COSTS FOR SOCIETY RELATED TO MAJOR BICYCLE ACCIDENTS IN FLANDERS (BELGIUM)

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Bas DE GEUS[1], Joris AERTSENS[2], Stefanie DEVOS[3], Luc INT PANIS[4, 5], Koen PUTMAN[3], Romain MEEUSEN[1]

[1] Dept. Human Physiology, Fac. LK, Vrije Universiteit Brussel, Belgium
bas.de.geus@vub.ac.be
rmeeusen@vub.ac.be

[2] Kessel-Lo, Belgium
Joris_Aertsens@hotmail.com

[3] Dept. Medical Sociology, Fac. GF, Vrije Universiteit Brussel, Belgium
sdevos@vub.ac.be
koen.putman@vub.ac.be

[4] Flemish Institute for Technological Research (VITO), Boeretang 200, 2400 Mol, Belgium
luc.intpanis@vito.be

[5] Transportation Research Institute (IMOB), University of Hasselt, Belgium
luc.intpanis@uhasselt.be

ABSTRACT

Utilitarian cycling is recognized as an excellent way of being physically active on a regular basis and maintaining good health [1]. Unfortunately, some cyclists will be involved in an accident, will need medical care and may incur temporal or permanent physical injuries, which will induce costs to the cyclist and society. Aertsens [2] estimated, in Belgium, the average total cost of minor bicycle accidents at 841 euro (95% CI: 579-1205) per accident or 0.125 euro per kilometre cycled. The aim of this study is to provide more insight into the resulting costs of major bicycle accidents in Flanders (Belgium).

Data were collected in a retrospective study design. In 2008, 2364 bicycle accidents in Flanders were registered by the National Trust for Accidents (FAO). From those 2364 invited participants, 289 returned the questionnaire and 26 were classified as a major accident (hospitalised > 24 hours) and used for data analysis. Direct costs (e.g. material damage and medical costs), as well as indirect costs (e.g. productivity loss), intangible costs and Willingness To Pay (WTP) are calculated. For calculating of costs a differentiation was made between a recovery phase and a permanent disability phase. Costs were calculated over a period of 3 year after the accident.

Nine respondents fully recovered and 17 had permanent damage. The average cost excluding WTP (€2011) per respondent (N=26) is €60,776±69,433, €35,190±39,317 for those who fully recovered and €74,322±78,718 for those who had permanent damage. When including WTP, the cost increases with +35% for the total group, +53% for those who fully recovered and +31% for those who had permanent damage.

Total annual bicycle injury costs are huge, but these costs must be balanced against the benefits of bicycling, related to health and environment.

Keywords: utilitarian cycling, major bicycle accidents, economic costs.

INTRODUCTION

Oja **et al.** (2011) published a systematic review of the literature to update the evidence on the health benefits of cycling, from the physical activity point of view. They concluded that the existing evidence reinforces the current efforts to promote cycling as an important contributor for better population health [1]. More recently, effort has been put in looking at those elements that could have a negative impact on health while cycling for transportation (in an urban environment): air pollution (e.g. [3]) and bicycle accidents (e.g. [4]). Recently, studies were published in which both the positive and negative impact of cycling on health are considered within one cost-benefit analysis (e.g. [5-10]). These cost-benefit analyses (CBA) and health impact assessment (HIA) studies are valuable because they are powerful tools that can be used to inform and show policy and decision makers the possible social benefit of a modal shift from car to bicycle. So far, most CBA and HIA studies use the concept 'Value of a Statistical Life' (VSL) in order to calculate the 'cost of a human life'. The most recent European statistics estimate the VSL to be 2.2 million euro for Belgium, and use a fixed percentage of this value to calculate the costs of severe (13%) and slight (1%) accidents [11]. Another shortcoming is that, to our knowledge, studies [11-15] that estimate the cost of VSL are mostly based on data from motorized traffic victims. As the number of cyclists increases throughout Europe, specific data for the costs of bicycle accidents are needed.

Future improvements in the modelling framework include estimating morbidity, given that mortality represents only a part of the underlying groups of health endpoints associated with the positive and negative impacts of cycling on health [16]. Although morbidity involves greater uncertainty in the cost-benefit calculations, it is important to include it, to have a more complete view on the effects of cycling on public health for both risks and benefits [8].

Only a very small number of authors thoroughly studied the costs of bicycle accidents. Veisten **et al.** [17] based their calculations on hospital statistics in Norway between 1990-1997 combined with cost figures from the US provided by Miller [18]. Aertsens et al. (2010), calculated the costs of minor bicycle accidents (defined as "bicycle accidents not involving death or heavily injured persons, implying that possible hospital visits last less than 24 hours") in Belgium and showed that the average total cost of minor accidents is estimated at 841 (95% CI: 579–1,205) euro (2010) per accident (or 0.125 euro per kilometre cycled) [2]. Interestingly, productivity loss was identified as the main component (399 euro; 47%) of the total cost of an average minor bicycle accident followed by intangible costs. It is estimated that 'willingness to

pay (WTP) to avoid pain' and 'WTP to avoid psychological consequences' accounted respectively for 14% and 13% of the total costs [2].

