Physical and psychological consequences of serious road traffic injuries

Deliverable 7.2

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Work package 7, Deliverable 7.2

Please refer to this report as follows:
Weijermars, W., Meunier, J.-C., Bos, N., Perez, C., Hours, M., Johannsen, H., Barnes, J., et al. (2016), Physical and psychological consequences of serious road traffic injuries**, Deliverable 7.2 of the H2020 project SafetyCube.**

Grant agreement No 633485 - SafetyCube - H2020-MG-2014-2015/ H2020-MG-2014_TwoStages

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Project Start date: 01/05/2015

Duration: 36 months

Organisation name of lead contractor for this deliverable:
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Due date of deliverable:	**01/01/2017**	**Submission date:**	**19/12/2016**

Project co-funded by the by the Horizon 2020 Framework Programme of the European Union
Version: Final
Dissemination Level: PU Public

Co-funded by the Horizon 2020
Framework Programme of the European Union

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Executive summary

SafetyCube aims to develop an innovative road safety Decision Support System (DSS) that will enable policy-makers and stakeholders to select the most appropriate strategies, measures and cost-effective approaches to reduce casualties of all road user types and all severities. Work Package 7 of SafetyCube is dedicated to serious road traffic injuries, their health impacts and their costs. This Deliverable discusses health impacts of (serious) road traffic injuries.

BACKGROUND AND OBJECTIVES

Serious road traffic injuries are increasingly being adopted as an additional indicator for road safety, next to fatalities. Reducing the number of serious traffic injuries is one of the key priorities in the road safety programme 2011-2020 of the European Commission. Serious and other non-fatal injuries can have a major impact on the quality of life of a crash survivor and their relatives and also pose a burden to society. The consequences of injuries are very determinative for the costs of injuries for society. Moreover, consequences of injuries differ between casualties. To further optimize road safety policy, it is important to obtain greater insight into the consequences of different road traffic injuries, both for the individual and for society as a whole.

This Deliverable discusses the impacts of non-fatal road traffic injuries in terms of:

- Physical/functional, psychological and socio-economic consequences for casualties
- Burden of injury (expressed in Years Lived with Disability)

METHODOLOGY AND RESULTS

Road traffic injuries have a wide range of potential consequences. The International Classification of Functioning, Disability and Health (ICF) provides a framework for discussing consequences for individual road traffic casualties. According to the ICF, road traffic injuries can result in disabilities related to one or more levels of human functioning:

1) Problems in body function or structure (impairments), e.g. paralysis
2) Activity limitations, e.g. being unable to walk
3) Participation restrictions, e.g. being unable to work

The extent to which an injury influences activities and participation of a casualty also depends on personal and environmental factors. By means of a literature review and a number of additional case studies, disabilities due to road traffic injuries related to different levels of human functioning as well as the influence of personal and environmental factors are investigated.

The societal burden of injuries can be expressed in 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). This Deliverable focuses on non-fatal injuries (YLDs). The burden of non-fatal road traffic injuries is examined by means of a literature review and by estimating the burden of road injuries for six countries, applying a method that was developed within the European INTEGRIS study.

Literature review (Chapter 3)

The literature review aims to provide an overview of current knowledge on consequences of road traffic injuries for both individual casualties and their relatives and society as a whole. The review is based on a recent review conducted by SWOV. This review has been extended and updated, and now covers studies published between 2000 and August 2016.

The literature review shows that road traffic injuries can have major consequences for lives of casualties (and their families) and that they create a major burden to society as a whole. According to the Global Burden of Disease Study 2013 (Haagsma et al., 2016), non-fatal road traffic injuries account for 8.6 million Years Lived with Disability (YLD) worldwide. Reported prevalence of disability differs considerably between studies, depending on the characteristics of the casualties taken into account (e.g. injury severity), the duration of the follow-up and the type of disabilities that are taken into account. Self-reported prevalence of disabilities varies for example between 11% and 80% according to the most recent review.

Reported consequences relate to all three levels of human functioning (impairments, activity limitations and participation restrictions) defined in the ICF. Reported consequences of being injured in a crash include for example pain, fatigue, mobility problems, problems carrying out daily activities, impacts on the everyday life of the family and on leisure activities and sick leaves. Moreover, the literature shows that road traffic injuries also lead to psychological disorders, the most common disorder being Post Traumatic Stress Disorder (PTSD).

