hand.

Differences in fleet composition between the Czech Republic and Hungary is related with, and can perhaps be explained by the different registration and assurance practices.

Observed seatbelt wearing rates are at the same level for the two countries. This is not very surprising, as many similarities in this area could be identified, such as the history of the introduction of legislative measures, awareness campaigns, or (insufficient) level of police enforcement.

The differences in the road type distribution in the two countries are caused by the different practices used for classification in the two countries. While Hungary also includes minor access roads among urban roads, in the Czech Republic only distributor roads and major connection roads are included. This leads to the disproportion observed for all road types.

3.2.6.3. Southern countries: Spain and Portugal

Compared with the graphs in Table 3.3, the following two graphs have been replaced in Table 3.7 for Spain and Portugal:

- fatality risk per road type (not sufficient data available) by the fatality share (percentage) per road type,
- vehicle kilometres per road type (not sufficient data available) by the road length share (percentage) per road type.

In Table 3.7 and in all other tables and figures of this report, values for Spain always include those for Catalonia, unless otherwise stated.

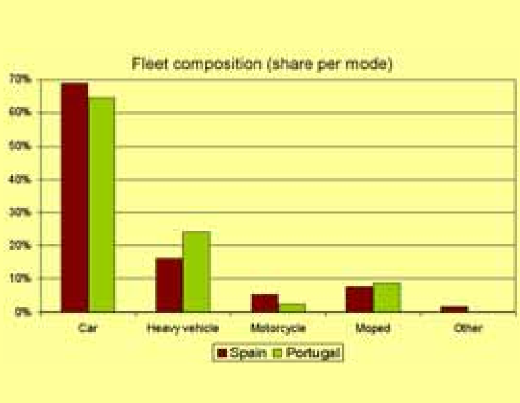
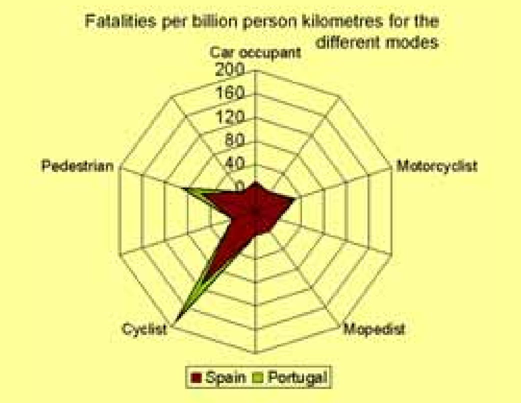
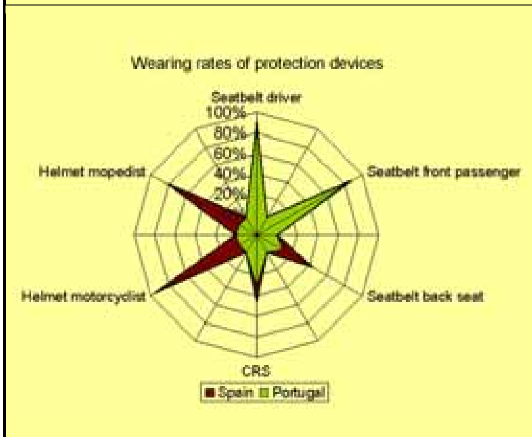
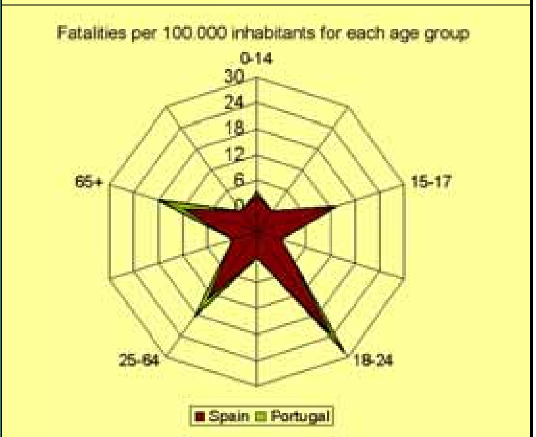
The bar graph showing fleet composition indicates a higher percentage of heavy vehicles for Portugal, with higher percentages of cars and motorcycles for Spain.

The graph showing mortality per age group denotes higher fatality levels for Portugal for the 18-24, 25-64 and 65+ age groups; the most noticeable difference is the higher level of elderly fatalities for Portugal.

The figures for wearing of protection devices show similar seatbelt wearing rates for drivers and front passengers in Portugal. The wearing rates for rear passengers and for child restraint systems are low for both countries, though somewhat higher for Spain. No Portuguese data is included about the wearing rates of helmets; rates of use, in terms of fatal crashes, are given in the Southern report (Hayes et al., 2005), with values for Portugal similar to those of Spain for motorcycles, and higher than those of Spain for mopeds.

Concerning crash opponents, the percentages are broadly similar for the various types of vehicle and crash. The higher percentage of motorcycles for Portugal is noteworthy with respect to the lower percentage of this vehicle in the fleet.

The graph showing fatalities by road type suggests that Portugal has a larger problem with fatalities on urban roads, and that Spain has a larger problem on motorways and other higher-speed roads. Data on road length percentages is not available for all types of Spanish roads, and this limits the extent to which these trends can be analysed.

Safety Performance Indicators	Final outcomes
	
	
	

Percentage of crash opponents in fatal crashes (2003)

Country	Single vehicle	Passenger car	Lorry	Bus	Motorcycle	Moped/Cycle
Spain	36.0	38.0	9.1	1.4	0.6	0.7
Portugal*	33.6	40.3	8.8	1.3	1.2	0.7

* Values for Portuguese national roads only.

Table 3.7. *Safety Performance Indicators and final outcomes for Spain and Portugal for the period 2001-2003*.

3.2.6.4. Between groups: Greece and Slovenia

Compared with the graphs in Table 3.3, the three following graphs have been replaced (due to insufficient data) in Table 3.8 for Greece and Slovenia:

- fatality risk per mode has been replaced by fatality rate per mode,
- fatality risk per road type has been replaced by the fatality share (percentage) per road type,
- vehicle kilometres per road type has been replaced by the road length share (percentage) per road type.

Observations regarding SPIs

Fleet composition

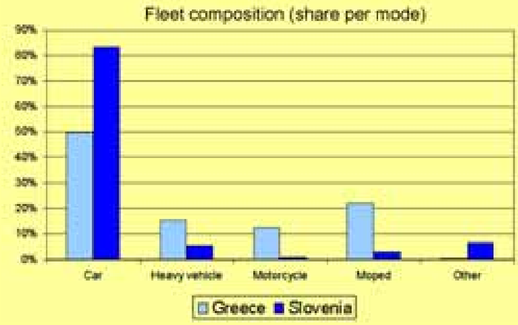
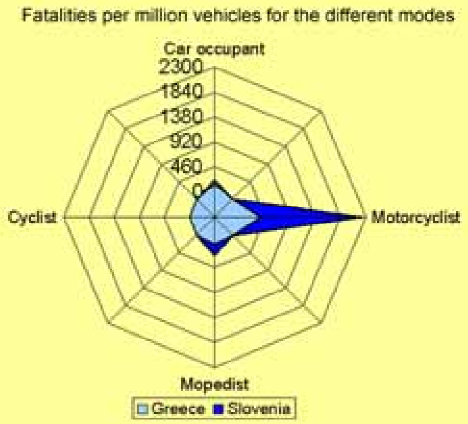
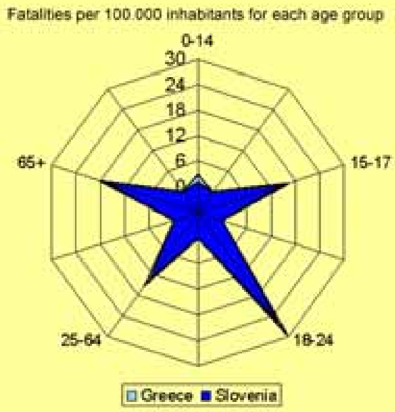
Cars are the dominant vehicle type in Slovenia, whereas PTWs only account for about 4% of all vehicles. Heavy vehicles are also scarce (approximately 7%). This classification resembles a typical profile of Northern and Central countries and reflects a combination of prevailing weather conditions and transport operations.

In Greece, on the other hand, only one in every two registered vehicles is a passenger car, in spite of a continuing sharp rise in the number of cars over the past decade. Interestingly, one in every three vehicles is a PTW, with there still being almost twice as many mopeds compared to motorcycles. This relative percentage is continuously changing in favour of motorcycles. Heavy vehicles also have a notable share, about 15%. This may be related to the comparative advantage that the road network has over the railway for freight transport.

Wearing rates of protection devices

The wearing rate of seatbelts for drivers is much higher in Slovenia than in Greece (70% against 50%), implying difficulties in the application of existing legislation in the latter. The Slovenian rate has been estimated from data on seatbelt wearing rates in crashes. Those rates are typically higher at about 90% but not suitable for international comparison (Eksler et al., 2005). Due to lack of disaggregate information for Slovenia, it is not possible to extend comparison to front/rear seat passengers.

Comparisons with respect to child restraint systems (CRS) are not possible due to the lack of well-organized surveys at the national level. Regarding PTWs, Slovenia presents helmet wearing rates of over 70% for mopeds and over 80% for motorcycles. Again, these data relate to wearing rates in crashes. According to accident-related data for Greece it appears that helmet use remains extremely low, presumably close to 40%.

Safety Performance Indicators	Final outcomes
	
	
	

Percentage of crash opponents in fatal crashes (2003)

Country	Single vehicle	Passenger car	Lorry	Bus	Motorcycle	Moped/Cycle
Greece	36.0	28.7	14.9	3.2	4.0	0.3
Slovenia	35.1	41.3	14.9	4.1	0.8	0.4

Slovenian wearing rates of protection devices relate to crashes only.

Table 3.8. *Safety Performance Indicators and final outcomes for Greece and Slovenia for the period 2001-2003.*

Road length percentage of road types
Motorways account for almost 3% of all roads in Slovenia, compared to less than 1% in Greece. This may be related to the more central position (with significant transit traffic) of Slovenia in Europe and especially to continuous increased construction of motorways, determined within the National Motorway Construction Programme of 1994. Motorway construction in Slovenia is given priority over the construction of other roads.
The percentage of A-level roads is relatively low in both countries. It is worth noting that in both countries motorways and A-level roads together, account for about 8% to 9% of the total network. Rural roads of lower standard (country roads) are over-represented in Slovenia (65% other rural roads). A similar trend is seen in Greece on urban-area roads. This is generally the case in countries of similar, relatively small size, which may perhaps partly explain this high percentage. The numerous islands of the country, with their specific road networks, may also influence length distribution across road types.

Observations regarding final outcomes

Fatality rate (fatalities/million vehicles) for different modes
Fatality rates are almost equal for car occupants in the two countries. Respective rates for PTWs are significantly higher in Slovenia (especially for motorcycles).

Mortality (fatalities/100,000 inhabitants) for different age groups
Overall, the two countries have very similar mortality rates in all age groups. This common pattern is typical of their comparable experience with the increase of the motorization rate.

Fatality share per road type
This comparison would be more meaningful if exposure data were also available This also holds true for the previous graph. Given this restriction, the interpretation of percentages is limited. In both countries motorways have a percentage that is four times larger than their percentage in the road type-length distribution. This is thought to be due to higher traffic volumes on these roads. Some further justification may be found in the impact of high speed, i.e., crashes on motorways may be more severe than those on other road types, presumably resulting more frequently in loss of lives – as argued in the analysis of the 'Speed management' case study.

This justification should also hold, to some extent, for A-level roads, where driving speeds are too high for the quality of the roads. Both countries exhibit fatality percentages on A-level roads that are five times higher than the percentages in the length distribution. Interestingly, Greece shows a relatively large percentage of fatalities on urban roads, where Slovenia demonstrates a large percentage on other rural (country) roads.

Observations regarding the percentage of crash opponents (%) in fatal crashes
Single-vehicle fatal crashes are rather common in both countries (over one third of the total number). Apart from that, most vehicle types exhibit percentages proportionate to their percentages in fleet composition. The only striking exception is lorries in Slovenia (almost 15%, as in Greece, but heavy vehicles are much less numerous in Slovenia than in Greece). Lorries as crash opponents relate to increased transit traffic in Slovenia. In absence of exposure data per road type and vehicle type, this can not be adequately explained.

3.2.6.5. A country and a region: Spain and Catalonia

Table 3.9 shows the footprints of Spain, including Catalonia, and the region of Catalonia itself. Compared with the graphs in Table 3.3, the two following graphs have been replaced:

- fatality risk per mode has been replaced by fatality rate per mode,
- fatality risk per road type has been replaced by the fatality share (percentage) per road type.

The fleet composition graph shows very similar vehicle stocks, with the main difference being the relatively high percentage of motorcycles in Catalonia, and the corresponding lower percentage of cars.

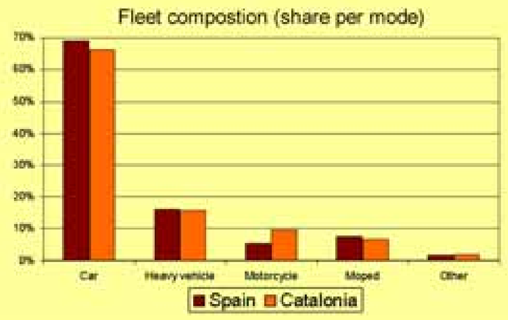
Regarding mortality, the only difference is the higher value for Catalonia in the 15-17 age group.

Values for wearing protection devices are almost identical. Values for Spain are a little higher for driver, front passenger and CRS (percentage values for Spain of 90%, 89% and 63%, compared with respective values of 87%, 84% and 60% for Catalonia). Motorcycle and moped helmet wearing rates for Spain (95% and 82%) are exceeded by the values for Catalonia (99% and 96%).

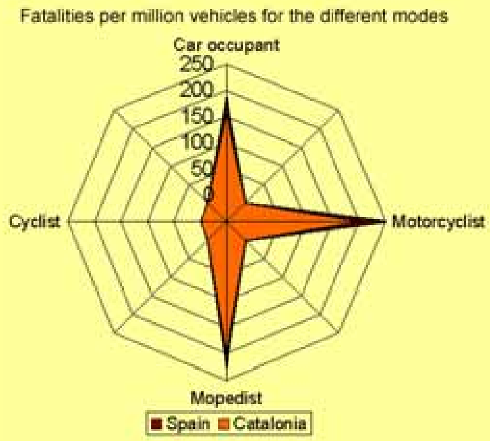
It is difficult to assess the crash situation regarding road type, since there is a lack of basic information. If the percentage of vehicle kilometres for Catalonia is accurate, then it should be possible to calculate the number of kilometres of urban roads (and compare this for both territories). Currently, the vehicle kilometre percentage for Spain does not add up to 100%. For the fatality percentage by road type (in 2003), the percentages are similar for motorways and somewhat higher for urban roads in Catalonia.

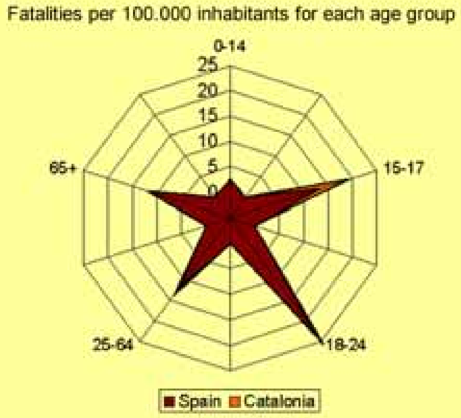
Concerning 'crash opponents', the main difference is seen in the percentages for single vehicle crashes. This percentage is lower for Catalonia than for Spain, which most probably can be explained by the urbanized character of Catalonia. Catalonia shows slightly higher crash percentages for passenger cars and PTWs, and Spain has slightly higher percentages for heavy vehicles (lorry and bus).

Safety Performance Indicators



Final outcomes





Transport background

Percentage of crash opponents in fatal crashes (2003)

Country	Single vehicle	Passenger car*	Lorry	Bus	Motorcycle	Moped/Cycle
Spain	36.0	38.0	9.1	1.4	0.6	0.7
Catalonia**	30.8	41.3	7.8	1.0	0.9	1.0

* Values include passenger cars and vans.
** Values for national roads only.

Table 3.9. *Safety Performance Indicators and final outcomes for Spain and Catalonia for the period 2001-2003.*

3.3. Summary footprint scheme

The detailed footprint scheme aims to give an overview of the contribution by different components of the traffic system to road safety. Furthermore, it intends to construct a framework for monitoring and understanding the effects of relevant safety processes through the levels of the pyramid. It provides information which can be used for benchmarking purposes. However the scheme may be too elaborate for policymakers, who wish for information in a compact form. Therefore, a more compact scheme is proposed in addition to the previous scheme.

3.3.1. Structure and scoring

3.3.1.1. Structure

A first proposal for a structure for the summary footprint scheme has been made in Table 3.10. The three pyramid levels policy output, SPI and final outcomes can be summarized in one sheet. This can eventually show an (explanatory) progression from the left to the right (or the other way around). Policy output has been renamed as 'organizational background' and the item 'transport background' is added at the bottom. For each of the four elements a selection of indicators has been made, which mainly serves as a preliminary illustration. It is recommended to develop more or more advanced indicators (as described in Chapter 2).

Transport background
Information on traffic volumes is relevant for this element. The percentage of motor vehicle kilometres per road type is considered appropriate and is therefore proposed as an indicator.

Organizational background
Three items have been selected to represent the organizational background of safety policy.
The first item describes the basis of road safety organization, dealing with:
- the existence of a policy plan,
- the existence of specific institutes with responsibilities for road safety,
- the existence of procedures for implementation .

The second item deals with the question whether quantitative targets exist.
With the third item the range of safety measures is described. They are the following types of measures (also described in Table 4.2): alcohol and drugs, seatbelts, helmets, speed, vehicle fleet, infrastructure, young road users, vulnerable road users. It should be noted that the range of measures and the type of their implementation are different matters.
More indicators may be added in the open space of the table, e.g. to distinguish between transport modes or user groups.

Organizational background	
Safety organization	
Quantitative targets	
Range of measures	

Safety Performance Indicators	
Per mode	
Car occupant	
% Cars	
Belt wearing rates	
Driver	
Front passenger	
Rear seat	
Child restraint	
% Heavy vehicles	
% Bicycles	
% Other vehicles	
Motorcyclist	
% Motorcycles	
Helmet wearing	
Mopedist	
% Mopeds	
Helmet wearing	
Per road type	
Motorways	
% Road length	
A-level roads	
% Road length	
Other rural roads	
% Road length	
Urban roads	
% Road length	

Final outcomes				
Per mode				
Car occupant				
All	Fat./pop.			
All	Fat./veh.			
All	Fat./vkm			
0-14	Fat./pkm		% Fatalities	
15-17	Fat./pkm		% Fatalities	
18-24	Fat./pkm		% Fatalities	
25-64	Fat./pkm		% Fatalities	
65+	Fat./pkm		% Fatalities	
Pedestrian				
All	Fat./pop.			
All	Fat./veh.			
All	Fat./pkm			
0-14	Fat./pkm		% Fatalities	
15-17	Fat./pkm		% Fatalities	
18-24	Fat./pkm		% Fatalities	
25-64	Fat./pkm		% Fatalities	
65+	Fat./pkm		% Fatalities	
Cyclist				
All	Fat./pop.			
All	Fat./veh.			
All	Fat./vkm			
0-14	Fat./pkm		% Fatalities	
15-17	Fat./pkm		% Fatalities	
18-24	Fat./pkm		% Fatalities	
25-64	Fat./pkm		% Fatalities	
65+	Fat./pkm		% Fatalities	
Motorcyclist				
All	Fat./pop.			
All	Fat./veh.			
All	Fat./vkm			
0-14	Fat./pkm		% Fatalities	
15-17	Fat./pkm		% Fatalities	
18-24	Fat./pkm		% Fatalities	
25-64	Fat./pkm		% Fatalities	
65+	Fat./pkm		% Fatalities	
Mopedist				
All	Fat./pop.			
All	Fat./veh.			
All	Fat./vkm			
0-14	Fat./pkm		% Fatalities	
15-17	Fat./pkm		% Fatalities	
18-24	Fat./pkm		% Fatalities	
25-64	Fat./pkm		% Fatalities	
65+	Fat./pkm		% Fatalities	
Per road type				
Motorways				
	Fat./vkm		% Fatalities	
A-level roads				
	Fat./vkm		% Fatalities	
Other rural roads				
	Fat./vkm		% Fatalities	
Urban roads				
	Fat./vkm		% Fatalities	

Transport background	
Motorways	
% Vehicle km	
A roads	
% Vehicle km	
Other rural roads	
% Vehicle km	
Urban roads	
% Vehicle km	

Fat. = fatalities; pop. = population; veh. = vehicles; pkm = person kilometres; vkm = vehicle kilometres.

Table 3.10. *Summary footprint scheme*.

Safety Performance Indicators
First, the different modes of transport are presented. The composition of the vehicle fleet is described by the percentages of the subsequent vehicle types, including 'other vehicles'. Bicycles are not included as a separate class. However, their number compared with the motorized vehicle fleet can be considered as an SPI for bicycles. Information on the access to different road types (and mixture with motorized traffic) would increase the validity of this indicator.
Secondly, behavioural aspects are taken into account by belt and helmet wearing rates. SPIs typical for pedestrians have not been incorporated, although the fleet percentage of HGVs gives some indication of vulnerable road user safety, especially when the HGVs frequently use urban roads (Lynam et al., 2005).
Thirdly, roads are presented by the road length percentage of road types as a substitute indicator, such as was done in the detailed scheme.

Final outcomes
For the different modes of transport, the mortality rate, the fatality rate, and fatality risk are described as an aggregate for all ages. Subsequently, disaggregate values for the mortality rate are presented for the different age groups. Mortality is chosen, since for the other two indicators disaggregate information is only available for few countries. Next to that, fatality shares (with respect to all fatalities) are presented, for all age groups together and per age group separately.
For the different road types, the fatality risk and the fatality share (with respect to all fatalities) are presented.

3.3.1.2. Scoring

Application areas for the summary scheme are identical to those for the detailed scheme as presented in Section 3.2.3. However, the presentation of results is different. The summary scheme contains no graphs, but gives a score per item. Scoring is done to the items in the shaded cells in Table 3.10. A score can be obtained in two ways. An absolute score applies to those items, for which target values are reasonably based on current knowledge (for example 100% wearing of seatbelts). Absolute scores are used for transport background, organizational background and SPIs. The only exception is the 'range of measures' for which a relative score is used (according to the overview of Table 4.2). Relative scores are used for all final outcomes which for instance are obtained by comparison with another country or with a reference such as the SUNflower+6 average, or by comparing different time frames. The scores can be expressed numerically (for example on a 5 point scale) or with different colours or stars (such as EuroNCAP and EuroRAP do).

Table 3.11 describes a first proposal for a scoring method to compare an individual SUNflower+6 country with the SUNflower+6 average. The three colours red, orange[2] and green are used to respectively indicate a bad/worse-than-average, moderate/average, or good/better-than-average score. A grey box means that no data is available. The score for 'range of measures', and the scoring intervals for transport background and SPIs, are mainly estimates based on the average values for the SUNflower+6 countries, and common road safety knowledge. For the relative scores for final outcomes, it is especially difficult to assess when a score is green. It was decided to use a 10 percent negative offset from the average.

[2] The colour orange is used because yellow is not suitable due to the background colour of the table.

Item	Scoring
Organizational background	
Safety organization	Red: only 1 item or none is applicable Orange: 2 items are applicable Green: 3 items are applicable
Quantitative targets	Red = no green = yes
Range of measures	Red: little measures Orange: many measures, many different measures Green: many measures, all measures, good distribution
Transport background	
Motorway: % vkm	Red: < 15% orange: 15-30% green: > 30%
A-level roads: % vkm	Red: < 10 % orange: 10 –20 % green: > 20%
Other rural roads: % vkm	Red: > 40% orange: 15-40% green: < 15%
Urban roads: % vkm	Red: > 40% orange: 20-40% green: < 20%
Safety Performance Indicators	
% Cars	Red: < 50% orange: 50-70% green: >70%
Belt wearing rates in cars	Red: < 70% orange: 70-90% green: >90%
% Heavy vehicles	Red: > 20% orange: 10-20% green: <10%
% Bicycles	Red: > 200% orange:100-200% green: <100%
% Other vehicles	Red: > 10% orange: 5-10% green: <5%
% Motorcycles	Red: > 10% orange: 5-10% green: < 5%
Helmet wearing motorcyclists	Red: < 85% orange: 85-95% green: 95-100%
% Mopeds	Red: > 10% orange: 5-10% green: < 5%
Helmet wearing mopedists	Red: < 85% orange: 85-95% green: 95-100%
Motorway: % road length	Red: < 2% orange: 2-4% green: > 4%
A-level roads: % road length	Red: < 5 % orange: 5-10% green: > 10%
Other rural roads: % road length	Red: > 60% orange: 40-60% green: < 40%
Urban roads: % road length	Red: > 60% orange: 40-60% green: < 40%
Final outcomes	
Per mode: *Fat./pop., Fat./veh., Fat./vkm, % Fatalities per age group*	Red: higher than 10% from SUNflower+6 average Orange: within a margin of 10% from SUNflower+6 average Green: lower than 10% from SUNflower+6 average
Per road type: *Fat./vkm, % Fatalities*	Red: higher than 10% from SUNflower+6 average Orange: within a margin of 10% from SUNflower+6 average Green: lower than 10% from SUNflower+6 average

Table 3.11. *Preliminary proposal for a scoring method for the summary footprint scheme.*

The compactness is a clear advantage of this approach. A disadvantage may be that the scheme only shows one country in one time frame. Displaying the outcomes of more countries or time frames can be done by adding additional columns, but this may jeopardize the clarity. In the current set-up, other countries or time frames can be shown on different sheets which can be scanned in turn for comparability.

3.3.2. Individual country's most recent footprint

3.3.2.1. The Netherlands

An example is worked out in Table 3.12 for the Netherlands compared with the SUNflower+6 average in the 2001-2003 period.

For final outcomes, per mode and per age group, fatality risks based on person kilometre data has been used instead of mortality rates. It should be noted that this data is insecure due to the disaggregation and estimation procedures for person kilometres and vehicle kilometres in general. Furthermore, only a few countries could be used to calculate the average values for the SUNflower+6 countries. For example, only the Netherlands could supply exposure data per age group for mopeds, and therefore no colour score (which would be orange in this case) has been specified in the table.

Table 3.12 indicates that the organizational background for road safety seems to be well established in the Netherlands. But a better distribution and/or balance of different safety measures could lead to further improvement.

At the SPI level, further improvements can be obtained in seatbelt wearing. Only the use of child restraint systems can be denoted as good. When this is related to car occupant fatalities risks, the table shows that the Netherlands does not have a best-in-class performance. Aggregate indicators may still suggest an excellent position, a disaggregation for different age groups shows worse results. However, it should be noted that only the SUN countries could provide some disaggregate information. So for these indicators, the Netherlands is actually compared with the SUN average. Mortality numbers may give a more balanced overview using more countries. A red score in the car occupant fatality share for the 18-24 year old, shows that this group is overrepresented. Their percentage among all car occupant fatalities is higher in the Netherlands than the SUNflower+6 average..

For pedestrians, the young have the highest risk, although not in the red area. However, the fatality share of the 0-14 and 15-17 among all pedestrian fatalities is significantly higher than the average. This bad record may relate to a relatively high exposure of this group or to a relatively frequent presence of heavy goods vehicles in urban centres, but more dedicated indicators are needed to better describe this observation. Risk for the over-65s is not bad.

The bicycle SPI is red, since the number of bicycles in the Netherlands is about twice the number of motorized vehicles. As a result mortality rates are high. Good scores for fatality risk, however, indicate that the Dutch traffic system has adapted relatively well to bicycles. The 0-14, 15-17 and over-65s are overrepresented, which may relate to higher exposure and relatively high vulnerability.

Organizational background	
Safety organization	
Quantitative targets	
Range of measures	

Transport background	
Motorways	
% Vehicle km	
A roads	
% Vehicle km	
Other rural roads	
% Vehicle km	
Urban roads	
% Vehicle km	

Safety Performance Indicators	
Per mode	
Car occupant	
% Cars	
Belt wearing rates	
Driver	
Front passenger	
Rear seat	
Child restraint	
% Heavy vehicles	
% Bicycles	
% Other vehicles	
Motorcyclist	
% Motorcycles	
Helmet wearing	
Mopedist	
% Mopeds	
Helmet wearing	
Per road type	
Motorways	
% Road length	
A-level roads	
% Road length	
Other rural roads	
% Road length	
Urban roads	
% Road length	

Final outcomes				
Per mode				
Car occupant				
All	Fat./pop.			
All	Fat./veh.			
All	Fat./vkm			
0-14	Fat./pkm		% Fatalities	
15-17	Fat./pkm		% Fatalities	
18-24	Fat./pkm		% Fatalities	
25-64	Fat./pkm		% Fatalities	
65+	Fat./pkm		% Fatalities	
Pedestrian				
All	Fat./pop.			
All	Fat./veh.			
All	Fat./pkm			
0-14	Fat./pkm		% Fatalities	
15-17	Fat./pkm		% Fatalities	
18-24	Fat./pkm		% Fatalities	
25-64	Fat./pkm		% Fatalities	
65+	Fat./pkm		% Fatalities	
Cyclist				
All	Fat./pop.			
All	Fat./veh.			
All	Fat./vkm			
0-14	Fat./pkm		% Fatalities	
15-17	Fat./pkm		% Fatalities	
18-24	Fat./pkm		% Fatalities	
25-64	Fat./pkm		% Fatalities	
65+	Fat./pkm		% Fatalities	
Motorcyclist				
All	Fat./pop.			
All	Fat./veh.			
All	Fat./vkm			
0-14	Fat./pkm		% Fatalities	
15-17	Fat./pkm		% Fatalities	
18-24	Fat./pkm		% Fatalities	
25-64	Fat./pkm		% Fatalities	
65+	Fat./pkm		% Fatalities	
Mopedist				
All	Fat./pop.			
All	Fat./veh.			
All	Fat./vkm			
0-14	Fat./pkm		% Fatalities	
15-17	Fat./pkm		% Fatalities	
18-24	Fat./pkm		% Fatalities	
25-64	Fat./pkm		% Fatalities	
65+	Fat./pkm		% Fatalities	
Per road type				
Motorways				
	Fat./vkm		% Fatalities	
A-level roads				
	Fat./vkm		% Fatalities	
Other rural roads				
	Fat./vkm		% Fatalities	
Urban roads				
	Fat./vkm		% Fatalities	

Fat. = fatalities; pop. = population; veh. = vehicles; pkm = person kilometres; vkm = vehicle kilometres.

Table 3.12. *An example of the summary footprint scheme for the Netherlands compared with the SUNflower+6 average in the period 2001-2003.*

The outcomes for motorcyclists show a relatively good performance for both SPIs and final outcomes. The 25-64 age group is overrepresented. The results for mopeds are at the average SUNflower+6 level. It should however be noted that the Netherlands performs worse when compared with the other SUN countries. This is reflected by the high fatality risk for which only the SUN countries could provide information. Especially the 15-17 year olds and the over-65s are overrepresented.

All road types show a better-than-average fatality risk. This relates to the relatively high-quality level of the road network, but also to the fact that the chosen reference is not very challenging. The high fatality share of motorways relates to the high vehicle kilometre share. The high fatality share on 'other rural roads' is more related to the known safety problems of this road type, which apply to all countries.