In order to further refine cost-benefit analyses on the health effects of cycling (in Belgium), the costs related to major bicycle accidents need to be studied in more detail. Major bicycle accidents are defined here as "non-fatal bicycle accidents due to which the cyclist stayed in hospital 24 hours or more for treatment of his/her injuries").

In this paper we focus on the total cost for society of major bicycle accidents, based on the 'cost of illness approach' [2, 19]. Attention was put on collecting cost data for the direct consequences of the injury and the possible permanent suffering and its related costs. We expect that these costs will have a strong share in the total cost of bicycle accidents based on earlier findings from [2, 5, 6].

2. METHODOLOGY

2.1. Theoretical framework

The cost of illness framework as defined by the US Environmental Protection Agency [19] and was applied to estimate the different cost categories involved in major bicycle accidents. This framework includes direct and indirect costs. Direct costs include *medical costs* (e.g. hospital costs, rehabilitation, and medication) and *non-medical costs* (e.g. damage to bike or clothes), whereas indirect costs involve *production losses* (due to temporary or permanent work disability or mortality) and *leisure time losses*. Indirect costs also include *intangible costs* (e.g. pain and psychological suffering). This methodology was shown to be effective in a former study, published by Aertsens et al. to estimate the costs of minor bicycle accidents [2].

2.2. Data collection and response rate

The data for the present study are collected through the Belgian national Fund for Work related Accidents (FWA; Fonds voor Arbeidsongevallen in Dutch). All Belgian employers have to report to the FWA all injury accidents involving their employees that occur during the working hours, including the trip to and from work.

In 2008, 2364 traffic accidents that occurred during commuting to and from work, involving a cyclist, in Flanders were registered by the FWA. All these bicycle accident victims received a

letter with a description of the study and an invitation to fill out an electronic questionnaire. The invitation letters were sent in June 2011.

The questionnaire was designed to collect information on: general socio-demographic data, cycling behaviour, circumstances of the accident, detailed information on injuries, and detailed costs incurred (up to three year after the accident). The questionnaire was based on the questionnaire used by Aertsens et al., but adapted due to the focus on major instead of minor bicycle accidents [2].

Two hundred eighty-nine questionnaires were returned. Seven of these were discarded from our analysis because respondents stopped filling out the questionnaire after the first 5 questions. One respondent was not the cyclist involved in the accident, but the car driver who hit a cyclist. Twenty-seven accidents were classified as a 'major accident' implying that a hospital visit lasted at least 24 hours. One questionnaire was excluded because of inconsistencies in the responses to different questions. Twenty-six (9.2%) were used for the final data analysis (Table 1).

Table 1: Flow chart for the in- and exclusion

Commuting accidents involving a cyclist in Flanders	2364
Returned questionnaires	289
Filled out most of the questionnaire	282
Bicycle accidents	281
Major bicycle accident (>24 h hospitalization)	27
Used for data analysis	26

Values are absolute numbers

2.3. Permanent consequences and temporary consequences

Within the questionnaire, a clear distinction was made between 'temporary consequences' (recovery period) and 'permanent consequences' of the accident (Figure 2). 'Temporary negative consequences' were defined as consequences from which the respondent completely recovered after a certain time (e.g. a broken bone that perfectly heals). 'Permanent negative consequences' were defined as impairments resulting from injuries that would not result in total recovery to the state before the accident.

For those with a 'permanent negative consequence', a separate section was added to the survey that questioned the respondents about the nature of the permanent consequences (including the associated costs) of the accident. The cut-off between the 'temporary consequences' and the 'permanent negative consequence' was estimated by the respondent with the following question: "How long (approximately) did it took before the negative

consequences your injury(s) fully stabilized?" Figure 1 was included in the questionnaire to facilitate the understanding of the question.