Consequences differ from one casualty to the other, depending on type and severity of injury, transport mode and several personal and environmental factors like age, gender, comorbidity and socio-economic status. Concerning injury severity, studies quite consistently show that the risks of mainly functional and socio-economic consequences increase as a function of the injury severity. However, minor injuries, like strain injuries to the spine, may also have grave long-term consequences. Moreover, as less severe injuries are much more common than severe ones, they are responsible for a high percentage of disabilities and consequently represent a large share in the burden of injury. Transport modes that are linked to a relatively high prevalence of long-term disabilities are pedestrians and motorcyclists. Concerning age, prevalence of physical health impacts appears to be lower for younger casualties and concerning gender, women experience more physical and psychological consequences than men.

Case studies on impacts of road traffic injuries on casualties' lives (Chapter 4)

Some of the SafetyCube partners have access to additional studies/data on impacts of injuries obtained in road traffic crashes. The results of the following five studies are included in this Deliverable:

- The Spanish study on the Health Impacts of Road traffic crashes; a nationwide household survey conducted among 213,626 respondents, including 473 persons who reported one or more disabilities due to a road traffic crash.
- The ESPARR study; a prospective cohort follow-up study in the Rhône region in France that determined the long term health impacts of road traffic crashes. 1972 participants, including 433 MAIS3+ casualties have been followed up to five years after the crash.
- An analysis of two datasets from the UK:
    1) a dataset collected as part of a PhD research, that followed 50 road crash casualties who were admitted to hospitals in the UK Midlands until one year after the crash, and;
    2) data collected for the Impact of Injury study, a multi-centre follow-up study, including 114 road traffic casualties, that explored the impact of unintentional injuries up to 1 year.
- Information collected one year after the crash by the Hannover Medical School for 608 respondents that were involved in crashes that were included in the GIDAS in-depth database.
- The MyLAC ('My Life After the Crash') study; an international retrospective survey that aimed to investigate medical, psychological, social and economic consequences of road traffic injuries. 755 road traffic casualties from 20 different countries responded to a questionnaire.

Most of these case studies, as most studies discussed in the literature review, are follow-up studies in which road traffic casualties were asked to fill out a questionnaire on perceived impacts of sustained injuries. The main limitation of such questionnaires is that non-response is often quite high and might introduce a bias, overestimating the proportion of casualties that experience negative consequences. Moreover, none of the studies provides a full picture of all possible impacts of road traffic injuries for different groups of injuries, on different moments in time. However, they all provide some interesting information. The ESPARR cohort study appears to be the most comprehensive study available concerning impacts of road traffic injuries.

The case studies confirm the conclusion from the literature review that (serious) road traffic injuries experience all kinds of functional, psychological and socio-economic consequences. According to the ESPARR study for example, three quarters of the MAIS3+ casualties and one third of the MAIS<3 casualties is not fully recovered three years after the crash.

Pain is the most often reported functional consequence in the ESPARR cohort study. In the Spanish study most reported disabilities due to road traffic crashes (all severities) are related to mobility and home life. Psychological consequences include PTSD, chronic depression or anxiety and fears. Socio-economic consequences discussed in the case studies include being unable to work, financial consequences, negative impact on family life and impacts on the housing situation. In Germany for example, 7% of the people involved in a crash reported that they were not able to return to their old job, 8% reported a slow restart and 2% had to modify their home or to move. The MyLAC study also provide information on the consequences of crashes for relatives of the road traffic casualties. More than one third of the casualties reported that the crash had had consequences on at least one of their relatives' personal or professional life.

Most of the case studies also include less severe injured casualties. In the ESPARR study and the UK case studies it is possible to compare the consequences for serious road traffic injuries with consequences perceived by people that are less severely injured. This analysis shows that also MAIS<3 casualties quite often encounter negative consequences, although less often and less long lasting than MAIS3+ casualties do. Looking at different types of road users, consequences appear to be larger for pedestrians and motorized two-wheelers.

Burden of injury calculation (Chapter 5)

The burden of injury has been calculated for road traffic casualties in Austria, Belgium, England, The Netherlands, the Rhône department of France and Spain. Each road traffic casualty has been assigned to one of the 39 EUROCOST injury groups. On the basis of the age of a casualty and disability information for the injury group from the INTEGRIS study, the burden of injury was calculated for each casualty. By summing the burden of injury of all individual casualties, the total burden of injury for a country has been estimated. Burden of injury body profiles were created to visualize the distribution of injuries and burden of injury over the body

The average burden of injury per MAIS3+ casualty varies between 2.4 YLD in Spain and 3.2 YLD in the Netherlands, with an average of 2.8 YLD per casualty for the six countries together. About 90% of the burden of injury is due to lifelong disabilities that are encountered by 19% (Spain) to 33% (Netherlands) of the MAIS3+ casualties.

