Serious road traffic injuries in Europe, lessons from the EU Research Project SafetyCube

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ABSTRACT

The EU research project SafetyCube pays specific attention to serious road injuries, defined as non-fatal road traffic casualties with an injury severity level of MAIS3+. By means of surveys, information was collected on current practices concerning the estimation of the number of MAIS3+ casualties and on costs related to serious road injuries in different European countries. Moreover, the effect of differences in practices on the estimated number of MAIS3+ casualties was investigated by applying different methods to the same data. Finally, by means of a literature review, analysis of additional case studies and burden of injury calculations, health impacts of serious road injuries were investigated. This paper presents six main lessons learnt from these activities.

Practices concerning the estimation of the number of MAIS3+ casualties differ between countries; some countries apply correction factors to police data, other countries use hospital data and a third group of countries uses linked police and hospital data. Practices also differ concerning the selection of MAIS3+ road traffic injuries within hospital data. Differences in methodology appear to affect the MAIS3+ estimate. Therefore, one should be careful when comparing figures from different countries. The SafetyCube guidelines can support further harmonization.

It is important to reduce the number of serious road injuries because injuries can have major impacts on a casualty's life and pose a burden to society. About 75% of the MAIS3+ road traffic casualties indicate not to be fully recovered three years post-crash. Moreover, serious road injuries cost countries up to 2.7% of their GDP.

1. INTRODUCTION

According to the European Commission, an estimated 135,000 casualties were seriously injured on Europe's roads in 2015 (*1*). Worldwide, road traffic crashes result in 78.2 million non-fatal injuries warranting medical care annually, including 9.2 million injuries requiring hospital admission (*2*). According to the Global Burden of Disease Study 2013, non-fatal road traffic injuries lead to 8.6 million Years Lived with Disability (YLD) worldwide (*3*). About 30% of the total burden of non-fatal injuries is due to road traffic injuries (*4*).

Because of their high numbers and large health impacts, serious road injuries are recently being adopted as an additional road safety performance indicator. Reducing the number of serious road injuries is one of the key priorities in the EU road safety program 2011-2020 (*5*). In June 2017, the European Union transport ministers have agreed to set a target of halving the number of serious injuries on EU roads between 2020 and 2030 (*6*). Also the Sustainable Development Goals (SDGs) of the United Nations include a target on non-fatal road injuries; the target is to halve the number of road traffic injuries between 2010 and 2020.

Serious road traffic injuries can be defined in several ways, for example as casualties admitted to a hospital or on the basis of injury severity levels. To be able to estimate the number of serious road injuries in the EU and for comparing rates and developments between countries, it is essential to have a common definition. In 2013 a common definition was established by the EU member states (*7*). Serious road injuries are defined as non-fatal road traffic casualties with an injury severity level of MAIS3+ (Maximum Abbreviated Injury Scale) (*8*). However, methodologies for estimating the number of serious road injuries differ between countries and it is not well known to what extent differences in methodology influence the estimated number of MAIS3+ casualties.

As serious road traffic injuries are a relatively new road safety performance indicator, information on the numbers, health impacts and costs related to serious road traffic injuries is quite scarce. Therefore, one of the work packages of the EU research project SafetyCube (https://www.safetycube-project.eu/) looked into:

- Current practices concerning the estimation of the number of serious road injuries across Europe and consequences of methodological differences for the estimated number
- Health impacts of serious road traffic injuries
- Costs related to serious road traffic injuries
- Risk factors that are associated with serious road traffic injuries

This paper discusses the current practices concerning the estimation of the number of serious road injuries as well as health impacts and costs related to serious road injuries. Figure 1 provides more information on the SafetyCube project in general.

2. METHOD

Determination of current practices and effect of method on estimated number

The High Level Group on Road Safety – based in Brussels and convening all EU Member States – identified three main ways in which Member states can collect data on MAIS3+ road traffic casualties:

1. by applying a correction to police data,
2. by using hospital data and
3. by using linked police and hospital data.

Within each method, additional choices need to be made, for example concerning the derivation of correction factors that are applied to police data, the selection of road traffic injuries in hospital data and the selection of casualties with an injury severity of MAIS3+. The

choices largely depend on the available data and may affect the estimated number of serious road injuries.

