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Costs related to serious road injuries

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Abstract

Costs related to serious injuries constitute an important input variable to assess the cost-efficiency of road safety measures, which is one of the objectives of the H2020 EU project SafetyCube. A survey collecting crash costs in European countries showed considerable variation in the costs related to serious injuries. The applied methodology to estimate human costs appeared to have a large influence. Other potential explanations are the applied definition, the registration procedure of crashes with serious injuries and the cost components that are included. Detailed analyses of medical costs and production loss showed the importance of assessing medical costs on the long term and taking into account the variation of these costs for different subgroups of traffic victims. To estimate monetary values for human costs, most countries use the Willingness To Pay method. While having a sound theoretical background, this method is rather limited in the specification of injuries. The use of Quality Adjusted Life Years (QALYs) gives the possibility to provide values for a larger diversity of injury types.

Keywords: serious injuries, costs, road safety policy

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1. Introduction

The H2020 EU project SafetyCube (http://www.safetycube-project.eu/) aims to develop an innovative road safety Decision Support System (DSS) which enables policy makers and stakeholders to select the most appropriate measures to improve road safety. Next to targeting the measures that are most effective in reducing road casualties, it is also important to select the most cost-beneficial measures because of budget constraints. Therefore the DSS also includes an Economic Efficiency Assessment (EEA) tool in which a cost-benefit analysis of road safety measures can be conducted. To calculate the benefits of road safety measures, it is necessary to have an estimate of the costs of crashes and casualties. A part of the work in SafetyCube is dedicated to estimate these costs (see Wijnen et al., 2017).

Furthermore special attention within SafetyCube is given to serious injuries. Given their high number, large health impact and their slow reduction over the last decades (as opposed to fatal injuries), serious road injuries are more commonly being adopted as an additional road safety performance indicator (Weijermars, Bos, & Stipdonk, 2015), for example by the European Commission (EC, 2010). In 2017, the EC agreed on a target reducing the number of serious road injuries (defined as MAIS3+ casualties) by 50% between 2020 and 2030.

This paper focusses specifically on the costs that are related to serious road injuries. It determines these costs in the different European countries, and additionally looks deeper into the influencing factors of certain material costs and the methodology related to estimating the immaterial costs.

The socio-economic costs of serious road injuries consist of different cost components. Based on classifications in the international literature, Wijnen et al. (2017) distinguish six cost components for road crashes and casualties:

- Medical costs
- Production loss: the loss of production or productive capacities
- Human costs: immaterial cost of lost quality of life and lost life years
- Administrative costs: police, fire service, insurance, legal costs
- Property damage: damage to vehicles, infrastructure, freight and personal property
- Other costs, such as costs of congestion resulting from road crashes, vehicle unavailability and funeral costs

A further classification of these cost components based on the European COST313 guidelines (Alfaro et al., 1994) distinguishes between “injury-related costs” and “crash-related costs”. The injury-related costs, which are most relevant for serious road injuries, are: medical costs, costs related to production loss, human costs and certain cost items that are categorized as other costs. In addition Wijnen et al. (2017) define good practices concerning the methodology for estimating each cost component.

The paper is structured as follows. The next chapter describes the cost estimates in the different European countries that were collected by means of a survey. It further examines the origin of the observed differences between countries. The third chapter provides more insight into the factors influencing medical costs and costs related to production loss, using different country-specific studies. Finally, since human costs represent the largest share in the costs related to serious injuries, the different approaches to calculate this type of cost will be examined and compared.

2. Costs of serious road injuries in the European countries

2.1. Data collection

By means of a survey among 32 European countries (EU28 + Iceland, Norway, Serbia and Switzerland) crash cost estimates were collected for 31 European countries. The data collection was a joint effort between the EU projects SafetyCube and InDeV (http://www.indev-project.eu/). The survey included questions concerning the national cost estimates per crash and per casualty by level of severity, the cost estimates per cost component and the total costs of crashes. Furthermore information was inquired on the methodology that was applied and the databases that were used. Next the completed surveys were integrated into a SQLite database and multiple

consistency checks were carried out, resulting in several corrections. In order 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) from Eurostat.