3.3.2.2. Catalonia

An example for Catalonia for the period 2001-2003 is worked out in Table 3.13.

The organizational background for Catalonia in 2003 is reported as satisfactory, with the possibility of further improvement to achieve a better distribution of the (many) measures of the plan. SPIs for Catalonia are above average (green) for motorcycle and mopedist helmet wearing. This is a good result considering that the vehicle fleet includes sizeable percentages of motorcycles and mopeds (and heavy vehicles, but only a small percentage of cycles). There is a need to improve belt wearing by all car occupants, including the usage of child restraint systems. The percentage of road length that is motorway standard is low (red), although it carries a high percentage of vehicle kilometres.

Concerning final outcomes the indicators of fatalities (for the overall population) show better-than-average results for pedestrians, but worse-than-average results for car occupants and mopedists. The general results for motorcycles, in terms of fatalities per vehicle and fatalities per vehicle kilometre, are better-than-average. The positive general result for cyclists is attributed to the low level of exposure (usage), and the division by age reveals an overrepresentation for ages between 15-17 and over-65s.

Although the mortality of pedestrians for the whole population is better than average, disaggregate outcomes are mostly average. The situation for Catalonia shows a worse performance in mortality for the 18-24 year olds for all motorized modes (car, motorcycle and moped). Looking at specific modes for the other age groups, the higher fatalities for 15-17 year old for mopeds, and 25-64 year olds for motorcycles, reflect the general tendency to use PTWs. Concerning these modes, the negative comparison for final outcomes needs to be considered against the good result for SPIs. The fatality share for urban roads is lower than the SUNflower+6 average, whilst that for motorways is higher.

Appendix F gives an additional example, displaying the development of Spain's footprint over time by comparing 2003 with1993 outcomes.

Organizational background	
Safety organization	
Quantitative targets	
Range of measures	

Transport background	
Motorways	
% Vehicle km	
A roads	
% Vehicle km	
Other rural roads	
% Vehicle km	
Urban roads	
% Vehicle km	

Safety Performance Indicators	
Per mode	
Car occupant	
% Cars	
Belt wearing rates	
Driver	
Front passenger	
Rear seat	
Child restraint	
% Heavy vehicles	
% Bicycles	
% Other vehicles	
Motorcyclist	
% Motorcycles	
Helmet wearing	
Mopedist	
% Mopeds	
Helmet wearing	
Per road type	
Motorways	
% Road length	
A-level roads	
% Road length	
Other rural roads	
% Road length	
Urban roads	
% Road length	

Final outcomes				
Per mode				
Car occupant				
All	Fat./pop.			
All	Fat./veh.			
All	Fat./vkm			
0-14	Fat./pkm		% Fatalities	
15-17	Fat./pkm		% Fatalities	
18-24	Fat./pkm		% Fatalities	
25-64	Fat./pkm		% Fatalities	
65+	Fat./pkm		% Fatalities	
Pedestrian				
All	Fat./pop.			
All	Fat./veh.			
All	Fat./pkm			
0-14	Fat./pkm		% Fatalities	
15-17	Fat./pkm		% Fatalities	
18-24	Fat./pkm		% Fatalities	
25-64	Fat./pkm		% Fatalities	
65+	Fat./pkm		% Fatalities	
Cyclist				
All	Fat./pop.			
All	Fat./veh.			
All	Fat./vkm			
0-14	Fat./pkm		% Fatalities	
15-17	Fat./pkm		% Fatalities	
18-24	Fat./pkm		% Fatalities	
25-64	Fat./pkm		% Fatalities	
65+	Fat./pkm		% Fatalities	
Motorcyclist				
All	Fat./pop.			
All	Fat./veh.			
All	Fat./vkm			
0-14	Fat./pkm		% Fatalities	
15-17	Fat./pkm		% Fatalities	
18-24	Fat./pkm		% Fatalities	
25-64	Fat./pkm		% Fatalities	
65+	Fat./pkm		% Fatalities	
Mopedist				
All	Fat./pop.			
All	Fat./veh.			
All	Fat./vkm			
0-14	Fat./pkm		% Fatalities	
15-17	Fat./pkm		% Fatalities	
18-24	Fat./pkm		% Fatalities	
25-64	Fat./pkm		% Fatalities	
65+	Fat./pkm		% Fatalities	
Per road type				
Motorways				
	Fat./vkm		% Fatalities	
A-level roads				
	Fat./vkm		% Fatalities	
Other rural roads				
	Fat./vkm		% Fatalities	
Urban roads				
	Fat./vkm		% Fatalities	

Fat. = fatalities; pop. = population; veh. = vehicles; pkm = person kilometres; vkm = vehicle kilometres.

Table 3.13. *An example of the summary footprint scheme for Catalonia compared with the SUNflower+6 average in the period 2001-2003.*

4. Applications for comparisons between safety outcomes of countries

In Chapter 3 information about the footprint method is discussed in detail. Examples are worked out for some aspects of the footprint on the basis of the information delivered by the participating countries.

Chapters 4 and 5 will make comparisons between all nine SUNflower+6 countries in more detail. Chapter 4 begins with level four in the safety pyramid, the road safety policy and organization, followed by an overview of actual safety measures. The major part of Chapter 4 gives an overview of the final safety outcomes. The developments of fatality rates and risks over a long period are compared for the nine countries, followed by detailed tests over the three three-year periods 1981-1983, 1991-1993 and 2001-2003.

Chapter 5 discusses the safety outcomes in more detail. Disaggregate data are compared to detect differences between the countries regarding safety outcomes and their developments for transport modes, for crash opponents of these transport modes, for age groups and for road types in 1993 and 2003.

4.1. Road safety policy and organization

4.1.1. Organizations, programmes and safety targets

Road safety improvement starts with the organization and planning of safety actions. The first actions are generally taken by the Ministry of Transport. However, if road safety becomes a serious and too comprehensive a problem for policy makers, dedicated national research institutions are established. This is what happened in an early stage for the SUN countries with institutes like TRRL (recently TRL) in the United Kingdom, SNRA (recently SRA) and VTI in Sweden, and SWOV in the Netherlands. These institutes prepare road safety policies and actions to be taken by the government. In later years, other countries followed with, for instance, CDV in the Czech Republic, KTI in Hungary and LNEC in Portugal.

The level of road safety activities is highly intensified if such national institutions exist. Actions to improve road safety require organization of safety measures, specification of measures in safety plans and support of safety regulations in specific actions, campaigns, laws and infrastructural measures.

Table 4.1 gives an overview of 'Organizational measures', 'Safety programmes' and 'Quantitative safety targets'. In this context 'Organizational measures' means the organization of safety plans.

The overview, taken from the listed road safety activities for each country in the group reports, is not complete, especially not for the period before 1975. For the SUN countries the data is taken from the previous SUNflower report, with additions for later years.

Although not complete, the table shows that generally speaking an increase in the Organization of Activities and Programmes can be seen from 1985 onwards. This is primarily the case for the new SUNflower+6 countries. For Sweden a quantitative target was already defined before this period. Not much later such targets were set for the United Kingdom and the Netherlands. From 1995 onwards quantitative targets are also set for Spain (Catalonia and the Basque Country), Portugal and Slovenia.

Period	SE	UK	NL	CZ	HU	SI	EL	PT	ES	Cat
Before 1975	O	O	O	P		O, P	O	O	O	
1975 - 1984	T	P	O, O				O		O, P	
1985 - 1994	O, P, P	O, P, T, P	O, T	O, P	O, P	P	O, P	O		O, O, P
1995 - 2004	O, P, T	O, O, P, P, P, T	P, T	P, T	P, T	P, T	O, P, T	O,P, T	O, P, T *	O, P, T

* Programme and Quantitative Target for Catalonia and later for the Basque Country.

Table 4.1. *Foundation of **O**rganization of road safety plans, Road Safety **P**rogrammes and Quantitative **T**argets in SUNflower+6 countries as a function of time*.

Table 4.1 may be interpreted as a first indication of actual safety initiatives. However, it is more important to see in which concrete safety measures these organizational measures and plans result. And still more important, what actual improvements in safety follow from these concrete measures, in terms of quality of roads, vehicles, traffic flow conditions and traffic behaviour. And furthermore, what actual decrease of casualties can be attributed to these initiatives.

4.1.2. Safety measures

Table 4.2 shows the actual measures that have been reported in the three Group reports. For the period before 1975 not all measures were reported. It is clear from this table that for the SUN countries a large number of measures were taken from 1975 onwards and even before that period.

For Portugal a spectacular increase in measures is seen from 1985 onwards. To a lesser extent this is also the case for Greece, Spain and Catalonia. For the Czech Republic, Hungary and Slovenia such an increase is found for the period from 1995 onwards. For Hungary this increase already begins in the period before that.

The specific measures reported show that from the 1970s onwards not only a large number, but also a wide variety of measures has been applied in the SUN countries. In later periods measures are more specific in these countries.

This tendency to use a wider variety of measures when the number of measures increases can be observed in the other countries as well, with the exception of Spain and Catalonia and in the latest period also for Greece. There we see more measures, however, in limited areas.

The major topics mentioned are safety belts (28), speed (25), fleet measures (19), alcohol (16), helmets (13) and young road users (12).

Period	SE	UK	NL	CZ	HU	SI	EL	PT	ES	Cat
Before 1975	5: b, s, f	8: y, a, f, h, s	6: a, b, h, s	3: a, b, s	0:	12: s, a, b, y, v	2: g, b	3: s, b, h	2: b, s	2: b, s
1975 - 1984	20: a, b, h, l, f, y	26: y, f, h, b, i	12: b, h, f, i, y	2: s, b	5: s, b, y	4: b, v	2: b, h	5: b, a, f	1: h	1: h
1985 - 1994	21: b, f, s, y	26: v, f, b, y, a	11: f, a, b, s	3: b, h, i	10: s^-, h, f, y, b^-	6: b, a, f, i	9: h, b, g, a, f, i	19: f, b, a, s, y	4: s, f	4: s, f
1995 - 2004	21: b, i, f, s, s^-, v, a	16: i, s, v, y, b	16: a, s, f, v, y	11: b, f, y, i, h, v, s, s^-	20: f, s^-, h, b, i	18: a, b, s, h, y, i	13: a, b, g, h, y	12: f, b^-, b	8: a, s, b	7: a, s, b

The cells contain the total number of measures, followed by a colon, followed by letters representing: **a**lcohol and drugs, **b**elts, **h**elmets, **s**peed, **f**leet measures, **i**nfrastructure, **y**oung road users and **v**ulnerable road users. A minus sign means supposed negative safety effect, for example an increase in speed limit.

Table 4.2. *Measures taken in SUNflower+6 countries as a function of time*.

Specific measures for vulnerable road users (3) and infrastructure (4) are hardly mentioned. This does not mean that these activities are absent. Many infrastructural improvements are carried out at a regional or local level. Although they are nationally planned but locally implemented, plans for the construction of motorways, living areas, roundabouts etc., are not found on the lists. These, however, are very important measures for the improvement of road safety.

The general conclusion may be that economic development and the corresponding rise of motorization in the SUN countries shortly after World War II resulted in a steep increase in road safety problems. A large number of safety initiatives and actual safety measures were taken in the late 1960s and early 1970s. This resulted in a large number of actual safety measures on a great variety of safety aspects. The effects of these efforts are mirrored in the decrease in the fatality rates and risks since the 1970s as will be shown later.

For the other SUNflower+6 countries these developments came later, often related to a political change. The same picture can be seen in these countries: an increased economical growth with a corresponding increase in motorized traffic and its safety problems. Here we also see the same reaction to this situation expressed in an increased attention to safety policy and organization and actual safety measures.

These initiatives have been very successful. Road safety, especially expressed in fatality rates, has been improved considerably, leading to low fatality risks in the SUN countries compared to the new SUNflower+6 countries. However, since the initiatives which were taken in these countries, the fatality rates have dropped considerably there as well. It will be shown that the gap in safety between the SUN countries and the other SUNflower+6 countries is narrowing.

Road safety efforts turn out to be very effective, as soon as they get political priority, resulting in a full scale application of organizational activities and actual safety measures on a wide variety of safety aspects.

For countries with a recent increase in economical development, the message is to start with the organization of safety on a national level as early as possible and to establish a national safety research unit to support the implementation of safety measures.

4.2. Safety outcomes

On the basis of the footprint data, comparisons are made between the safety developments in the SUNflower+6 countries. The first comparisons regard the development of the fatality rates (fatalities divided by the number of vehicles) and fatality risks (fatalities divided by the number of vehicle kilometres) over a long period of time. These general analyses are followed by more detailed analyses over the three periods chosen: from 1981-1983, from 1991-1993 and from 2001-2003.

4.2.1. Safety trends

An interesting comparison between the SUNflower+6 countries is the development over time. The developments of fatality rates give a better indication of road safety than the fatalities themselves, because fatalities depend largely on the amount of traffic.

The most commonly used and preferred rates are fatalities divided by vehicle kilometres, often called 'fatality risk'. However, this data is not available for all countries for long periods of time. Therefore, a surrogate measure for this is fatalities divided by the amount of motor vehicles. This data is available from 1970-2003 for all nine countries and Catalonia. Given the differences in vehicle use per country and per year, this data can only be a proxy for the fatality risks.

The IRTAD database is used as the basic source for the comparisons. It is decided to use the IRTAD data from Great Britain, because the United Kingdom data is largely missing.

The data has been checked by the partners in this project. Missing data and some corrections were delivered by the partners themselves. Some missing data is (linearly) interpolated to complete the tables for analysis.

The first comparisons are made for the developments of the nine series of fatality rates, which are shown in Figure 4.1.

After that, fatality risks are compared for those countries for which data is available from 1980-2003. Figure 4.2 shows the fatality risks for the SUNflower+6 countries, except Hungary and Greece. The values for the SUN countries alone are also given in Figure 4.3 in order to show the differences between these countries more clearly.

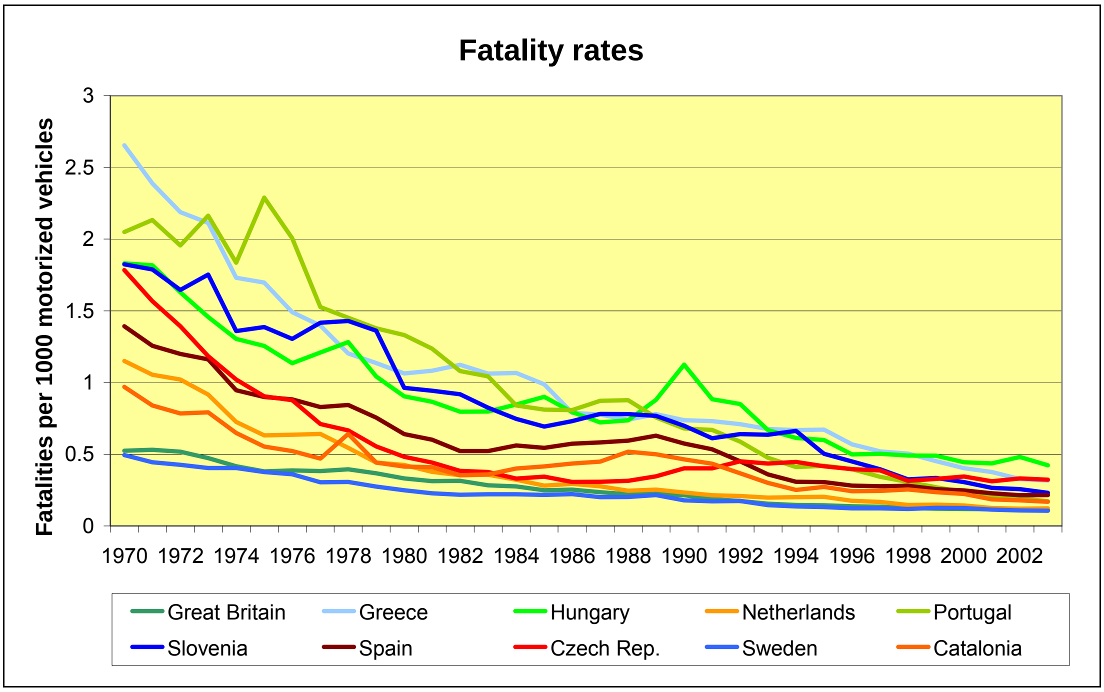


Figure 4.1. *Fatality rates (fatalities per 1000 motor vehicles) from 1970-2003 for the SUNflower+6 countries.*

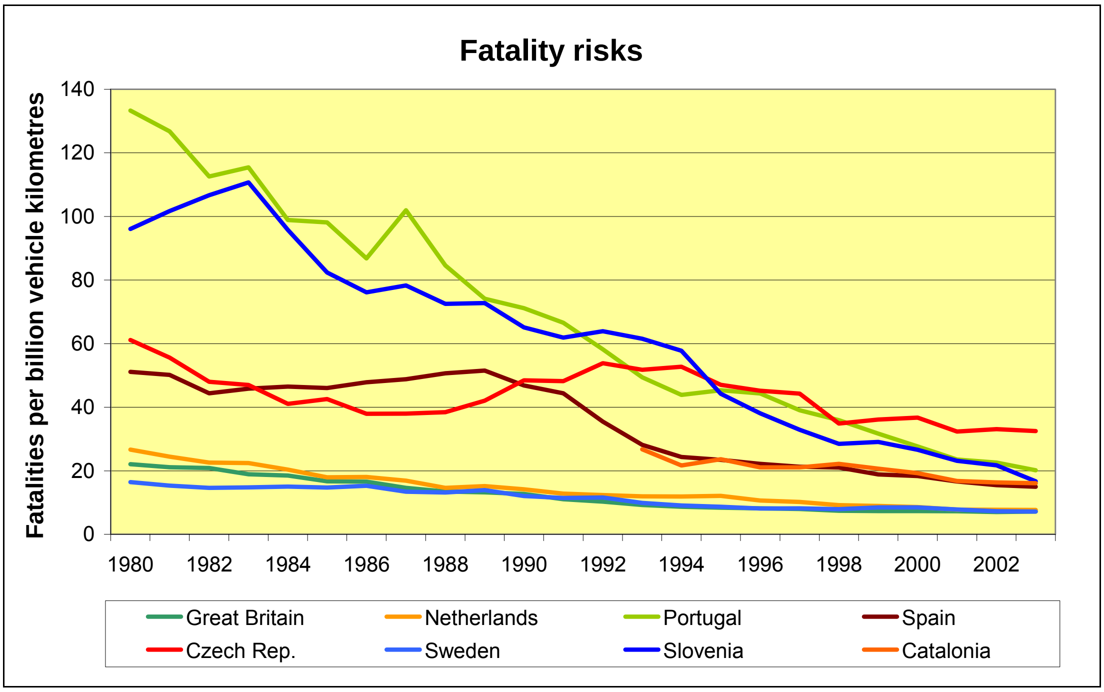


Figure 4.2. *Fatality risks (fatalities per 10^9 vehicle kilometres) for seven countries and Catalonia from 1980-2003.*

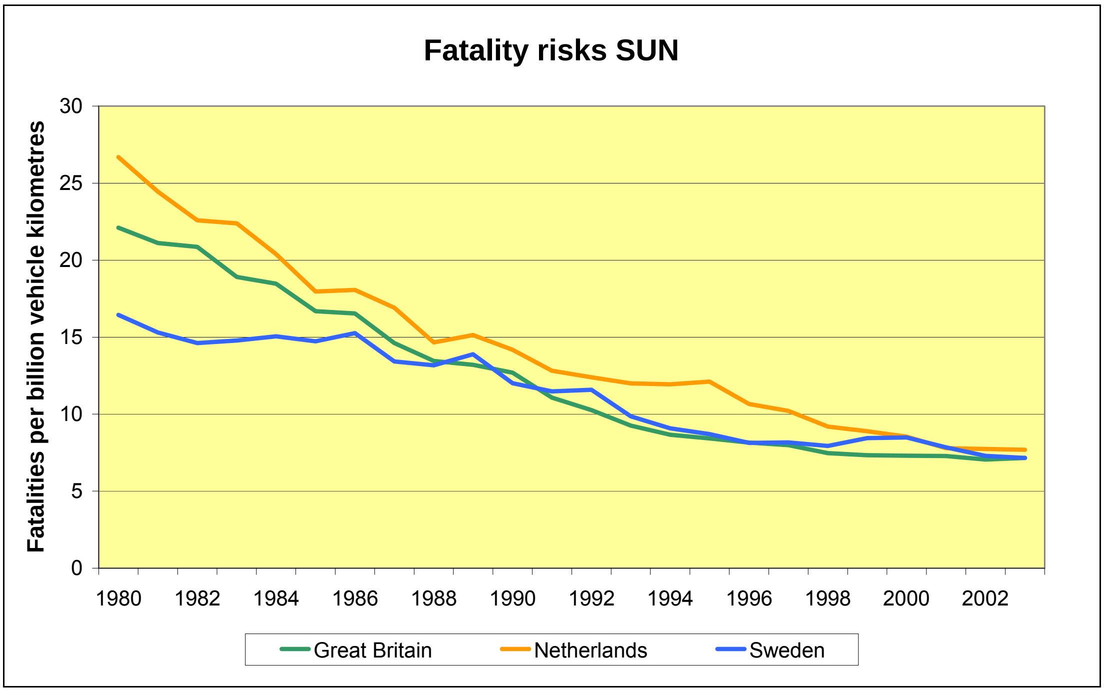


Figure 4.3. *Fatality risks (fatalities per 10^9 vehicle kilometres) for the SUN countries from 1980-2003*.

The Figures 4.2 and 4.3 show that there has been a steady decrease in rates over time for all countries, with sometimes an incidental increase. For the Czech Republic and Spain these increases are over longer periods. For these countries the same trends for the fatality risks are found as for the fatality rates, for Spain from 1982-1989 and for the Czech Republic from 1988-1994.

The steepest decreases are found for Portugal and Slovenia. For Spain there is a steep decrease in values from 1989 up to 1993 which becomes more moderate after that period. For the Czech Republic the improvement after 1994 is rather continuous, but also impressive.

4.2.2. Analysis of trends

To compare the developments in the nine countries an analysis was carried out on the fatality rates instead of the fatality risks, because these values are available for all nine countries.

The Singular Value Decomposition (SVD) technique (see Oppe, 2001) is used to look for similarities and dissimilarities between the developments of fatality rates for the nine countries over the years. This technique, based on a Principal Component Analysis (PCA) is often used to detect common trends in time series. A description of the SVD technique is given in Appendix G.

Using the SVD technique it was investigated to what extent the original nine series of fatality rates can be reduced to a small number of series (components) each representing a common characteristic of the original series. With each component a country weight is given, For the first component this weight is a constant that gives the best fit of the component for the fatality rates of that country. The weights for the next components are correction factors. A zero weight for these components means ‘no correction’. A positive weight means a correction similar to the component, a negative weight means a correction opposite to that component. The value of the weight determines the extent of the correction (small weights mean minor corrections, large weights substantive corrections).

The analysis is first carried out on the actual rates and subsequently on normalized rates (see Appendix G). Normalized rates are linearly transformed fatality rates in such a way that for each country the mean value of the series is equal to zero and the variance equal to 1. The reason for analysing normalized rates is to see whether fatality rate developments are similar in shape, apart from the differences in level and speed of fatality rate reduction, which differences are expressed by the mean value and variance of the actual series. The country weights for the first component in the analysis of the actual rates show the differences in the general level and speed of fatality rate reduction for the countries. Therefore, only the analysis of these series is discussed in detail.

4.2.2.1. Trend components

Nine components will reproduce the nine original series perfectly, but as in Principal Components Analysis, far fewer components are expected to be found. Six components were calculated in the analyses to ensure that no common factors were lost. The choice of the number of components does not have an effect on the results for each component.

The results are given in Table 4.3. The table shows that the nine series can be represented reasonably well by three components that represent three underlying trends. The singular values (sv) of component 1 is dominant (sv= 14.31). However, the sv’s of the components 2 and 3 are relatively high compared with the sv’s of the components 4, 5 and 6, which suggests that these two components are also particular trends and no ‘white noise’.

The first and far most important component (or general trend) can be regarded as the common trend underlying all nine series. This first component represents 98% of the variance in the series of actual rates and 95% of the variance in the normalized rates.

The second and third component represent deviations from this general trend. Components 4 through 6 represent ‘white noise’ (yearly fluctuations) in the data.

Singular values	Comp. 1	Comp. 2	Comp. 3	Comp. 4	Comp. 5	Comp. 6
Actual rates	14.31	1.33	1.10	0.49	0.46	0.29
Normalized rates	17.06	2.88	1.69	1.14	1.04	0.78
Cumulative percentage explained variance	Comp. 1	Comp. 2	Comp. 3	Comp. 4	Comp. 5	Comp. 6
Actual rates	0.98	0.99	1.00	1.00	1.00	1.00
Normalized rates	0.95	0.98	0.99	0.99	1.00	1.00

Table 4.3. *Singular values and cumulative percentage of explained variance for the fatality rates (fatalities per 1000 motor vehicles) and the normalized fatality rates*.

The country weights that result from the analysis for the first three components for the actual fatality rates are given in Figure 4.4.

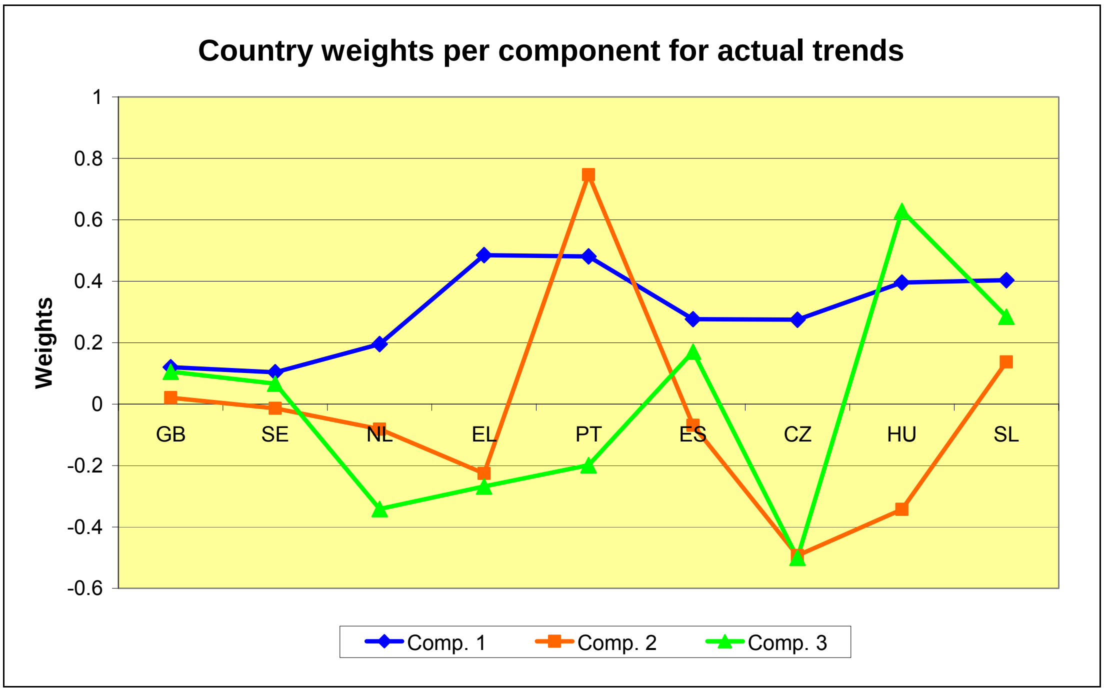


Figure 4.4. *Country weights for three SVD components from the analysis of actual trends.*

The weights related to the first component of the analysis on actual rates are an indication of the general safety level in a country. The weights for the normalized solution were all between 0.32 and 0.34, showing that the trends are very similar, except for the level and speed of the decrease in fatality rates. Therefore, the differences in weights for the countries on the first component from the analysis of the actual rates can indeed be interpreted as differences in level and speed of decrease in the rates.

As was to be expected from the differences in fatality rates as pictured in Figure 4.1, the weights of the actual data show the lowest values for Sweden and Great Britain, followed by the Netherlands. The weights for Greece and Portugal are highest, followed by Hungary and Slovenia. The values for Spain and the Czech Republic are moderate. The results agree with the order in Figure 4.1, because the country weight is the constant which results in the best fit of the common trend for the original values of that country. Countries with an overall higher fatality rate therefore will have a larger constant.

The second and third series of weights have the same general structure, but differ to some extent. The second series primarily represents differences in the development of safety in Portugal compared to Hungary, the Czech Republic and Greece. The third series represents the differences between Hungary (and to a lesser extent Slovenia and Spain) and the Czech Republic (and to a lesser extent the Netherlands, Portugal and Greece).

The general trend, corresponding with the first component, is given in Figure 4.5, together with an exponential fit to this data.

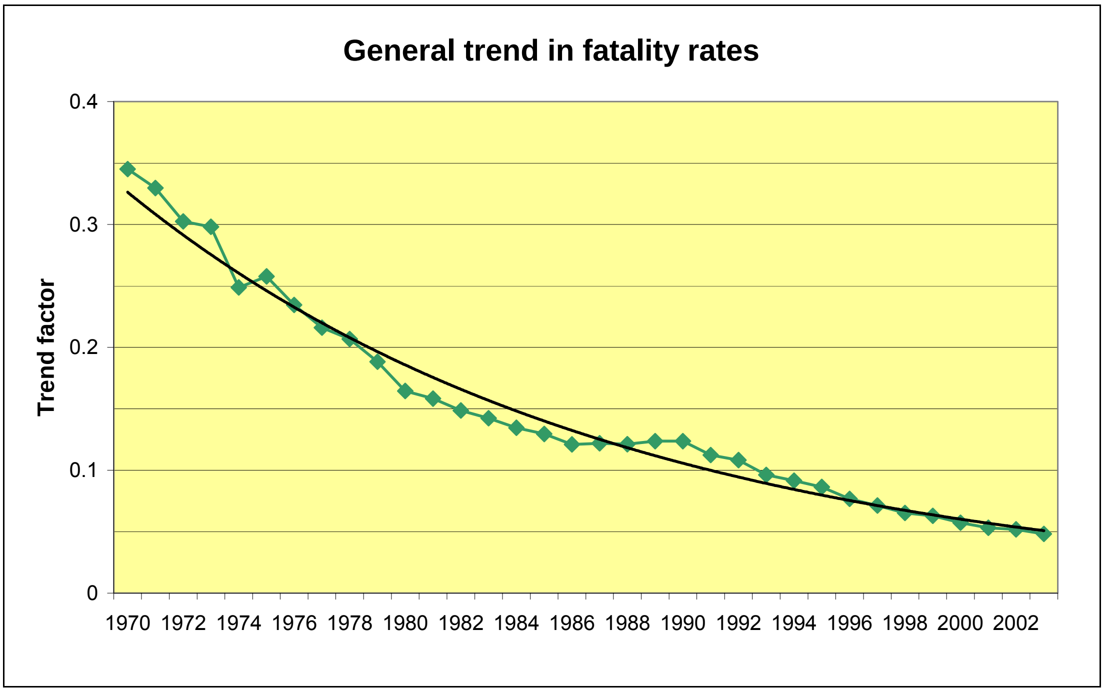


Figure 4.5. *General trend in fatality rates for the SUNflower+6 countries, resulting from an SVD analysis together with the best fitting exponential trend*.