An expert survey of 32 European countries was conducted, documenting current and planned practices concerning the estimation of the number of MAIS3+ road traffic injuries. The questionnaire was inspired by a survey that had been conducted by the Forum of European Road Safety Research Institutes (FERSI) (*9*). The response rate was over 80%; 26 out of 32 countries responded to the questionnaire.

To examine the comparability of numbers determined by different methods, all three methods proposed by the High Level Group were applied to the Netherlands. The 'official' estimated number of serious road injuries in the Netherlands is based on linked police and hospital data, including a 'capture-recapture' estimate of casualties that are missing in both datasets. Within SafetyCube, this estimate was compared to the estimate that results from applying correction factors to police data and the estimate that results from using hospital data only. A set of 70 correction factors for different combinations of age, gender and transport mode was derived using police and hospital data for the period 2004-2008. To examine whether correction factors are stable in time, the set of correction factors determined for the period 2004-2008 was also applied to estimate the number of MAIS3+ casualties in the period 2009-2014.

In addition to the comparison of the three main methods proposed by the High Level Group discussed in this paper, within SafetyCube we also analyzed consequences of differences in methodology between countries that applied hospital data. These differences are mainly related to a) the selection of road traffic casualties within all injury patients and b) the selection of casualties with injury severity MAIS3+. Consequences of differences were analyzed by applying different selection criteria to the same data. These sensitivity analyses, using German, Dutch, Spanish and Belgium data are discussed in more detail in (*10*) and (*11*).

Health impacts of serious road traffic injuries

Road traffic injuries can have a variety of consequences for individual casualties, for their relatives and friends, for other people involved in the crash and for society as a whole. Within SafetyCube, we focused on consequences for individual casualties and for society as a whole.

Consequences for individual casualties were investigated by means of a literature review and analysis of a number of additional studies and data that project partners had access to. One of the additional studies included is the ESPARR study (e.g. *12*, *13*), a prospective cohort study that follows a group of more than 1100 road traffic casualties, including 320 MAIS3+ casualties, seeking medical care in health facilities in the Rhône administrative area in France up to five years.

According to the International Classification of Functioning, Disability and Health (ICF), injuries may result in disabilities related to one or more levels of human functioning (*14*):

- impairments, i.e. problems related to body function or body structure, e.g. paralysis
- activity limitations, e.g. being unable to walk
- participation restrictions, e.g. being unable to work

The extent to which an injury impacts human functioning also depends on personal and environmental factors. The literature review and analysis of additional data/studies included effects on all three levels of human functioning as well as the influence of personal and environmental factors.

The burden of non-fatal injuries to society can be expressed by Disability Adjusted Life Years (DALYs). This measure integrates mortality - expressed in Years of Life Lost (YLL) - and morbidity, expressed in Years Lived with Disability (YLD) and has been applied to road traffic injuries before (e.g. *2*, *15*, *16*). Within SafetyCube, the method that was developed within the European INTEGRIS study (*17*) was applied to calculate the burden of

non-fatal MAIS3+ road traffic injuries. The method combines incidence data of injuries with disability information for these injuries, applying the EUROCOST injury classification (*18*). The burden of injury was calculated for the following countries/regions: Austria, Belgium, England, The Netherlands, the Rhone department of France, and Spain. For more information on the burden of injury calculations done in SafetyCube see (*19*).

Costs related to serious road traffic injuries

On the basis of a survey among 32 European countries, crash cost estimates were collected for 30 European countries. The data collection was a joint effort between the EU projects SafetyCube and InDeV (http://www.indev-project.eu/). The questionnaire included questions concerning available information on costs and methodologies applied for determining these costs as well as questions regarding cost estimates per crash and casualty by severity, per cost component by severity and total costs of crashes and their percentage of Gross Domestic Product (GDP). The questionnaires were pre-filled by project partners using available crash cost reports and were then sent to a selected expert in each country for checking and completion. Within SafetyCube, the questionnaires were integrated into a SQLite database and multiple consistency checks were carried out, resulting in several corrections. To be able to compare costs from different countries, all values are expressed in EUR price level 2015 and adjusted for relative income differences using Purchasing Power Parities (PPP). Purchasing Power Parities are the rates of currency conversion that equalize the purchasing power of different currencies, they are price relatives that show the ratio of the prices in national currencies of the same good or service in different countries (*20*). For more information on the data collection see (*21*).