2.2. The costs related to serious injuries compared between the different European countries

The results of the survey indicate that the official national cost estimates for serious injuries differ considerably between European countries. This is the case for both the unit cost per serious injury and the total costs related to serious injuries. The values for the cost per serious injury range from €28,205 in Latvia to €975,074 in Poland. The median value is €254,777. Geographically, the values per serious injury appear to be higher in Northern European countries and in some Eastern European countries (Poland, Estonia and Hungary) (Fig. 1).

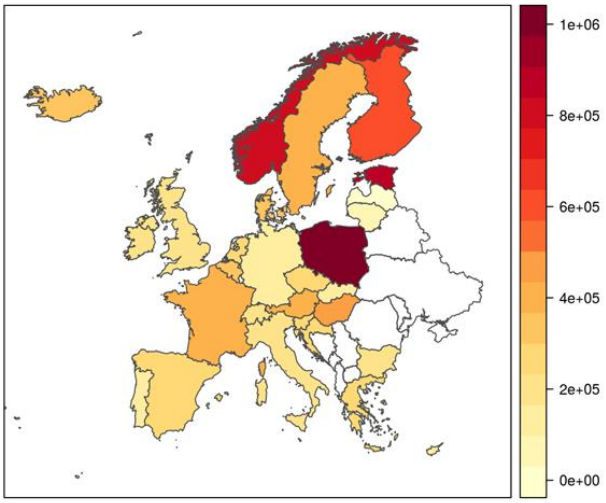

Fig. 1 Unit cost per serious injury (EUR 2015, adjusted for PPP)

With regards to the total costs related to serious injuries, these costs are presented as a percentage of the Gross Domestic Product (GDP) of a country using data for 2015 from Eurostat. In that way, the effect of factors influencing the number of casualties, such as the number of inhabitants and the size of the country, are cancelled out so comparisons between countries are more meaningful (Wijnen and Stipdonk, 2016; Elvik, 2000). As shown in Fig. 2, also total costs related to serious injuries as a percentage of GDP vary considerably. It is shown that the total costs range between 0.04% of GDP in Ireland to 2.7% of GDP in Poland. The median percentage is 0.3%. As opposed to the unit cost per serious injury, there is no clear geographical pattern.

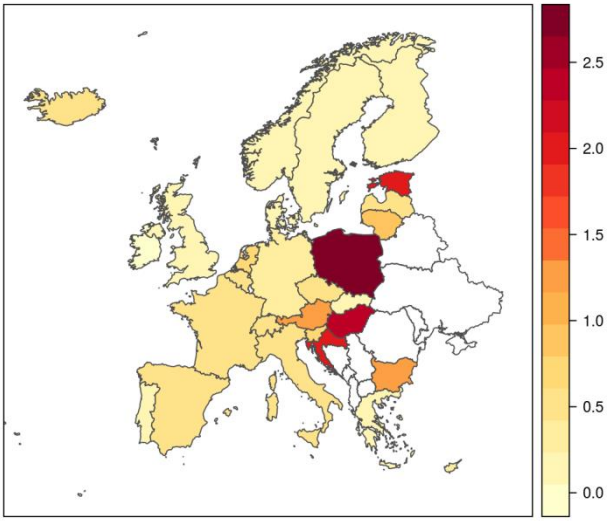

Fig. 2 Total costs related to serious injuries as percentage of GDP

2.3. Potential explanations for differences in the cost estimates between European countries

There are several potential explanations for the large differences observed in the unit costs related to serious injuries. Among these explanations are:

- differences in the definition of a serious injury;
- differences in the cost components that have been included;
- differences in the methodology used to calculate the cost components;
- differences in the reporting rate of serious injuries.

With regards to the total costs related to serious injuries, a supplementary potential explanation is:

- differences in the level of road safety.