The burden of injury for an individual casualty depends on the nature of the injury and on the age of the casualty. The average burden per casualty is by far the highest for spinal cord injuries (24.4 – 30.0 YLD). Spinal cord injuries also have a large share in the total burden of injury, as have 'other skull-brain injuries', hip fractures, femur shaft fractures, and fractures in knees and lower legs. The average burden per casualty decreases with age, because life expectancy and thus years lived with permanent disability decrease with age. Moreover, in most countries, the average burden per MAIS3+ casualty is higher for men than for women. Men also have a higher share in the number of MAIS3+ casualties than women; therefore their total burden of injury is higher than for women.

Since the age distribution and the distribution of injuries over the EUROCOST injury groups differ between transport modes, the average burden of injury per casualty also differs between transport modes. For the six countries together, the average burden per MAIS3+ casualty is highest for car/van occupants (3.4 YLD) and lowest for cyclists (2.3 YLD on average for Belgium, Spain and the Rhone region). It should be noted however that the YLD figures per transport mode differ between countries. Moreover, the distribution of the total burden of injury over transport modes differs between countries, mainly due to differences in the distribution of MAIS3+ casualties over transport modes.

As expected, the average burden per casualty is lower for less severely injured (MAIS<3 and ED treated) casualties. However as there are relatively many less severely injured casualties, they have a high share in the total burden of injury in a country. On the basis of data from the Netherlands and the Rhone region we estimated that less severely injured casualties (including casualties that were only treated at the Emergency department) are responsible for 67-74% of the burden of non-fatal road traffic injury.

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The literature review, health impact studies and burden of injury calculations presented in this SafetyCube deliverable show that non-fatal (serious) road traffic injuries have a substantial impact, both at the individual level as for society as a whole. The ESPARR cohort study for example shows that about 75% of the MAIS3+ road traffic casualties and about 33% of the MAIS<3 casualties are not fully recovered three years after the crash. The burden of injury calculations that are discussed in this Deliverable show that a MAIS3+ casualty on average has a burden of injury of 2.8 years lived with disability and that 19% to 33% of the MAIS3+ casualties experience lifelong disabilities.

Reported consequences of road crashes include:

- **Functional consequences**: e.g. pain, fatigue, mobility problems, and problems carrying out daily activities.
- **Psychological consequences**: e.g. PTSD, major depressive disorders and anxiety/fear
- **Socio economic consequences**: e.g. impacts on everyday life of the family and on leisure activities, sick leaves from work or study and financial problems.

Consequences differ considerably between casualties, depending on the injury sustained and several personal and environmental factors.

Recommendations

Ideally, road safety policies should also be aimed at reducing health impacts in addition to reducing the number of casualties. This could imply a different prioritization of transport modes, and increased focus on certain types of injuries, like spinal cord injuries. It should be further analysed which crash types and risk factors –related to road safety behaviour, infrastructure and vehicles- have relative large health impacts for individual casualties and/or contribute substantially to the burden of injury. Road safety measures could be (additionally) aimed at preventing or limiting the consequences of these crash types and risk factors. Additionally, measures could be developed that specifically aim at reducing the health impacts of crashes that already have occurred, for example aimed at early detection and treatment of injuries that are known to have large long term impacts.

In this respect, it should be noted that also less severe injuries are very relevant from a health burden perspective. MAIS3+ casualties are responsible for less than half of the total burden of non-fatal road traffic injury. We recommend countries that also have information about less severe injuries, to monitor developments and burden of injury for this group of casualties as well. Moreover, countries that do not yet have information on the incidence of less severe injuries could consider the options for registering less serious injuries as well.

Finally, further research is needed. We recommend repeating the burden of injury calculations for a larger number of countries. Besides, additional analyses could be helpful when further improving road safety policy. It seems useful to create burden of injury body profiles for different transport modes, age categories, genders and combinations of these variables. Furthermore, a European-wide follow-up study would be very useful, both for obtaining more information on individual impacts of road traffic injuries and for deriving road traffic injury specific disability information for calculating the burden of injury.

1 Introduction

The purpose of this Deliverable is to discuss the health impacts of serious road traffic injuries. This Deliverable is produced within Work Package 7 of the Horizon2020 project SafetyCube.