The following six cost components were distinguished in the survey, on the basis of a review of international guidelines and best practices (*21*):

1. medical costs
2. costs related to production loss
3. human costs; costs related to loss of quality of life, grief, pain, sorrow
4. administrative costs, e.g. police and fire brigade costs related to the handling of road crashes
5. costs related to property damage
6. other costs, e.g. congestion costs

In relation to serious road injuries, medical costs, costs related to production loss and human costs are most relevant (*22*). Besides, crashes with serious road injuries also induce crash-related costs including administrative costs, property damage and other costs.

3. RESULTS

Current practices and effect of method on estimated number

In June 2016, 17 out of the 26 countries that responded to the survey had either already estimated the number of MAIS3+ casualties or reported that they would be able to estimate the number very soon. The remaining nine countries were in a very early stage of the estimation process or hadn’t started yet. One of the main reported problems was accessing hospital discharge data, this was due to privacy regulations.

The methods for estimating the number of MAIS3+ road traffic casualties appear to differ between countries. Two countries applied correction to police data, nine countries used only hospital data, four countries used linked police and hospital data and two countries applied a combination of methods. Several countries mentioned plans for modifying their method in the future, the majority of them towards linking police and hospital data.

The survey also revealed that the nine countries that used hospital data, show differences concerning the selection of road traffic casualties and the determination of the MAIS level of casualties. In some countries it appeared to be problematic to identify road traffic casualties within all injury patients. In Poland for example, for 38% of the injury patients in the hospital data, the cause of the injury is missing. In addition, some countries experience difficulties in determining the MAIS level of injury patients. In Austria for example, for about 20% of the injury patients, the MAIS could not be determined. The sensitivity analyses discussed in (*10*) and (*11*) show that differences in hospital data can lead to substantial differences in the estimated number of MAIS3+ casualties.

Figure 2 shows the estimated numbers of serious road injuries in the Netherlands resulting from the three different methods. The figure shows that for all years, the estimated number of MAIS3+ casualties is highest when using linked police and hospital data. This can be explained by the fact that the linking procedure that is applied includes an estimation of the number of casualties that is missing in both police and hospital data. Police data deals with quite high levels of underreporting in the Netherlands; in 2004, 41% of the MAIS3+ casualties were reported by the police and in 2014 this was only 24%. The 70 correction factors that were estimated within SafetyCube appear not to be able to fully correct for the underreporting by the police. All MAIS3+ road traffic casualties are assumed to be reported in the hospital data, but as a result of missing or incorrect external causes, they are not always recognized as a road traffic casualty. As a consequence, the estimated number of MAIS3+ casualties on the basis of only hospital data is lower than the estimate based on linking police and hospital data.

Figure 2 also shows that applying correction factors to police data for 2009 onwards, results in a very high underestimation of the number of MAIS3+ casualties. This can be explained by the fact that the number of police reported casualties dramatically decreased since 2009, due to new regulations and problems with a new reporting system. This example shows that one should be careful when applying correction factors to police data. Before correction factors are applied, one should check whether registration levels remained constant.

Health impacts of serious road traffic injuries

Both the literature and the additional studies show that non-fatal road traffic injuries can have a major impact on lives of casualties (and their families). Reported prevalence of disabilities varies widely between studies, depending on the casualties included in the study (e.g. injury severity levels), the duration of follow-up and the type of disabilities taken into account. According to a recent literature review (*16*), self-reported prevalence of disability resulting from road traffic injuries varies between 11% and 80%. Data from the ESPARR cohort study shows that about 75% of the MAIS3+ road traffic casualties have not fully recovered three years after the crash (*19*).

Reported consequences of road traffic injuries relate to all three levels of human functioning defined in the ICF and include for example pain, fatigue, mobility problems, sick leaves and problems carrying out daily activities. Additionally, road traffic injuries lead to psychological disorders like Post Traumatic Stress Disorder (PTSD) and fear which in their turn also affect human functioning. Literature reports a prevalence of PTSD between 2% and 33% one year post-crash (*19*). Moreover, the problems related to human functioning can also lead to socio-economic consequences like financial or relational problems. Data from the ESPARR study for example shows that more than 10% of MAIS3+ casualties encounter financial difficulties five years post-crash (*19*).