2.3.1.1. Definition of a serious injury

The survey shows that the definition of a serious injury that is applied in national cost estimations varies strongly between the included countries. While it is difficult to find a pattern, it seems that countries where a serious injury is defined more strictly, i.e. by a hospital admission of more than 48 hours or by permanent disability payments, have a higher cost per serious injury. Countries that use a definition of a hospital admission of more than 24 hours, show on the other hand, average to low costs per unit (€368,029 to €11,948). However, the large variation in the unit costs among countries that use the same definition indicates that there are also other factors on the basis of the found differences.

2.3.1.2. Cost components included

Wijnen et al. (2017) have defined six cost components that should be included in the calculation of the costs of serious injuries. Table 1 shows how many countries have included each cost component in the cost per serious injury. It is shown that not all countries have included the same components; furthermore most countries have included the injury-related cost components, while the crash-related components are only included by 6 to 10 countries. These differences could probably explain some variability in the cost per serious injury.

Table 1 Number of countries for which cost components are included in the calculation of the cost per serious injury (EUR 2015, adjusted for PPP)

Injury-related cost components		Crash-related cost components	
Medical costs	16	Property damage	6
Production loss	17	Administrative costs	10
Human costs	21	Other costs	9

2.3.1.3. Methodology

Next to the definition of the cost components, Wijnen et al. (2017) have defined good practices regarding the methodology to estimate the different components. While all countries generally use the recommended method to calculate medicals costs (Restitution Cost method[†]) and costs related to production loss (Human Capital method[‡]), the method used to calculate human costs differs among countries. While the Willingness To Pay (WTP) method is generally recommended, other methods such as the Human Capital approach and the Restitution Costs approach are also used by some countries. In this case the Restitution Costs method means that the valuation of the quality of life is based on compensation payments by courts or insurances.

Variation in the method used to calculate human costs can have a large influence on the costs related to serious injuries because human costs generally represent a very large share of the cost per serious injury. The positive relationship between the human cost component of a serious injury and the unit cost of a serious injury is illustrated in Fig. 3. This relationship is confirmed by a linear regression that shows that the human cost component explains 67% of the variability in the cost per serious injury (Adjusted R^2=0.67, p<0.001). Moreover the effect of the applied method is demonstrated in Fig. 3. Countries that used the WTP method show the largest

[†] This approach implies a calculation of the costs of the resources that are necessary to restore road casualties to the situation which would exist if they had not been involved in a road crash. If available, market prices are used to calculate these costs (Wijnen et al., 2017).

[‡] This approach implies that the value for society of the loss of productive capacities is calculated. In general, these costs are calculated by multiplying the period of time road casualties are not able to work due to the crash by a valuation of the production per person per unit of time (Wijnen et al., 2017).

human cost (and thus cost per serious injury); if a factor 'WTP – non-WTP' is included in a linear regression model, the fraction of explained variation increases to 0.88 (Adjusted R^2=0.88, p<0.001).

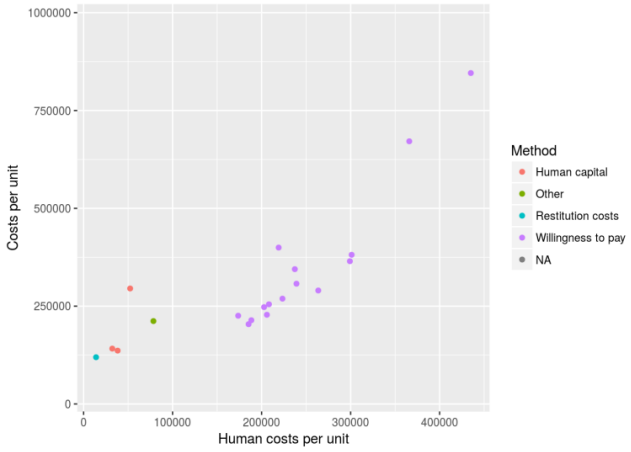

Fig. 3 Relation between cost per serious injury and human cost per serious injury, for different methods to calculate human costs (EUR 2015, adjusted for PPP)