This trend shows the general decline of the fatality rates over the years. An exponential decline is often regarded as a fair description of the decline in fatality risks over the years for many countries. The fatality rates (in fatalities per 1000 motor vehicles) estimated from this general trend for a particular country are found by multiplying the trend factor for each year with the country weight and with the singular value for the general trend (e.g., for Sweden with 0.10 x 14.31, for Greece with 0.49 x 14.31 etc.).

It can be seen that from the mid-1970s to the mid-1980s the decrease is higher than the exponential fit of the data and lower from the late eighties to the beginning of the 1990s. In that period major traffic developments took place in some countries.

After 1988 a substantial increase in the rates can be observed. It is the period of change for the Central countries. In a way it can be said that there are two exponential trends which are steeper than the trend over the whole range: one in the period before 1987 and a similar one from 1990 onwards, and between the two there is a transition period.

The trends related to the second and third component are given in Figure 4.6.

Both trends have almost the same shape, however, shifted in time. Portugal has the highest (positive) weight on the second component and the Czech Republic and Hungary the lowest (negative) weight (see Figure 4.4). It means that the second trend as given in Figure 4.6 primarily represents the deviations for Portugal and that this trend is reversed for the Czech Republic and Hungary.

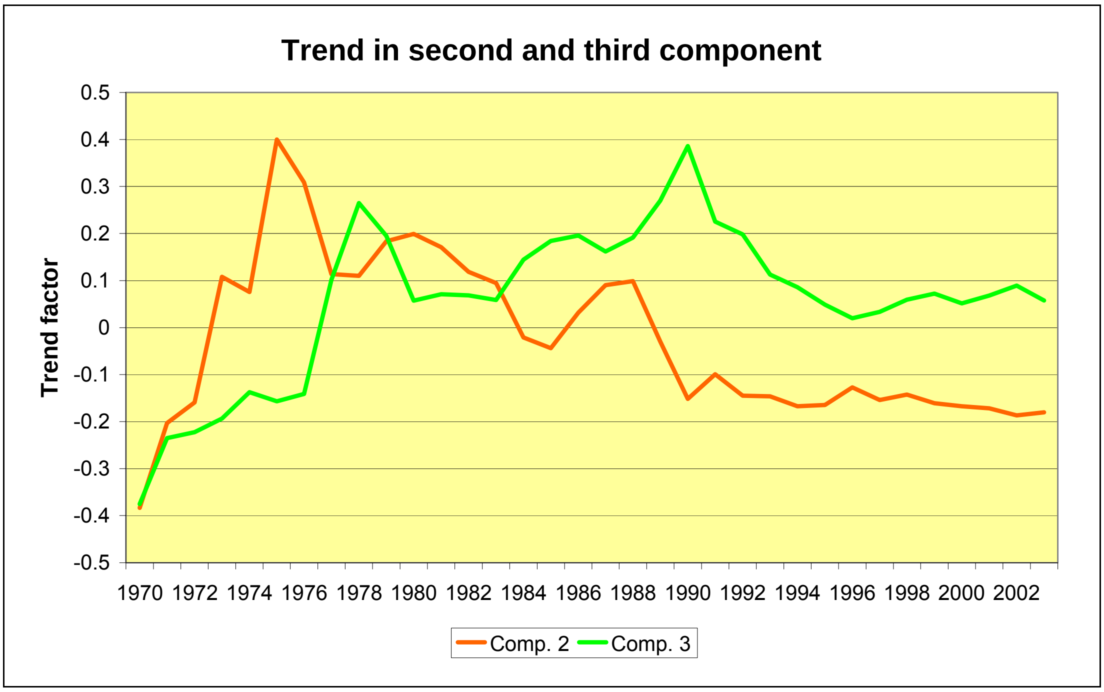


Figure 4.6. *Second and third component, resulting from an SVD analysis of the fatality rates (fatalities per 1000 motor vehicles) for the SUNflower+6 countries*.

The third trend primarily compensates for the effect of the second trend: with a shift in time it adds to the effect of the second trend for the Czech Republic, but reduces this trend for Hungary.

4.2.2.2. Deviations from trends

It was already stated that the first SVD component 'explains' 98% of the variation in the actual fatality rates. The residuals that remain after subtracting the predicted values of the first component from the observed values, illustrate the deviations from this trend for the various countries. The zero level represents the values of the first component, weighted for each country. The positive and negative fluctuations around zero show the periods of relatively higher and lower fatality rates than predicted by the common trend.

For reasons of clarity the results are given in separate figures for the three groups of countries. Figure 4.7 gives the results for the original SUNflower countries.

Figure 4.7 shows that the decrease in the fatality rates as represented by the general trend deteriorates slightly for Great Britain and Sweden from the 1970s to the mid-1980s. For the Netherlands, an initial relatively high fatality rate is followed by a low rate from the mid-1970s onwards. This shows that the Netherlands was closing the gap with Great Britain and Sweden during that period. The low rate is particularly found for the period from 1988 to 1996. The curves for Great Britain and Sweden are also a bit lower during this period. This is clearly caused by the increase of the general trend due to the developments in Central Europe.

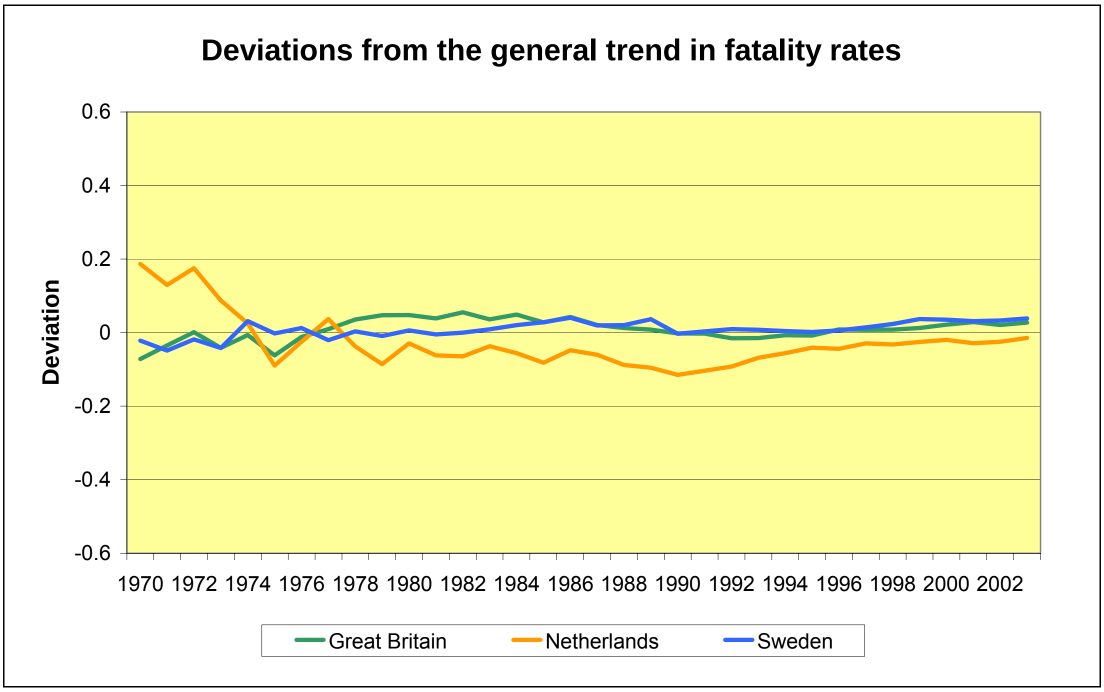


Figure 4.7. *Deviations from the general trend in fatality rates for the original SUNflower countries, resulting from an SVD analysis.*

Compared to the general trend there has been a relative increase in the rates for the last eight years for all three countries. This could partly be caused by the improvement in the Central countries after the initial deterioration from 1988 onwards. However, as stated earlier, the improvement in the SUN countries themselves also seems to have slowed down in recent years.

An analysis of the SUNflower+6 countries separately would have resulted in a smoother common trend and a more genuine picture of the deviations from that common trend.

Figure 4.8 shows that after an initial improvement for the Czech Republic in the 1980s compared to the 1970s, a steep increase in the rates can be noticed, which levels off from 1994 onwards. The trend, however, is still high.

For Hungary there also is a steep but more sudden increase from 1988 till 1994, followed by a development similar to the one in the Czech Republic. For Slovenia a relative improvement in safety is found inform the mid-1990s onwards, after a fluctuating but generally negative trend since the late 1970s.

Figure 4.9 shows that Spain was not performing well during the 1980s, but does not deviate much from the general trend since the 1990s. Portugal had a peak around 1974 (the year of the Portuguese Revolution) and around 1980, but is doing well from the beginning of the 1990s onwards. After an initial positive development the trend for Greece was deteriorating in the early 1980s. It was doing relatively well from the mid-1980s to the beginning of the 1990s. After a short deterioration in the early 1990s Greece has been doing better again recently.

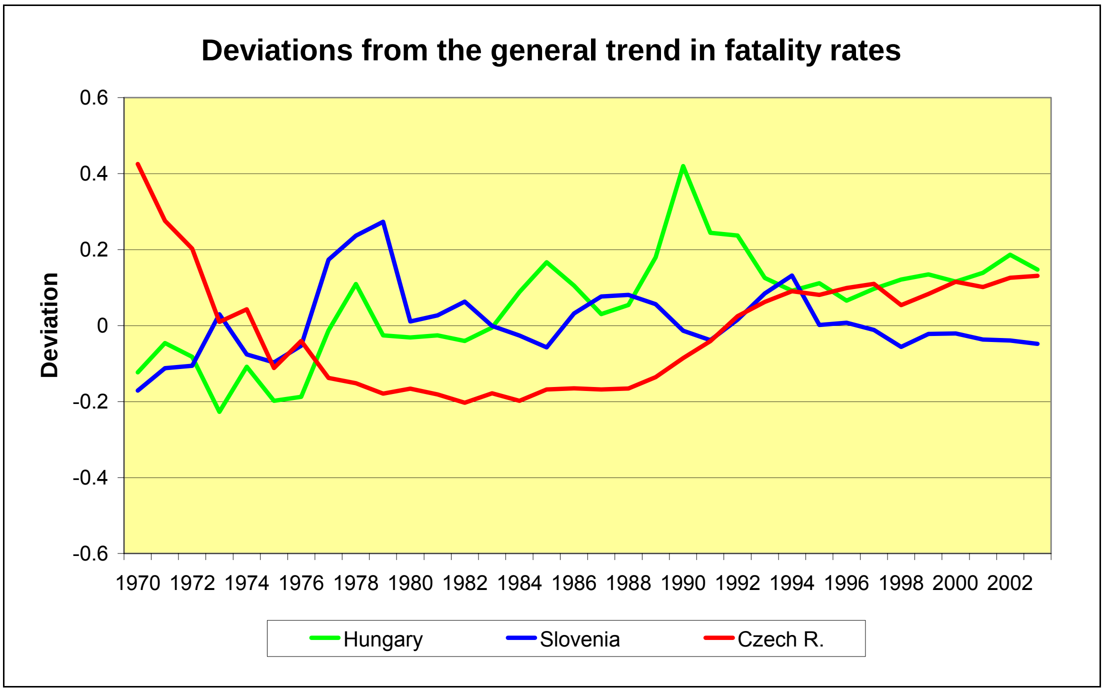


Figure 4.8. *Deviations from the general trend in fatality rates for the Central countries, resulting from an SVD analysis.*

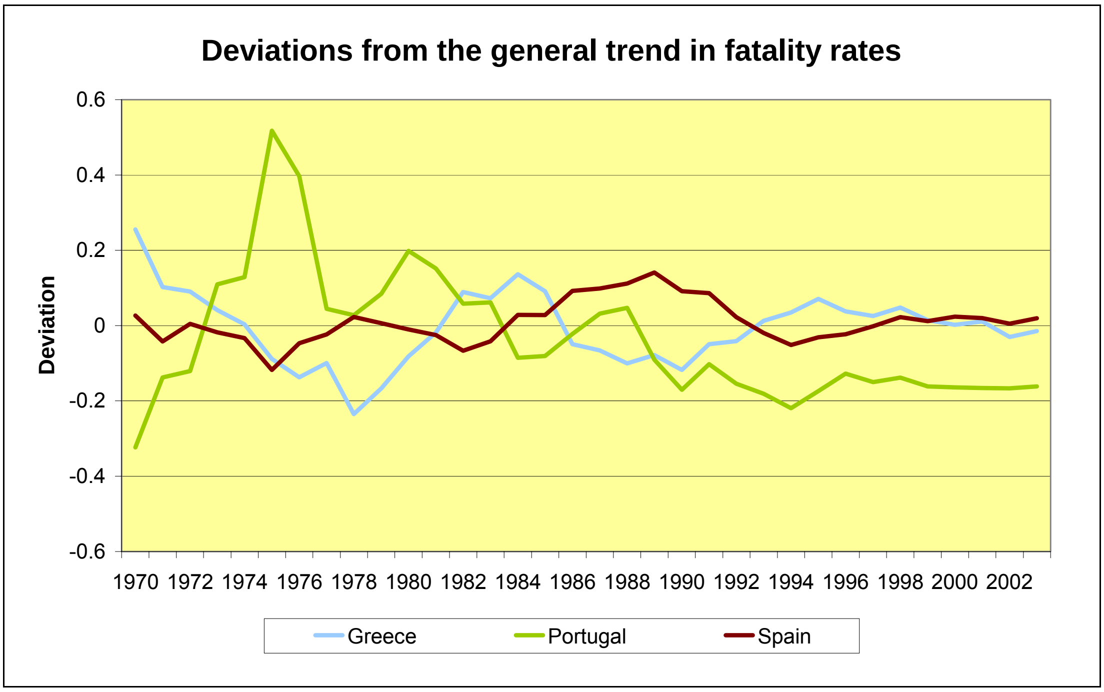


Figure 4.9. *Deviations from the general trend in fatality rates for the Southern countries, resulting from an SVD analysis*.

4.2.3. Mortality rates, fatality rates and fatality risks

To make an overall safety comparison for the SUNflower+6 countries, the mortality rates (fatalities/population), fatality rates (fatalities/vehicles) and fatality risks (fatalities/vehicle kilometres) of these countries are compared for three time periods: 1981-1983, 1991-1993 and 2001-2003. For this, averages of yearly fatalities, population size (in millions), vehicle numbers (in millions) and vehicle kilometres (in billions) have to be used. Table 4.4 gives an overview of this data for the nine countries and Catalonia.

Data for 1981, 1991 and 1992 has been available in Spain and Catalonia, but was deleted because of a change in registration in 1982 and 1993. For Catalonia, the vehicle kilometres are missing for the period 1981-1983.

Vehicle kilometres are missing for Hungary for all three periods.

1981-1983	SE	UK	NL	CZ	HU	SI	EL	PT	ES	Cat
Population x10^6	8.32	54.81	14.28	10.31	10.71	1.93	9.79	9.47	38.03	5.98
Fatalities	774	5742	1758	1102	1581	554	1499	2498	6102	877
Vkms x10^9	51.93	283.14	76.01	23.40	-	5.22	33.35	21.15	130.48	-
Vehicles x10^6	3.49	18.96	4.85	2.75	1.93	0.54	1.62	2.24	11.16	2.35
Kms/vehicle	14872	14935	15680	8499	-	9737	20558	9442	11692	-
1991-1993										
Population x10^6	8.64	55.96	15.13	10.33	10.34	1.99	10.36	9.38	39.11	6.09
Fatalities	712	4204	1273	1462	1966	482	1816	2631	7677	1153
Vkms x10^9	64.85	413.33	102.66	29.52	-	7.73	61.67	45.57	215.46	36.23
Vehicles x10^6	4.37	24.46	6.15	3.41	2.46	0.78	3.02	2.70	17.23	3.16
Kms/vehicle	14849	16895	16691	8669	-	9899	20393	16873	12505	11465
2001-2003										
Population x10^6	8.91	57.63	16.09	10.21	10.17	2.00	11.00	10.23	41.53	6.50
Fatalities	538	3463	1003	1404	1331	263	1706	1631	5421	798
Vkms x10^9	72.86	483.78	131.3	43.61	-	12.98	110.64	72.31	345.64	48.60
Vehicles x10^6	4.94	30.39	8.18	4.37	2.98	1.04	5.70	5.09	24.83	4.19
Kms/vehicle	14762	15917	16059	9980	-	12423	19412	14202	13921	11600

Table 4.4. *Average yearly number of fatalities, population size, number of motor vehicles, vehicle kilometres and kilometres per vehicle for the nine SUNflower+6 countries and Catalonia for three time periods*.

For the SUN countries the average distance travelled by car per year is around 15,000 km for all three periods. For Spain and Catalonia the distances are a bit less. For some other countries there is a large difference. For the Czech Republic the numbers are considerably lower with only a slight increase over the years. For Slovenia there is a steep increase in the last period and for Portugal in the last two periods. The numbers for Greece are high in all three periods.
Although some of the greatest variations will be related to the different vehicle oriented policies and economical developments in the countries, doubts must be

expressed about some reported estimates of the total number of vehicle kilometres per year, especially concerning the high numbers in Greece and the discrepancies between periods for Slovenia and Portugal. The values for the last period seem to be more equal, with only low numbers for The Czech Republic and high numbers for Greece.

It is important that uniform procedures for measuring the total number of vehicle kilometres per year are defined, in order to make reliable estimates of fatality risks for a country or road type.

4.2.3.1. Mortality rates

Figure 4.10 shows the mortality rates for the nine countries and Catalonia for three periods of time 1981-1983, 1991-1993 and 2001-2003.
The Czech Republic, Hungary, Greece, Portugal and Spain show an increase in the second period. For the Czech Republic and Hungary this effect is due to the political change and the resulting increase in motorization. For Greece, Portugal and Spain it is probably due to the increase in motorization as such. All countries show an improvement over the last 10 years, although this is especially the case for the countries that had the highest rates in the second period (Slovenia and Portugal).

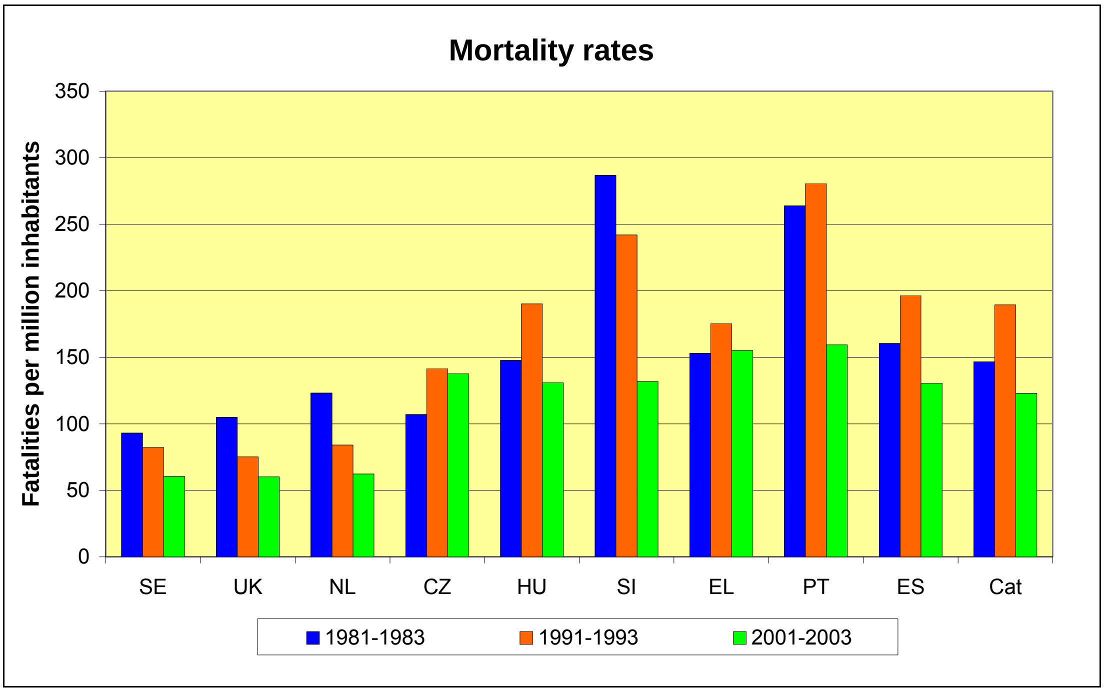


Figure 4.10. *Mortality rates (fatalities per million inhabitants) of the nine SUNflower+6 countries and Catalonia in three time periods*.

It can be concluded that the safety improvement expressed in absolute mortality in the countries with a high mortality in the first two periods, is highest in the third period. This agrees with the general phenomenon that trend followers, compared with trend setters, will make up for initial arrears, because there are more opportunities for improvement. It will be shown later that this need not be the case for the percentage of reduction.

4.2.3.2. Fatality rates and fatality risks

The fatality rates are given in Figure 4.11. It is shown that initially these rates are highest for Portugal, Slovenia and Greece, followed by Hungary, Spain and the Czech Republic. The value for Portugal improves considerably in the last period and is then almost equal to that for Spain and lower than the fatality rates for the Czech Republic and Hungary. The second largest reduction is for Slovenia, followed by Greece.

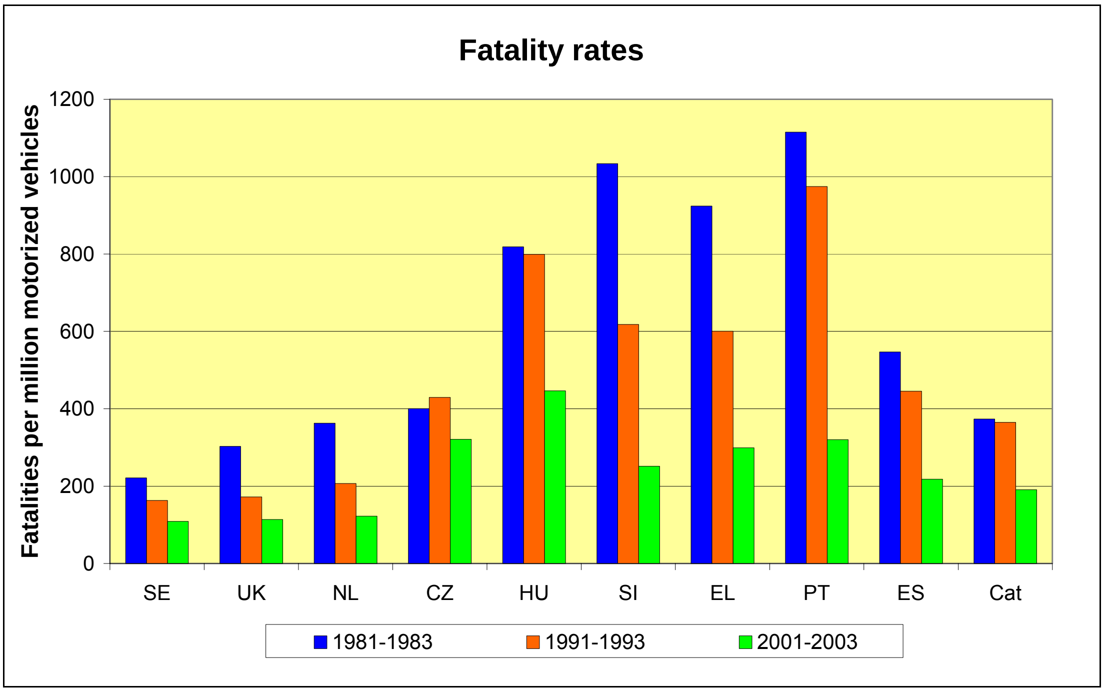


Figure 4.11. *Fatality rates (fatalities per million motorized vehicles) of the nine SUNflower+6 countries and Catalonia in three time periods*.

Finally, Figure 4.12 shows the fatality risks for the three periods. Data for Hungary is missing in all three periods and for Catalonia in the first period.

The figures for Slovenia show a more than proportional growth of the motor vehicle kilometres, compared with the growth of the vehicle fleet. This makes the improvement in safety even more impressive: a 73% decrease in fatality risk was achieved.

For the Czech Republic also, a better performance in fatality risk than in fatality rate is found for the last period, although not as impressive as in Slovenia.

A possible explanation for the achievement in Slovenia is the substantive construction of motorways in recent years. From literature we know that fatality rates on motorways are approximately five times lower than on other rural roads (see also Figure 5.10).
This measure taken in Slovenia shows, that road safety will benefit considerably from a substantive redirection of traffic from the underlying road system to the motorways.

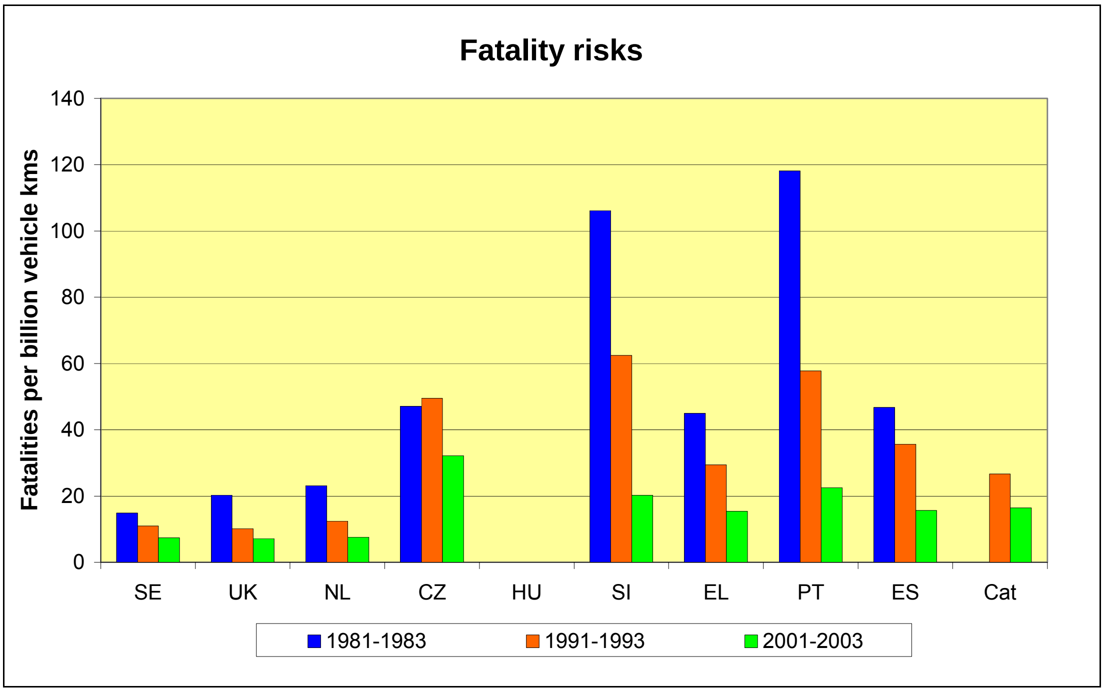


Figure 4.12. *Fatality risks (fatalities per 10^9 vehicle kilometres) of the nine SUNflower+6 countries and Catalonia in three time periods*.

4.2.3.3. Comparison of mortality, fatality rates and fatality risks between (groups of) countries

One of the main purposes of the SUNflower+6 project is the comparison of safety developments between countries and groups of countries. A direct comparison of the safety outcomes in the nine countries and the autonomous region of Catalonia in terms of the total number of fatalities, does not make sense. A weighting of these numbers is necessary, because countries differ in population size and amount of travel. Data for such a comparison using population size or number of vehicles as a weight is available.

However, a direct comparison of mortality rates, fatality rates or fatality risks using t-tests or ordinary Chi-squares is, statistically speaking, also misleading. Rates from large denominators are more reliable than equal rates from small denominators.

A Weighted Poisson Analysis Technique (WPM) is used for the comparison of countries and groups of countries (De Leeuw & Oppe, 1976). The WPM technique makes it possible to analyse tables of counts, weighted for constants. Statistical tests have been carried out based on this data. For more information on this method: see Appendix H.

Mortality rates

In the first series of analyses the mortality rates for the nine countries are compared for the time periods 1981-1983, 1991-1993 and 2001-2003. For Spain data is missing for 1981, 1991 and 1992. Catalonia is included in Spain. Figure 4.13 shows the effects of the comparison of mortality rates for (groups of) countries for the three periods of time.

The data used are the same as those described in the preceding sections. However, sums of fatalities and population sizes are analysed instead of averages. Using averages would have influenced the statistics incorrectly because these are based on different numbers of years.
Because of the weighting procedure used in WPM the parameters do express differences between the mortality rates.

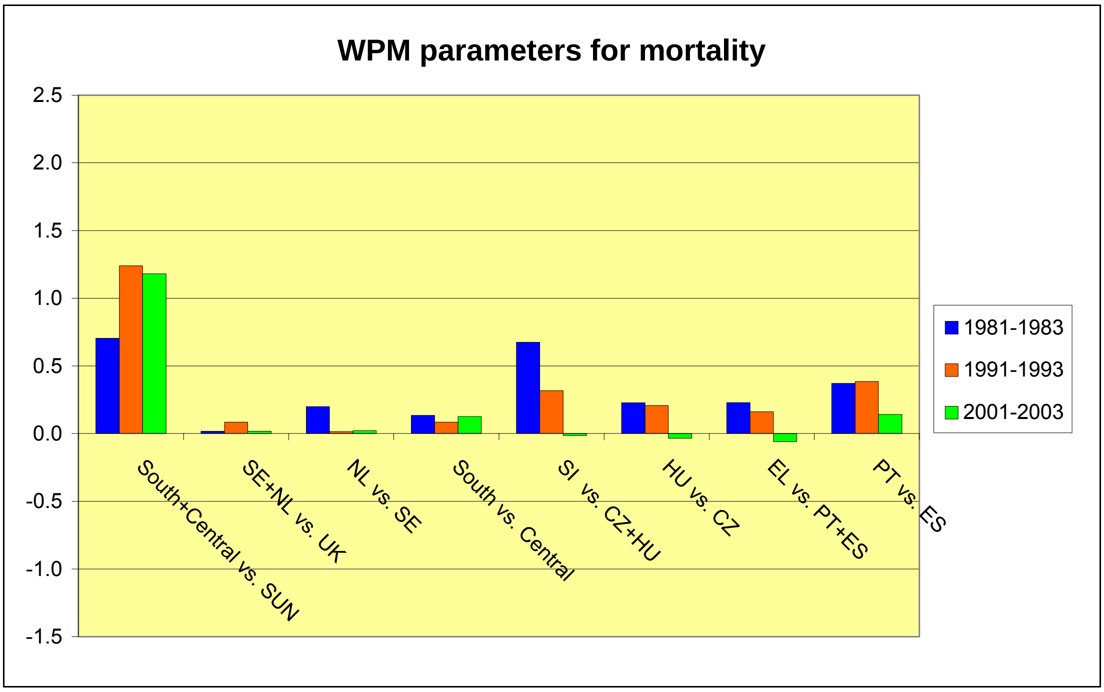


Figure 4.13. *WPM parameter values for comparisons between mortality rates of (groups of) countries for three time periods*.

The first comparison in Figure 4.13 is between the Southern + Central countries and the SUN countries. The figures should be interpreted as follows: a high positive value means that the first term in the comparison (Southern + Central) has a higher mortality than the second term (SUN).

This comparison between the Southern + Central countries and the SUN countries shows the largest effects for all three periods. The values show that the mortality rates for the Central and Southern countries together is much higher than for the SUN countries. It also shows that the effect is smaller for the first period than for the later periods and that for the last period it is slightly smaller than for the period before that. All effects are highly significant. They show that from the first to the second period the mortality decreased much more in the SUN countries than in the Southern and Central countries in that period and that the difference was somewhat less in the last period.