The burden of injury calculations reveal that the average burden of injury per MAIS3+ casualty varies between 2.4 YLD in Spain and 3.2 YLD in The Netherlands. Moreover, between 19% (Spain) and 33% (the Netherlands) of the MAIS3+ casualties experience

lifelong disabilities. These lifelong disabilities are responsible for about 90% of the total burden of injury of MAIS3+ casualties. For the Netherlands and England, we compared the burden of injury of MAIS3+ casualties (expressed in YLD) with the burden of injury of fatalities (expressed in YLL). In the Netherlands, the burden of injury of MAIS3+ casualties appeared to be similar to the burden of fatalities.

Reported consequences differ between casualties, depending on for example the injury sustained, age, comorbidity and socio-economic status. The average burden of injury per casualty depends on the injury and the age of the casualty. According to the literature, comorbidity and a lower social-economic status are associated with a higher risk of experiencing consequences. Concerning age, younger casualties have a lower risk to encounter physical consequences, but have a higher average burden per injury as they have a longer remaining life. Concerning the injury sustained, studies quite consistently show that consequences increase with injury severity, although minor injuries, like whiplash associated disorders, may also have substantial long-term consequences. This can also be seen from the burden of injury calculations. However, as less severe injuries are much more common, they have quite a high share in the total burden of injury in a country. Table 1 shows information on the burden of injury for hospitalized MAIS3+ and MAIS2- casualties in various countries. The Netherlands and the Rhone department in France also have information on the burden of injury of road traffic injuries that are treated at an Emergency Department and discharged to the home environment. For the Netherlands, (*23*) estimated that casualties treated at the emergency department, are responsible for 26% of the total burden of non-fatal injury. So, MAIS3+ casualties are responsible for only 36% (48%*74%) of the total burden of non-fatal traffic injuries in the Netherlands. For the Rhone department, almost 7% of all non-fatal road traffic casualties (including casualties treated at an Emergency Department or admitted to a hospital) have an injury severity of MAIS3+. These MAIS3+ casualties are responsible for 26% of the total burden of injury of all treated non-fatal traffic casualties.

Costs related to serious road traffic injuries

The survey showed that costs related to serious road injuries differ considerably between European countries. Figure 3 shows that the costs per serious road injury vary between roughly €28,000 and €975,000 per casualty. Figure 4 shows that the total costs related to serious injuries vary between 0.04% and 2.7% of a country's GDP. Costs related to serious road injuries account for 14% to 77% of the total costs of road crashes in a country. There seem to be a couple of outliers in Figures 3 and 4. In Poland and in Estonia, as well the costs per serious road injury (figure 3) as the total costs of serious road injuries (figure 4) appear to be very high. In addition, total costs are relatively high in Hungary and Croatia. We should note that information on costs is provided by experts and for some countries – especially Poland and Hungary- there is only very little information on how these costs are calculated. Further researched is needed into costs of serious road injuries in these countries.

Differences between the other countries are mainly due to whether or not the Willingness To Pay (WTP) method is applied for calculating the human costs. In a WTP study, it is estimated how much money an individual or the society is willing to pay for a risk reduction and from the results, the so called Value of a Statistical Life (VOSL) is derived. The VOSL is subsequently used to calculate human costs of fatalities. Information on human costs of serious injuries is relatively poor compared to human costs of fatalities, although in some countries thorough WTP studies are carried out in which the WTP for reducing the risk of getting injured is estimated relative to the WTP for reducing risk of being killed (*24, 25*). The Willingness To Pay method is the generally recommended method for the calculation of human costs (*25, 26*) and results in higher human costs than alternative approaches like the

use of financial compensations that are awarded to road casualties in courts of law that is applied in Germany (*27*) and Australia (*28*).

Other factors that contribute to differences between countries are differences in the definition of a serious road injury, differences regarding the cost components that are included and differences in reporting rates of serious road injuries. In addition, differences in total costs of serious road injuries in relation to a country's GDP are also due to differences in road safety levels.

In most countries, human costs represent the largest share in the costs of serious road injuries. This is particularly the case for countries that use the WTP method; in these countries the share of human costs varies between 51% and 91%. Some countries show a high share of human costs because other cost components are not included. This applies particularly to countries that used the HEATCO approach (*25*) that implies that all costs other than human costs and consumption loss are estimated at 10% of the VOSL. Medical costs and production loss are the two other main components of the costs related to serious injuries. These components both have a median share in the total costs of 18% (only taking into account countries that included these components).