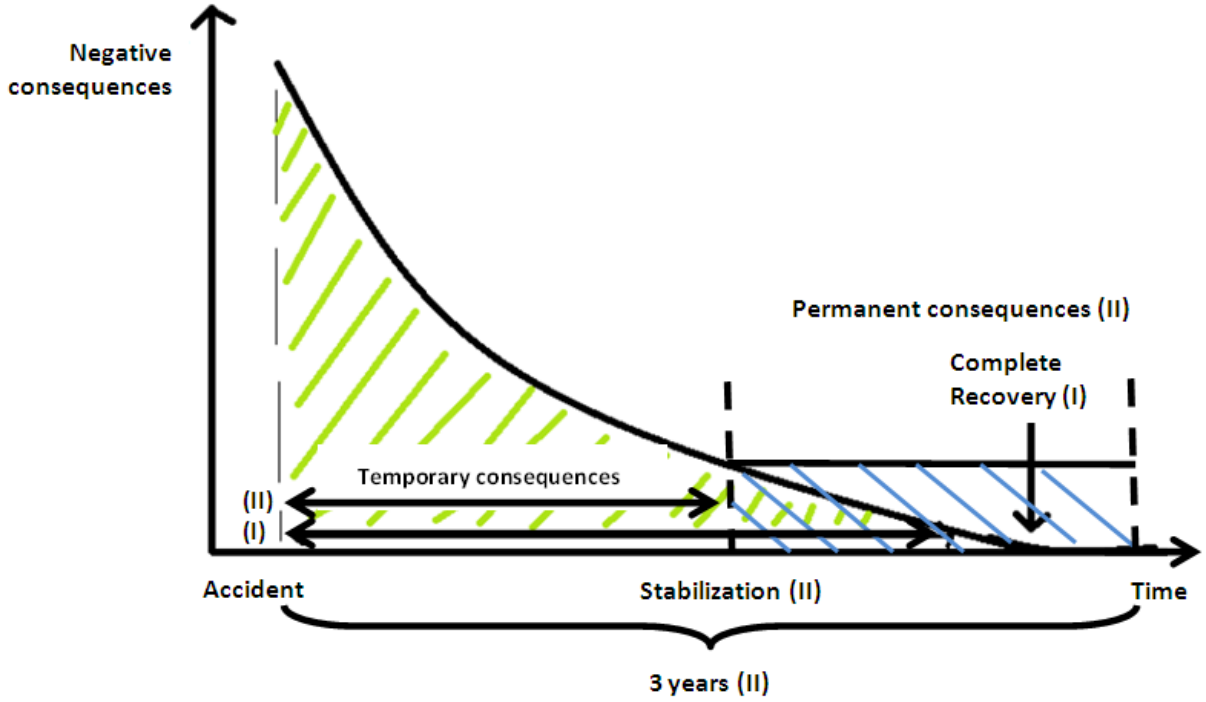

Figure 1: Evolution of the negative consequences

(I) indicates the situation for those who completely recovered from the accident

(II) indicates the situation for those who did not completely recover from the accident and still had consequences from the accident at the moment of filling out the questionnaire

3. RESULTS

3.1. General results and self-reported injuries

The respondents in this study are a cohort of regular adult (45.1 ±9.7; 24-58 years old) cyclists. They reported that in the year before the accident, they cycled on average 4.4 ±1.2 times per week to work. The mean cycling distance per trip was 10.6 ±6.8 kilometre, with a range between 2 and 30 kilometre. Sixty-five percent were men.

Of the 26 major accidents, thirteen (50%) accidents occurred in an agglomeration or built-up area outside the city centre, 17% in the centre of a city and 33% outside the built-up area.

Forty-five percent of the accidents occurred on a bicycle lane (public road with markings for bicycles), 33% on a public road without any markings for bicycles and 20% on a bicycle path (section of the road reserved for bicycles only).

For the 9 respondents who recovered completely from the accident, it took on average 173 ±145 (15-450) days to fully recover. For the 17 respondents (65%) who had not recovered completely from the accident at the moment of filling out the questionnaire, it took on average 13 ±10 (range 4-36) months to arrive at a stage of 'stabilised' permanent consequences. Only one respondent indicated that he had not arrived at the stage of 'stabilised' permanent consequences at the moment of filling out the questionnaire.

3.1.1. Type of injuries

The types of reported injuries are shown in Table 2. Shoulder and arm were the two most frequently injured body parts (Table 3).

Table 2: Types of injuries self-reported after major bicycle accidents

Injury type	**Most important injury**	**2nd most important injury**
Bone fracture (closed)	17	4
Dislocation, sprain or strain	3	5
Superficial injury (e.g. bruise, graze, contusion)	1	5
Head trauma (e.g. concussion, internal bleeding)	3	2
Internal injury of trunk	1	0
Open wounds (e.g. cut, abrasion, ...)	0	4

Numbers indicate the absolute number of times a specific type of injury occurred

Table 3: Injured body parts self-reported after major bicycle accidents

Body part	**Most important injury**	**2nd most important injury**
Hip, knee and leg	5	2
Shoulder and arm	14	11
Head and neck	5	5
Back	1	0
Trunk (front side)	1	2

Numbers indicate the absolute number of times a specific body part was injured

3.1.2. Self-perceived cause of the accident

A separate question in the questionnaire dealt with the self-perceived cause of the accident. 'Distraction' and 'high speed from the other road user (e.g. car driver)' were most often cited

as cause of the accident. Bad condition of the road (ice/snow or puddles), 'high cycling speed' and 'imprudence' from the cyclist itself were also commonly cited causes of accidents.
Not wearing a helmet and high cycling speed were perceived as contributing factors to the severity of the injuries.