The second comparison shows that the mortality rates in the middle period are slightly higher in Sweden and the Netherlands than in the United Kingdom. The effect for both other periods is almost zero and not significant. The third comparison shows that in the first period the mortality rate is (significantly) higher for the Netherlands than for Sweden. For the next periods this effect is small and not significant anymore. In the second period the United Kingdom did relatively better than the other SUN countries, but this effect levelled off in the last period. The Netherlands had a higher mortality rate than Sweden in the first period, but closed the gap with Sweden in the second and third period.

The Southern countries have a significantly higher mortality than the Central countries in all three periods. Slovenia compared with the Czech Republic and Hungary has a much higher significant mortality in the first period which is halved in the second period and further reduced to a (non-significant) lower rate in the last period, closing the gap with the Czech Republic and Hungary. This relative improvement in the last two decades is considerable. Hungary has a significantly higher mortality rate than the Czech Republic in the first two periods, but a slightly lower, but just significant rate in the last period.

For Greece we see a similar decreasing trend as for Slovenia: a higher mortality rate than Portugal and Spain in the first and second period which is significantly lower in the third period.

Finally, Portugal has a significantly higher mortality rate than Spain in all three periods. The difference is largest in the first period, smaller in the second and again smaller (but still significantly higher) in the last period.

Fatality rates

The second series of analyses regard the fatality rates (number of fatalities per million motor vehicles). The analyses are similar to those of the mortality rates.
Data for Spain is missing again for 1981, 1991 and 1992.

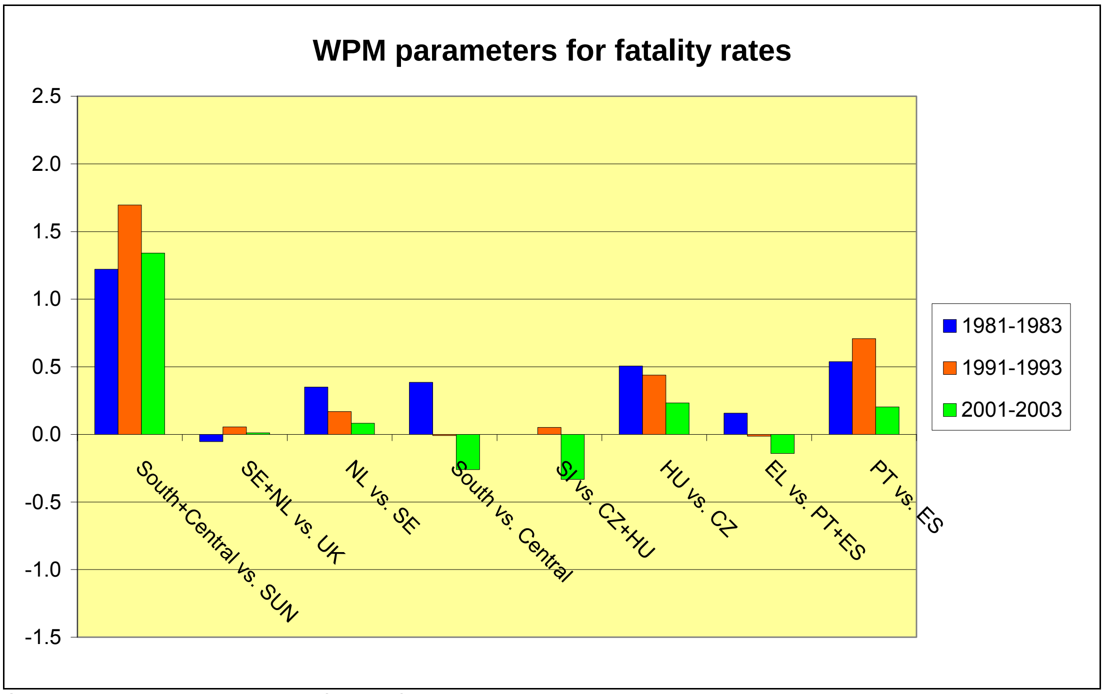
Figure 4.14 shows that the differences between the SUN countries and the new SUNflower+6 countries are larger for the fatality rates than for the mortality rates. This indicates that, given the amount of vehicles, safety in the SUN countries is even better than shown in the mortality figures. The Central and Southern countries are decreasing their arrears in terms of fatality rates somewhat more lately.

Furthermore it can be noticed that the effect for the comparison of the Central countries versus the Southern countries is different from the mortality effect. The Southern countries changed their arrears in terms of the fatality rates into a lead over the last 20 years. Therefore, when the relative increase of the vehicle park in the Southern countries compared to the Central countries is taken into account, then the Southern countries performed better than suggested by the mortality rates.

The positive trend for Slovenia compared with the Czech Republic and Hungary is larger for the fatality rates than for the mortality rates. For Greece compared with Portugal and Spain the effect is somewhat stronger.

The positive trend for Portugal compared with Spain in the last period is larger for the fatality rates than for the mortality rates, although the fatality rate for 2001-2003 is still higher than in Spain.

All effects are significant, except the effect for Sweden and the Netherlands versus the United Kingdom in the last period, and Slovenia versus the Czech Republic and Hungary in the second period.



Slovenian values are missing for the first time period.

Figure 4.14. *WPM parameter values for comparisons between fatality rates of (groups of) countries for three time periods.*

In order to make comparisons between countries, the amount of traffic and their developments over time is a key factor. However, the vehicle fleet itself is not the best indicator for traffic growth. Countries differ in the way and intensity of the use of cars. The estimate of the total number of vehicle kilometres driven in a country in a certain year is therefore a better indicator to correct the number of fatalities than population and vehicle park size. It was already shown that the fatality rates differ considerably from the mortality rates. It is important to compare both results with the comparison of fatality risks: the fatalities corrected for the amount of traffic, expressed in fatalities divided by the total number of vehicle kilometres.

<u>Fatality risk</u>

Although in principle fatality risk is a better indicator, the results depend largely on the reliability of the estimated number of vehicle kilometres. However, these estimates are more liable to errors than population size and vehicle fleet. Fatality rates can be used to check whether the preferable fatality risks are trustworthy. For instance, large deviations per year from the average yearly number of kilometres of cars can be used as indications for unreliability.

Figure 4.15 shows the parameter values for the fatality risks. The data from Hungary is missing for all three periods, from Spain and Catalonia for 1981,1991 and 1992. Therefore the effects for differences between groups of countries are not directly comparable to the values for the fatality rate and the mortality rate.

All comparisons except one are significant. The only not-significant parameter is for the comparison of the Netherlands with Sweden in the last period.

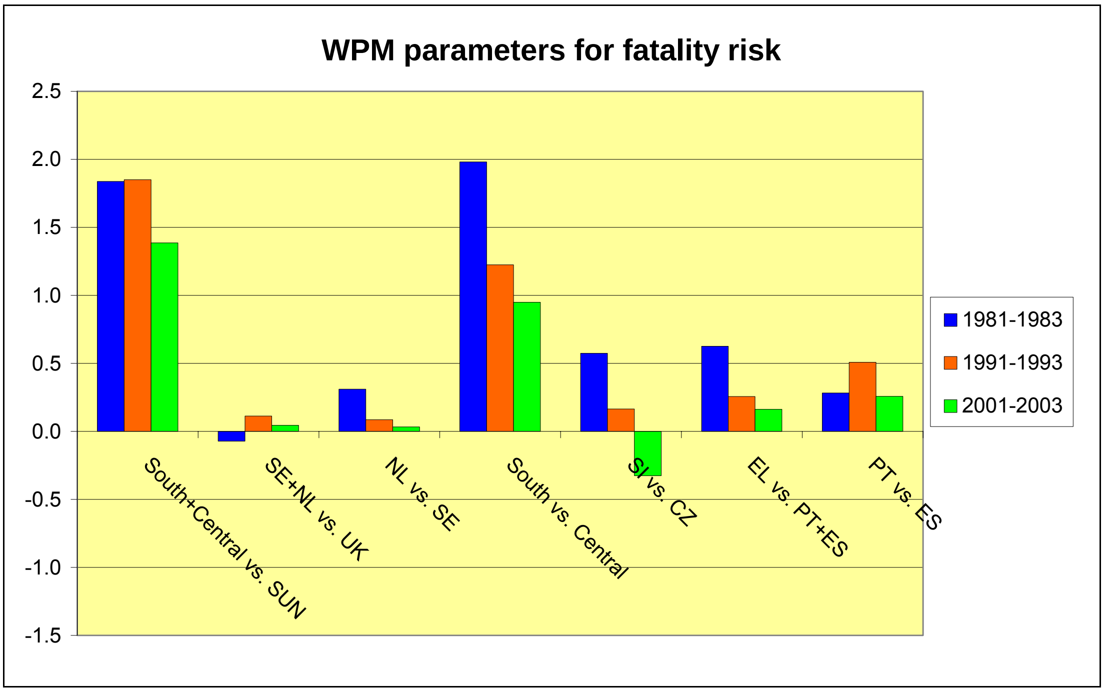


Figure 4.15. *WPM parameter values for the comparisons between fatality risks of (groups of) countries for three time periods.*

From the comparison between SUN countries and new SUNflower+6 countries it is seen that the fatality risk parameters for the first two periods are even more extreme than the fatality rate parameters.
For the 2001-2003 period, the value of the fatality risk parameter is a bit more reduced than the value of the fatality rate parameter, compared with the 1991-1993 period.

The fatality risk parameters for Southern versus Central are much higher than the parameters for the mortality and fatality rates. In the last period there even is a considerably higher fatality risk in the Southern countries. This effect is partly due to the fact that Hungary is missing in this comparison.
For Slovenia we see almost the same picture for the fatality risk as for the fatality rate: a considerable improvement over time, compared with the Czech Republic.
The fatality risk for Greece is much higher than for Portugal and Spain in all three periods, and also much higher than the fatality rates in these periods.
The fatality risks for Portugal are higher than for Spain, particularly in the second period.

4.2.3.4. Personal safety versus traffic safety

An interesting overview of the time development of road safety is given by plotting personal safety against traffic safety. Personal safety is the degree to which road crashes affect the safety of a population and is expressed here as mortality. Traffic safety can be understood as a measure of how safely the road transport function of a country is executed and is expressed as the fatality rate or fatality risk (Trinca et al., 1988). Personal safety is plotted against traffic safety for the nine SUNflower+6 countries, aggregated over the periods 1981-1983, 1991-1993, 2001-2003 in Figure 4.16 (with fatality rate) and Figure 4.17 (with fatality risk).

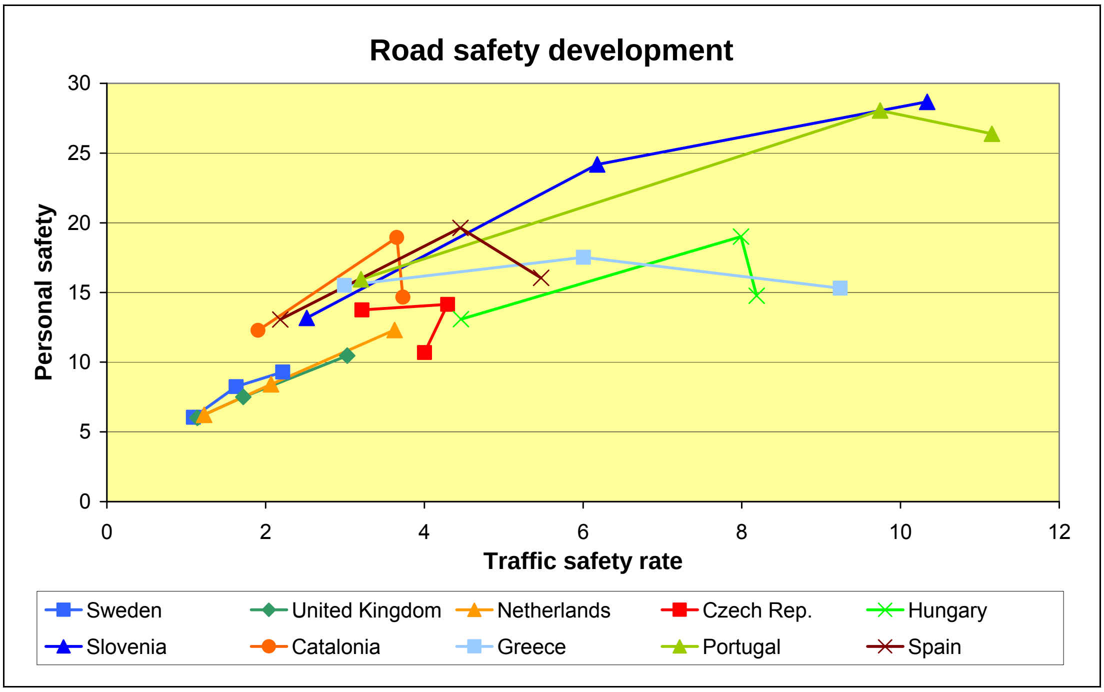


Figure 4.16. *Development of road safety in SUNflower+6 countries, visualized as* ***personal safety*** *(fatalities per 100 000 inhabitants) versus the* ***traffic safety rate*** *(fatalities per 10 000 motorized vehicles). Time development from the 1981-1983 period for points at the right side of graph, via 1991-1993 to 2001-2003 for points at the left side of the graph.*

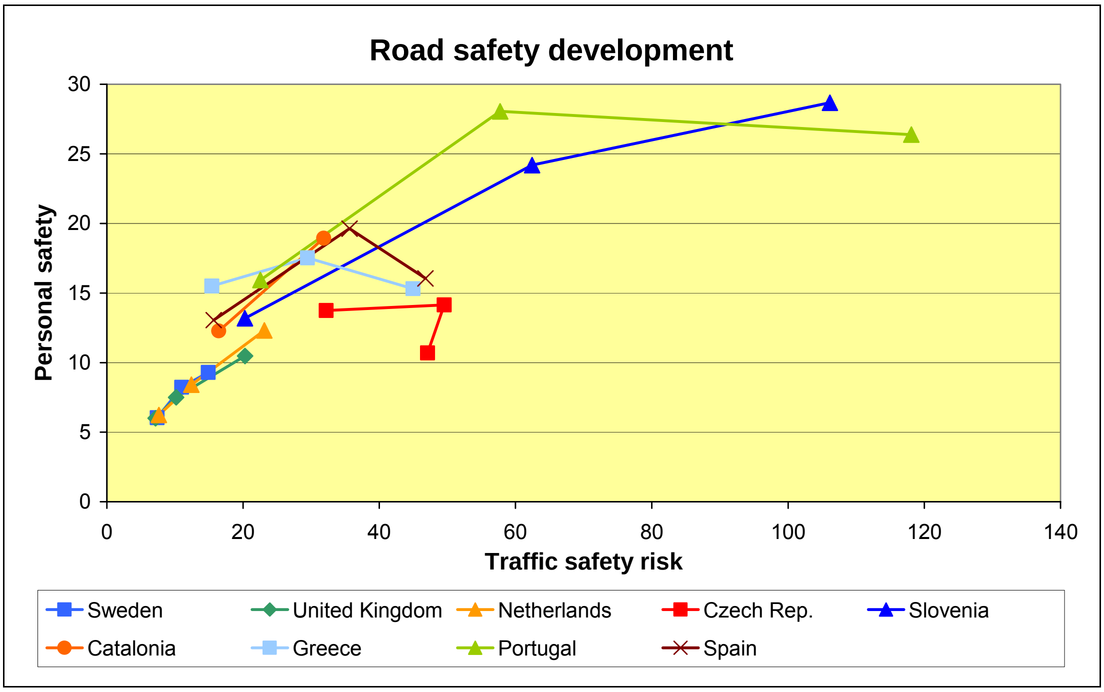


Figure 4.17. *Development of road safety in SUNflower+6 countries, visualized as* ***personal safety*** *(fatalities per 100 000 inhabitants) versus the* ***traffic safety risk*** *(fatalities per 10^9 vehicle kilometres). Time development from the 1981-1983 period for points at the right side of graph, via 1991-1993 to 2001-2003 for points at the left side of the graph.*

Figure 4.16 shows the parabolic time development trend, as depicted in Figure 2.2, fairly well for most of the Central and Southern countries. The SUN countries already reached the top of the curve before the early 1980s, and continued to have almost identical motorization rates. The developments are almost along the same line, with almost identical values for the safety and mortality rates in the last period.

All countries experienced a growth of the motorization rate over the period. Two further trends can be observed in this graph. First, all countries have improved their position both on the personal safety scale and on the traffic safety scale. But the speed of improvement is not the same. The most impressive improvements are shown by Slovenia and Portugal. The same 'direction' of improvement during the last decade (which seems to be identical for the SUN countries) can be observed in some of the other countries as well. The exceptions here are Greece and the Czech Republic. A last observation from this graph is the development in the period 1981-1983 and 1991-1993 in four countries: Spain (incl. Catalonia), Portugal, Hungary and the Czech Republic. In these three countries a very marginal decrease of traffic safety rate went together with an increase in personal safety.

The trends shown in Figure 4.17 are almost the same as in Figure 4.16. Fatality risk data is missing for Hungary for all periods and for Catalonia for the first period. In Portugal changes in fatality risk are more equally divided over the three periods than fatality rate changes.

In Table 4.5 the relative improvements can be seen for the nine countries and Catalonia for the last two periods, given as percentages of the first period.

1991-1993	SE	UK	NL	CZ	HU	SI	EL	PT	ES	Cat*
Mortality	88.6	71.7	68.3	132.3	128.8	84.3	114.4	106.3	122.3	129.1
Fatality rate	73.6	56.7	57.1	107.3	97.6	59.8	65.0	87.4	81.5	98.0
Fatality risk	73.7	50.2	53.6	105.2	-	58.8	65.5	48.9	76.2	-
2001-2003										
Mortality	65.0	57.4	50.6	128.5	88.7	46.0	101.3	60.4	81.3	83.7
Fatality rate	49.2	37.6	33.8	80.3	54.5	24.4	32.4	28.7	39.9	51.1
Fatality risk	49.6	35.3	33.0	68.4	-	19.1	34.3	19.1	33.5	61.5 *

* Catalonia: 2001-2003 compared with 1993.

Table 4.5. *Mortality, fatality rate and fatality risk for the periods 1991-1993 and 2001-2003 as a percentage of the values for 1981-1983.*

It is shown that mortality increases considerably for the Czech Republic and Hungary during the early 1990s, and to a lesser extent for Greece, Portugal and Spain. For the SUN countries and Slovenia there is a considerable decrease.

In 2001-2003 the mortality for the Czech Republic and Greece is lower than in 1991-1993, but still higher than in 1981-1983. Particularly for Portugal, but also for Spain, the mortality is much lower. Again, this is also the case for the SUN countries and Slovenia.

The fatality rates are lower in 1991-1993 for all countries, except for the Czech Republic, and lower for all countries in 2001-2003 compared with 1981-1983 as well as with 1991-1993. The reductions are most impressive for Slovenia, Portugal, Greece and the Netherlands. These figures show that the improvement in safety more than compensates the growth in motorization.

The fatality risk figures show comparable effects as seen with the fatality rates, except for Portugal where the fatality risk is much lower in both periods and for Spain and the Czech Republic in the last period. For these two countries not only the number of vehicles, but also their use increased considerably.

The largest fatality risk reductions of around 80% are found for Slovenia, Portugal and Spain in 2001-2003 compared with 1981-1983. For the United Kingdom, the Netherlands and Greece, these reductions are around 65%.

Sweden follows with 50% and for the Czech Republic the reduction is 32%. For Hungary no data is available. These figures show that, although the non-SUN countries have the largest reductions in absolute numbers, the proportional change for the SUN countries is equally impressive.

5. Disaggregate safety outcomes

For a more detailed comparison of road safety in the nine countries, several disaggregate comparisons are made. For the comparisons two years were selected, 1993 and 2003. The comparisons regard modal split, conflict type of crash, age, and road type.

5.1. Safety per transport mode

5.1.1. Number of fatalities per transport mode

Table 5.1 gives the number of fatalities for each transport mode in percentages for all nine SUNflower+6 countries and Catalonia. It should be kept in mind that the comparison between transport modes does not only express differences in risk, but also differences in use. For example, the Netherlands has a high percentage of bicycles on the roads. In Southern countries relatively more motorized two-wheelers are used during longer periods of the year than in more Northern countries.

To make fair safety comparisons, weights should be used to cancel the exposure effect. However, reliable exposure data for transport modes is hardly available. The comparison of relative percentages of road users killed per transport mode still is informative.

Table 5.1 shows the percentages of fatalities per transport mode and the total number of fatalities for the nine countries, for the years 1993 and 2003. Cars, lorries and other/unknown are put in one category, because classification into separate categories is not uniform in all countries. Lorries are sometimes classified as 'other', vans sometimes as 'car'.

1993	SE	UK	NL	CZ	HU	SI	EL	PT	ES	Cat
Car + lorry + other/unknown	65.2	51.4	53.0	56.6	49.6	62.5	50.7	43.6	65.6	60.6
Motorcycle	6.6	10.6	8.5	4.9	3.4	3.7	14.8	8.0	9.2	14.2
Moped	2.2	0.6	7.3	2.3	3.5	3.7	9.8	18.8	5.7	5.5
Cycle	11.1	4.9	19.5	10.0	12.8	7.5	1.7	3.7	2.3	1.8
Pedestrian	14.9	32.5	11.7	26.3	30.7	22.7	23.1	25.9	17.3	18.0
Total number	632	3814	1252	1524	1678	493	1830	2368	6378	967
2003										
Car + lorry + other/unknown	72.4	54.9	53.9	61.2	56.3	65.3	60.1	53.9	69.9	63.6
Motorcycle	8.9	19.1	9.2	7.0	5.0	10.7	19.3	13.8	6.8	11.3
Moped	1.7	0.7	9.1	0.8	2.7	2.5	3.3	10.2	7.2	8.1
Cycle	6.6	3.3	18.3	11.0	13.4	5.8	1.3	4.1	1.4	1.6
Pedestrian	10.4	22.1	9.4	20.0	22.5	15.7	16.0	18.1	14.6	15.4
Total number	529	3508	1028	1447	1326	242	1605	1546	5399	767

Table 5.1. *Percentages of fatalities per transport mode and the total number of fatalities in the SUNflower+6 countries and Catalonia in 1993 and 2003*.

Table 5.1 shows that there are large differences in percentages between the countries and over the years.

The Netherlands has the highest percentage of fatalities as cyclist and the lowest as pedestrian in 1993 and 2003.

Portugal has a high percentage of pedestrian fatalities in 1993, but a rather low percentage in 2003. It has the highest percentage of moped fatalities and the lowest percentage of car, lorry and other/unknown fatalities in both 1993 and 2003. This is in spite of the facts that the percentage of moped fatalities has decreased a lot in 2003, and the percentage of car, lorry and other/unknown fatalities has increased in 2003.

The United Kingdom and Hungary have the highest percentage of pedestrian fatalities in 1993 and 2003, although less extreme in 2003.

The United Kingdom, Sweden and the Czech Republic have the lowest percentage of moped fatalities; the UK, Greece and Catalonia have a high percentage of motorcycle fatalities in 1993 and the UK and Greece especially in 2003.

Sweden and Spain, followed by Slovenia, have the highest percentage of car, lorry and other/unknown fatalities, especially in 2003.

The percentages of motorcycle fatalities in general are much higher in 2003 than in 1993, except for Spain and Catalonia. This is partly due to changes in exposure and also to age effects. For example, in the United Kingdom there recently was a sudden increase in the popularity of motorcycles among older riders.

Table 5.2 shows the percentages of transport modes for the two years and the percentages of change from 1993 to 2003 for the three groups of countries. The percentages of change are computed from the absolute numbers of fatalities, because the totals for 1993 are larger then the totals for 2003. All values decrease, except the number of fatalities for motorcyclists in the SUN and Central countries. For the SUN countries the number of fatalities for mopedists in 2003 is almost equal to that number in 1993.

The overall reduction is highest for the Southern countries, followed by the Central countries.

In general, reductions are highest for mopedists, cyclists and pedestrians, except for the cyclists in the Central countries and the mopedists in the SUN countries. This general trend is in agreement with the substantial decrease of urban fatalities over the years (see Figure 5.6 and 5.7).

1993	SUN countries	Central countries	Southern countries
Car + lorry + other/unknown	53.3	54.2	58.1
Motorcycle	9.7	4.0	9.9
Moped	2.2	3.0	9.3
Cycle	8.8	10.9	2.5
Pedestrian	26.0	27.8	20.2
Total number	5698	3695	10576
2003			
Car + lorry + other/unknown	56.6	59.4	65.2
Motorcycle	16.0	6.4	10.4
Moped	2.5	1.8	7.0
Cycle	6.7	11.6	1.9
Pedestrian	18.3	20.8	15.5
Total number	5065	3015	8550
Percentage change 1993-2003			
Car + lorry + other/unknown	-5.6	-10.5	-9.2
Motorcycle	46.7	29.5	-15.0
Moped	-0.8	-52.7	-39.0
Cycle	-32.6	-13.1	-38.6
Pedestrian	-37.5	-39.0	-38.1
Total	-11.1	-18.4	-19.2

Table 5.2. *Percentages of fatalities per transport mode and total number of fatalities, together with the percentage change from 1993 to 2003 in the absolute number of fatalities per transport mode for the three groups of countries*.

A weighted Poisson analysis (that is not reported in detail) showed that the relative reduction in cyclist and pedestrian fatalities compared with all other modes is significantly lower in the SUN countries than in the new SUNflower+6 countries (t=2.42). The same counts for cars, lorries and other compared with motorcyclists and mopedists together (t=2.46) and for mopedists compared with motorcyclists (t=2.70).

There is a significantly lower reduction of motorcycle fatalities than moped fatalities in the Central countries compared with the Southern countries (t=2.00). This is also the case in Portugal and Spain compared with Greece (t=4.50). Portugal and Spain have also less reduction in pedestrian fatalities than in cycle fatalities compared with Greece (t=2.20)
The reduction for cars, lorries and other compared with motorcyclists and mopedists together is significantly lower in Spain than in Portugal (t=4.27).
No other effects are significant.

Table 5.3 shows the parameter values of the weighted Poisson analysis of the number of fatalities for the nine countries (1993 and 2003 together). Non-significant effects are explicitly indicated with '(n.s.)'. All other effects are significant.

Country (groups)	Motorized vs. Cy + Ped	Car + lorry + other/unknown vs. Mot + Mop	Motorcycle vs. Moped	Cycle vs. Pedestrian
SUN vs. Central + South	-0.51	0.31	**1.03**	**0.95**
SE + NL vs. UK	0.28	-0.34	**-1.40**	**1.16**
SE vs. NL	-0.12 (n.s.)	**0.59**	**0.63**	**-0.46**
Central vs. South	**-2.00**	**1.03**	0.41	**1.12**
CZ + HU vs. SI	**-0.54**	0.11 (n.s.)	0.11 (n.s.)	0.18 (n.s.)
CZ vs. HU	0.09 (n.s.)	0.17	0.54	-0.04 (n.s.)
PT + ES vs. EL	0.34	0.41	0.57	**-0.33**
PT vs. ES	0.16	-0.35	0.34	-0.21

Table 5.3. *WPM parameter values of comparisons of fatality numbers between (grouped) countries combined with (grouped) transport modes for 1993 and 2003 together; n.s. = not significant; the largest parameter values are bold.*

The values are to be interpreted as follows. If a parameter is positive, then there are more fatalities for the first term in a row comparison combined with the first term in a column comparison. If the value is negative then there are less fatalities for that combination.

For instance, in the comparison of the SUN versus the Central + Southern countries, combined with the comparison of motorized vehicles versus cyclists + pedestrians (Cy + Ped), the value of -0.51 is found in the upper left cell of the table. This means that there are relatively less fatalities for motorized transport modes in the SUN countries than there are in the new SUNflower+6 countries (and relatively more cycle and pedestrian fatalities in the SUN countries). This effect is significant (t=6.32).

The opposite effect is significant for Sweden + the Netherlands versus the United Kingdom; relatively less cyclist and pedestrian fatalities in Sweden and the Netherlands (parameter value: 0.28; t=3.84).

The largest parameters are printed in bold. It is seen that the major differences are between the SUN countries and the new SUNflower+6 countries, between Sweden and the Netherlands compared to the United Kingdom and between the Central countries compared with the Southern countries.

There are relatively more motorcycle fatalities and less moped fatalities in the United Kingdom than in Sweden and the Netherlands (parameter value: -1.40; t=12.41); and relatively more pedestrian fatalities than cyclist fatalities in the United Kingdom than in Sweden and the Netherlands (parameter value: 1.16; t=20.70).

There are relatively more cyclists and pedestrians than motorized road users killed in the Central countries than in the Southern countries (parameter value: -2.00;

t=25.38); relatively more car, lorry and other/unknown road users than motorcyclists and mopedists (Mot + Mop; parameter value: 1.03; t=16.48); relatively more motorcyclists than mopedists (parameter value: 0.41; t=4.11) and relatively more cyclists than pedestrians (parameter value: 1.12; t=14.88).

These last conclusions from Table 5.3 can be checked directly from Table 5.2, (adding both years together - ignoring the minor interaction effects - or looking at the percentages for the Central and Southern countries for each year separately).

Most effects for the Central countries are not significant, which shows that these countries are rather homogeneous with regard to the distribution of fatalities over transport modes in the years 1993 and 2003.This is to a lesser extent also the case for the Southern countries.

A separate analysis has been carried out for Spain (without Catalonia) and Catalonia. Two effects are significant. The percentage of motorcycle + moped fatalities is significantly higher in Catalonia than in Spain compared to other motorized vehicles (t=5.79); the percentage of motorcycle fatalities in Spain is smaller than the percentage of moped fatalities, compared to Catalonia (t=4.17). These two effects are primarily due to the relatively large number of fatal motorcycle crashes in Catalonia.

5.1.2. Fatality risks per transport mode

For the SUN countries the amount of travel kilometres is known for 2003 except for ‘other’, and only partially for 1993. An analysis of the 2003 data was carried out for these countries. The data is given in Table 5.4.
It can be seen that the number of cyclist kilometres is relatively large and the number of car and pedestrian kilometres small in the Netherlands. The percentage of moped and cyclist kilometres is low in the United Kingdom. In Sweden the percentage of motorcycle kilometres is relatively high and the percentage of kilometres for lorries is low.

The most significant conclusions drawn from the risk figures is that the risks for cars are comparable for the three countries; the risk for lorries is relatively low in the Netherlands; the risk for motorcycles, cyclists and pedestrians is relatively high for the United Kingdom; the risk for mopeds is relatively high in the Netherlands; the risk in Sweden is relatively low for all transport modes except for cars.

Transport mode	Fatalities			Travel distance (x 10^9 km)			Fatality risks		
	SE	UK	NL	SE	UK	NL	SE	UK	NL
Car	346	1769	538	61.7	393	108	5.6	4.5	5.0
Lorry	22	116	8	11.5	86.4	28	1.9	1.3	0.3
Motorcycle	47	669	95	1.1	5.6	1.7	42.7	119.5	55.9
Moped	9	24	94	0.4	0.4	0.9	22.5	60.0	104.4
Cyclist	35	114	188	3	4.5	13.8	11.7	25.3	13.6
Pedestrian	55	774	97	3	20	3.2	18.3	38.7	30.3

Table 5.4. *Fatalities per transport mode, distance travelled in billion kilometres, and fatality risks for the original SUN countries in 2003*.