4. MAIN LESSONS LEARNED FROM SAFETYCUBE

This section summarizes the lessons that were learned from the work that we have done within SafetyCube on serious road injuries.

1. **As practices concerning the estimation of the number of MAIS3+ casualties differ between countries and differences in methodology affect the estimate, one should be careful when comparing figures from different countries**
   From the survey can be concluded that practices differ between countries, depending on the available data. Moreover, (sensitivity) analyses showed that these differences have a considerable effect on the estimated number of MAIS3+ casualties. Therefore, one should be careful when comparing figures from different countries. Differences in methodology should be reported and discussed. Moreover, further harmonization of methods is certainly desirable to ensure that the estimated numbers of MAIS3+ casualties are comparable across Europe. The guidelines that are developed within SafetyCube can help improving comparability. A four page summary of the guidelines can be found at: https://www.safetycube-project.eu/wp-content/uploads/SafetyCube-D7.1-Leaflet.pdf
2. **When applying correction to police data to estimate the number of MAIS3+ casualties it is important to assure police registration levels are stable.**
   From the comparison of the three methods for calculating MAIS 3+ using data from the Netherlands it can be seen that application of correction factors to police data can result in a huge underestimation when reporting rate drops. Therefore, one should be careful when applying correction factors to police data. One should assure that police reporting rates are stable and one should have access to at least a sample of good quality hospital data in order to estimate reliable correction factors.
3. **Good quality hospital data is essential for the estimation of the number of MAIS3+ casualties**
   All three methods proposed by the EU High Level Group on road safety require at least a sample of good quality hospital data. The survey revealed that some EU countries encounter difficulties getting access to hospital discharge data, due to privacy regulations. Furthermore,
   some countries experience problems related to the quality of hospital data that complicate the estimation of the number of MAIS3+ road traffic injuries. More inter-sectorial collaboration between the health and the transport actors at national and

international level could be beneficial for improving hospital data. Besides, correction factors might be applied to hospital data to provide a more accurate estimate of the number of MAIS3+ casualties and linking of police and hospital data might be beneficial in case of problems related to the selection of road traffic casualties in hospital data.

4. **It is important to reduce the number of MAIS3+ casualties as AIS3+ injuries can have major impacts on casualties' lives, pose a burden to society and result in considerable costs**
   From the literature review on consequences of road traffic injuries and the additional studies can be concluded that road traffic injuries have long term consequences for quite a high proportion of MAIS3+ casualties. The ESPARR study for example shows that about 75% of the MAIS3+ road traffic casualties have not fully recovered three years after the crash. The burden of injury calculations show that a MAIS3+ casualty, on average has a burden of 2.4 to 3.2 YLD. In total 19% to 33% of the MAIS3+ casualties experience lifelong disabilities. In addition, in the Netherlands, the total health burden of MAIS3+ casualties is comparable to the health burden of fatalities. Finally, cost estimates show that serious road injuries cost countries up to 2.7% of their GDP each year and they account for up to 77% of the total costs of road crashes in a country.
5. **From a burden of injury perspective, less serious injuries are also relevant**
   Although in general, less seriously injured casualties less often experience long-term consequences, consequences can be severe for minor injuries as well. Moreover, because of their high number, they are also relevant from a burden of injury perspective. More than half of the burden of non-fatal road traffic injuries appears to be due to MAIS2- injuries (including injuries that are only treated at an Emergency Department).
6. **Cost estimates differ considerably between countries**
   The cost estimates collected by the survey appeared to differ considerably between countries. Costs per serious road injury for example vary between €28,000 and €975,000 per casualty. Differences between countries are mainly due to whether or not the Willingness To Pay (WTP) method is applied for calculating the human costs.

5. CONCLUSION

This paper presents the main lessons learnt from the SafetyCube research on serious road injuries. On an EU level, serious road injuries are defined as non-fatal road traffic casualties with an injury severity of MAIS3+. EU Member states can collect data on serious road injuries by applying one of the following methods: 1) by applying a correction to police data, 2) by using hospital data and 3) by using linked police and hospital data.

The methodology applied for estimating the number of MAIS3+ casualties appear to differ between countries, mainly as a result of differences in data availability. The differences in methodology appear to have a considerable effect on the MAIS3+ estimate and therefore, one should be careful when comparing figures from different countries. The guidelines that were developed in SafetyCube aim to improve comparability of estimates from different countries.