1.1 SAFETYCUBE

Safety CaUsation, Benefits and Efficiency (SafetyCube) is a European Commission supported Horizon 2020 project with the objective of developing an innovative road safety Decision Support System (DSS) that will enable policy-makers and stakeholders to select and implement the most appropriate strategies, measures and cost-effective approaches to reduce casualties of all road user types and all severities.

SafetyCube aims to:

1. Develop new analysis methods for (a) Priority setting, (b) Evaluating the effectiveness of measures (c) Monitoring serious injuries and assessing their socio-economic costs (d) Cost-benefit analysis taking account of human and material costs.
1. Apply these methods to safety data to identify the key accident causation mechanisms, risk factors and the most cost-effective measures for fatally and seriously injured casualties.
2. Develop an operational framework to ensure the project facilities can be accessed and updated beyond the completion of SafetyCube.
3. Enhance the European Road Safety Observatory and work with road safety stakeholders to ensure the results of the project can be implemented as widely as possible.

The core of the project is a comprehensive analysis of accident risks and the effectiveness and cost-benefit of safety measures focusing on road users, infrastructure, vehicles and injuries framed within a systems approach with road safety stakeholders at the national level, EU and beyond having involvement at all stages.

1.1.1 Work Package 7

Work Package 7 is dedicated to serious road traffic injuries (MAIS3+), their health impacts and their costs. The main objectives of this work package are to:

- Assess and improve the estimation of the numbers of serious road traffic injuries
- Determine and quantify health impacts of serious road traffic injuries
- Estimate economic and immaterial costs related to serious road traffic injuries
- Identify key risk factors related to serious road traffic injuries and their health impacts

1.2 PURPOSE OF THIS DELIVERABLE

Traditionally, road safety policy has been primarily aimed at reducing the number of road fatalities. However, road traffic crashes also cause a large number of non-fatal (serious) road traffic injuries, resulting in considerable economic and human costs (Weijermars, Bos, & Stipdonk, 2015). Besides, the number of serious road traffic injuries has not been decreasing as fast as the number of fatalities in some countries, and has even been increasing in other countries (see for example Berecki-Gisolf, Collie, & McClure, 2013a; OECD/ITF, 2011). Therefore, serious road traffic injuries are increasingly being adopted as an additional indicator for road safety. Reducing the number of serious traffic injuries is one of the key priorities in the road safety programme 2011-2020 of the European Commission (EC, 2010).

Non-fatal injuries can have a major impact on the quality of life of a crash survivor and their relatives and also pose a burden to society. The consequences of injuries are very determinative for the costs of injuries for society. Therefore, it is important to obtain information on these consequences. Moreover, consequences differ between individual casualties and probably also between groups of casualties. Certain types of injuries, e.g. spinal cord injuries, have larger long-term consequences than other types of injuries, e.g. internal organ injuries. In case a group of casualties (e.g. a certain transport mode) experiences relatively large health impacts from their injuries, it might be advisable to develop specific measures for this group of casualties. Finally, measures might also aim at reducing health impacts. For all these reasons, insight into health impacts of different groups of road traffic casualties is very useful to further improve road safety policy.

This Deliverable deals with the second objective of WP7. It discusses the health impacts of non-fatal (serious) road traffic injuries in terms of:

- Physical/functional, psychological and socio-economic consequences for casualties
- Burden of injury (expressed in Years Lived with Disability)

Injuries can have all kinds of physical, psychological and socio-economic consequences for the lives of road traffic casualties (and their family) and on a more aggregated level, also pose a burden to society. The International Classification of Functioning, Disability and Health (ICF) provides a useful framework for discussing consequences for individual casualties. The ICF is introduced in Chapter 2. Moreover, Chapter 2 also provides some background on the definition of serious road traffic injuries as road traffic injuries with a maximum AIS level of 3 or higher (MAIS3+).

Chapter 3 provides a literature review on consequences of road traffic injuries on the lives of casualties and their relatives. Moreover, it also discusses literature on the burden of injury for society as a whole. Subsequently, Chapter 4 discusses a number of additional studies on impacts of road traffic injuries on lives of casualties and their relatives. In Chapter 5, the burden of injury is calculated for several of countries, applying a method developed within the European INTEGRIS (Integrating of European Injury Statistics) study and described by Haagsma et al.(2012). Finally, Chapter 6 presents the conclusions and recommendations of this Deliverable.

2 Theoretical framework

Background and context

This chapter discusses the International Classification of Functioning, Disability and Health (ICF) that provides a framework for discussing physical and psychological consequences of injuries for individual road traffic casualties. The societal burden of non-fatal injuries can be expressed in Years Lived with Disability (YLD).This report focuses on the impacts and burden of serious road traffic injuries which are defined as MAIS3+ road traffic casualties.