The outcomes of the weighted Poisson analysis on the fatality risks per mode are given in Table 5.5.

Transport modes	SE + NL versus UK	SE versus NL
Motorized versus cyclist + pedestrians	0.22 (n.s.)	0.29 (n.s.)
Car + lorry versus motorcyclist + mopedist	0.30	**1.29**
Car versus lorry	0.37	**-0.80**
Motorcyclist versus mopedist	-0.39	0.61
Cyclist versus pedestrian	-0.12 (n.s.)	0.18 (n.s.)

Table 5.5. *WPM parameter values of comparisons of fatality risks between SUN countries, combined with effects for (grouped) transport modes for 2003; n.s. = not significant; the largest parameter values are bold.*

A comparison of Table 5.5 (analysis of fatality risks) with Table 5.3 (analysis of absolute fatality numbers) shows a significant change of effect for the comparison of car + lorry versus motorcycle + moped in the SUN countries: the parameter value changes from -0.34 to +0.30. Thus, after correction for exposure Sweden and the Netherlands show more car + lorry fatalities compared to motor + moped crashes instead of less. This effect agrees with the relatively low percentage of motorcycle + moped kilometres in the United Kingdom.
This comparison is not completely fair, because the year 2003 in Table 5.5 is compared with the years 1993 + 2003 in Table 5.3. However, the effect of Table 5.3 holds for both years separately as well.

A similar effect is noticed for the comparison of Sweden with the Netherlands. The value is a much higher in Table 5.5 than in Table 5.3 (1.29 compared with 0.59).

The effect of motorcyclist versus mopedist in the comparison of Sweden + the Netherlands versus the United Kingdom is considerably reduced from -1.40 to -0.39. The effects for cyclist versus pedestrian have opposite signs and are not significant anymore.

These comparisons show that it is most important to have exposure data available in order to interpret differences in fatalities per mode of transport. It is important to know whether high percentages of fatalities per mode also mean a high risk per unit of travel, in order to look for measures to be taken (for example, infrastructural measures versus education).

5.2. Safety per transport mode and different crash opponents

It is also interesting to look at the crash opponent to see whether differences exist between fatalities per transport mode for countries. This data is analysed for 2003 only.

In order not to complicate matters too much, first comparisons are made between the grouped data for the SUN countries and the Southern countries. The data for Hungary and the Czech Republic were not detailed enough to use in this comparison. Therefore the Central countries are left out of this comparison.

Furthermore, the crash opponent categories are restricted to single vehicle crashes, crashes with cars, and crashes with lorries or buses. The category 'other' is deleted from the occupancy data. Portuguese data was only available for national roads, which data has been used in the comparison. The fatalities are given in Table 5.6.

A first analysis is carried out on the three-way table of values for the two country groups x the three crash opponents types x the six occupancy types. This analysis (not reported here) showed that only 1 of the 10 second order effects was significant. There are relatively fewer fatalities in single vehicle motorcycle crashes than in moped crashes in the SUN countries compared with the Southern countries (t=2.45).

This effect is explained by the higher percentage of moped and motorcycle crashes with cars, lorries and buses in the Southern countries (15.5% for motorcycles + 17.5% for mopeds = 33.0%) than in the SUN countries (25.5% for motorcycles + 4.7% for mopeds = 30.2%). The percentages of single vehicle moped and motorcycle crashes are higher in the SUN countries (18.4%) than in the Southern countries (16.5%).

It is primarily the relatively high percentage of moped fatalities for mopeds in collision with cars, lorries and buses (17.5% in the Southern countries compared with 4.7% in the SUN countries) that explains the significant effect. For motorcycles the percentages are even reversed, although less in value (15.5% in the Southern countries vs. 25.5% in the SUN countries).

SUN countries			
Transport mode	Single	Car	Lorry + bus
Car	1025	795	430
Lorry	50	14	43
Motorcycle	214	322	81
Moped	39	54	17
Cycle	40	188	58
Pedestrian	1	631	232
Southern countries			
Transport mode	Single	Car	Lorry + bus
Car	2084	1389	593
Lorry	153	29	53
Motorcycle	309	292	67
Moped	135	265	57
Cycle	11	74	18
Pedestrian	0	778	146

Table 5.6. *Crash opponents (reduced to three categories) for different transport modes in the SUN countries and Southern countries in 2003.*

The first order interaction between the SUN and Southern countries and the crash opponents (added over transport modes) is significant for cars compared with lorries and buses (t=3.42). There are relatively more lorries and buses than cars involved in fatal crashes in the SUN countries. The effect for single vehicle crashes versus crashes with cars, lorries and buses is not significant.

The comparisons for crash opponent and transport mode (added over countries) are given in Table 5.7.

Transport modes	Crash opponent	
	Single versus car + lorry + bus	Car versus lorry + bus
Motorized versus cyclist + pedestrian	**5.54**	-0.75
Car + lorry versus motorcycle + moped	0.59	**-1.43**
Lorry versus car	0.27	**-1.12**
Motorcycle versus moped	0.30	0.06 (n.s.)
Cyclist versus pedestrian	**4.06**	-0.04 (n.s.)

Table 5.7. *WPM parameter values for crash opponents and transport modes; n.s. = not significant; the largest parameter values are bold.*

Table 5.7 shows that all effects except two are significant. The major effects are found for four-wheelers compared with other modes, especially cyclists and pedestrians: motorized vehicles are more involved in single vehicle crashes. This is also the case for four-wheelers compared with motorized two-wheelers, mopeds as well as motorcycles. This may sound surprising, but restricted protection and greater vulnerability result in safer behaviour and prevent single vehicle crashes.

The high values (5.54 and 4.06) for single versus car + lorry + bus are due to the practically zero value for pedestrian fatalities (the value should by definition be equal to zero, because a single pedestrian crash should not be registered as a road accident; still it was registered once).

The value for motorized versus cyclist + pedestrian is higher than the value for cyclist versus pedestrian. It shows that the effect that four-wheelers are more frequently involved in single vehicle crashes than motorized two-wheelers, is valid for cyclists as well.

Three major effects are found in the comparison of cars versus lorries + buses as crash opponents. For cyclists and pedestrians (-0.75) as well as motor and moped riders (-1.43) lorries + buses are less often the crash opponent. The argument given for single vehicle crashes probably is valid here as well: vulnerable road users are more careful with lorries and buses than car drivers. Furthermore, the exposure to encounters between cars and lorries + buses might be greater than encounters between cyclists + pedestrians and lorries + buses.
Finally, there are relatively more fatal lorry crashes than car crashes in conflicts with lorries and buses compared with cars. This is probably due to the mass of a car compared with a lorry or bus as an opponent in a fatal lorry accident.

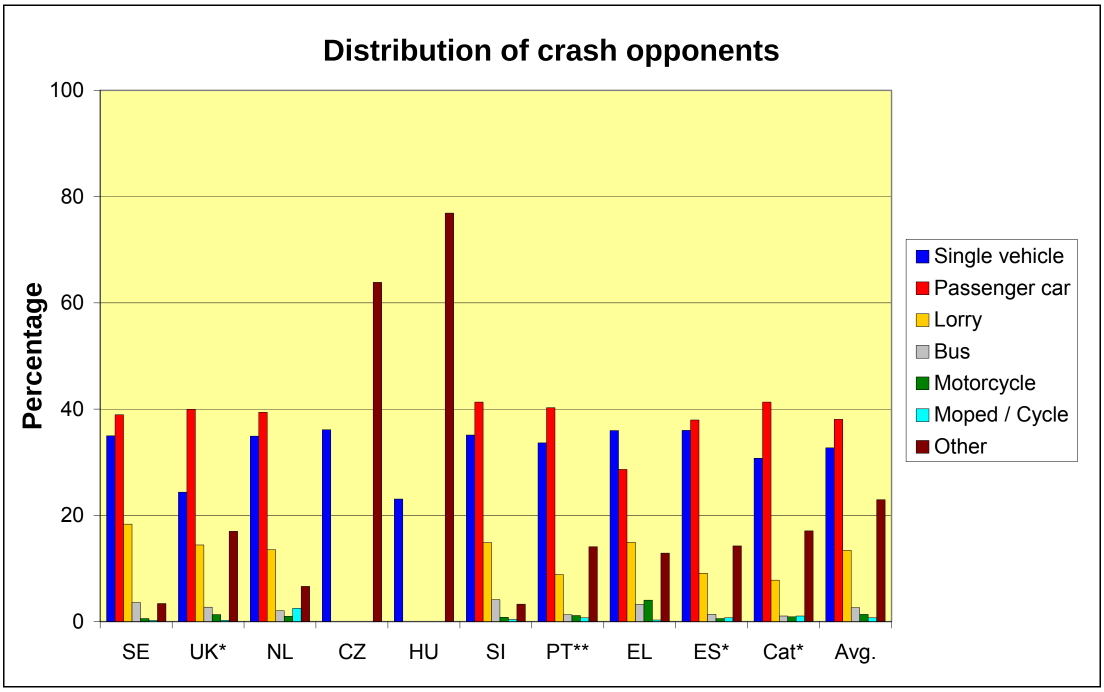
Because only 1 out of 10 second order interactions was just significant, as described earlier, all the effects discussed from Table 5.7 can be regarded as similar for the two groups of countries.

Table 5.8 and Figure 5.1 show the percentages of single vehicle fatalities and crash opponents of transport modes for the SUNflower+6 countries.

Crash opponent	SE	UK*	NL	CZ	HU	SI	EL	PT**	ES*	Cat*	Avg.
Single vehicle	35.0	24.4	34.9	36.1	23.1	35.1	36.0	33.6	36.0	30.8	32.7
Passenger car	38.9	40.0	39.4	-	-	41.3	28.7	40.3	38.0	41.3	38.1
Lorry	18.3	14.4	13.5	-	-	14.9	14.9	8.8	9.1	7.8	13.4
Bus	3.6	2.7	2.0	-	-	4.1	3.2	1.3	1.4	1.0	2.6
Motorcycle	0.6	1.3	1.0	-	-	0.8	4.0	1.2	0.6	0.9	1.4
Moped/Cycle	0.2	0.2	2.5	-	-	0.4	0.3	0.7	0.7	1.0	0.7
Other	3.4	17.0	6.6	63.9	76.9	3.3	12.9	14.1	14.3	17.1	22.9
Total	529	3507	1028	1447	1326	242	1605	859	5399	767	-

* 'Three vehicles' category included in 'other' for the UK, Spain and Catalonia, and also for Portugal.
** Values for Portuguese national roads only.

Table 5.8. *Percentages of crash opponents involved in fatal crashes in the SUNflower+6 countries and Catalonia in 2003.*



* 'Three vehicles' category included in 'other' for the UK, Spain and Catalonia, and also for Portugal.
** Values for Portuguese national roads only.

Figure 5.1. *Percentages of crash opponents involved in fatal crashes in the SUNflower+6 countries and Catalonia in 2003.*

The major differences between the SUNflower+6 countries are the following:

- The number of single vehicle crashes is relatively low in the United Kingdom and Hungary.
- The number of fatal crashes with lorries is relatively small in Spain and Portugal.
- The number of (not-single-sided) motorcycle crashes is relatively large and the number of fatal crashes with cars is small in Greece.

Figure 5.2 shows the percentage of transport modes for each crash opponent and Figure 5.3 shows the percentage of crash opponents for each transport mode for all countries added together except for the Czech Republic and Hungary in 2003.

Figure 5.2 shows that car occupants are killed primarily in single vehicle crashes and crashes with lorries and buses. Almost 60% of all road users killed are car occupants.
Almost 20% of all fatalities are pedestrians. Remarkable is the high percentage of pedestrians in motorcycle, moped and bicycle crashes.
The high percentage of motorcyclists with another motorcyclist as a crash opponent (20% of the cases) may be caused by erroneous classification of the crash not being a single vehicle crash.

Figure 5.3 shows that most road users killed in lorries and buses are involved in single sided crashes.
Cars are mostly the crash opponent in crashes. The percentage increases with vulnerability of the crash opponent and is highest for pedestrians and cyclists.

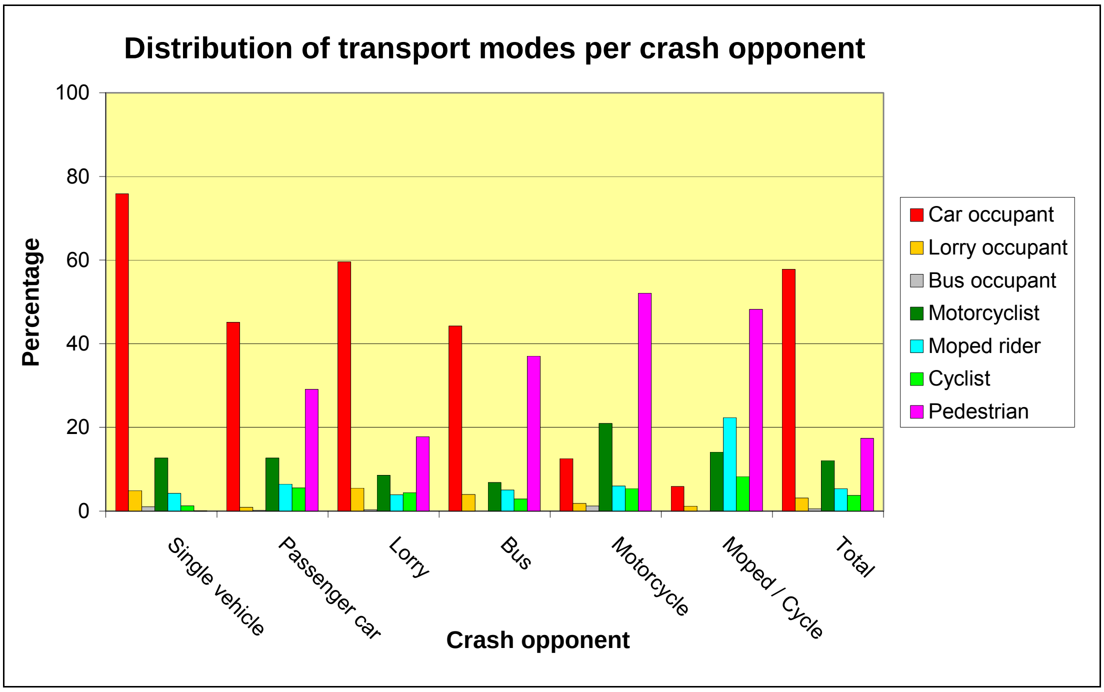


Figure 5.2. *Percentage of type of road user killed for each crash opponent for all countries together (except the Czech Republic and Hungary) in 2003*.

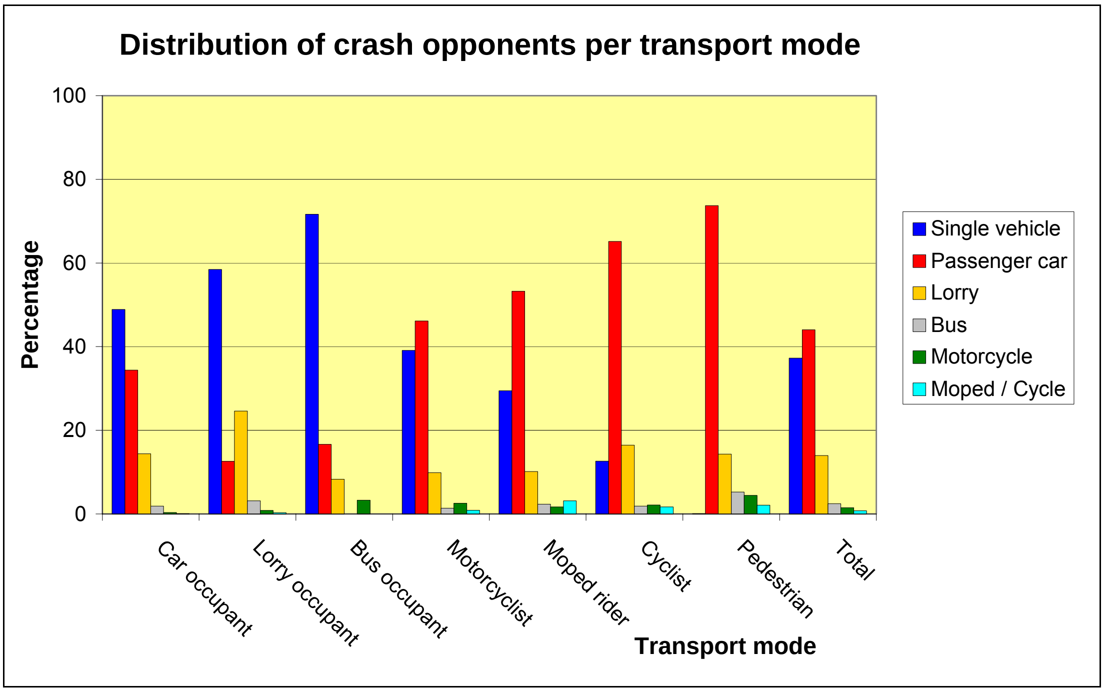


Figure 5.3. *Percentage of crash opponents for each transport mode for all countries together (except the Czech Republic and Hungary) in 2003*.

Table 5.9 shows the differences in the distribution of fatalities for crash opponents x countries (added over transport modes). Because no disaggregate values are available for the Czech Republic and Hungary, these countries are not included in the analysis.

2003	SUN vs. not-SUN	SE + NL vs. UK	SE vs. NL	SI vs. South	PT + ES vs. EL	PT vs. ES
Single vs. rest	-0.20 (n.s.)	0.14 (n.s.)	0.23 (n.s.)	-0.18 (n.s.)	0.26	-0.14 (n.s.)
Motorized vs. moped/cycle	0.12 (n.s.)	**-0.99**	**1.46**	0.15 (n.s.)	**-1.05**	0.10 (n.s.)
Four-wheels vs. motorcycle	0.56 (n.s.)	0.36 (n.s.)	0.44 (n.s.)	0.59 (n.s.)	0.86	-0.45 (n.s.)
Car vs. lorry + bus	-0.18 (n.s.)	-0.05 (n.s.)	-0.26	-0.31	0.67	0.05 (n.s.)
Lorry vs. bus	0.07 (n.s.)	0.04 (n.s.)	-0.13 (n.s.)	-0.32 (n.s.)	0.22 (n.s.)	0.00 (n.s.)

Table 5.9. *WPM parameters for analysis of crash opponents x SUNflower+6 countries in 2003. n.s. = not significant; the largest parameter values are bold*.

Table 5.9 shows that the main differences exist between Greece and Portugal + Spain. For Greece there are less single vehicle fatal crashes and more fatalities with motorized crash opponents than with mopeds and bicycles. There are also significantly fewer motorcyclists than four-wheelers as crash opponents and fewer lorries + buses than cars as crash opponents.
The only not-significant effect for these countries is between lorries and buses.

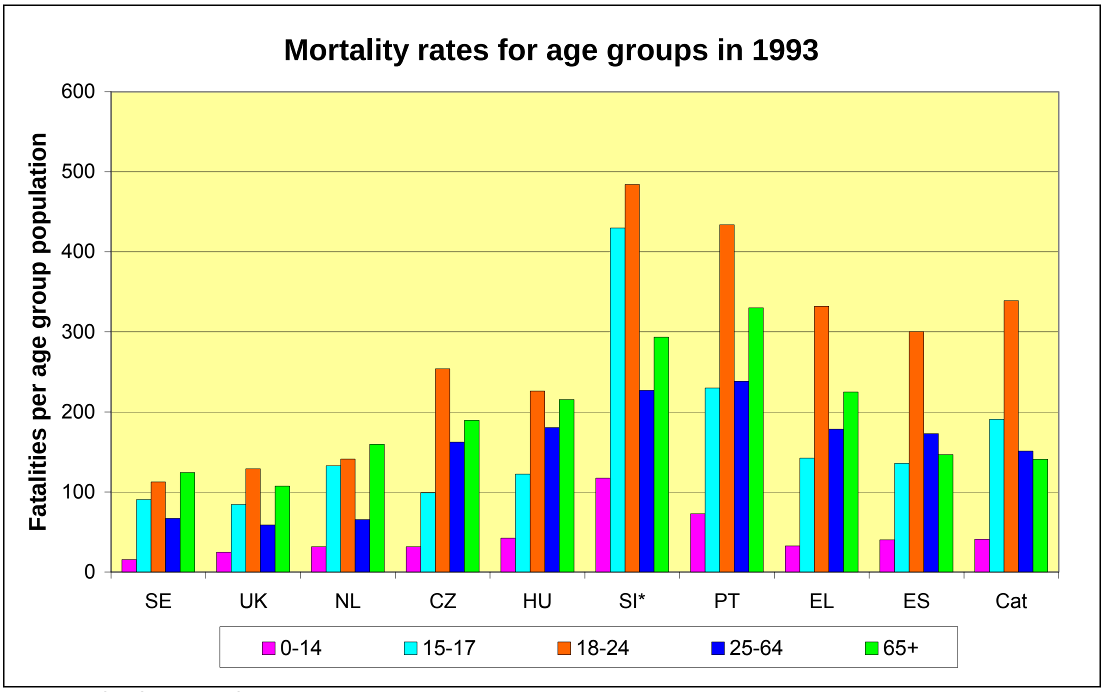
There are significantly more mopedists and bicyclists as crash opponent than motorized road users in Sweden and the Netherlands compared with the United Kingdom, and more in the Netherlands than in Sweden. The first effect is caused by the deviating numbers in the Netherlands from Sweden and the United Kingdom.

There are significantly more lorries and buses than cars as crash opponent in Sweden than in the Netherlands. The same effect is found for Slovenia compared with the Southern countries.

All other effects are not significant.

5.3. Safety of different age groups

Figures 5.4 and 5.5 show the fatalities for age groups, divided by the population size for each age group in 1993 and 2003. The Figures 5.4 and 5.5 should not be misinterpreted. Firstly, the modal split differs for each year of age, and secondly the age groups differ in amount of exposure (per transport mode and time of day and day of the week) and in rate (again per transport mode, time of day and day of the week).



* Values for Slovenia from 1994.

Figure 5.4. *Number of fatalities divided by the population size of each group for five age groups in the SUNflower+6 countries and Catalonia in 1993.*

Comparison of Figure 5.4 with Figure 5.5 shows that there has been a considerable improvement for all age groups. The reduction percentages of the fatality rates from 1993 to 2003 for the five groups are given in Table 5.10.

There are substantial differences in percentage changes between the countries, not just in overall percentages but also between age groups.

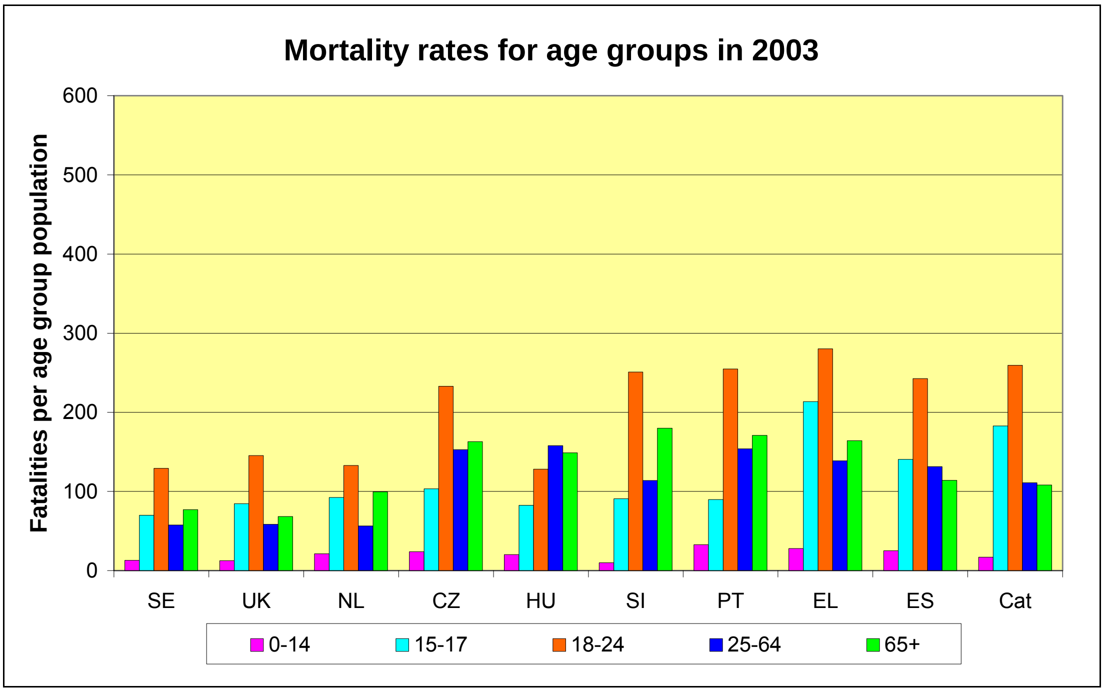


Figure 5.5. *The number of fatalities divided by the population size of each group for five age groups in the SUNflower+6 countries and Catalonia in 2003.*

Age group	SE	UK	NL	CZ	HU	SI*	EL	PT	ES	Cat*	Avg.
0-14	-16.3	-49.4	-32.6	-24.1	-52.3	-91.5	-14.0	-55.1	-37.7	-58.5	-41.4
15-17	-22.9	0.3	-30.2	4.7	-32.6	-78.9	49.8	-60.9	3.6	-4.2	-18.6
18-24	14.8	12.8	-5.9	-8.2	-43.2	-48.2	-15.6	-41.3	-19.2	-23.5	-17.1
25-64	-13.8	-0.7	-13.8	-5.8	-12.5	-49.8	-22.2	-35.4	-23.9	-26.5	-19.8
65+	-38.2	-36.3	-37.7	-14.1	-30.9	-38.6	-26.9	-48.2	-22.1	-23.2	-32.5

* Values for Slovenia from 1994. Values for Catalonia from 2002.

Table 5.10. *Percentage change of the mortality rates between 1993 and 2003.*

In Sweden and the United Kingdom, the mortality of the 18-24 age group has increased This group also has the smallest improvement for the Netherlands. For the Czech Republic, Spain and especially Greece there is an increase for the 15-17 age group. All other values show an improvement.

For Slovenia the highest reductions are found for the youngest age groups: 92% and 79% respectively, which is an enormous improvement. In the already mentioned New Road Safety Act much attention is given to young road users. However, the effect is probably biased by very small absolute fatality numbers in respective years and age groups.

For Portugal and Hungary the reduction is more evenly spread over the age groups, although highest for the groups of younger people. For Greece the effect may be partly due to the change in moped use after the introduction of an obligatory licence. This may have caused change over to higher powered motorcycles.

The average improvement is highest for the 0-14 group, followed by the 65+ group. The average reduction is smallest for the 18-24 group, followed by the 15-17 group. A possible explanation of this difference in effect for the age groups is the reduction in the risk per transport mode. Furthermore, the effect is in agreement with the substantial decrease of the number of fatalities on urban roads (see next section).

There is hardly any information available about the exposure per transport mode per year of age. Without this data no fair comparison can be made between the groups.

5.4. Safety of different road types

Figures 5.6 and 5.7 show the distribution of fatalities on different road types: motorways, A-level roads, other rural roads, and urban roads.

For Sweden, Spain and Catalonia no complete data is available for 1993. For Sweden data is available for 2001, but not for 2003. For Spain and Catalonia the data for 2003 is not complete. For Hungary data is missing for 1993 and data for 2002 is available, but not for 2003. For Slovenia data for 1994 is available, but not for 1993.

The figures are not completely comparable between countries, because definitions (especially for A-level roads) differ between countries.

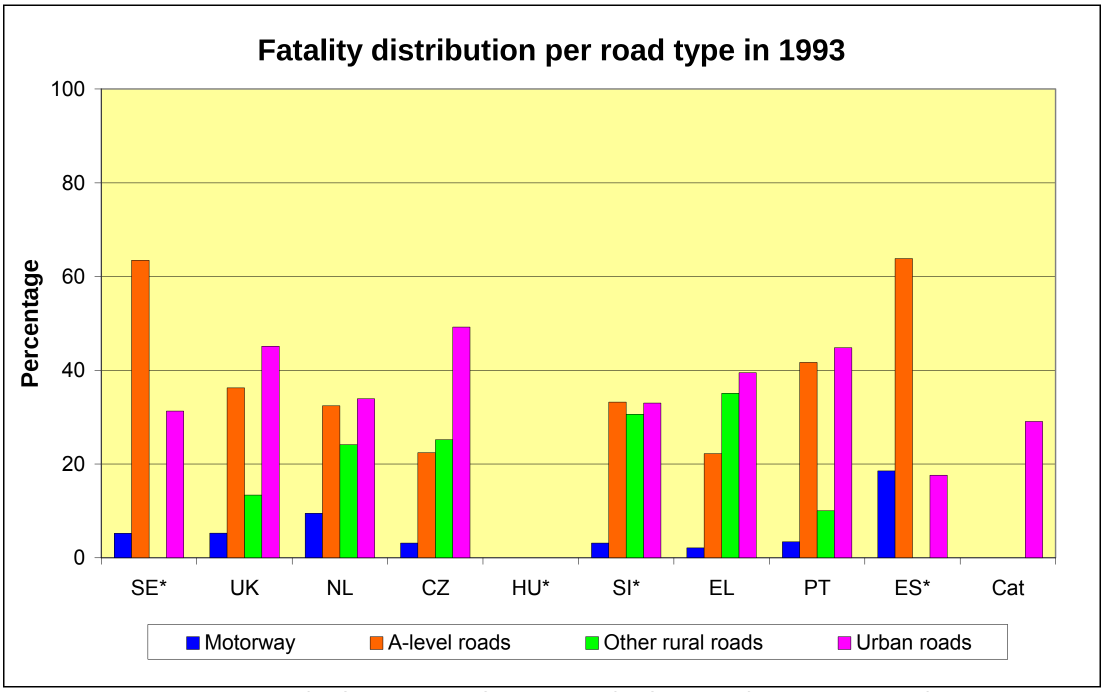
For a comparison between road types, it must be kept in mind that differences in shares can be explained partly by the layout and length of road types in the network and also by differences in usage of network components, design standards, speed limits etc. Furthermore, there are important differences in the number of vehicle kilometres and the mix of transport modes.

Given these remarks, it is seen that in general the percentage of fatalities is highest on A-level roads and other rural roads together, except for the Czech Republic in 1993. The percentages are low for motorways, but relatively high for the Netherlands and Spain in 1993 and for the Netherlands, Portugal, Spain, Catalonia and Slovenia in 2003. The main explanation for these differences is probably the total number of vehicle kilometres on motorways. For Spain this seems to be only partly the case, because also the number of fatalities per vehicle kilometre is very high on Spanish motorways, both in 1993 as well as in 2003 (see Figure 5.8). Road design, differences in travel behaviour, and experience of driving on motorways might also be partly the cause. The percentage of fatalities on urban roads is highest for the Czech Republic in 1993, and for the United Kingdom, Portugal and the Czech Republic in 2003. They are lowest for Spain in both years, but not for Catalonia.

Comparison of Figure 5.6 with Figure 5.7 shows a general decrease in the percentages for urban roads. This decrease is most noticeable for Greece and the Czech Republic, and least noticeable for the Netherlands, Portugal and Spain.