The literature review and additional case studies show that serious road injuries can have large consequences for individual casualties. About 75% of the MAIS3+ casualties report that they are not fully recovered five years post-crash. The burden of injury calculations show that serious road injuries also pose a considerable burden to society. In the Netherlands, the health burden of MAIS3+ road casualties is comparable to the health burden of road fatalities. Cost estimates appear to differ between countries. Serious road injuries cost

countries up to 2.7% of their GDP each year and costs of serious road injuries account for up to 77% of the total costs of road crashes in a country. Because of their high costs and large potential consequences, road safety policy should also be aimed at reducing the number of (serious) non-fatal road injuries, next to reducing the number of fatalities.

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FIGURE 1 General information about the EU funded SafetyCube project

FIGURE 2 Comparison of number of MAIS3+ casualties per year for three methods in the Netherlands for 2004-2014

TABLE 1 Summary information concerning the burden of injury per hospitalized casualty for different severity levels and the percentage of MAIS3+ in the total number and burden of injury of hospitalized casualties

FIGURE 3 Costs per serious road injury (EUR 2015, adjusted for PPP). Source (*22*)

FIGURE 4 Total costs related to serious road injuries as a percentage of GDP. Source (*22*)

SafetyCube project

SafetyCube (Safety CaUsation, Benefits and Efficiency) is a EU funded research project that started in May 2015 and will be finished in April 2018.

Within SafetyCube an **innovative road safety Decision Support System (DSS)** is developed, that aims to enable road policy makers and other stakeholders to select the most appropriate measures to reduce casualties of all road user types and all severities in Europe and worldwide. The DSS provides information about a wide variety of behaviour, infrastructure and vehicle related risk factors and about the effectiveness and cost-effectiveness of measures that can be taken to reduce these risk factors. The DSS will be available through: http://www.roadsafety-dss.eu/dss/

FIGURE 1 General information about the EU funded SafetyCube project

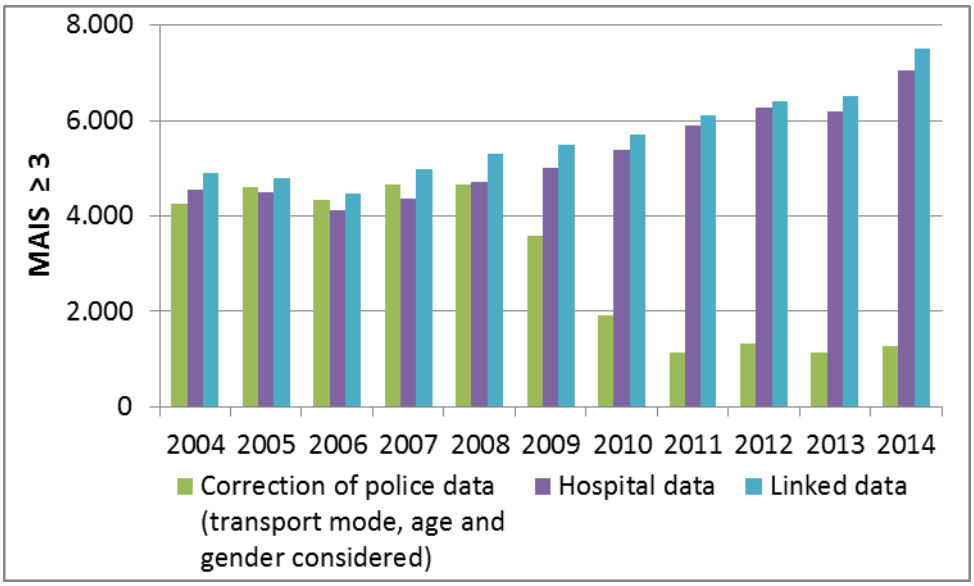

FIGURE 2 Comparison of number of MAIS3+ casualties per year for three methods in the Netherlands for 2004-2014

TABLE 1 Summary information concerning the burden of injury per hospitalized casualty for different severity levels and the percentage of MAIS3+ in the total number and burden of injury of hospitalized casualties