2.3.1.4. Reporting rate

Differences in the reporting rate of serious injuries by the police or by hospitals can cause variation in the cost per serious injury. A higher reporting rate usually implies that more injuries of a lower severity are included in the cost calculations. This results in a relatively lower value per serious injury. When the reporting rate is presented as the number of serious injuries relative to the number of fatalities, it is shown that a higher reporting rate is accompanied by relatively lower costs of a serious injury. After exclusion of two outliers, a linear regression shows that the reporting rate explains 23% of the variation of the cost of serious injuries (Adjusted R^2=0.23, p<0.01).

2.3.1.5. Level of road safety

Regarding the differences in the total costs of serious injuries as a percentage of GDP, there are several explanations. Next to the influence of the unit cost of a serious injury, for which the explanations are given above, these variations can reflect differences in the level of road safety. A better road safety performance should result in lower road crash costs. The relationship between the number of serious injuries per inhabitant and the total costs of serious injuries as percentage of GDP is examined in Fig. 4. The linear regression shows however no relationship (Adjusted R^2=-0.02, p>0.1). After removing 5 outliers (Poland, Hungary, Estonia, Croatia and Bulgaria), the relationship becomes highly significant and the level of road safety explains 40% of the variability of the costs as a percentage of GDP (Adjusted R^2=0.40, p<0.001). Apart from the fact that all outliers are situated in Eastern Europe, there is not enough information to give an explanation why the effect is absent in these countries. Further research is necessary to give more insights.

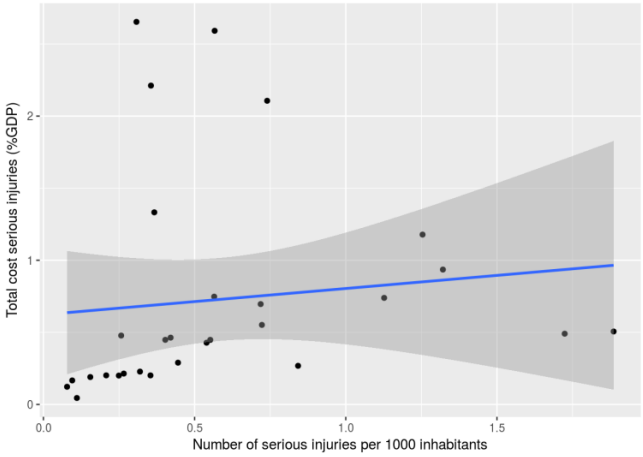

Fig. 4 Relation between number of serious injuries per million inhabitants, and total costs related to serious injuries as percentage of GDP

3. An insight in the factors influencing medical costs and costs related to production loss

Data analysis based on the survey on crash costs that was conducted in 32 European countries, shows the relevance of medical costs and costs related to production loss for serious injuries. These cost components represent on average 18% of the cost of a serious injury. Different studies conducted in European countries that provide more detailed analyses on medical costs and costs related to production loss are consulted to get more insight in the factors that influence these cost components. This information can contribute to a better estimation of these costs and can support policymakers in defining a policy to reduce these costs.

3.1. Factors influencing medical costs

Table 2 gives an overview of the consulted studies that deal with medical costs of road casualties. All studies included hospitalized road casualties.