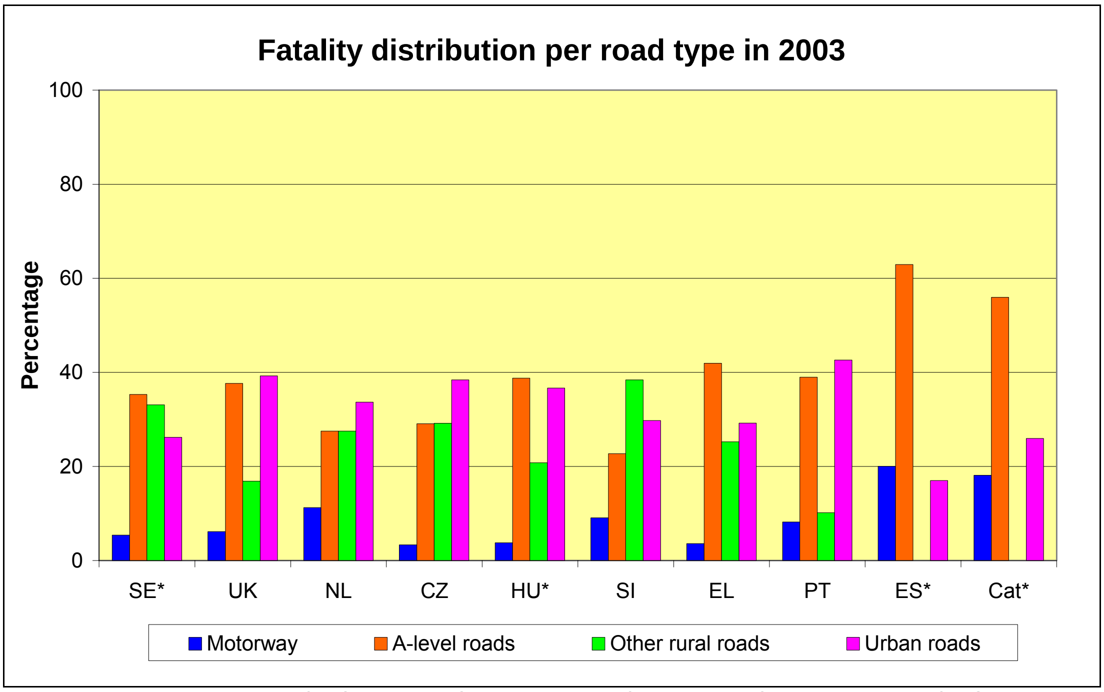
For 'other rural roads' an increase is found in all countries except Greece and Portugal. The increase is highest in the United Kingdom and Slovenia.

The percentages of fatalities on A-level roads decrease in the Netherlands, Slovenia and Portugal and increase in Greece and the Czech Republic.



* A-level + other rural roads for Sweden and Spain. Data for Slovenia from 1994. Data for Hungary not available.

Figure 5.6. *Percentage of fatalities for different road types in 1993*.



* A-level + other rural roads for Spain and Catalonia. Data for Hungary from 2002. Data for Sweden from 2001.

Figure 5.7. *Percentage of fatalities for different road types in 2003*.

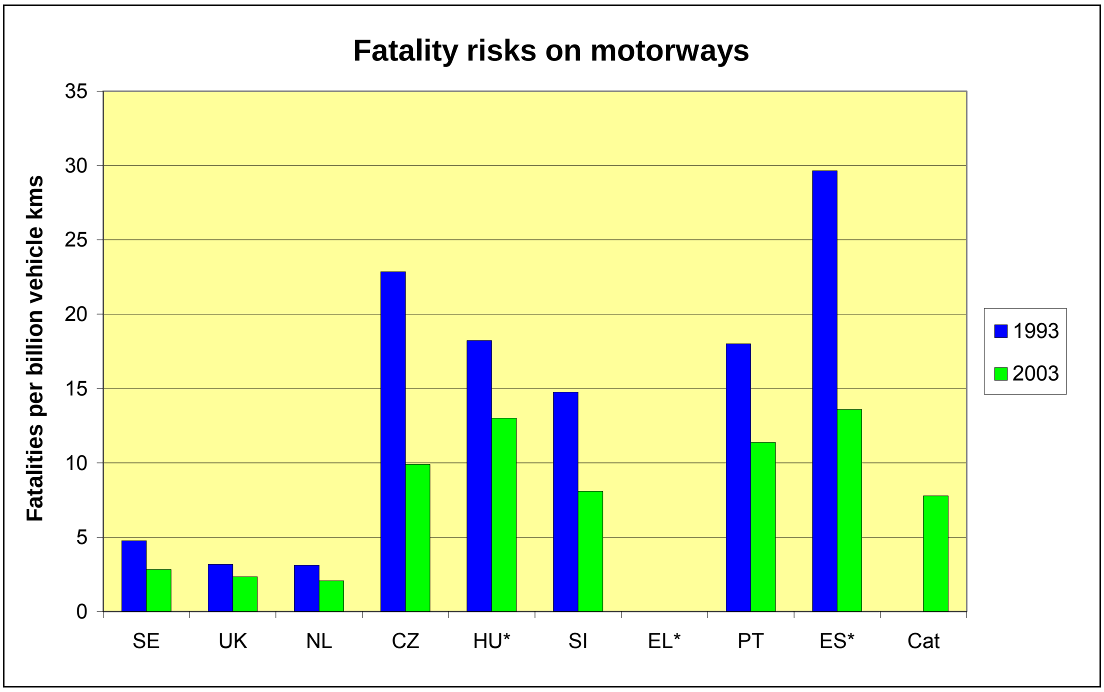
For motorways there is an increase in the percentage for all countries. It shows the effect of the increased use of motorways (see Figure 5.8).

For A-level roads the discrepancies between countries is the largest, ranging from a 32% decrease in Slovenia to an almost 90% increase in Greece. For Slovenia this decrease agrees with the explanation of the increased length of motorways and the resulting increase in the percentage of motorway fatalities. The major concern for Slovenia should now be with the other rural roads.

For a comparison of the fatality risks (the fatalities divided by the number of vehicle kilometres x 10^9) for most countries sufficient data is only available for motorways. This data is pictured in Figure 5.8.

In all countries there was an increase in the number of fatalities on motorways in 2003 compared with 1993 (Figures 5.6 and 5.7). Figure 5.8 shows that this is due to an increase in vehicle kilometres caused by an increased amount of traffic combined with the construction of new motorways in Central and Southern Europe. The higher risks for the Central and Southern countries might be due to higher speed or different behaviour in general. The design standards are approximately the same. The speed limit on motorways in the Central countries is 130 km/h. However, not only the speed limit is of importance, but also the compliance with the limits and, for instance, congestion on motorways.

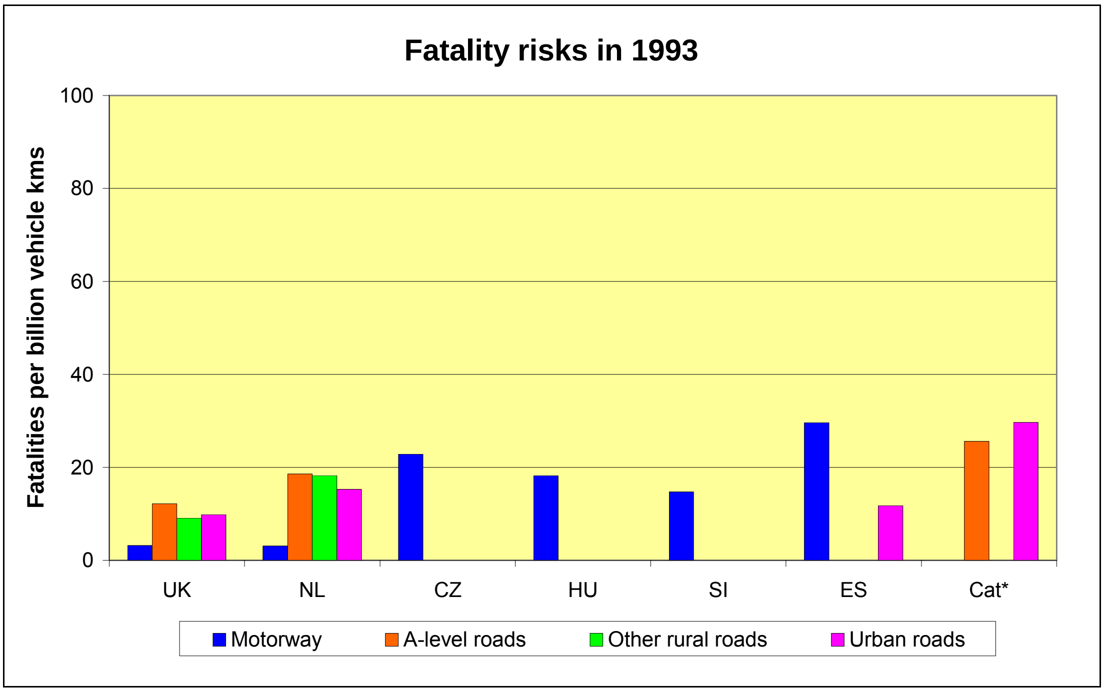
The fatality risk in 2003 is lower for all countries comparing the values for both years. The decrease is highest for the Czech Republic and Spain, followed by Slovenia and Portugal.
The risk on motorways is considerably lower in the SUN countries than in the other SUNflower+6 countries.



* For Spain: State-managed Interurban Road Network only. For Hungary, data from 2002. For Greece: data not available

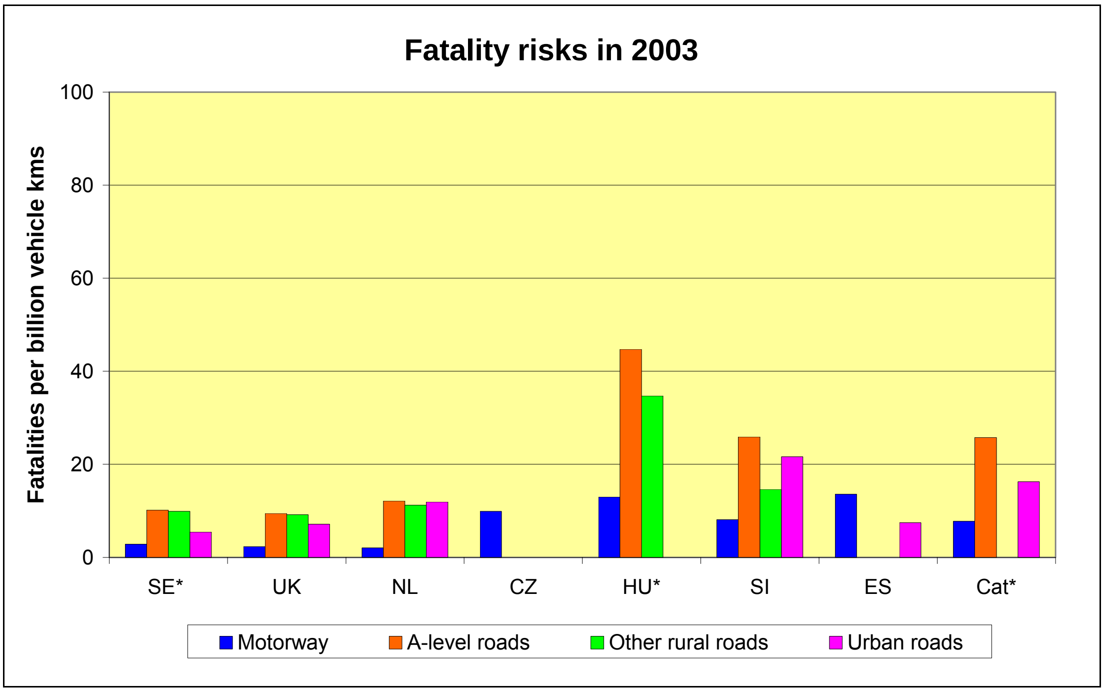
Figure 5.8. *Fatality risks (fatalities per 10^9 vehicle kilometres) on motorways for the SUNflower+6 countries in 1993 and 2003*.

Risk data for all road types is available for the United Kingdom and the Netherlands in 1993 and 2003, for Slovenia and Sweden in 2003, and partly for Hungary, the Czech Republic, Spain and Catalonia. Figures 5.9 and 5.10 show this data for the two years.



* For Catalonia Motorways + A-level roads + other rural roads.

Figure 5.9. *Fatality risks on all road types in 1993*.



* For Catalonia A-level roads + other rural roads. Data for Hungary from 2002. Data for Sweden from 2001.

Figure 5.10. *Fatality risks on all road types in 2003*.

For Sweden, the Netherlands and Hungary the picture in 2003 is rather similar to the fatality distribution in Figure 5.7. For the UK the picture is different: although the number of fatalities is much lower on ‘other rural roads’ than on ‘A-level roads’, the risks on these two road types are almost equal because of the lower number of vehicle kilometres on 'other rural roads'. For Slovenia a reversed trend is found, which might be caused by the change from ‘other rural roads’ to ‘A-level roads’. The definition of ‘A-level road’ may also play a part.

Caution with the conclusions is recommended, because of the low quality of exposure data in general, and on roads other than motorways and A-level roads in particular.

6. Conclusions and recommendations

6.1. Usefulness of the methodology

Valuable information is available in the three group reports of the countries within the project: the original SUN countries, the Central countries and the Southern countries. This footprint report adds information to the three group reports, concerning the comparisons between the nine countries. The footprint method has been developed to give insight in the road safety status and the development over time of the SUNflower+6 countries. At this stage it is considered a first step towards the definition of a methodology that may grow into a widespread tool for benchmarking road safety. As yet, the initial application of the footprint method has been successful for the SUNflower+6 countries (and region).

The footprint consists of indicators for the road safety toll in terms of fatalities, indicators for the safety quality of the traffic system (vehicles, infrastructure, and road user specifications) and indicators that describe policy plans and measures. By comparing them with safety standards or with the state of the art in one or more other countries, the footprint can help to identify strong and weak points, can indicate the need for further and more detailed analysis and can assist in showing ways to road safety improvements.

A specification has been made of the contents of the footprint, based on state-of-the-art knowledge. At a conceptual level, this has resulted in a comprehensive scheme which is called a 'best practice' scheme. Parts of this have been elaborated to compare an individual country with the SUNflower+6 average, and to show the development over time of the indicators for that country. Furthermore, pairs of countries have been compared within their geographical group and between the groups, involving all SUNflower+6 countries. Based on the detailed scheme, a summary scheme has been proposed as a more concise, though fairly complete, overview.

In general, the application of the footprint schemes meets the expectations. This has been achieved by elaborating a methodology that intends to give a wide and interrelated overview of different aspects of the safety system. The demonstrated way of presenting the information is useful to facilitate this process. However, more practical experience and further steps in development are needed to give a more complete and robust representation of road safety performances. It has been shown that sufficient data is available for a general comparison of the state of the art of road safety and its development between the countries, but more high-quality data is needed for more detailed comparisons. These items will be discussed further in Section 6.4.

More detailed analyses deepen the understanding of footprint outcomes. As such they are a valuable part of the footprint methodology, in addition to the schemes discussed above. The conclusions of these analyses of aggregate safety outcomes over time and disaggregate safety outcomes are discussed in Sections 6.2 and 6.3.

6.2. Development of road safety over time

For the comparison of the development of road safety over time (expressed in fatalities per number of vehicles, per year) between the countries, the singular value decomposition technique was carried out on the trends in all nine countries. The outcomes show that this technique is a valuable tool for this comparison.

It has been shown that safety developments in all nine countries show considerable progress over time and that these improvements follow the same trend of exponential decline in risk, with different parameters for the level of risk and the speed of decline. It has also been illustrated that road safety improvements do not just happen by accident, but that they are rather the result of continuing efforts to improve road safety. Generally speaking, there are strong indications that an increase in the organization of activities and quality improvement of road safety programmes can be seen from 1985 onwards. This is primarily the case for the new SUNflower+6 countries. The SUN countries were already rather active before that year.

The measures that were reported make it apparent that from the 1970s onwards not only a large number, but also a wide variety of measures has been taken in the SUN countries. In later periods measures in these countries become more specific. This tendency of a wider variety of measures as the number of measures increases can be observed in the other countries as well.

Economic growth and the corresponding rise of motorization in the SUN countries shortly after World War II, resulted in a steep increase in road safety problems. A large number of safety initiatives and safety measures were taken on a wide variety of safety aspects in the late 1960s and early 1970s. The effects of these efforts are mirrored in the decrease in the fatality rates and risks since the 1970s. Further improvements took place in later periods as well.

For the other countries (in Central and Southern Europe) these developments manifested themselves later. For some countries these changes were related to important political changes (e.g. Portugal, Hungary, and the Czech Republic). The same picture as in the SUN countries can be seen in these countries: an increase in motorized traffic resulting in a growing number of casualties. These growing numbers caused an increased attention for road safety, leading to new road safety policies and organizational measures and safety measures in the SUNflower+6 countries, without any exception. These measures were of a similar nature, but addressed the specific nature of the road safety problem in a country. The pace of improvements differed between the countries.

Apart from examining the continuous time trends, comparisons of the safety outcomes have been made between countries for three time periods, one decade apart: for 1981-1983, 1991-1993 and 2001-2003. The SUN countries show a decrease in mortality rates (fatalities per population) over the three periods. For the other countries we see an initial increase from period 1 to period 2 (except for Slovenia), followed by a decrease in the third period. In Slovenia and Portugal, countries with a high mortality rate in the first and second period, this decrease is most impressive. All non-SUN countries are closing the gap between themselves and the SUN countries. Among the SUN countries, the Netherlands is also closing the gap with the United Kingdom and Sweden.

These general trends are even more noticeable for the fatality rates (fatalities per number of vehicles). The decrease already begins in the second period for almost all countries, and is spectacular for Portugal, but also considerable for Slovenia, Greece, the Netherlands and Spain. The fatality risks (fatalities per motor vehicle kilometres) show the same pattern, with spectacular decreases in Portugal, Slovenia and Greece.

The general conclusion is that large improvements in safety have been accomplished in all nine countries, especially for the non-SUN countries in the second and third period, notwithstanding the considerable increase in traffic. Furthermore, countries with an initially low level of safety are closing the gap and appear to benefit from the dialectics of progress.

6.3. Comparison of disaggregate safety outcomes

Apart from differences in the overall levels of risk between countries, there are also differences on disaggregated safety levels for all nine countries. Explanations for such differences request detailed data. In many SUNflower+6 countries this necessary data is not yet available, especially exposure data. This data is mainly needed for comparisons on the level of final outcomes. However, if more layers of the pyramid are involved, there is also a lack of well-defined indicators and a lack of high-quality data on SPIs and policy output. To overcome this, disaggregate analyses have been performed while specifying a minimum amount of necessary data. Two years, 1993 and 2003, have been selected instead of the three three-year periods mentioned earlier.

There are large differences between the nine countries in percentages of fatalities per transport mode. The differences were not as enormous in 2003 as in 1993. There seems to be a general tendency towards more equal percentages, in which the percentage of fatalities in car, lorry and other/unknown vehicles tends to increase to a value of 55% to 70% of all fatalities. The percentage of pedestrian fatalities is decreasing considerably in all countries, for cyclists in all countries except the Czech Republic, Hungary and Portugal, and for mopedists in all countries except the Netherlands, United Kingdom, Spain and Catalonia. The percentage of motorcyclist fatalities has increased in all the countries, except Spain (Catalonia included). This general trend is in agreement with the substantial decrease in the number of urban fatalities where non-motorized fatalities are more numerous than on rural roads).

The absolute number of fatalities for car, lorry and other/unknown vehicles decreased in all countries in the period studied, except in the Czech Republic. However, the absolute number of fatalities among motorcyclists increased in all countries, except in the Netherlands and Spain.

The Weighted Poisson Models technique was used to test differences between fatality rates. Statistics were defined and significance tests applied for comparisons between groups of countries and between individual countries. The technique turned out to be a useful tool for statistical testing of differences between weighted fatality numbers in the SUNflower+6 countries.

Detailed information is available on the amount of travel per mode for the SUN countries. A comparison of the outcomes for fatalities weighted and not weighted for travel distance, showed for example that the Netherlands and Sweden compared with the United Kingdom show a reverse effect for motorcyclists and mopedists compared with cars and lorries. If the number of fatalities is weighted for travel distance, then Sweden and the Netherlands show relatively more car and lorry crashes instead of fewer, compared with motorcyclists and mopedists. This effect is significant and agrees with the relatively high percentage of motor + moped kilometres in Sweden and the Netherlands compared to the United Kingdom. It shows how important exposure data are for a correct interpretation of safety outcomes.

For the SUN and Southern countries, the comparison of crash opponents for transport modes in fatal crashes showed that motorized vehicles are involved in single crashes significantly more frequently than cyclists and pedestrians. But also car and lorry drivers are significantly more frequently involved in single vehicle crashes than motorcyclists, mopedists and cyclists.
In these countries, lorries and buses are significantly less frequently the crash opponent in crashes with fatalities among pedestrians and cyclists than other motorized vehicles. Motorcyclists and mopedists are also less often the crash opponent than cars, lorries and buses, and cars less frequently than lorries. All these effects are highly significant. A possible explanation is that vulnerable road users are more careful in encounters with lorries and buses. Furthermore, the exposure to encounters might be greater for motorized vehicles.

Most SUNflower+6 countries (all but the Czech Republic and Hungary) have information about both the transport modes of the fatalities and their crash opponents. Some detailed outcomes are:

- Almost 60% of all road users killed are car occupants.
- Almost 20% of all fatalities are pedestrians. Remarkable is the high percentage of pedestrians as crash opponents in motorcycle, moped and bicycle crashes.
- In 20% of the cases motorcyclists have a motorcyclist as a crash opponent (this number may be caused by erroneous classification of the crash as not being a single vehicle crash).
- Most road users killed in lorries and buses are involved in single vehicle crashes.
- Cars are the most frequent crash opponent in crashes. The percentage increases with vulnerability of the crash opponent and is highest for pedestrians and cyclists.

The comparison of mortality rates by age group shows that there is a considerable improvement of safety for all age groups in 2003 compared with 1993. The average improvement is highest for the 0-14 year olds, followed by the group of over-65s. The average reduction is smallest for the 18-24 age group, followed by the 15-17 year olds. A possible explanation for this difference in effect for the age groups is the decrease in risks per transport mode. Furthermore, the effect is also in agreement with the general and substantial decrease of the number of fatalities on urban roads. It is difficult to make comparisons for other road types outside urban areas, because exposure data of good quality is often missing. Also major differences in classification and standards and geographical differences for these types of road explain the differences in risks.

The fatality risk on motorways is lower in 2003 than in 1993 for all countries which have values for the two years. The decrease is highest for the Czech Republic and Spain, followed by Slovenia and Portugal. But the risk on motorways remains considerably lower in the SUN countries than in the other SUNflower+6 countries. There is a general decrease in the percentage of fatalities on urban roads. Comparisons for other rural road types are difficult to make, because exposure data of good quality is often missing. There are also major differences in classification and standards for these types of road.

6.4. Recommendations

6.4.1. Methodology

When further developing the footprint methodology, the following recommendations should be taken into account.

Firstly, it turned out to be quite difficult to interrelate the safety outcomes of specific components (road user, vehicle, road) of the traffic system consistently between the different pyramid levels. In principle, the footprint method enables the differentiation of performances in specific areas, such as the different transport modes, road types or age groups. To achieve interrelated safety policies, we have to improve our understanding of the causal relationships between the indicators at the different pyramid levels. Further research is needed, since this is a prerequisite to understand how safety performances evolve. And in relation to this, the footprint content needs regular updates based on new insights and newly emerging road safety problems.

Secondly, there is a considerable lack of data to fill in the complete footprint for all countries. More high-quality data should be made available and more effort should be put into harmonizing data definitions to improve the comparability of countries. Sufficient data, in terms of availability and quality, is a prerequisite for making relations between pyramid levels more precise. There is a need for the improvement of the quality of data for future comparisons, particularly of exposure data, safety performance indicators, policy output and severely injured road users.

Thirdly, a working prototype of an expert system was developed, based on the detailed footprint scheme. The available data has been gathered in a template. If this template is filled with data for a country, even with missing data in several places, the prototype can be used to benchmark safety against a chosen reference. As part of the footprint methodology the expert system is a major step forward, but it needs further development. It is recommended to improve it with the above mentioned functionality regarding the differentiation of components at each pyramid level. It is not too optimistic to expect that the expert system automatically generates relevant selections of graphs, figures and tables, and carries out relevant statistical tests for further analysis and diagnosis.

6.4.2. For SUNflower+6 and other EU countries

Many helpful suggestions for the improvement of safety in each country have been formulated. Not one country turned out to be in the lead on all safety issues. Therefore, it is recommended to continue to look for the less developed parts in each country's state of the art on safety, in order to identify promising areas for improvement.

It is also recommended to continue this exercise in future years and to use and further develop the footprint method, the resulting schemes and the available and preferably improved prototype of an expert system, in order to address key elements in road safety.

Because of the differences in background of the nine countries, it is easy to find a comparable country for almost each country, which would like to apply the methodology. Furthermore, numerous detailed comparisons and suggestions for improvement have been made that may be of interest to other countries as well. Countries can add their road safety information to the working (and preferably improved) prototype of the expert system. This will enable preliminary benchmarking with the average outcome of the SUNflower+6 countries or with each individual SUNflower+6 country.

6.4.3. For the European Commission

The definition of safety indicators and of background information about the state of the art and the development of safety turned out to be useful. Many comparisons of road safety have been made that throw light upon questions about differences between countries.

However, much essential background data, in particular data about traffic exposure of different subgroups such as age groups, transport modes, road types, is missing. Furthermore, data on safety performance indicators such as seatbelt and helmet use, and, most urgently, on the use of alcohol and drugs, and on speeding is scarce. And if it is collected, there are some differences in definition. Final outcomes data on fatalities is available in sufficient detail. However, information about severely injured road users is incomplete and biased. Therefore a major part of the safety problem still remains invisible.

The recommendation for the European Commission, therefore, is to focus specifically on these three major issues: exposure data, information on safety performance indicators, and data of severely injured road users. Standards should be developed for the definition of such indicators and for data collection procedures, in order to come to comparable data systems which will result in meaningful international comparisons.

Further development of know-how should be stimulated in order to assure that the footprint gives a reliable picture of the road safety profile in a country. Attention should be paid to the improvement of indicators for known safety aspects, which should be made operational. Future knowledge should propose indicators for newly surfacing road safety aspects.

Finally, a prototype of a benchmark system has been developed. The data template used in this project can be improved and evaluated for future use. It is recommended to arrive at a European standard of such a safety template to be used in all European (Union) countries. It is further recommended to develop the existing and already operational prototype of a benchmark system into a user-friendly final format for use with the safety template.

References

Aarts, L. & Schagen, I. van (2006). *Driving speed and the rate of crashes*; A review. In: Accident Analysis and Prevention, vol. 38, nr. 2, p. 215-224.

ATSB (2002). *International Road Safety Comparisons - the 2002 report; A comparison of road safety statistics in OECD nations and Australia.* Australian Government/Australian Transport Safety Bureau ATSB, Canberra/Civic Square.

ATSB (2003). *International Road Safety Comparisons - the 2003 report*; *A comparison of road safety statistics in OECD nations and Australia.* Australian Government/Australian Transport Safety Bureau ATSB, Canberra/Civic Square.

Brüde, U. (2005). *Basic statistics for accidents and traffic and other background variables in Sweden*. VTI Notat 27A. Swedish National Road and Transport Research Institute VTI, Linköping.

Cauzard, J.-P. (ed.) (2004). *European drivers and road risk; Project on Social Attitudes to Road Traffic Risk in Europe SARTRE 3. Part 1: report on principal analyses.* Institut National de Recherche sur les Transports et leur Sécurité INRETS, Arcueil.

Ecorys (2005). *Impact Assessment Road Safety Action Programme: Assessment for mid term review*. Final report. Ecorys Transport, Rotterdam.

Eksler V., Heinrich, J., Gyurmati, J., Holló, P., Bensa, B., Bolko, N. & Krivec, D. (2005). *SUNflower+6; A comparative study of the development of road safety in the Czech Republic, Hungary, and Slovenia.* Transport Research Centre (Centrum Dopravniho výzkumu, CDV), Brno, Czech Republic.

Elvik, R. (2000). *How much do road accidents cost the national economy?* In: Accident Analysis and Prevention, vol. 32, nr. 6, p. 849-851.

Elvik, R., Christensen, P. & Amundsen, A. (2004). *Speed and road accidents; An evaluation of the Power Model*. TØI Report 740/2004. Institute of Transport Economics TØI, Oslo.

ERF (2005). *European Road Statistics 2005*. European Union Road Federation ERF, Brussels.

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

ETSC (2001). *Transport safety performance indicators*. European Transport Safety Council, Brussels.

Goodman, L.A. (1970). *The multivariate analysis of qualitative data: Interactions among multiple classifications.* In: Journal of the American Statistical Association JASA, vol.65, nr. 329, p. 226-256.

Hakkert, A.S. & Wesemann, P. (eds.) (2005). *The use of efficiency assessment tools; solutions to barriers*. Workpackage 3 of the European research project Road

Safety and Environmental Benefit-Cost and Cost-Effectiveness Analysis for Use in Decision-Making ROSEBUD. R-2005-2. SWOV Institute for Road Safety Research, Leidschendam, the Netherlands.

Hayes, S., Serrano, S., Pagès, L., Zori, P., Handanos, Y., Katscochis, D., Lemonde de Macedo. A., Cordoso, J. & Vieira Gomes, S. (2005). *SUNflower+6; A comparative study of the development of road safety in Greece, Portugal, Spain, and Catalonia.* Design & Systems Development DSD, Barcelona.

Koornstra, M., Lynam, D., Nilsson, G., Noordzij, P., Pettersson, H-E., Wegman, F. & Wouters, P. (2002). *SUNflower; A comparative study of the development of road safety in Sweden, the United Kingdom, and the Netherlands*. SWOV Institute for Road Safety Research, Leidschendam, the Netherlands.

Lay, D.C. (1994). *Linear Algebra and its Applications*. Addison-Wesley Publishing Company, New York.

Leeuw, J. de & Oppe,S. (1976). *The analysis of contingency tables; Log-linear Poisson models for weighted numbers.* R-76-31. SWOV Institute for Road Safety Research, Leidschendam, the Netherlands.

LTSA (2000). *Road safety strategy 2010; A consultation document.* National Road Safety Committee, Land Transport Safety Authority LTSA, Wellington, New Zealand.

Lynam, D., Nilsson, G., Morsink, P., Sexton, B., Twisk, D., Goldenbeld, Ch. & Wegman, F. (2005). *SUNflower+6*; *An extended study of the development of road safety in Sweden, the United Kingdom, and the Netherlands*. TRL Ltd., Crowthorne, United Kingdom.

Lynam, D.T., Sutch, T., Broughton, J. & Lawson, S.D. (2003). *The European Road Assessment Programme (EuroRAP).* Pilot Phase Technical Report. AA Foundation for Road Safety Research, Farnborough.

Nilsson, G. (2004). *Traffic safety dimensions and the power model to describe the effect of speed on safety*. Lund Bulletin 221. Lund Institute of Technology, Department of Technology and Society, Lund.

Oppe, S. (2001). *International comparisons of road safety using Singular Value Decomposition.* D-2001-9. SWOV Institute for Road Safety Research, Leidschendam, the Netherlands.

Rumar, K. (1999). *Transport safety visions, targets and strategies: beyond 2000;The first European Transport Safety Lecture*. European Transport Safety Council ETSC, Brussels.