3.1.3. Impact on the respondent and "third parties – not involved in the accident"

The accidents had an important physical and mental impact on the respondents. On the question 'did you change your cycling habit after the accident', all respondents indicated they did change their commuting habits. The most often mentioned change was that respondents cycle more carefully (54%) and wear protective clothing more often (helmet: 32%; reflective clothing: 16%). One respondent never wanted to cycle again. Forty-two percent indicated to be psychologically affected by the accident.

Table 4 indicates the impact on leisure time and domestic occupations of the respondents.

Table 4: Impact on leisure time and domestic occupations of the respondents

Negative effect on	**1. Totally agree**	**2.**	**3.**	**4. Neutral**	**5.**	**6.**	**7. Totally not agree**	**Not applicable**
Leisure time	11	2	5	1	0	0	4	2
Domestic occupations	11	3	4	0	1	3	2	2

The numbers indicate the number of respondents gave that response

A major accident has in most cases also affected "third parties – not involved in the accident" like family and friends of the respondent. The respondents were asked if they had the perception that third parties were affected by the accident. Table 5 shows what the respondents perceived as the impact of the accident on "third parties – not involved in the accident" like family and friends.

Table 5: Impact on "third parties – not involved in the accident"

Negative effect on	**1. Totally agree**	**2.**	**3.**	**4. Neutral**	**5.**	**6.**	**7. Totally not agree**	**Not applicable**
Partner	0	0	1	4	1	1	9	10
Children	2	0	1	3	0	1	9	10
Friends	2	1	2	3	0	1	12	5

The numbers indicate the number of respondents gave that response

No costs were calculated for the impact of the accident on third parties.

3.1.4. Impact on "other road users involved in the accident"

In twelve cases another road user was involved in the accident, mostly car drivers (42%), other cyclists (33%) or pedestrians (17%). In none of these cases there were physical injuries for the other road user, whereas in only 4 cases there was material damage. The material damage was related to a car in 3 cases and to another bicycle in one case. Costs, related to these other road users were not quantified in this study. Only two respondents indicated that the accident caused a traffic disturbance (e.g. blocking cross-road). Traffic delays for other road users – not involved in the accident – were also not estimated in this study.

3.2. Costs of major bicycle accidents

Although an initial distinction was made between respondents with only 'temporary consequences' (N=9) and respondents who have also 'permanent consequences' (N=17) (**Error! Reference source not found.**) the number of respondents in each category was deemed too small to treat them separately. Therefore, most costs are calculated for the whole sample size (N=26), except for the costs associated with permanent consequences, as these only apply for the last category (N=17).

For respondents with permanent consequences, the 'period with permanent consequences' was calculated by subtracting the recovery period ('temporary consequences') from the total study period (= 3 years (accident in 2008 and filling out the questionnaire in 2011)). This was done to avoid overlap between the costs for the recovery period and the costs resulting from the permanent consequences. All costs due to permanent consequences were calculated up to three year after the accident.

All medical costs include costs paid by the respondent (patients' co-payments), health insurances and/or other insurances.

All costs were indexed to 2011 by applying the consumption-index for "productivity loss" and the health-index for the medical costs [20].

Table 6 gives an overview of the different cost categories, for those with and those without permanent consequences and for the total study sample.

- insert Table 6 here -

Supplementary Figures S1-S9 show the detailed composition of the total costs by category, and separately for the groups with and without permanent consequences, and the total costs, with and without WTP and with and without job disability rate and moral damage.

3.2.1. Direct medical costs

Duration of hospital stay. In line with the definition, all respondents stayed in the hospital for more than 24 hours. Fourteen (54%) respondents stayed in the hospital between 1 and 2 days. Four (15%) between 3 and 7 days, and 7 (27%) between 8 and 15 days. One respondent was hospitalized between 31 and 75 days. The average hospital stay was 6.7 days.

Cost of hospital stay. Costs of the hospital stay are calculated, based on the Belgian Diagnosis Related Groups (DRG) database and according to the severity level of the injury which is estimated from the above mentioned length of stay (for each respondent individually) (https://tct.fgov.be/webetct/etct-web/anonymous?lang=nl). This database provides average hospitalization costs reimbursed by the health insurances for defined medical conditions expected to have similar hospital resource use. Because costs are considered here from a societal point of view, nine percent was added to the hospital costs, to include the average personal share (co-payment) of hospital patients in 2011 (http://www.cm.be/binaries/2012-11-29%20Persdossier%20ziekenhuis-barometer_tcm375-119406. pdf).