Table 2 Description of the studies that provide more detailed analyses on medical costs

	Database used	Dependent variable	Influencing factors	Country
Devos, 2017	Linked hospital- medical insurance dataset, covering the whole Belgian population	Acute hospital costs	Socio-demographic characteristics and clinical conditions	Belgium
Devos et al., 2017	Linked hospital- medical insurance dataset, covering the whole Belgian population	All medical costs attributable to a road injury until one year after the crash	Road user type and injury severity	Belgium
Achit, 2015	Insurance database, representative sample for the French population	All medical costs attributable to a road injury until four years after the crash	Age, gender, road user type, injury severity, medical spending before the crash	France

All studies showed that certain characteristics of road victims have a significant influence on the amount of medical costs. Devos (2017) showed that an older age, a low socio-economic status, a higher severity of injuries, certain types of injuries, and certain pre-existing comorbidities lead to significantly higher acute hospital costs. The influence of most of these characteristics was confirmed in a study by Achit (2015) in which the total amount of medical costs attributable to a road crash was examined. Moreover Achit (2015) identified higher costs for male victims and for motorcyclists. This implies that when estimating medical costs for cost-benefit analysis, one should ideally take into account certain characteristics of potential traffic victims such as the age, socio-economic status and health state. Another implication for policy makers is that an increasingly older population (with more comorbidities) can increase future medical costs.

Moreover Devos et al. (2017) and Achit (2015) identified the long term cost trajectories of all medical costs that are related to road injuries. Both studies found that medical costs were still significantly higher one year after the occurrence of the road crash. This finding stresses the importance of including non-hospital costs, and more generally non-acute medical costs, in the estimation of medical costs of seriously injured road casualties.

Furthermore characteristics of the road victims and their injuries also seem to have an influence on the long term cost trajectory of their medical costs attributable to a road crash. Devos et al. (2017) found that cost patterns one year after a road crash, generally show a large increase in medical costs immediately after the crash followed by a steady decrease. A comparison of the cost trajectories of different injury severities shows similar patterns that differ in magnitude. The initial increase of costs appears to be much larger for more severe injuries. Achit (2015) identified three groups on the basis of the cost pattern over the four years after the crash. While for the majority of the road victims the medical costs have disappeared after two years, this is not the case for two types of victims. The first of these types shows a very high increase of medical costs during the first year after the crash, which only disappears after four years. This group consists of slightly older and more severely injured victims. The second group are the victims that previous to the crash already had higher medical costs and were in a worse health state. They are characterized by an older age and a longer hospital stay. For these victims the medical costs further increase after the occurrence of the crash and remain on a higher level, even four years after the crash. These findings lead to the recommendation that when estimating longer term medical costs, one should also take into account different trajectories according to the characteristics of the victim population.

This detailed information allows policy makers and researchers to estimate medical costs more accurately by taking into account the variation for different subgroups of traffic victims and the total amount of costs on the long term. It also serves as an additional source of information when calculating the total burden of road injuries. Here the variation and total long-term costs should be taken into account. For example, the analyses show the high impact on medical costs of certain comorbidities. With an increasingly older population, the proportion of victims with comorbidities will increase, resulting in higher costs even if the total number of traffic victims stagnates or decreases. Furthermore this detailed analysis can assist policymakers in improving policy aimed at reducing these medical costs.

3.2. Factors influencing costs related to production loss

Two studies were consulted to give an insight in the costs of serious road injuries related to production loss. Table 3 gives more details on these studies.

Table 3. Description of the studies that provide more detailed analyses on medical costs

	Database used	Dependent variable	Influencing factors	Country
Achit and Carnis (2014)	Five year cohort follow-up study with 1,372 patients that were admitted to an emergency department of a hospital	Average revenue loss	Injury severity, type of professional category	France, Rhône department
Papadakaki et al., 2016	One year cohort follow-up study with 120 patients admitted in the intensive care units of 7 hospitals	Indirect costs (including production loss)	Age, gender, road user type and injury severity	Germany, Greece and Italy

The average revenue loss resulting from a road crash is examined by Achit and Carnis (2014). This study indicated that the average revenue loss appears to increase with increasing injury severity, but the study also found that there is a threshold at a severity level of MAIS 3. Furthermore the study examined the influence of the professional category and found a large variation. The average revenue loss due to a road crash can differ between different professional categories due to a different average length of absence and different average wage levels.