Mortality is often considered as the primary indicator of the scale of any health problem, including road traffic crashes. However, to fully consider the burden of any health problem, it is also important to take into account non-fatal outcomes. Crashes also cause numerous serious traffic injuries; up to 50 million people sustain nonfatal injuries each year as a consequence of road traffic crashes, with many incurring a disability as a result of their injury (World Health Organization, 2015). Serious traffic injuries are more commonly being adopted by policy makers as an additional indicator of road safety. Reducing the number of serious traffic injuries is one of the key priorities in the road safety programme 2011-2020 of the European Commission (EC, 2010).

Injuries can have a major impact on the quality of life of crash survivors and their relatives and also pose a burden to society. As the consequences of injuries are very determinative for the costs of injuries for society, it is also important to obtain information on these consequences.

2.1 SERIOUS ROAD TRAFFIC INJURIES

Serious road traffic injuries are defined as road traffic casualties with a Maximum AIS level of 3 or higher (MAIS3+). The Maximum AIS represents the most severe injury obtained by a casualty according to the Abbreviated Injury Scale (AIS). This definition was established in 2013 by the High Level Group on Road Safety, representing all EU Member States.

The Abbreviated Injury Scale (AIS) is an anatomical-based consensus derived, coding system created by the Association for the Advancement of Automotive Medicine (AAAM) to describe injuries and ranks injuries by severity. The severity is based on a 6-point ordinal scale, one being a minor injury and six being maximal (currently untreatable)[1]. Table 2-1 provides some examples of injuries of different AIS levels.

[1] An AIS- Severity Code of 6 is not the arbitrary code for a deceased patient or fatal injury, but the code for injuries specifically assigned an AIS 6 severity.

Table 2-1 Examples of injuries of different severity levels.

AIS level	Examples of injuries
AIS1	skin contusion (hematoma), contusion of ankle, strain of cervical spine
AIS2	calcaneus fracture, dislocation of hip, contusion of cranial nerve
AIS3	amputation below knee, superficial penetrating skull injury, spinal cord contusion
AIS4	amputation above knee, major penetrating skull injury, incomplete cord syndrome
AIS5	complete cord syndrome (quadriplegia), vertebral artery laceration
AIS6	hepatic avulsion of liver (total separation of all vascular attachments), penetrating injury in brain stem

Injury severity can be measured on a number of dimensions such as threat to life, (threat of) disability, quality of life, injury burden, or cost (IRTAD Working Group on Serious Road Traffic Casualties, 2010). The MAIS represents the threat to life associated with the injury rather than a comprehensive assessment of the severity of the injury. Also, other severity scores based on hospital discharge data fail to capture an important part of the disabilities, cost and burden resulting from the injuries (IRTAD Working Group on Serious Road Traffic Casualties, 2010).

The definition of MAIS3+ casualties is based on recommendations of Broughton et al. (2008) and IRTAD (2010). Both Broughton et al. (2008) and IRTAD (2010) concluded MAIS3+ to be the most appropriate definition, as the number of MAIS3+ casualties is influenced less by clinical practices and the availability and organisation of hospital services compared to indicators based on length of stay at hospital. Broughton et al. also discussed which MAIS range to include in the definition of a serious injury. The threshold could be 2 given that AIS2 describes a moderate injury and that an appreciable number of MAIS2 casualties die. However, since the data available in some countries does not enable the estimation of MAIS1 and 2 separately, the minimum feasible value for the threshold appears to be 3 (Broughton et al., 2010).

The High Level Group identified three main methods for Member States to collect data on serious traffic injuries (MAIS ≥ 3):

1) by applying a correction on police record data,
2) by using hospital record data and,
3) by using linked police and hospital record data.

SafetyCube's Deliverable 7.1 (Pérez et al., 2016) provides practical guidelines for estimating the number of serious road traffic injuries. The estimated number of MAIS3+ casualties appears to be highly influenced by the method applied. The linking of police and hospital data leads to the most reliable estimate, followed by the use of hospital data. Differences may also occur between countries that apply the same method because of differences in the data and/or in the operationalisation of the method applied (Pérez et al., 2016).