The average total cost for the hospital stay was 3,722 ±3,105 (range 1,091-16,683) euro per respondent.

Costs of doctor, specialist & physiotherapist visits. Respondents visited a medical doctor or specialist on average 14 ±20 times during the recovery period. Respondents reported on average 37 ±47 visits to a physiotherapist. The resulting average medical costs (N=26) during the 'recovery period' was 1,557 ±1,529 (107-5,114) euro.

After leaving the hospital, 15 out of 26 respondents had additional costs for medication of 133 ±234 (0-919) euro per respondent.

Respondents suffering permanent consequences (N=17) visited, on average, a medical doctor or specialist 4 ±9 (0-35) times per year after their recovery period. During their permanent consequences phase, these 17 respondents had an average cost of 481 ±741 (0-2,709) euro per respondent.

Cost of transport by ambulance. Sixteen (59%) respondents were transported to a hospital by ambulance. There is an important difference in the costs that may be attributed to an ambulance intervention depending on whether one opts for (a) dividing the total costs of the provision of the ambulance service equally among all interventions which results in a cost of 245 euro per intervention or (b) the average variable costs of an ambulance intervention. Here the variable cost approach was chosen similar to the approach taken by Aertsens et al (2010). We attribute an average cost of 58.2 euro (2011) based on the Belgian national RIZIV (RijksInstituut voor Ziekte- en InvaliditeitsVerzekering) pricing.

3.2.2. Direct non-medical costs

3.2.2.1. Material costs for the cyclist

Together with the medical consequences of the accident, the accidents also caused material damage, including damage to bicycles, clothes etc, in fifty-four percent of the cases. The total average cost for material damage was 399 ±847 (0-3,991) euro per respondent.

3.2.2.2. Police intervention

Forty-two percent of the respondents indicated that their accident was registered by the police, compared to 7.1% reported in the SHAPES study for minor bicycle accidents with acute body injuries [2].

Similar to the ambulance interventions, the costs of police interventions are mainly due to the time invested by the police men. The cost for a police intervention in Belgium is estimated at 90 euro in year 2010. Because all accidents had major physical consequences for the cyclist, we estimate that the police made an official reporting of all these accidents. We therefore used a lump sum of 90 euro per accident. This amount was indexed to 94.5 euro for 2011.

3.2.3. Productivity loss

3.2.3.1. Period unable to work

All respondents were absent from work for at least one day as a consequence of the accident. The average absence from work for the whole group was 163 ±213 days. For those (N=2) who still had not returned to work at the moment of filling out the questionnaire, a maximum of 780 days (3 years * 260 effective working days per year) was assumed. One respondent had to find another job and 1 respondent has a permanent job disability after the accident.

When applying the 'Human capital approach', the cost to society of productivity loss can be estimated by multiplying the number of days that respondents were unable to work with 'the cost of a workday'. The OECD (2011) reports that in Belgium in 2011, 4.554 million people were employed. In total 7.063 million hours work have been delivered. On average an employee worked 1,551 hours in 2011, or 29.81 hours per week (52 weeks in a year). The total GDP of Belgium was 368 billion euro. The GDP per hour worked in Belgium in 2011 is thus 52.35 euro. The average GDP per employees work week equalled 1,561 euro. So for absence from work of an average Belgian employee, the Human capital approach estimates a loss of 1,561 euro per week (312 euro/day) for society.

The total cost for society that results from the absence of work is on average 50,904 ±66,577 (312-243,360) euro per respondent.

3.2.3.2. Lower productivity

On average, respondents (N=11 out of 26) reported to be less productive once they were back at work. The respondents estimated to have lost 34 ±62 hours while they were back at work. This can be due both to psychological consequences (e.g. being more distracted) or to physical injuries resulting from the accident. One hour of work is calculated to be 52.35 euro (=1,561 euro/ 29.81 hours). The total costs of the lower productivity is calculated by multiplying the hours that the respondents lost (34 ±62 hours) and the price of work hour (52.35 euro) and is estimated to be 1,758 ±3,218 euro per respondent.

3.2.4. Leisure time loss

The following categories of time loss are accounted for: time invested in (1) taking care of injuries during the recovery period, and (2) submitting claims to receive reimbursement.

The value of a marginal time saving is often measured by a willingness to pay (WTP) approach. Several approaches indicate that the value of leisure time in Belgium is about 5 euro/hour in 2010 or 5.26 euro 2011 prices [2].

(1) Taking care of injuries: on average the time spent on injury care during the recovery period was 50 ±100 (2.5-480) minutes per day. The average cost per respondent (N=26) is then 1,846 ±4,805 (0-22,723) euro.