SWOV (2004). *Zone 30: urban residential areas*. SWOV fact sheet. SWOV Institute for Road Safety Research, Leidschendam, the Netherlands.

SWOV (ed.) (2005). *State of the art report on road safety performance indicators*. Deliverable D3.1 of the SafetyNet project. European Commission, Brussels.

Trinca, G.W., Johnstone, I.R., Campbell, B.J., Haight, F.A., Knight, P.R., Mackay, G.M., McLean, A.J. & Petrucelli, E. (1988). *Reducing traffic injury; A global challenge.* Royal Australasian College of Surgeons, Melbourne.

Wegman, F. (2004). *Implementing, monitoring, evaluating and updating a road safety programme*. D-2003-12. SWOV Institute for Road Safety Research, Leidschendam, the Netherlands.

Appendix A. Fundamental safety problems

Road safety problems can be categorized in different ways. Rumar (1999) describes three orders of road safety problems in the EU. First order problems are obvious even by superficial crash analysis. Second order problems reduce the effectiveness of solving the first order problems. Third order problems are problems that prevent or block the possible solutions of the first and second order problems. The orders relate to the levels of the pyramid: first order problems can be measured by final outcomes and intermediate outcomes and second and third order problems mainly act at the level of safety measures and programmes.

First order problems
• Speeds, especially in built up areas, are too high. • Use of alcohol and drugs is too frequent in road traffic. • Road safety is too low in urban areas. • The road safety of children is inadequate. • The road safety of unprotected road users is too low. • The crash risk for young drivers is too high. • Use of cars is too widespread especially in urban areas. • The standard of the roads and streets is not correct in many places. • The crash and injury risks for elderly road users are too high. • Injury prevention is inadequate for too many roads and vehicles. • The usage of protective devices (seatbelts, helmets, etc.) is too low. • The rescue service and medical treatment of traffic victims is not effective enough. • The conspicuity of road users is insufficient in daylight. Their conspicuity at night is much worse. • The crash rate in reduced visibility conditions such as darkness and fog is too high. • The crash rate in winter traffic is too high. • Heavy vehicles are over-represented in serious crashes. • Some types of intersections have crash risks which are too high.
Second order problems
• Road traffic rules (legislation) are not clear, not logical and not consistent. • Enforcement of licence requirements and traffic rules is not efficient enough. • Inspection of road condition from the safety point of view is insufficient. • Inspection of vehicle condition from the safety point of view is insufficient. • Training and examination for driver licensing is not good enough. • Road safety education of citizens is inadequate. • The way traffic offences and crimes are dealt with in court is irregular and not in harmony with the corresponding risks.
Third order problems
• Current awareness of the seriousness of road safety problems and the value of road safety measures is too low among decision-makers and road users. This prevents implementation of existing knowledge. • The present management system for road safety work is inadequate. A quick and efficient road safety management system requires result management based on performance indicators. • No vision of the future with enough support from society stand to create creativity, energy and participation. • No quantitative targets. • The present information and diagnosis system for road safety is very crude and partly inaccurate. • Poorly supported and coordinated research. • Consumers, communities and companies need to be more actively involved in the road safety effort.

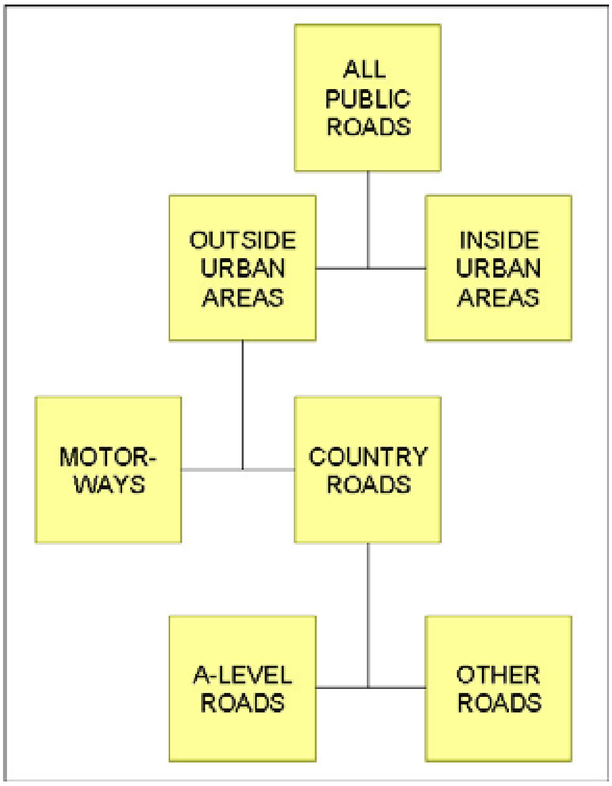
Table A.1. *Three orders of road safety problems in the EU (Rumar, 1999)*.

Appendix B. Road classification schemes

Road classification according to IRTAD and SafetyNet

The international IRTAD database uses the following road types according to the hierarchy shown in Figure B.1:

- Roads inside urban areas (urban roads, excl. all motorways)
- Roads outside urban areas (rural roads, incl. all motorways)
    - Motorways
    - Country roads
        - A-level roads (roads outside urban areas that are not motorways, but belong to the top level road network)
        - Other roads



Total public road network = outside urban areas + inside urban areas

Outside urban areas = motorways + country roads

Country roads = A-level roads outside urban areas + other roads outside urban areas

Figure B.1. *The IRTAD road classification*.

SafetyNet proposes a functional road classification, as presented in Table B.1 (SWOV, 2005). The classification was obtained from current practices in the Netherlands according to the 'Sustainable Safety' vision and road type definitions in IRTAD. The IRTAD categorization does not provide enough information to distil road safety performance indicators related to the road infrastructure. At least a further specification of A-level roads and other roads, and preferably urban roads as well, is needed to monitor the functional specifications.

Area	Road category type		Characteristics
	Abbreviation	Subcategory	
Rural areas	AAA	Motorway	Through-road with a flow function Dual carriageway 2x2 or more lane configuration Wide obstacle-free zone or safety barrier Intersections: grade-separated
	AA	A-level road 1	Through-road with a flow function Dual carriageway 2x1 lane configuration Obstacle-free zone or safety barrier
	A	A-level road 2	Through-road with a flow function Single carriageway 1x4 or 1x2 lane configuration Obstacle-free zone or safety barrier
	BB	Rural distributor 1	Dual carriageway 2x2 or 2x1 lane configuration
	B	Rural distributor 2	Single carriageway 1x2 lane configuration
	C	Rural access road	Single carriageway 1x2 and 1x1 lane configuration
Urban areas	DD	Urban distributor road 1	Dual carriageway 2x2 or 2x1 lane configuration
	D	Urban distributor road 2	Single carriageway 1x4 or 1x2 lane configuration
	E	Urban access road	Single carriageway 1x2 or 1x1 lane configuration

Table B.1. *Road categories for international harmonization (SWOV, 2005).*

The three functional categories are described as follows:

- **Through-road**; road with a flow function: enabling high speeds of long distance traffic and, often, large traffic volumes
- **Distributor road**: serving districts and regions containing scattered destinations
- **Access road**: enabling direct access to properties alongside a road or street

Nine road classes (=road type) are distinguished in the table columns:

- **AAA** (Motorway)
- **AA** (A-level road 1)
- **A** (A-level road 2)
- **BB** (Rural distributor road 1)
- **B** (Rural distributor road 2)
- **C** (Rural access road)
- **DD** (Urban distributor road 1)
- **D** (Urban distributor road 2)
- **E** (Urban access road)

Each road class is distinguished by a number of characteristics, given in the road class columns. Some of the characteristic cells are empty; most cells contain a description of a characteristic. Cells are left empty if it is not possible to give a specification beforehand for all countries.

The road classes relate to the functional categories in the rural areas as follows:

Through-road (with a flow function and only outside built-up areas)

Starting with the road type definition which is available in the IRTAD database, motorways and A-level roads have been assigned to this category. AAA refers to motorways. The characteristics of this road category are a dual carriageway; a wide obstacle-free zone or a safety barrier and grade-separated intersections. AA and A refer to the A-level roads according to the IRTAD definition: roads outside urban areas that are not motorways but belong to the top-level road network. AA is a dual carriageway road; A is a single carriageway road. Other main characteristics of these last two road categories are an obstacle-free zone or at least a safety barrier. In member countries they are often stated as primary roads, national roads, semi-motorways or non-interstate arteries.

Rural distributor road

IRTAD does not define this road type. All rural roads other than motorway and A-level road are defined as 'other road'. Here a distinction is made between BB and B roads. The BB road typically is a dual carriageway road, whereas a B road typically is a single carriageway road. Obstacle zones and intersections occur in various layouts among the various countries.

Rural access road

This type of road, indicated as category C, typically is a single carriageway road with one driving lane or two lanes separated by access marking only.

IRTAD does not define any road types inside urban areas. Here a distinction is made between urban distributor roads and urban access roads.

Urban distributor roads

This type of roads facilitates road users to enter and leave an urban area and connects zones within urban areas. Here a distinction is made between DD and D roads. The DD road typically is a dual carriageway road, whereas a D road typically is a single carriageway road. In various countries these roads have been indicated as urban arteries or main urban roads.

Urban access road

This road category, indicated as category E, typically is a single carriageway road with one driving lane or two lanes separated by access marking only. These roads provide entrance to residential areas, so each road user will be able to reach an individual dwelling, shop or company.

Appendix C. International data sources

CARE database

CARE (the Community database on Accidents on the Roads in Europe) is the European Union database (beside the basic EUROSAT database) on road crashes. The major difference between CARE and most other existing international databases (including IRTAD) is its high level of disaggregation. CARE contains detailed data on individual crashes ('records') as collected by the member states. This structure allows the highest flexibility and potential with regard to analysing the information contained in the system and it also opens a wide range of new possibilities in the field of crash analysis.

Today the only system comparable with CARE database is the FARS system (Fatality Analysis and Reporting System) which operates at the federal level in the USA since the 1970s.

The purpose of the CARE system is to provide a powerful tool which makes it possible to identify and quantify road safety problems throughout the European Union, to evaluate the efficiency of road safety measures, to determine the relevance of EU actions, and to facilitate the exchange of experiences in this field.

Origins of the CARE project go back to the 1980s and 1990s. The CARE database was based on a feasibility study and was established by decision of the European Council in December 1993. This project continued with further studies, dealt with harmonization of the data it contained and the full operation of the system. Today the Governmental Agencies and the European Commission can use a user-friendly interface to produce detailed multidimensional reports. The compatibility of a large number of data variables and values has been thoroughly examined, and a set of 38 variables containing 488 common definition values has been proposed.

Recognizing that his would require considerable changes for all national administrations, it was decided that the national data sets should be integrated into the CARE database in their original national structure and definitions, instead of entering into a long process of defining and adopting a new standardized structure. Confidential data in the national data sets is blanked. Subsequently the Commission provided the framework of transformation rules so that CARE can provide compatible data. The process of improving the homogenization of crash data within CARE and the process of developing continues.

The central idea behind CARE is to collect all member crash databases with all injury crash records and to make them available so that they can provide output tables to arbitrary queries. Full access will be reserved for selected national authorities (for example ministries). The basic data should however be available for a wide public.

CARE is a large-scale database which contains road crash data from 14 old EU member states (except Germany) from 1991 in a disaggregated form. Various aggregated output reports can be made from this data. At present some selected aggregated data from 10 new member states and Germany already are available.

The main output variables are the data on killed, (severely and slightly) injured and injury crashes distributed by the age, sex, modal split and other characteristics. Using a correction factor, the number of killed could be corrected to 30 days. It is possible to obtain output reports at different levels of distribution and cross-table structures.

The basic data tables with key variables and appropriate graphs are freely available on the public Internet page: http://europa.eu.int/comm/transport/care

IRTAD database

The International Road Traffic Accident Database (IRTAD) is one the most important, reliable and perspective crash databases widely used especially for crash investigation.

This database was established in the mid-1980s by BASt (Bundesanstalt für Straßenwesen, Germany). Originally, it was a national database, but soon it gained an international scope and was incorporated into the transport research activities of the OECD as its official crash database in 1989. It has been operated by BASt till this time. Since January 2004 it is operated in the frame of the Joint Transport Research Centre of the OECD and ECMT (JTRC OECD/ECMT).

Nowadays this database contains crash and exposure data from 29 OECD member states (except Mexico), and beside this also the data from Slovenia as one non-member OECD state. All data is aggregated at the national level. The number killed is strictly defined by a 30-day term (it means that fore some countries correction factors are applied). The database contains data on killed, injured and hospitalized crash victims, injury crash data in disaggregation by the age, modal split, road type, as well as exposure (background) data on vehicle park, road network, road traffic volumes, traffic modal split and demographic data by nation. This data has been collected from 1970 per every year, but some key data (accident, killed and injured numbers) are also collected with monthly intervals. At present, about a total of 500 variables is being collected.

In order to improve the reliability and quality of the crash data, IRTAD has written several 'Special reports' about problems with underreporting, definitions, exposure data, 30-days correction, and hospitalized injuries.

IRTAD operates on an intergovernmental base. Particular member states are represented by appointed research institutes or other bodies from the state sector, sometime also by other institutes from practical or education areas. Only these member institutes have direct access to the crash data from IRTAD and they can disseminate them further according to the actual demands.

The data from the database can be accessed on CD-ROM (off-line mode) or directly via the Internet on the IRTAD member page with the restricted access (on-line mode). Some general crash data also is freely available on the public Internet page:
http://www.bast.de/htdocs/fachthemen/irtad/english/englisch.html.

IRTAD is not only a crash database, but it also is the basis for closer cooperation of the group of road safety professionals. They share their national experiences and strengthen the international comparability responding to the needs of governments, researchers and international organizations.

IRTAD plans to extend the scope of its activities by also collecting and distributing other types of data, and by large scale analyses of road traffic crash data. It has ambitions to include data of more countries in the future.

Other databases

ECMT database
The ECMT (European Council of Ministers of Transport) has its own transport database which, among data on other topics, also contains data on road traffic crashes. This data is collected by representatives of individual states (ministries and statistics agencies).
A brief annual report 'Road Safety in Europe' (with a comparison of the development of road fatalities) is published and is freely available on the Internet. Also a special publication 'Statistical report on road accidents' is written every other year and is published in written form and is also freely available on the Internet: http://www.cemt.org.
This database contains data from all member states on killed, injured and injury crashes, as well as some exposure data. For fatality data correction factors are used. Steps are being made to integrate the IRTAD and ECMT database.

UN ECE database
The UN ECE (the United Nations Economic Commission for Europe) also has its own transport database. Parts of it deals with road traffic crashes. These data is also collected by representatives of individual states (ministries and statistics agencies).
An annual report 'Statistics of road traffic accidents in Europe and North America' is published in written form.
This database involves data from all member states on killed, injured and injury crashes, as well as some exposure data. No correction factors are used for fatality data.

EUROSTAT database
EUROSTAT, the statistics agency of the European Union, operates with very extensive databases of various areas of activities of all member states. The data on road traffic crashes are freely available on the EUROSTAT Internet pages, also at a certain level of regional distribution. The Directorate General of the EU for Energy and Transport, in co-operation with EUROSTAT, also publishes its own brief annual statistics report (freely available on the Internet - http://europa.eu.int/comm/eurostat - and in a written form).

WHO database
The WHO (World Health Organisation) as the affiliated UNO organization, also has its own database containing, among other topics, the mortality statistics. These statistics, which are a part of the WHO Statistical Information System (WHOSIS), contain data on registered deaths distributed by cause, sex and age. One of the causes is motor vehicle and other traffic fatalities.
The data is also freely available on the Internet: http://www.who.int.

IRF database
The IRF (International Road Federation), as a non-governmental organization, has its database of road traffic and road crashes. In part, publication from this database is freely available on the Internet: http://www.irfnet.org.

FARS database

The FARS (Fatality Analysis Reporting System) is the crash database operated by the NHTSA (National Highway Traffic Safety Administration) on a federal basis in the USA. It involves disaggregated crash data on individual crashes for all USA territory and its individual states from 1994 (similar to CARE).

The database is freely available on the Internet: http://www-fars.nhtsa.dot.gov.

Communication is available through queries on many variables with aggregated output reports.

Appendix D. Data aspects regarding SPIs

Example seatbelts

Table D.1 shows the number of years in each period for which seatbelt wearing rates are available in the SUNflower+6 countries.

Safety belt		SE	UK	NL	CZ	HU	SI	PT	EL	ES	Cat
1981-1983	Driver	1	3	3							
	Front										
	Rear	1									
1991-1993	Driver	1	3	3						1	1
	Front	1	3							1	1
	Rear	1	3	3						1	1
2001-2003	Driver	3	3	3	3	1	3	1	1	3	3
	Front	3	3	2	1	1		1	1	3	3
	Rear	3	3	3	1	1		1	1	3	3

Table D.1. *Number of years with seatbelt wearing rates for drivers, front passengers and rear seat passengers in the SUNflower+6 countries for three time periods.*

From Table D.1 the conclusion is that for all three years of the three periods observations for drivers are available for the United Kingdom and the Netherlands, for Sweden for drivers and rear seat passengers for one year of the first two periods, and for front seat passengers for one year in the second period. For Spain and Catalonia observations are available for drivers, front seat passengers, and rear seat passengers in one year of the second period.

All countries at least have observations for the drivers in the period 2001-2003.

Apart from Slovenia, all countries at least have figures over one year for front seat passengers and rear seat passengers.

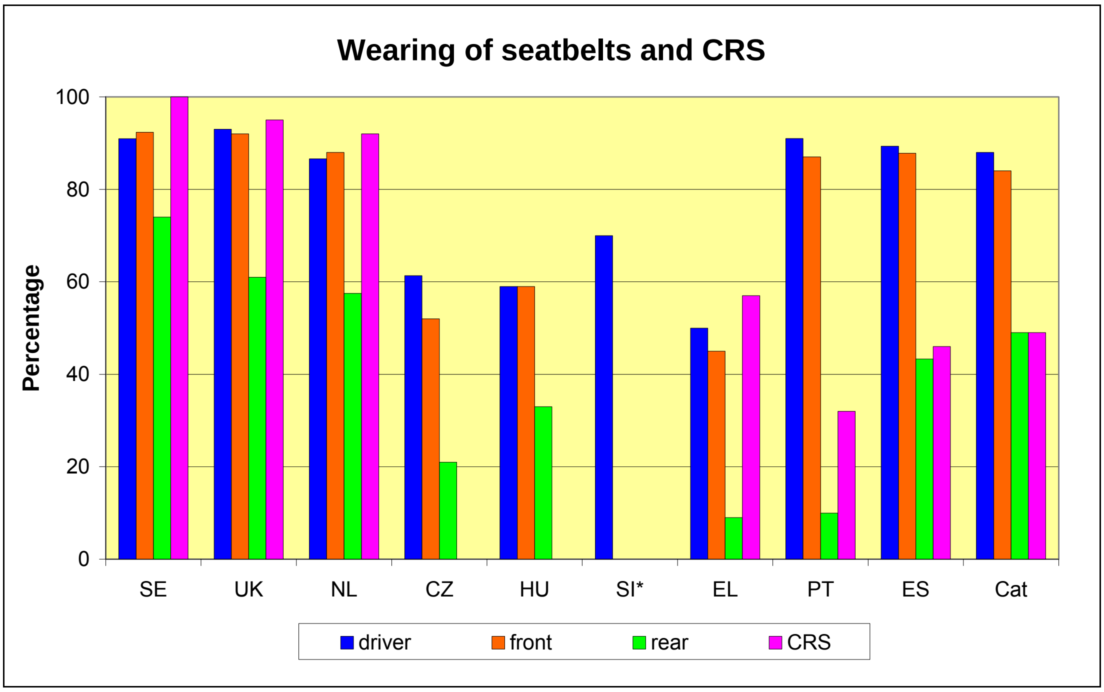
This shows that much more attention is given to this protection device in recent years than in the past.

The average values of the wearing rates of drivers for this period are given in Figure D.1. For the SUN countries data is available from observations in traffic and from self reports from the SARTRE questionnaire (Cauzard, 2004). The values do not differ much.

For the Central countries values are available from surveys and from the SARTRE questionnaire. In the Czech Republic and Slovenia also from police reports and fatal crashes. The survey data is used here.

The values for the Southern countries are based on (mostly urban) observations. SARTRE rates are not much different, but show larger discrepancies between road types than the observations.

The detailed discussion for the Central countries shows that it is very important to define standards for the registration of wearing rates. Given the various values mentioned, 'statistics can lie' in both directions.



* Estimate, see Eksler et al., 2005.

Figure D.1. *Average wearing percentages of seatbelts by drivers, front and rear seat passengers, and of child restraint systems (CRS) in the SUNflower+6 countries for 2001-2003.*

Figure D.1 shows that wearing rates for driver and front passengers in the SUN countries (especially in the United Kingdom), Slovenia, Portugal and Spain (including Catalonia) are much higher than in the Czech Republic, Hungary and Greece.
Seatbelt wearing in the back of the car is highest in Sweden, followed by the United Kingdom and the Netherlands, Spain, Catalonia and Hungary. For all countries, especially the non-SUN countries, wearing rates in the back are considerable lower than in the front of the car. However, the percentages of child restraint systems usage is even higher than the wearing percentages for drivers and front passengers in the SUN countries and Greece. For Portugal it is higher than for rear seats; for Spain and Catalonia the percentages are the same for CRSs and rear seats.

The above information about CRSs for the Southern countries regards CRSs used in crashes, however, with high levels of missing observations (see Hayes et al., 2005, for details). Wearing rates for Sweden are 17%, 86% and 100% for period 1, 2 and 3. In the United Kingdom 76% and 95% and in the Netherlands 88% and 92% in period 2 and 3.
In Greece in 57% of the injury crashes no CRS was used in the last period. For Portugal this is 32%, in Spain 46% and Catalonia 49% for injury crashes.

The percentage was reduced in Spain from 77% in the second period to the 46% and in Catalonia from 73% to 49% in the last period.

Figure D.2 shows the development of wearing rates over time for the United Kingdom, Sweden, the Netherlands and Spain averaged over the available years.

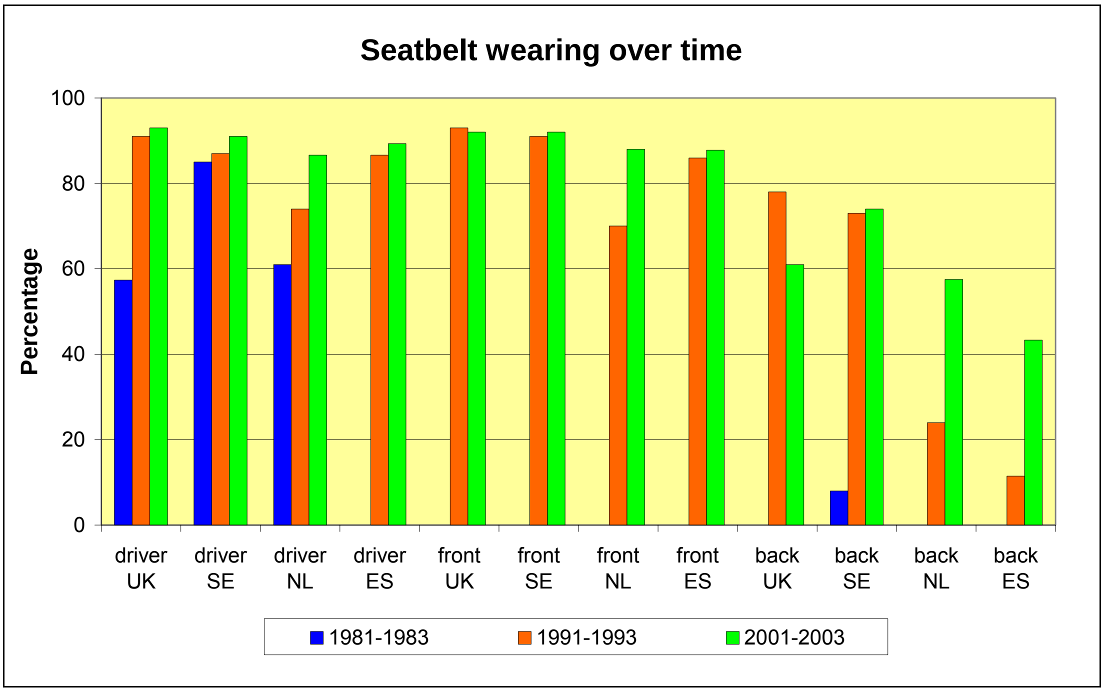


Figure D.2. *Average seatbelt wearing percentages for drivers, front and rear seat passengers in the United Kingdom, Sweden, the Netherlands and Spain in three time periods.*

In the first period, wearing rates in the United Kingdom and the Netherlands were around 60% and already over 80% for drivers in Sweden. In the United Kingdom the wearing rates increased considerably after the first period.

For the Netherlands these rates increased more gradually, however, not to the same level as in the United Kingdom

The values in Spain in the last two periods are comparable to those in the Netherlands in the last period. These values include Catalonia. In general, the percentages for Catalonia are slightly lower, except for the rear seat passengers. The percentages are equal in 1993 and 5% higher in 2003.

Little data is available for statistics about other protective systems.

Example helmets

Helmet wearing rates for motorcyclists and mopedists are available for the Netherlands (in all nine years except 2003 for mopedists and in 2001 for motorcyclists) for Spain and Catalonia (for 1993, 2001, 2002, and 2003) and Slovenia (for 2001, 2002, and 2003)

For the United Kingdom no official figures are available. The reason is that wearing rates for motorcyclists and mopedists are almost 100%.

For the Netherlands wearing rates for mopedists went from 100% in the first period to 92% in the last period. The wearing rate for motorcyclists is 95%.

For Spain the wearing rates 74% in 1993 and 82% in the last period for mopedists and 91% and 95% for motorcyclists. For Catalonia these rates are 92% and 99% for motorcyclists, and 81% and 95% for mopedists in 1993 and the last period respectively.

In Slovenia the wearing rates in the last period are 87% for motorcyclists and 71% for mopedists.

Example speed

In many countries incidental speed measurements have been carried out. However, only for four SUNflower+6 countries is data available in the footprint about the mean speed (averaged over 24 hrs) on different road types; see Figure D.3.

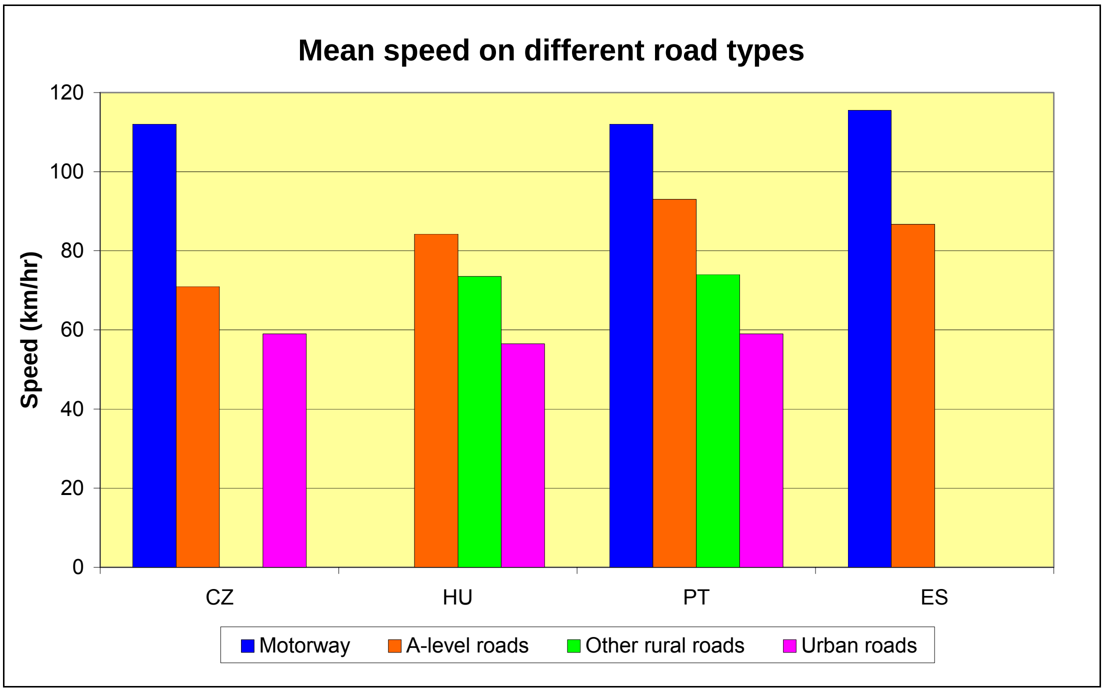


Figure D.3. *Mean speed (averaged over 24 hrs) on different road types for four SUNflower+6 countries in 2001*.

The differences in mean speed are not large. The most significant one is the low mean speed on A-level roads in the Czech Republic. For a good interpretation of the figures it is important to know the differences in definitions of road types, the geographical structure of the country, the quality of the roads within a road type and the speed limits. The speed limit systems have been described in the group reports (Lynam et al., 2005; Eksler et al., 2005; Hayes et al., 2005).

Although the speed limits on motorways are higher in the Czech Republic and Hungary, the mean speeds are not. No information is available about the 85-percentile speed or similar measures in these countries.

The differences in mean speed on A-level roads are not in agreement with the differences in speed limit. Without further information about for instance free flow speed, the 85-percentile speed or road characteristics, no explanation is possible.

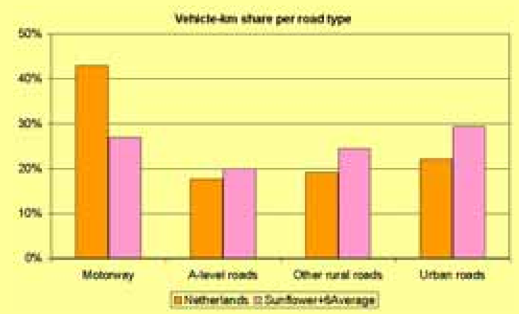
The general conclusion is that although the availability of safety performance indicators is of greatest importance for the evaluation of the compliance with behavioural measures, the most urgent data on speed, alcohol and use of drugs is missing in almost all countries as well as detailed information on wearing seatbelts. And if data is available, then it is often not comparable or unreliable. More uniformity in speed and drinking & driving laws in Europe as well as a better registration of the compliance is necessary.

Appendix E. Detailed footprint scheme example

The table below contains the complete footprint for the Netherlands in the period 2001-2003. The structure of the scheme refers to Table 3.2.