Further, the study by Papadakaki et al. (2016) identified the amount of indirect costs (which includes production loss) due to a road crash. Despite the absence of significant results, the study indicates a lower level of indirect costs among women, older victims and pedestrians. Contrary to the findings of Achit and Carnis (2014) the study found the costs among victims with MAIS 1-2 to be slightly higher than those for victims with MAIS 3+ injuries. Especially this last finding needs further research.

These results provide insight into the determinants of production loss. They can help policymakers and researchers in estimating production loss for different types of injury severities by taking into account the victim's characteristics such as the professional category.

4. A comparison of different approaches to estimate human costs

Human costs represent the pain, grief, sorrow and mainly the loss of quality of life due to the injuries caused by a road crash (Wijnen et al., 2017). Contrary to medical costs and costs related to production loss, the human costs of road casualties have no market value. To facilitate inclusion of these costs in a cost-benefit analysis, there are different approaches to attribute a monetary value to this type of consequences. Data analysis in section 2 has indicated that this cost component generally represents a very large share of the costs related to serious injuries. Their share varies between 10% and 91%. As a consequence variation in the method used to calculate human costs has a large influence on the costs of serious injuries. This section will discuss and compare three approaches to estimate these costs: the Willingness To Pay (WTP) approach, the Quality Adjusted Life Years (QALYs) approach and the court awards approach.

4.1. Different approaches to estimate human costs

4.1.1. Willingness To Pay

The WTP method is the method that is generally recommended to estimate human costs (Wijnen et al., 2017). The survey on crash costs showed that the majority of the European countries use the WTP method, and that this method is related to the highest costs.

An (individual) WTP study estimates the amount of money a potential victim is willing to pay for a risk reduction. This amount will be determined by the probability an adverse event (such as a road crash) occurs and the amount of distress the victim would suffer from this event. A WTP study gives a monetary value that potential victims are 'willing to pay' for a specific risk reduction. This value will be the result of a trade-off between money and loss of quality of life, and could be determined through a utility maximization process (Jones-Lee, 1976). This value for a risk reduction gives an indication of the value of life (or the value of quality of life) as assigned by society. A WTP study does not measure the value of a specific individual life, but of a statistical (i.e. unspecified) life. The valuation occurs ex ante, before the incident occurs: it is the willingness to pay for reducing the probability of becoming a victim that is estimated (Bahamonde-Birke et al, 2015). Methods to asses this trade-off are based on actual behaviour (revealed preference) or by surveys in which respondents are asked how much they would pay for more safety (stated preference).

Most WTP studies focus on the value of a statistical life (VOSL) and thus on the estimation of human costs of fatalities. Information about the value of the quality of life and thus about the human cost of serious and slight injuries is relatively poor compared to the human costs of fatalities. WTP studies regarding injuries are very complex, among other reasons because of large variations in the severity of injuries and the impact of these injuries on the quality of life. Nevertheless there are examples of thorough WTP studies in the UK (O'Reilly et al, 1994), Sweden (Persson et al., 1995; Persson, 2004) and Belgium (De Brabander, 2004). In these studies, WTP methods are used, in which valuations for health impacts of non-fatal road crashes are derived in an indirect way. Using surveys, respondents are asked to make choices between different scenarios regarding health states resulting from a road crash. In these studies the value of an injury is determined relative to the VOSL. Next to that WTP studies can also determine the monetary valuation of road injuries in a direct way by asking how much money people are willing to pay for a lower non-fatal risk (contingent valuation).

4.1.2. QALY

The QALY approach is mainly applied for cost-utility analyses in the field of public health, but it can also be applied to road safety. A QALY expresses impacts of diseases or injuries on the quality of life combining the years of life lost (YLL) and years lived with disability (YLD). The severity of the injuries is expressed in disability weights, ranging from 0 (death) to 1 (perfect health). The QALY for a specific injury is calculated by multiplying the number of years lived with quality of life loss due to an injury, with a disability weight for this impact on quality of life. There exist different methods to determine the disability weights for specific injuries. For several injury categories the number of QALYs is estimated and multiplied by a monetary value per QALY.