(2) In order to receive reimbursement of the costs related to the accident, nineteen respondents undertook administrative steps (e.g. contacting the insurance company, employer, ...). Three respondents undertook judicial steps. On average, all these actions took on average 22 ±36 (1-113) hours per respondent. Not only time but also monetary costs were questioned. Respondents spent on average an additional 20 ±54 (1-213) euro. The total cost was on average 123 ±218 (0-817) euro per respondent.

3.2.5. Compensation of physical and psychological consequences – Intangible costs

In order to estimate the cost for 'pain and suffering', two different approaches were applied in this study. The first one is an actual refund paid to the respondents by the government or an insurance company. When compensating the costs of permanent injuries, we distinguish between (i) a permanent disability to perform certain tasks that leads to economic losses, and (ii) a permanent disability for which a "moral" compensation is paid which is equal for all individuals [2]. The second one is a conceptual cost measured with the so called 'Willingness To Pay' (WTP) method. Because these are two different approaches in order to compensate for the same concept, the results are shown separately and will be compared in the discussion section.

3.2.5.1. Refunds for permanent disability by the government or insurance company

Six respondents (35%) with permanent disability did not receive any public or private social security benefits, 11 (65%) did receive benefits from an insurance company or government and for 1 (6%) respondent the lawsuit was still hanging. There were 5 (29%) cases with a permanent job disability rate (BAO) of <5%, 2 cases with 5-10% and 3 cases with 10-20%. One respondent indicated to have a permanent job disability of 76-100% and is not able to perform his/her job anymore. The average permanent job disability rate is 4.8 ±5.7 (0-18)%.

The respondents indicated that they receive benefits from an insurance company or FWA for permanent job disability of on average 1,601 ±2,468 (0-11,400) euro per year per respondent. For the total period of the study (3 years), the average is 5,044 ±9,225 (0-35,910) euro per respondent.

To compensate for the moral damage, insurance companies use common amounts provided by Assuralia, the Belgian federation of insurance companies. The compensation (lump sum) for each percentage point of disability equalled 721.86 euro indexed to 2011 [2]. Eleven (65%) respondents received a compensation for moral damage. By multiplying the permanent job disability rate with 721.85 euro, the average compensation for moral damage is 3,482 ±5,381 (0-12,993) euro per respondent.

3.2.5.2. Willingness to pay

Another approach to estimate the intangible costs is 'Willingness to Pay'. We applied this approach, based on Rowe et al. (1996), by asking respondents questions related to their willingness to pay in order not to have suffered the physical pain, negative psychological consequences and disability related to their bicycle accident. WTP was estimated for the 'permanent disability' and for the 'temporary consequences' separately.

3.2.5.2.1. WTP – Temporary consequences

We have to acknowledge that it was difficult for most respondents to answer this question and only 16 out of 26 provided an answer. The 16 respondents who answered the question about temporary consequences, were willing to pay an average sum of 29,757 ±41,210 (0-150,000) euro per respondent in order not to suffer the temporary consequences of the accident. The other 10 respondents could not answer this question because they had no idea what they would have to pay in order not to have to suffer the consequences of accident.

The difference between those who had only temporary consequences (N=9) and those who had permanent consequences (N=17) is small (31,925 ±46,313 euro and 28,609 ±39,712 euro, respectively).

3.2.5.2.2. WTP – Permanent consequences

Only 11 out of 17 respondents could answer the difficult questions relating the WTP to avoid permanent consequences. The average WTP per respondent was 276 ±368 (0-1,000) euro per month. This amount is multiplied by the time of the permanent consequences until 3 years after the accident. The total amount per respondent for the 3 year period is 4,731 ±5,533 euro.

4. DISCUSSION

4.1. Costs of major bicycle accidents: national and international comparison

In this study, the 'economic cost' for cyclists with a major injury (so excluding WTP, job disability rate and moral damage) is estimated at 60,776 euro for the total group and 35,190 euro for the group with temporary consequences and 74,322 euro for the group with permanent consequences for a time period of 3 year. These amounts are in the same order of magnitude as the League tables used by the Flemish Government [21] who estimated the economic cost of major accidents (all transport modes) at 69,000 euro (€2010), based on HEATCO D5 [12].