2.2 HEALTH IMPACTS OF SERIOUS ROAD TRAFFIC INJURIES

Serious injuries are very diverse in nature and in impact. In some cases, casualties fully recover from their injuries, whereas others are permanently disabled as a result of a road traffic crash injury. It is clear that injuries can have a major impact on the quality of personal, social and working life of a crash survivor as well on the quality of life of their relatives. Besides these individual consequences, road traffic injuries also pose a burden to society.

2.2.1 Framework for describing consequences of injuries for the road traffic casualties

As a general framework for discussing health impacts for individuals, the International Classification of Functioning, Disability and Health (ICF) provides the most recent and comprehensive model of functioning and disability. ICF (WHO, 2002) belongs to the WHO family of international classifications, the best known member of which is the ICD-10 (the International statistical Classification of Diseases and related health problems). The ICF is complementary to the ICD-10 as it classifies functioning and disability associated with health problems that are categorised using the ICD-10.

According to the ICF model (Figure 2-1), a person's functioning and disability is conceived as a dynamic interaction between the health condition (disorder, disease, injury, trauma, etc.) and contextual factors.

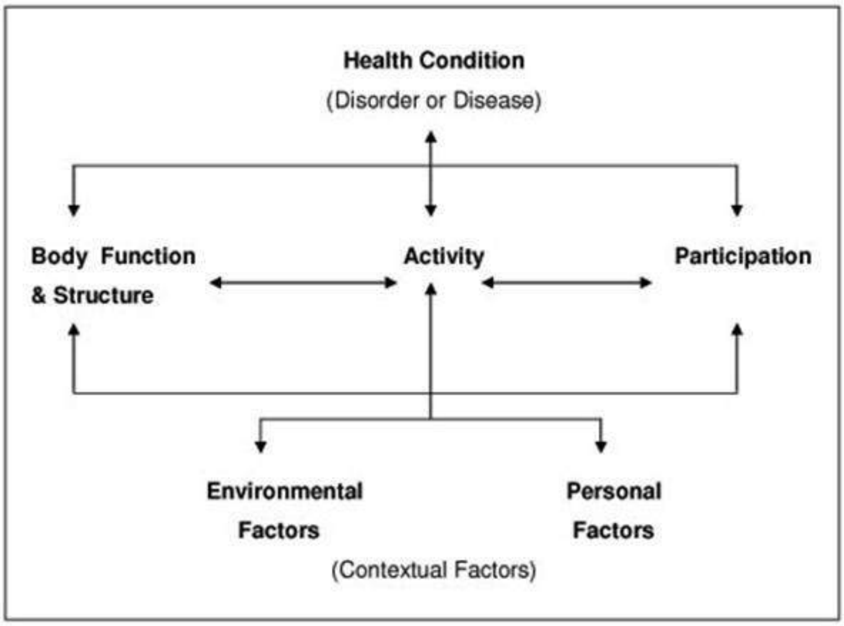

Figure 2-1ICF model: interaction between ICF components[2]

Among contextual factors are *environmental factors* (for example, social attitudes, legal and social structures, climate, terrain) and *personal factors*, which include for example age and gender, coping styles, social background, profession, and other factors that influence how disability is experienced by the individual.

Figure 2-1 identifies the three levels of human functioning classified by ICF: functioning at the level of body or body part (health condition, body function and structure), the whole person (activity), and the whole person in a social context (participation). Disabilities refer to problems on one or more levels of human functioning. Impairments are defined as problems related to the health condition, such as a significant deviation or loss (for example, paralysis or deafness). Activity limitations are described as difficulties an individual may have in executing activities (inability to go for a walk, not being able to answer the phone). Finally, participation restrictions are conceived of as problems an individual may experience in involvement in life situations (inability to go to work because the office

[2] *Source: http://www.who.int/classifications/icf/icfbeginnersguide.pdf?ua=1*

is not accessible to wheelchairs, not being able to join friends for a movie because of a lack of subtitles).

The ICF[1] uses the following definitions (WHO, 2002):

- Body functions: The physiological functions of body systems (including psychological functions).
- Body structures: Anatomical parts of the body such as organs, limbs, and their components.
- Impairments: problems in body function or structure such as a significant deviation or loss.
- Activity: the execution of a task or action by an individual.
- Activity Limitations: difficulties an individual may have in executing activities
- Participation: involvement in a life situation.
- Participation Restrictions: problems an individual may experience in involvement in life situations.
- Environmental Factors: physical, social and attitudinal environment in which people live and conduct their lives.