This monetary value per QALY reflects the human costs and is estimated using the WTP method. In general there are two approaches to estimate a WTP value of a QALY (Ryen & Svensson, 2014). Firstly, the WTP can be derived directly by a contingent valuation study. In this approach people are asked about the amount of money they are willing to pay for a specific health improvement. Secondly, a monetary value of a QALY can be derived from the VOSL. Since the VOSL represents the value of all remaining life years at a specific age, it can be translated into a value per life year (which is equal to a QALY) on the basis of (average) age, life expectancy and a discount rate.

4.1.3. Court awards

In the court awards approach human costs are estimated as restitution costs to restore the road victim in its original state before the occurrence of the road crash. This approach uses the 'pretium doloris' compensations awarded by courts to traffic victims as an indication of human costs. The compensation for immaterial damage is not based on the individual preference of the road users, but consists of a judgement of a fair value by the judicial system. To be consistent with economic welfare theory, this value should reflect the trade-off individuals

make between money and loss of quality of life, which is determined through a utility maximization process (Jones-Lee, 1976). In general the estimations for human costs by courts are much lower than those obtained in WTP studies. The method is applied in a few countries, for example Germany (Baum et al., 2007) and Australia (BITRE, 2009).

4.2. A comparison between different approaches

When selecting the appropriate method to estimate human costs of serious injuries for cost-benefit analyses the methods can be compared based on the quality of the resulting estimates and on their practicability. In this section the strengths and weaknesses of the methods are assessed by the reliability of their results, their level of detail, fairness, consistency with economic welfare theory, data availability and complexity. Consistency with economic welfare theory is crucial since this is the basis of cost-benefit analysis. This means that costs of serious injuries, as an input for cost-benefit analysis should be economic values that are recognized as expressions of individual/household preferences (see for example Boardman et al., 2011). Moreover values to be used in a cost-benefit analysis should be based on risks, which implies that the valuation of a risk reduction should occur ex ante (Schelling, 1968; Mishan, 1671).

One of the strengths of the WTP method is that it is based on individual preferences, which implies that the method is consistent with economic welfare theory. Besides, the values are determined before the occurrence of the crash, so they can be used as an input for cost-benefit analyses. There exists a large consensus among researchers concerning the importance of individual choices. This technique is therefore used in different research areas to elicit the value of a risk reduction, for example environmental, transport, occupational and fire risks (Lindhjem et al, 2011: Miller, 2000). On the other hand the WTP method is criticized for its complex method for eliciting values for the quality of life. Especially stated preference methods where the trade-off between money and risk reduction is simulated by questionnaires in which people are asked how much they would pay for more safety, are prone to several potential biases. This leads to a large variability of results (Baum et al., 2010; Bahamonde-Birke et al., 2015). Furthermore a WTP study only provides global information and cannot reflect the great diversity of types of road injuries, their severity and health consequences.

Since the QALY approach is based on a WTP value, this method shares most of the strengths and weaknesses of the WTP approach. However, while the QALY approach has not been commonly used to estimate costs of road injuries, it has a large advantage above the direct WTP approach: the great level of detail makes the QALY approach more applicable for valuing non-fatal injuries. The QALY concept has the ability to compare diseases and injuries with different impacts on mortality and morbidity, or in the case of road safety, fatalities and injuries of different severities. While direct WTP studies distinguish between only three to nine injury types or health states after a crash, the QALY approach enables estimating WTP values for a large diversity of injury types. However it was found that values based on QALYs were lower than values based on direct WTP studies (Schoeters et al, 2017). This is because the valuation of improving the quality of life appears to be lower than the estimation of extending life, and the direct WTP approach uses the value of life to derive human costs of injuries. Therefore, it can be argued that QALY-values that are based on extending a life would result in an overestimation of human costs of non-fatal injuries. However, more research into the question of why the direct WTP approach results in higher values than the QALY approach is recommended.