When including WTP, we estimate the cost of a major bicycle accident to be 82,235 euro, 53,890 euro and 92,241 euro for the total group, the group with temporary consequences, the group with permanent consequences (for a time period of 3 year), respectively. The costs reported here in detail are much lower than those based on fixed percentages of Value of Statistical Life (VSL) for Belgium or neighbouring countries [13, 14, 22]. In Europe, the Value of safety per se is based on the UNITE project (market price 1998 – 1.25 million euro factor costs 2002) [23] and is for all traffic modes together. The Ricardo-AEA (2014) project updated the UNITE study data to represent the average income level in the EU in 2010 prices, which amounts, for Belgium, to a value of statistical life (VSL) of 2.178 million euro in order to avoid a fatal accident, €330,400 euro for a severe injury and 21,300 euro for a slight injury [11]. De Brabander and Vereeck (2007) estimated that the marginal unit value of preventing a road casualty is 2 million euro per fatality, 725,512 euro per seriously injured and 20,943 euro per victim with minor injuries (€2004) [14]. The unit cost per accident amounts to 2.4 million euro, 850,033 euro and 34,944 euro for fatal, severe and slight injury, respectively [14].

The costs for permanent damage were calculated for a period of three years after the occurrence of the accident. By doing this, we assume that the major part of the costs is included in those three years. The medical costs are to a large extend included as most medical treatments and chirurgical interventions were done and no major severity injuries (permanent brain damage or paralysis) were reported. The costs, resulting from the productivity loss are mostly taken into account as 92% of the participants were back to work at the time of filling out the questionnaire. Waiting more than three years would have resulted in a less precise

description of the accident caused by the recall bias. Waiting less than three years would not have made it possible to distinguish between temporary and permanent consequences.

4.2. Estimation of the total cost of bicycle accidents in Belgium

4.2.1. Underreporting

When calculating the total costs of bicycle accidents, we have to take into account that not all accidents are reported [2, 4, 12, 24]. Especially when there is no hospitalisation and/or when the cyclist is the only party involved in the accident, traffic victims do not appear in accident statistics [4, 25, 26].

In Belgium in 2008 (all age categories), out of all 6,877 officially *registered* victims from bicycle accidents, 6,017 (88%) were classified as "minor bicycle accidents", 774 (11%) as "major accidents" and 86 (1%) victims died within 30 days after the accident [27]. When considering these official statistics it is important to realize that most road accident statistics strongly underestimate the total number of cycling accidents.

In Belgium, only 7% to 30% of cycling accidents are officially reported [4, 24, 28, 29], with more serious accidents being more likely to be reported [4, 12]. The Belgian Road Safety Institute (BRSI) studied the number of cyclists admitted to hospitals and those officially reported by police based on data collected between 2004-2007 [29]. The results of that study indicate that only 18% of the major accidents is reported in the official statistics. As only 18% of the accidents are officially reported to the police, it is estimated that 4,300 victims were involved in a major bicycle accident in Belgium in 2008.

4.2.2. Calculation of total costs

Based on the figures for underreporting [2, 4, 12, 29] and cost calculations from the data of this study, Aertsens et al. (2010) and HEATCO (2006), we calculated the average cost of a major accident to be 82,235 euro and estimate the total cost of major bicycle accidents for Belgium to be 353,610,500 euro (Table 7).

Taken into account the costs for minor accidents in Belgium [2], and the estimated costs from fatal accidents, based on Ricardo-AEA (2014), the total cost of bicycle accidents in Belgium is 620,229,129 euro (Table 7).

Table 7: Total cost (incl WTP) of bicycle accidents in Belgium, based on Casteels (2011)

	Casteels	Official	Estimated #	Cost/accident	Total

	2011	reporting	accidents		Average
Fatal	86	98%[a]	88	2,178,000[d]	191,664,000
Major accidents	774	18%[b]	4,300	82,235[e]	353,610,500
Minor accidents	6017	7%[c]	85,957	872[f]	74,954,629
Total	**6877**		**90,345**	**2,261,107**	**620,229,129**

[a] based on HEATCO (2006), all transport modes together
[b] based on Nuyttens (2013)
[c] self-reported from Aertsens et al. (2010) and de Geus et al. (2012)
[d] based on Ricardo-AEA, euro 2011 prices
[e] costs cut off 3 year post accident
[f] based on Aertsens et al. (2010), euro 2011 prices

We have to take into account that Table 7 represents an estimation for the total costs of bicycle accidents in Belgium. Our study was conducted in Flanders, the largest institutional region in the northern part of Belgium. Because the social security system and productivity costs are the same for the different Belgium regions, we can expect that the calculated costs for Flanders can be used as representative for Belgium.

Aertsens **et al.** calculated the costs of minor bicycle accidents in Belgium, with a similar study design [2]. Minor bicycle accidents (hospitalisation <24h) were subdivided in 4 groups, based on the severity of the accident: (1) without injuries (only material damage), (2) with light injuries limited to a bruise or cramp, (3) Acute Body Injury with only Short Term (< 9 months) consequences, (4) Acute Body Injury with Long Term (> 9 months) consequences. The average cost of (1), (2), (3) and (4) was 295, 322, 820 and 9,348 euro (2010 euro), respectively. The accidents that were registered in this study should be seen as a next step on the severity scale as the accidents resulted in hospitalizations of >24 hours, but no respondents suffered severe brain damage or paralysis and needed internment in a hospital or rehabilitation center for a long time period. Taking these figures into account, we can state that the severity of the injury plays a major role in the costs. It seems that the cost per accidents shows an exponential increase with the severity.