The activities and participation chapters that are included in the ICF are (WHO, 2002)):

- Learning and applying knowledge; including problem solving and decision making
- General tasks and demands; including organizing routines and handling stress
- Communication; by language, signs and symbols, including receiving and producing messages, carrying on conversations, and using communication devices and techniques
- Mobility; moving by changing body position or location or by transferring from one place to another
- Self care; e.g. washing and dressing oneself, eating and drinking
- Domestic life; e.g. household cleaning and repairing, caring for personal and household objects and assisting others
- Interpersonal interactions and relationships; carrying out actions and tasks required for interactions with other people –relatives, friends and strangers- in a contextually and socially appropriate manner
- Major life areas; tasks and actions required to engage in education, work and employment and to conduct economic transactions
- Community, social and civic life; actions and tasks required to engage in organized social life outside the family, in community, social and civic areas of life

As a result of a (serious road) injury, a casualty can encounter all kinds of disabilities. The extent to which an injury influences activities and participation of a casualty depends on contextual factors. Someone's age and personality affect for example the capability of rehabilitation and therefore activity limitations and participation possibilities. Moreover, impairment related to the voice and speech function has far more consequences for a professional singer than for an administrative worker. Regarding environmental factors, adaptation of someone's work environment for example can enable a person to participate in labour and social norms and values in a country affect participation opportunities for disabled people in social life.

Some diseases are progressive and result in a slow deterioration of health. Injuries have a sudden negative impact on body functions and structures and subsequently influence activities and participation. In general the health condition of an injured person will improve following the first negative impact, until a stable end-condition is reached. However, for some situations the impact of injury may become worse as time following the accident increases. For example, participation may decrease at a later stage because a casualty can no longer make use of temporary disability benefits.

The ICF focuses on the impacts of diseases and injuries for the individual victim. Impacts on relatives are not explicitly taken into account (implicitly it is taken into account to a certain extent in the chapter interactions with other people).

2.2.2 Burden of injury

The ICF framework provides a nice structure to discuss consequences of crashes for individual casualties. On the basis of information on consequences for a sample of traffic casualties, consequences of traffic crashes can be described on a more aggregated, societal level. Additionally, the consequences of diseases and injuries on a society level can be further quantified in terms of costs or by calculating the so called burden of injury. The costs of injury are considered in Deliverable 7.3. In the current deliverable we focus on the so called burden of injury expressed in Disability Adjusted Life Years (DALYs).

DALYs quantify the loss of healthy life due to (a given) disease or injury in the population. As such, it integrates mortality, expressed in Years of Life Lost (YLL) due to early death, and morbidity, expressed in Years Lived with Disability (YLD) attributed to a given condition in a population. More specifically, the DALY is calculated by adding the number of years of life lost due to mortality (YLL) to time spent in less than perfect health due to morbidity and disability, expressed in healthy year equivalents lost to disability (YLD) (Murray & Acharya, 1997). Since this Deliverable focuses on non-fatal injuries, only YLDs will be discussed.

2.3 SUMMARY

Serious road traffic injuries are defined as road traffic casualties with a Maximum AIS level of 3 or higher (MAIS3+). The MAIS represents the threat to life associated with the injury and thus does not provide information on consequences of injuries, while it is clear that injuries can have major physical, psychological and socio-economic consequences for the casualty as well as his or her relatives. On a more aggregated level, road traffic injuries also pose a burden to society.

The International Classification of Functioning, Disability and Health (ICF) provides a framework for discussing consequences for individual road traffic casualties. According to the ICF, road traffic injuries can result in disabilities related to one or more levels of human functioning: 1) problems in body function or structure (impairments), 2) activity limitations and 3) participation restrictions. The extent to which an injury influences activities and participation of a casualty also depends on personal and environmental factors. Consequences for relatives of the road traffic casualty are not explicitly taken into account in the ICF.

The societal burden of injuries can be expressed in DALYs. This measure integrates mortality, expressed in Years of Life Lost (YLL) and morbidity, expressed in Years Lived with Disability (YLD). Since this Deliverable focuses on non-fatal injuries, only YLDs will be discussed.

3 Literature review

The literature shows that (serious) injuries caused by traffic crashes have major consequences, often for a long period, and to the casualties' life beyond their sole health status. It even appears that many patients with less serious or no injuries were still suffering long-term health and other problems.

This chapter provides an extensive overview of the existing knowledge concerning the various consequences – both the short and the long term ones- of being injured in a traffic crash. More specifically, the consequences considered are physical, psychological and socio-economic consequences for individual casualties as well as consequences for the society as a whole in terms of burden of injury. It is important to note that this literature review is not limited to serious road traffic injuries (defined as MAIS3+ casualties), but also covers less serious traffic injuries, e.g. injuries that are only treated at the emergency department of a hospital. However, the influence of injury severity on consequences of crashes is discussed and when possible, consequences are discussed for MAIS3+ casualties separately.