Transport background

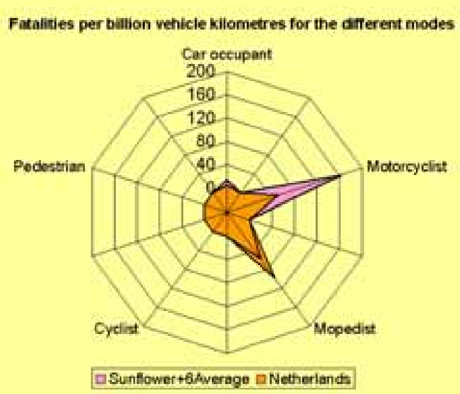
Road traffic fatalities: 1002
Population (million): 16.1
Area (thousands of km^2): 41526
Road length (thousand km): 131
Motorway length (km): 2274
Number of motor vehicles (million): 8,16
Motor vehicle kilometres (x 10^9): 131
Motor vehicle kilometres on motorways (x 10^9): 56

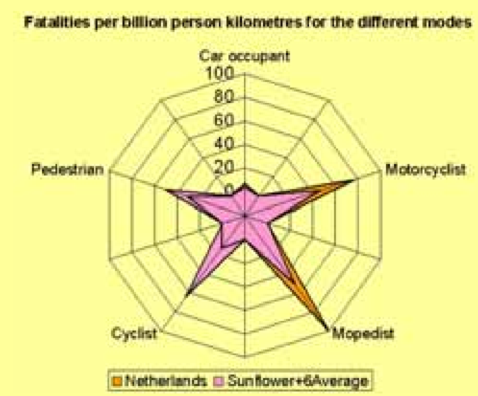


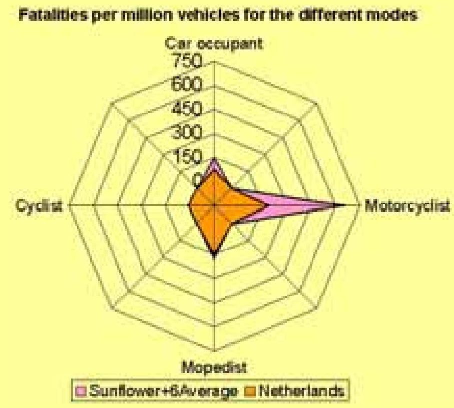
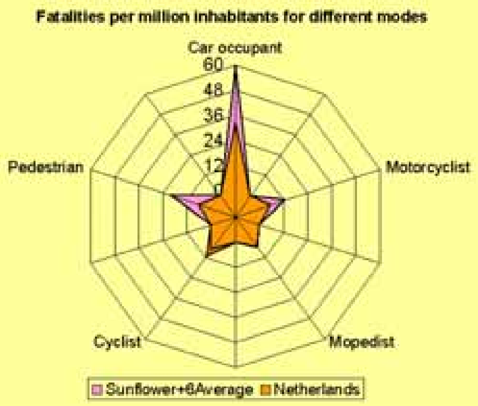
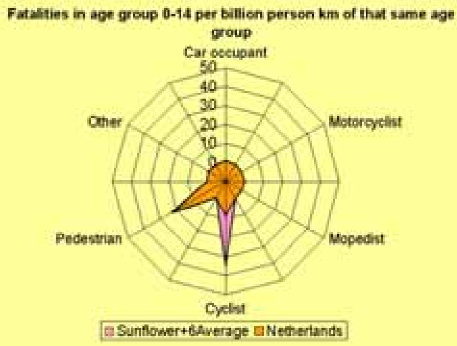
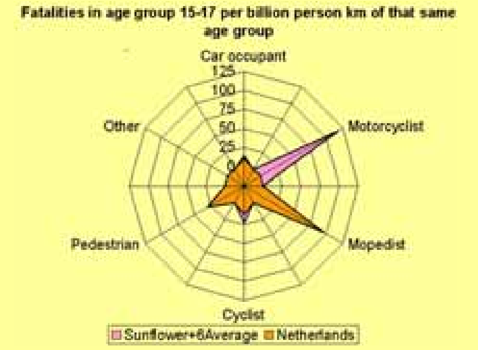
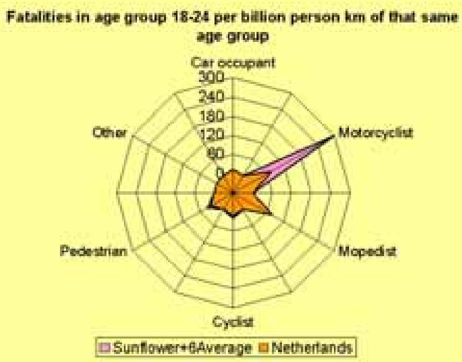
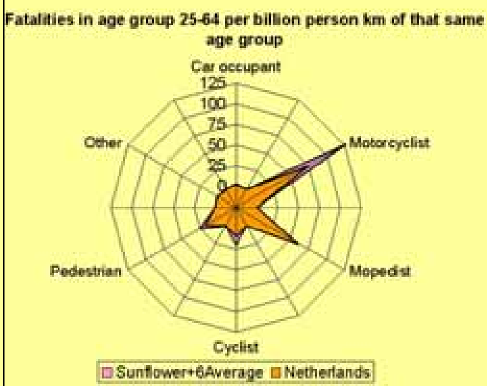
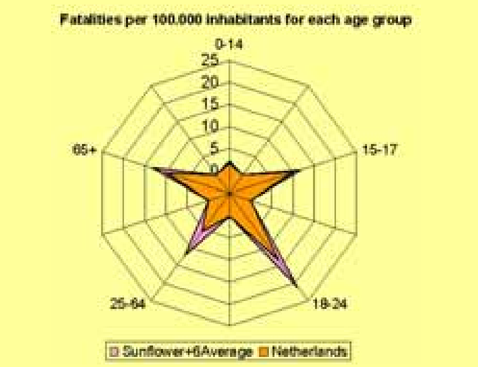
Final outcomes - fatalities

Killed as	Percent single vehicle	Percentage in collision with (2001-2003)									Total
		Car	Lorry	Bus	Motor cycle	Moped/ Cycle	Train	Tram	Animal	Other	
Car occupant	27.79	13.96	7.95	0.47	0.10	0.07	0.96	0.13	0.07	0.76	52.26
Lorry occupant	0.47	0.13	0.33	0.03	0.03	0.00	0.13	0.00	0.00	0.03	1.16
Bus occupant	0.03	0.00	0.03	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.07
Motorcyclist	2.63	4.55	0.70	0.10	0.23	0.17	0.03	0.00	0.00	0.37	8.78
Mopedist	2.59	3.92	0.83	0.20	0.13	0.80	0.10	0.00	0.03	0.37	8.98
Cyclist	1.20	11.07	2.49	0.66	0.20	0.96	0.60	0.37	0.03	0.76	18.35
Pedestrian	0.00	6.62	1.03	0.70	0.33	0.80	0.10	0.37	0.00	0.03	9.97
Other	0.30	0.00	0.03	0.03	0.00	0.00	0.03	0.03	0.00	0.00	0.43
Total	35.01	40.26	13.40	2.19	1.03	2.79	1.96	0.90	0.13	2.33	100

Modes





		
Age groups		
		
		

Fatalities per million vehicles for the different modes
Car occupant
750
600
450
300
150
0
Cyclist
Motorcyclist
Mopedist
Sunflower+6Average
Netherlands

Fatalities per million inhabitants for different modes
Car occupant
60
48
36
24
12
0
Pedestrian
Motorcyclist
Cyclist
Mopedist
Sunflower+6Average
Netherlands

Fatalities in age group 0-14 per billion person km of that same age group
Car occupant
50
40
30
20
10
0
Other
Motorcyclist
Pedestrian
Mopedist
Cyclist
Sunflower+6Average
Netherlands

Fatalities in age group 15-17 per billion person km of that same age group
Car occupant
125
100
75
50
25
0
Other
Motorcyclist
Pedestrian
Mopedist
Cyclist
Sunflower+6Average
Netherlands

Fatalities in age group 18-24 per billion person km of that same age group
Car occupant
300
240
180
120
60
0
Other
Motorcyclist
Pedestrian
Mopedist
Cyclist
Sunflower+6Average
Netherlands

Fatalities in age group 25-64 per billion person km of that same age group
Car occupant
125
100
75
50
25
0
Other
Motorcyclist
Pedestrian
Mopedist
Cyclist
Sunflower+6Average
Netherlands

Fatalities in age group 65+ per billion person km of that same age group
Car occupant
800
640
480
320
160
0
Other
Motorcyclist
Pedestrian
Mopedist
Cyclist
Sunflower+6Average
Netherlands

Fatalities per 100.000 inhabitants for each age group
0-14
25
20
15
10
5
0
65+
15-17
25-64
18-24
Sunflower+6Average
Netherlands

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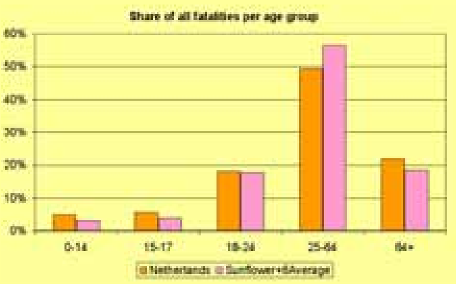
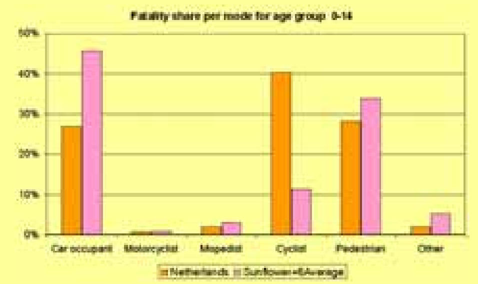
<tr><td></td><td colspan="2">
</td><td colspan="2">
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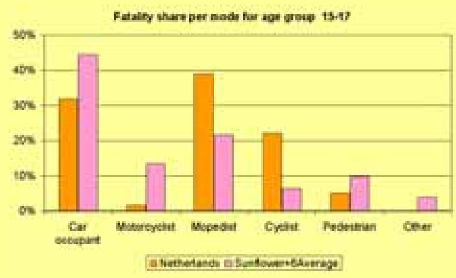
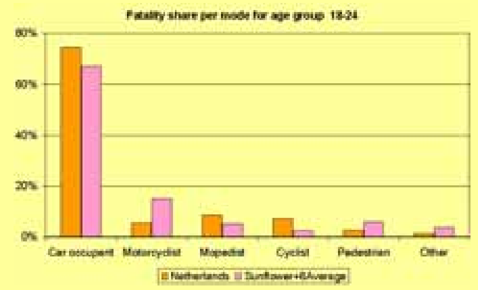
<tr><td></td><td colspan="2">
</td><td colspan="2">
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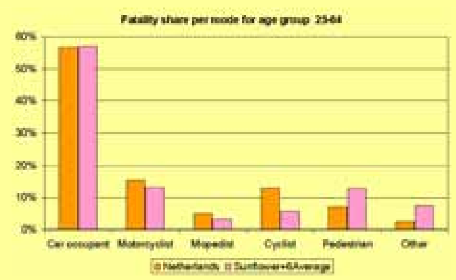
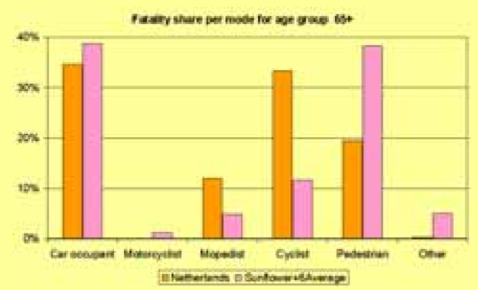
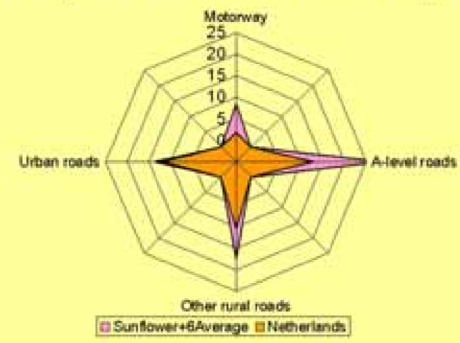
<tr><td></td><td colspan="2">
</td><td colspan="2">
</td></tr>
<tr><td>Behaviour</td><td colspan="4">Not available</td></tr>
<tr><td>Roads</td><td>Not available</td><td>Not available</td><td>Not available</td><td>Not available</td></tr>
<tr><td></td><td colspan="2">Fatalities per billion vehicle kilometres for the different road types

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</td></tr>
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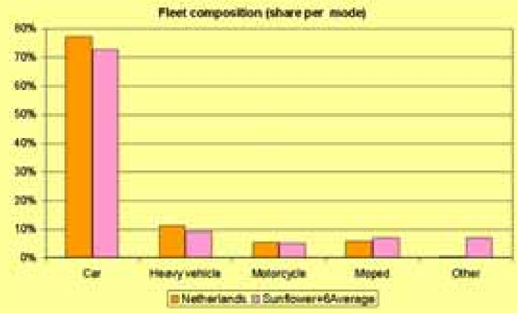
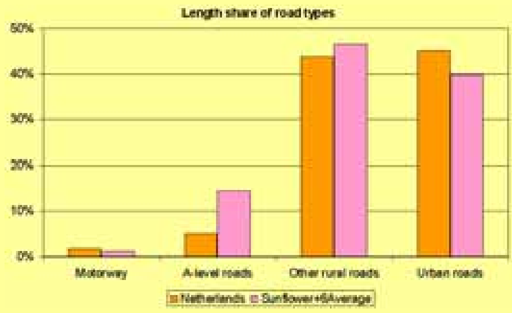
<table>
<tr><th colspan="7">Safety Performance Indicators</th></tr>
<tr><td rowspan="2">Modes</td><td colspan="3">Not available</td><td colspan="3">Not available</td></tr>
<tr><td colspan="6">
</td></tr>
<tr><td rowspan="3">Behaviour</td><td>Speeding</td><td>Not available</td><td>Not available</td><td>Not available</td><td>Not available</td><td>Not available</td></tr>
<tr><td>DRL</td><td>Not available</td><td>Not available</td><td>Not available</td><td>Not available</td><td>Not available</td></tr>
<tr><td>Other</td><td colspan="5">
</td></tr>
<tr><td>Roads</td><td colspan="6">
</td></tr>
<tr><td></td><td colspan="6">Not available</td></tr>
</table>

Policy output

Types and number of measures

	Before 1975	1975 - 1984	1985 - 1994	1995 - 2004
Safety measures	6: a, b, h, s	12: b, h, f, i, y	11: f, a, b, s	10: a, s, f

The cells contain the total number of measures, followed by a colon, followed by letters representing: alcohol and drugs, belts, helmets, speed, fleet measures, infrastructure, young road users and vulnerable road users. A minus sign means supposed negative safety effect.

Policy document

Not available

Implementation

Organization: Not available

Modes: Cars and vans which weigh under 3500 kg (fully loaded) and older than 3 years have to be checked annually.

Behaviour/ enforcement:

The legal BAC limit in the Netherlands is 0.05%.

The speed limit system is given in the following table:

Vehicle type	Speed limits (km/h) on road types				
	Motor-way	Main roads	Other roads outside built-up areas	Other roads inside built-up areas	Certain roads inside built-up areas
Cars and motorcycles	120/100	100	80/60	50	30
Vans, lorries and coaches	80	80	80	50	30
Motor vehicle towing trailers	80	80	80	50	30
Microcars	-	-	45	45	30
Mopeds and motor-powered invalid carriages	-	-	40	30	30
Motor-assisted bicycles and agricultural vehicles	-	-	25	25	25

The number of violations is given in the following table:

Violations in the Netherlands (2002)	Number of violations (thousands)	
	Fixed penalty	Courts
Speeding	6925	
Alcohol/drugs	12	18
Seatbelts	23	

Besides the varying court sanctions for violation of the BAC, there is a programme with administrative sanctions. This programme includes:

1. a driver improvement course at an alcohol level of over 0.15% (0.08% for repeat offenders),
2. medical test at a level of over 0.18% or with four previous convictions in the past five years or when involved in a serious accident, or refusal to be tested,
3. immediate licence withdrawal at a level of over 0.25%, or with four previous convictions in the past five years.

<table>
<tr><td></td><td></td><td>The fine for
1. not using a seatbelt is €30,
2. not wearing a helmet on a moped is €55,
3. not wearing a helmet on a motorcycle is €70.</td></tr>
<tr><td></td><td></td><td>Speed tolerance level:
For 80 km/h roads excess speeds are not enforced until speed reach 87 km/h. For 100 and 120 km/h roads excess speeds above 107 and 127 km/h respectively are enforced.
Sanctions for different speeding violations in the Netherlands are given in the next table (prize level 2004).
<table>
<tr><th>Sanction type</th><th>Speed violation</th><th>Motorways</th><th>Other roads</th></tr>
<tr><td rowspan="5">Sanction registered under administrative law</td><td>up to 10 km/h</td><td>€ 30</td><td>€ 30</td></tr>
<tr><td>11 to 15 km/h</td><td>€ 45</td><td>€ 45</td></tr>
<tr><td>16 to 20 km/h</td><td>€ 55</td><td>€ 70</td></tr>
<tr><td>21 to 25 km/h</td><td>€ 90</td><td>€ 100</td></tr>
<tr><td>26 to 30 km/h</td><td>€ 115</td><td>€ 125</td></tr>
<tr><td rowspan="4">Sanction registered under criminal law</td><td>31 to 35 km/h</td><td>€ 145</td><td>€ 205</td></tr>
<tr><td>36 to 40 km/h</td><td>€ 170</td><td>€ 240</td></tr>
<tr><td>> 30 km/h</td><td colspan="2">Violation registered under criminal law; dependent upon case history prosecution by court</td></tr>
<tr><td>> 50 km/h</td><td colspan="2">Revocation of licence</td></tr>
</table></td></tr>
<tr><td></td><td>Behaviour/ education</td><td>The access age for mopeds is 16. The access age to all other motorized vehicles is 18.

Until the age of 21, access is restricted to 25 kW, 0.16 kW/kg motorcycles. After 21 all motorcycles can be ridden, also for novice riders. Riders with two years experience on the 'restricted' bikes can get access to all motorcycles before 21.</td></tr>
<tr><td></td><td>Roads</td><td>Not available</td></tr>
</table>

Appendix F. Summary footprint scheme example

Example Spain: 2003 versus 1993

This example indicates how the summary footprint scheme can be used for showing developments over time, by displaying the Spanish situation in 2003 compared with 1993. The colour coding is according to Table 3.11, but with SUNflower+6 average values replaced by 1993 values for Spain as a reference for scoring. Thus, for this example, scores for the background indicators and SPIs represent ranges in the absolute values in 2003, while for final outcomes the differences in 2003 with respect to 1993 are shown.

The organizational background in 2003 is reported as satisfactory, with the possibility of further improvement to achieve a better distribution of the (many) measures of the plan. SPIs (Safety Performance Indicators) in 2003 were satisfactory (green) for driver seatbelt wearing and motorcycle helmet wearing, and in need of improvement (red) for rear passenger seatbelt wearing, usage of child restraint systems and helmet wearing by mopedists. The vehicle fleet includes sizeable percentages of heavy vehicles, motorcycles and mopeds, but only a small percentage of bicycles. The percentage of road length that is motorway standard is low (red).

Concerning final outcomes, mortality rates for the overall population show positive reductions (from 1993) in fatalities for all modes except mopedists. Fatality risks for cars is not markedly different, and for motorcycles has become worse. The available data indicates improved trends for fatality risks for motorways and urban roads.

Looking at mortality per transport mode by age group, remarkable items are:
- not much change for young car occupants,
- increase for young mopedists (but a decrease for motorcyclists).

Organizational background	
Safety organization	
Quantitative targets	
Range of measures	

Transport background	
Motorways	
% Vehicle km	
A roads	
% Vehicle km	
Other rural roads	
% Vehicle km	
Urban roads	
% Vehicle km	

Safety Performance Indicators	
Per mode	
Car occupant	
% Cars	
Belt wearing rates	
Driver	
Front passenger	
Rear seat	
Child restraint	
% Heavy vehicles	
% Bicycles	
% Other vehicles	
Motorcyclist	
% Motorcycles	
Helmet wearing	
Mopedist	
% Mopeds	
Helmet wearing	
Per road type	
Motorways	
% Road length	
A-level roads	
% Road length	
Other rural roads	
% Road length	
Urban roads	
% Road length	

Final outcomes				
Per mode				
Car occupant				
All	Fat./pop.			
All	Fat./veh.			
All	Fat./vkm			
0-14	Fat./pkm		% Fatalities	
15-17	Fat./pkm		% Fatalities	
18-24	Fat./pkm		% Fatalities	
25-64	Fat./pkm		% Fatalities	
65+	Fat./pkm		% Fatalities	
Pedestrian				
All	Fat./pop.			
All	Fat./veh.			
All	Fat./pkm			
0-14	Fat./pkm		% Fatalities	
15-17	Fat./pkm		% Fatalities	
18-24	Fat./pkm		% Fatalities	
25-64	Fat./pkm		% Fatalities	
65+	Fat./pkm		% Fatalities	
Cyclist				
All	Fat./pop.			
All	Fat./veh.			
All	Fat./vkm			
0-14	Fat./pkm		% Fatalities	
15-17	Fat./pkm		% Fatalities	
18-24	Fat./pkm		% Fatalities	
25-64	Fat./pkm		% Fatalities	
65+	Fat./pkm		% Fatalities	
Motorcyclist				
All	Fat./pop.			
All	Fat./veh.			
All	Fat./vkm			
0-14	Fat./pkm		% Fatalities	
15-17	Fat./pkm		% Fatalities	
18-24	Fat./pkm		% Fatalities	
25-64	Fat./pkm		% Fatalities	
65+	Fat./pkm		% Fatalities	
Mopedist				
All	Fat./pop.			
All	Fat./veh.			
All	Fat./vkm			
0-14	Fat./pkm		% Fatalities	
15-17	Fat./pkm		% Fatalities	
18-24	Fat./pkm		% Fatalities	
25-64	Fat./pkm		% Fatalities	
65+	Fat./pkm		% Fatalities	
Per road type				
Motorways				
	Fat./vkm		% Fatalities	
A-level roads				
	Fat./vkm		% Fatalities	
Other rural roads				
	Fat./vkm		% Fatalities	
Urban roads				
	Fat./vkm		% Fatalities	

Appendix G. The Singular Value Decomposition

A description of the singular value decomposition (SVD) of a matrix can be found in any basic text book on linear algebra (see for example Lay, 1994). In this appendix only a very short overview will be given.

The SVD of a matrix A involves two orthogonal matrices and a matrix containing the singular values of A. Therefore, the definitions of orthogonallity and singular values are given before the SVD is introduced.

Firstly, a matrix U is called orthogonal if it is a square matrix with orthonormal columns. With other words, its columns form an orthogonal set of unit vectors. From the definition it immediately follows that an $n \times n$ orthogonal matrix U satisfies the equality $U^T U = UU^T = I_n$ where I_n is the $n \times n$ identity matrix.

Secondly, the singular values of an $m \times n$ matrix A are the square roots of the eigenvalues of $A^T A$. A scalar λ is by definition an eigenvalue of $A^T A$ if there exists a non-zero n-dimensional vector x such that $A^T Ax = \lambda x$. Each $n \times n$ matrix has exactly n eigenvalues (counting multiplicities), from which is follows that each $m \times n$ matrix has exactly n singular values (also counting multiplicities).

Although the two definitions above are sufficient to define the SVD of an $m \times n$ matrix A, it is helpful to introduce some notation first. The singular values of A will be denoted by $\sigma_1 \geq \sigma_2 \geq ... \geq \sigma_r > 0 = \sigma_{r+1} = ... = \sigma_n$, so A has exactly r strictly positive singular values. The matrix D will be the $r \times r$ diagonal matrix with the strictly positive singular values of A on the diagonal and Σ will be the $m \times n$ matrix given by

$$\Sigma = \begin{pmatrix} D & 0 \\ 0 & 0 \end{pmatrix}.$$

It follows that Σ has m-r rows containing only zeros and n-r columns containing only zeros.

The matrix Σ plays an important role in the SVD of an $m \times n$ matrix A. Indeed, the SVD of A is given by

$$A = U \Sigma V^T. \tag{1}$$

where U is an $m \times m$ orthogonal matrix and V an $n \times n$ orthogonal matrix. There always exist orthogonal matrices U and V such that equality (1) holds. Moreover, they are not unique For each choice of U and V such that the previous equation holds, the columns of U are called the left singular vectors of A, whereas V are called the right singular vectors of A.

Because Σ possibly contains zero columns and rows, the SVD can be reduced to the following expression:

$$A = U_r D V_r^T,$$

where U_r and V_r are the matrices consisting of the first r columns of U and V respectively. Working out this expression shows that A can be written as the following sum of matrices:

$$A = A_1 + A_2 + \ldots + A_r, \text{ where } A_i = u_i \sigma_i v_i^T.$$

Here u_i and v_i are the i-th columns of U_r and V_r respectively. The matrix A_i is called the i-th component of the SVD. Each component A_i can be written out explicitly:

$$A_i = \sigma_i \begin{pmatrix} u_{i1}v_{i1} & u_{i1}v_{i2} & \cdots & u_{i1}v_{in} \\ u_{i2}v_{i1} & u_{i2}v_{i2} & \cdots & u_{i2}v_{in} \\ \vdots & \vdots & \ddots & \vdots \\ u_{im}v_{i1} & u_{im}v_{i2} & \cdots & u_{im}v_{in} \end{pmatrix}, \qquad (2)$$

where u_{ij} and v_{ij} denote the j-th element of u_i and v_i respectively. It follows that the rows of A_i are multiples of the row vector v_i^T and the columns of A_i are multiples of the vector u_i.

The singular value σ_i is a measure of the contribution of matrix A_i to A. Because the singular values are in decreasing order, A_1 contributes the most to A, i.e., it explains most of the variance in the values of A. The cumulative percentage of explained variance of the k-th component, denoted by $CPEV_k$, is the variance of A explained by $A_1 + \ldots + A_k$. It is computed as

$$CPEV_k = 1 - \frac{\sum_{i=1}^{m}\sum_{j=1}^{n}\left(A_{(i,j)} - \left(A_1 + \ldots + A_k\right)_{(i,j)}\right)^2}{\sum_{i=1}^{m}\sum_{j=1}^{n}\left(A_{(i,j)}\right)^2}.$$

If the $CPEV_k$ is very large, then A is reasonably well approximated by $A_1 + \ldots + A_k$.

In this report the SVD is used to study the similarities and dissimilarities between the development of the fatality rates over the years 1970 up to 2003 for the nine countries. The matrix A represents in this case a table with in its (i,j)-entry the fatality rate of country i in year j.

If A is reasonably well approximated by A_1, then the development over time of the fatality rate in the nine countries is similar. In other words, for each country the 34-dimensional row vector containing the fatality rates over the years is equal to the row vector $\sigma_1 v_1^T$ multiplied with a scalar. For country j this scalar is u_{1j}. The row vector v_1^T is called the general trend of the SVD and the scalars u_{1j} the country weights of the first component. Analysing the country weights gives an idea of the road safety in a country. Countries with larger weights perform worse than countries with smaller weights.

The terminology introduced above can be extended if more components are added to the approximation of A. The row vector v_j^T is called the trend of the j-th component and the scalar u_{ij} is called the country weight of country i of the j-th component. Adding more SVD components to the approximation of A makes it possible to study in which way a country deviates from the general trend. If country i has the highest country weight (in absolute value) of component j, then the trend of component j primarily represents the deviations of the combined trend of the first j-1 components for country i.

Appendix H. Weighted Poisson Models (WPM)

WPM is a member of the family of log-linear models for the analysis of contingency tables. Contingency tables or cross tables are tables of counts. In this report the technique is used for the analysis of numbers of fatalities. The basic model assumption is that fatalities are Poisson distributed events. This implies that each fatality is an observation independent from other fatalities. This is not strictly the case. There are crashes with more than one fatality. In practice, however, this drawback is not very serious.

A specific characteristic of the WPM program is that the numbers of fatalities can be weighted in the analysis. I.e., to test whether the number of fatalities in one country is higher than in another country, one would like to compare mortality rates (fatalities divided by population size). A direct comparison of the mortality rates is not possible, because equal rates depending on different numbers of fatalities and population size have different stochastic properties. The WPM program takes this into account.

The WPM program regards the data as an array of observations with a structure imposed on it by the experimenter. This structure corresponds with the parameters in the (log) linear model.

The structure is defined by orthogonal design matrices. Therefore, the parameters are independent statistics.

For instance, an analysis of the mortality rates for two countries over three time periods can be established by choosing a design matrix consisting of one contrast for the two countries (country 1 compared with country 2) combined with a design matrix consisting of two contrasts for the three time periods (for example, time period 1 and 2 together compared with time period 3, and time period 1 compared with time period 2 ignoring time period 3).

This results in the following design matrices:
For countries:
1 -1
For time periods:
1 1 -2
1 -1 0

The two contrast for time periods are orthogonal (their inner product is zero: 1 x 1 + 1 x -1 + -2 x 0).

For the analysis these design matrices are combined, using external products of all design contrasts (and adding a column vector of ones for the total), to the following structure:

1	1	1	1	1	1
1	1	1	-1	1	-1
1	1	-2	0	-2	0
1	-1	1	1	-1	-1
1	-1	1	-1	-1	1
1	-1	-2	0	2	0

The first column vector of ones represents the total and corresponds to a dummy parameter.

The second column vector represents the contrast between the three observations for country 1 and those for country 2. It corresponds to the parameter for the difference between the two countries.

The third column vector represents the first contrast between the time periods and the fourth column represents the second contrast between the time periods. They correspond to the two time period parameters.

The fifth vector corresponds to the interaction parameter for the differences between the two countries with regard to the first contrast in the design matrix for the time periods (the first two periods compared with the third period). The sixth column corresponds with the interaction parameter for the differences between time period 1 and 2 for the two countries.

It can be checked that all six column vectors are orthogonal. For the analysis the design matrix is made orthonormal by dividing each column vector by the square root of its length. For example, the first vector then consists of the six values $1/\sqrt{5}$.

The vector consisting of the six (log) mortality rates (m_{11}, m_{12}, m_{13}, m_{21}, m_{22}, m_{23}) post-multiplied by the design matrix results in six contrasts between the observations.

The first contrast represents the average of all log-mortality rates. The second contrast the first three log-rates minus the last three log-rates (the country effect). The last vector represents the interaction effect of $\log(m_{11} \times m_{22} / m_{12} \times m_{21})$, the odds ratio of the first two periods for the two countries.

Parameters are calculated for these contrasts separately, using the modified minimum Chi-square method. These parameters are assumed to be normally distributed and can be tested, using an ordinary t-test. Groups of contrasts can be tested using a Chi-square test. In our case, for the interaction a Chi-square with two degrees of freedom can be computed as in ordinary contingency table analysis.

The advantage of WPM is that (apart from the weighing of counts) overall Chi-square values can be broken down to parameters for more specific effects.

A model in which all six column vectors and corresponding parameters are used is a saturated model. Such a model is perfect and explains all variation in mortality rates. If the interaction parameters in the saturated model are zero, then there is no interaction in the 2 x 3 table of mortality rates.

By leaving parameters out of the model, it can be checked whether the model deteriorates significantly. The measure of deterioration is the modified minimum Chi-square value of the table. I.e., parameters are calculated such, that $\sum_{ij} (m_{ij} - e_{ij})^2 / m_{ij}$ is minimal, where e_{ij} is the expected value predicted by the model.

The advantage of this measure of deterioration instead of the usual maximum likelihood is, that estimates for all parameters result from one analysis, in which all parameters are estimated together and are therefore comparable. The resulting values are identical to the 'direct estimates' used by Goodman (1970).

The sign of the parameters is important: it shows the direction of the difference in each contrast or combination of contrasts.

The analysis can easily be extended to multi-dimensional tables. For example, the structure for a three way table analysis is found combining the design matrix of the third dimension with the combined design matrix for dimension one and two using the external product rule again. This super design matrix consisting of r x c x l rows and columns defines the structure for the r x c x l vector of observations, with contrasts for the total, the r-1, c-1 and l-1main effects, the (r-1) x (c-1), (r-1) x (l-1) and (c-1) x (l-1) first order interaction effects and (r-1) x (c-1) x (l-1) second order interaction effects.

The analysis for four, five etc. dimensional tables is extended the same way.

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