As a comparison, external costs of cars accidents in Belgium in 2008 was 4.790 million euro per year [30].

4.2.3. Costs of major bicycle accidents per distance cycled

Calculating the costs of bicycle accidents is meaningful to make a proper cost benefit analysis and to be able to calculate how much should be invested in order to reduce the burden caused by these accidents. The absolute amount that society has to pay does not make much sense if we do not take into account how many people cycle on a daily basis. We could expect that the total cost from bicycle injuries in the Netherlands is much higher compared to Belgium, as 25%

of the inhabitants in the Netherlands cycle for transportation on a regular basis [31] and in Flanders 'only' 13% [32].

The data of the National Institute of Statistics [33] registered 290,995 cyclists that commuted regularly by bicycle. In a recent study [34], conducted between 2008 and 2009 bicycle commuting trips in a cohort of 1187 regular cyclists were registered in a prospective study design. The results showed that the mean trip distance in Belgium is 7.2 km and that cyclists cycle on average 5.5 times a week to work or other places for transportation purposes. Assuming that the number of cyclists commuting on a regular basis did not change by 2008, and that these cyclists commute 48 weeks per year, a total of 1,1 billion kilometres were cycled in one year in Belgium. With a total cost of 353,610,500 euro (incl WTP) for all major accidents in Belgium, we estimate the cost of major accidents per kilometre cycled in Belgium to be 0.322 euro per kilometre cycled, for 3 years.

The estimated cost for minor accidents is 0.125 euro per kilometre cycled [2].

4.2.3.1. Comparison of the 2 different approaches to calculate the Intangible costs

It is interesting to see that the compensation for the permanent consequences that the respondents receive from the government and/or insurance companies is almost twice as high as the amount that they were willing to pay themselves in order not to have to suffer the permanent consequences, 8,526 ±12,646 euro (5,044 ±9,225 euro BAO + 3,482 ±4,109 euro moral) and 4,731 ±5,533 euro (cut-off after 3 years) respectively. We point out that the amount they receive from the government is a lump sum and the amount we calculated is only for a maximal period of 3 years. The average amount respondents were willing to pay was 276 ±368 euro per month. Depending on their age at the time of filling out the questionnaire and their retirement age, this amount can vary. As an example, we calculate that the lifelong WTP would be 144,051 euro: 28,131 euro (average amount for the recovery period) + 276 euro (average/month for permanent consequences) * 12 months * 35 year (mean age of the sample was 45 year and 35 year life expectancy). This amount is about half the amount (330,400 euro) of the European key figures for Belgium [11].

The WTP for the Recovery phase in the group with only temporary consequences (N=9) and the group with permanent consequence (N=17) is 33,660 ±65,431 euro and 28,131 ±78,718 euro per respondent, respectively.

In the Aertsens et al. (2010) study, calculating the costs of minor bicycle accidents (<24h hospitalisation), respondents were willing to pay 1,885 euro in order to avoid physical pain and 858 euro for the psychological consequences. Adding both numbers tells us that the WTP was 2,743 euro per respondent. As could be expected, this amount is lower than the amount the respondents were willing to pay in order to avoid the consequences of a major accident. In this study, no difference was made between the physical pain and psychological consequences.

4.3. Study limitations

Some study limitations should be recognized. The relatively small number of respondents (N=26) included in the data analysis, results in relatively wide standard deviations.

As mentioned above in the discussion section, waiting three years after the accident could have caused a recall bias. Waiting less than three years would have caused less complete cost estimations.

5. CONCLUSION

Although the study sample is relatively small (N=26), the results of this study are consistent with findings from other national and international studies. From these self-reported data, it is estimated that the direct and indirect costs (excluding intangible costs) of a major bicycle accident (defined as hospitalisation of >24h, excluding fatal injuries) is on average 60,776 euro per injured cyclist. When including intangible costs, the cost of a major bicycle accident is on average 82,236 euro. The results indicate that the major part of the costs are a result of the productivity loss and the willingness to pay, 55% and 31% respectively. As the WTP is about the same amount in the group with permanent consequences compared to the group that fully recovered, the total amount in the first group is almost doubled because of the longer period that these respondents were unable to work.

The total cost for major bicycle accidents in Belgium is 353,610,500 euro for 3 years. The total cost for all bicycle accidents in Belgium in 2008 is estimated at 620,229,129 euro.

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7. CONFLICT OF INTEREST

The authors declare to have no conflict of interest with respect to the results discussed in this paper.

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