Country	Burden pp			MAIS3+ as % of hospitalized	Burden MAIS3+ as % of burden hospitalized
	MAIS3+	MAIS2	MAIS1		
Austria	3,1	1,0		9%	22%
Belgium	2,7	1,6	0,6	22%	44%
England	3,1	2,1	0,3	17%	34%
Netherlands	3,2	1,6	0,5	26%	48%
Rhone	2,5	1,9	0,6	45%	58%
Spain	2,4	1,3		34%	48%

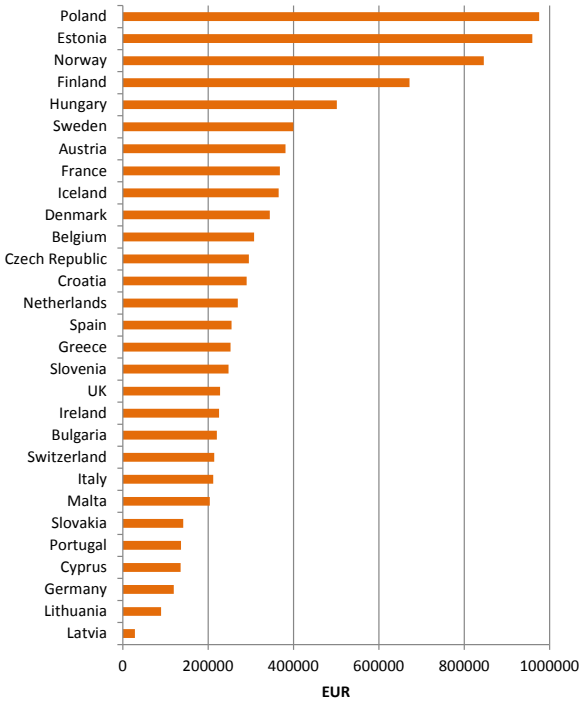

FIGURE 3 Costs per serious road injury (EUR 2015, adjusted for PPP). Source: (*22*)

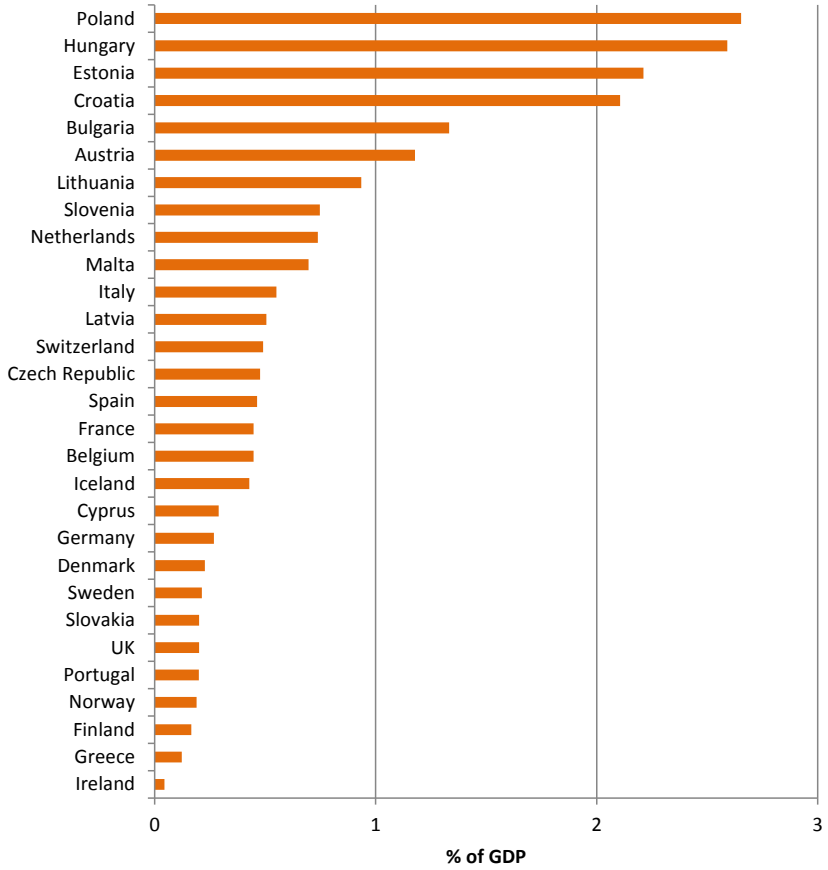

FIGURE 4 Total costs related to serious road injuries as a percentage of GDP. Source: (*22*)