A large advantage of the court awards approach is its practicability: the data is readily available and no complex study has to be conducted. However the approach has some fundamental limitations. One of the major weaknesses is that the values in the court award approach are not based on individual preferences and therefore are not consistent with economic welfare theory. Furthermore, court award values are determined ex post and thus do not reflect the value of a risk reduction of the occurrence of an uncertain event. Next to that these values concern a specific individual case, and do not indicate the value of a statistical life. Moreover, the amounts awarded by judges vary widely. The level of compensation payments for immaterial costs is very dependent on the type of judicial system and the type of settlement. It is not always very clear how court amounts are defined (e.g. Germany) and whether they actually compensate the victims.

Globally there exists very little information on the human costs of injuries. For future cost-benefit analyses, it can be recommended to use direct WTP studies or QALYs to estimate the monetary values of non-fatal road injuries, since these approaches accord to the principles of the economic welfare theory. QALYs are more complex to estimate but have the advantage of giving more detailed information on different types of injuries.

For cost-benefit analyses it is not advised to use the court awards approach because of its unpredictability (the awards are among others highly dependent on the type of judicial system) and because it has no foundation in the economic welfare theory.

5. Conclusion

Costs of road casualties are an important input variable to evaluate road safety measures, which is one of the objectives of the SafetyCube project. Since serious injuries are a new road safety indicator, the research on this topic is relatively scarce. Therefore part of the work within SafetyCube focussed on the costs of serious injuries. The main findings are presented in this paper. Next to a comparison of the official cost estimates in European countries, three cost components that are most relevant for serious injuries are examined in more detail. The factors that influence medical costs and production loss are looked into, and three approaches to put monetary values to human costs are discussed and compared.

The cost information that was collected by means of a survey in 32 European countries revealed that the costs related to serious injuries vary considerably between countries. The reported cost per serious injury varies between €28,205 and €975,074 and the total costs vary between 0.04% and 2.7% of a country's GDP. Differences can be explained by whether or not the WTP method is used for calculating the human costs, differences in the definition of a serious injury and differences in the cost components that are included. Moreover, the reporting rate of serious injuries appeared to be associated with the cost per serious injury. The relation of the level of road safety and the total costs was less clear. It is recommended to develop a common methodology for all European countries in order to enhance international comparability of cost estimates.

More detailed information on medical costs and production loss is given by several studies conducted in different European countries. Age, socio-economic status, type of injury, injury severity, health status (pre-existing comorbidities) and road user type appear to have a significant influence on the medical costs attributable to a road crash. Particularly older victims with a worse health status (and more comorbidities) show higher acute and long term costs. This has implications for researchers and policymakers in assessing the (future) medical costs of potential traffic victims. Furthermore the importance of assessing medical costs on the long term was shown. The studies found a significantly higher level of medical costs attributable to the road crash the first year after the crash.

Concerning production loss, it was shown that revenue loss increases when injury severity is higher, although MAIS 4 and MAIS 5 injuries do not lead to much higher production losses than MAIS 3 injuries. Furthermore, the revenue loss differs between professional groups which could be explained by the average wage and the average length of absence inherent to a certain profession.

With regards to human costs of serious injuries, most countries use the WTP method. This method is compared with two alternative approaches: the QALY approach and the court awards approach. Whereas WTP studies are mainly constituted to measure the human costs of fatalities, WTP studies that specifically estimate the human costs of non-fatal injuries are rare and rather limited in the specification of road injuries. Using the WTP method to estimate the value of QALYs on the other hand gives the possibility of providing values for a large diversity of injury types.

While the WTP approach and the QALY approach use complex studies, for which there are some methodological issues, the court awards approach makes use of existing information. The compensation payments to road injuries awarded by courts are in most cases however much lower than the values obtained in the other methods, and are characterized by a huge unpredictability since they are highly dependent on the judicial system. Since these values are not based on individual preferences, and they are determined ex post and apply to a specific case, they cannot be used in a cost-benefit analysis.

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