Although all elements of the ICF are covered in this chapter, the structure of the Chapter differs somewhat of the structure of the ICF. As discussed in the previous chapter, the ICF distinguishes three levels of human functioning: functioning at the level of 1) body or body part (health condition, body function and structure), 2) the whole person (activity), and 3) the whole person in a social context (participation). Road traffic injuries can be seen as a health condition that affect human functioning at one or more levels and results in: 1) impairments, 2) activity limitations and 3) participation restrictions. The extent to which an injury influences activities and participation of a casualty also depends on personal and environmental factors.

Reviewing the literature, we found quite a few studies that discuss psychological consequences of road traffic injuries, like Post Traumatic Stress Disorder (PTSD). Within the ICF, PTSD and other psychological consequences of crashes can be considered to be disorders (health conditions) which may affect human functioning at each of the three levels discussed above. In that respect, road traffic injuries can be considered to lead to other disorders, which also influence human functioning. In this report, we deal with psychological disorders in terms of consequences of road traffic injuries. We will discuss the prevalence of reported psychological disorders among road traffic casualties, but will not separately discuss the impacts of these disorders on human functioning.

Moreover, we decided to make a distinction between functional consequences (Section 3.2), psychological consequences (Section 3.3) and socio-economic consequences (Section 3.4) in this chapter. Some of the activities and participation chapters in the ICF also deal with socio-economic issues, like interpersonal interactions and relationships and community, social and civic life, but the literature on socio-economic consequences of road traffic injuries was considered to cover a sufficiently broad area to be discussed in a separate section.

3.1 LITERATURE SEARCH

The current chapter is based on a recent review of the literature conducted by SWOV Institute for road safety Research (Weijermars, Wijnen, Bos, & Wijlhuizen, 2014). The original review was only available in Dutch and has been used for this chapter with the permission of the first author. The search of the literature focused on two databases (Pubmed and TRID) and included the following search terms:

- In Pubmed:
  - (Functional decline or disability) and (road traffic or motor vehicle) and (accident or casualty) and (injury or trauma)
- In TRID :
  - (Long-term Health Consequence) and (Road traffic injuries)
  - (Consequence) and (Accident) and (Long-term)

In the original literature review, studies published from January 2000 until March 2013, were considered, including peer-reviewed and non-peer-reviewed articles (coming both from road safety journals and from medical journals) as well as grey literature (e.g. report from recognised road safety organisations)[3]. Additionally relevant references were added on the basis of references in the selected papers.

Using a similar methodology, the current chapter extends this first review covering the period from March 2013 until August 2016. After a preselection of studies conducted on two databases (Google Scholar and Pubmed) and based on the same keywords as those mentioned above[4], studies aimed at investigating consequences (including medical/functional, psychological, socio-economic and professional consequences) of injuries caused by traffic crashes were considered as relevant and included in the current review. Evaluation of the relevance was based on both reference title and abstract. As for the original review, some additional relevant references were added on the basis of the reference lists in the selected papers.

3.2 FUNCTIONAL CONSEQUENCES OF INJURIES

3.2.1 Impairments

Relatively few studies have investigated the consequences of traffic injuries at the level of impairments. Bull (1985) investigated the prevalence of impairments amongst injured casualties that were taken to the hospital (Birmingham, UK). Following a 5 point impairment scale (0 - no impairment; intact activity/participation level; 4 - extreme impairment, activity/participation extremely impaired or impossible), the author observed that amongst the 2,502 casualties, 23% encountered moderate impairment (rated 2 or higher) and 3% suffered from extreme impairment.

Malm et al. (2008) using insurance data followed 20,484 car occupants injured in crashes (insurance data) that occurred between 1995 and 2001 for at least 5 years following a crash to assess Permanent Medical Impairment (PMI).Permanent medical impairment is established by consensus between medical doctors, claims adjustment specialists and lawyers specialized in insurance matters and reflects the physical and/or mental functional reduction associated with an injury. Impairment is considered permanent when no further improvement in physical and/or mental function is expected with additional treatment (Malm et al., 2008, p. 2-3). The degree of medical impairment varies from 1 to 99%. An unstable ankle joint amounts for example to a degree of permanent impairment of 7%, while severe dementia is equivalent to a degree of impairment of 99%. The authors observed that about 11.2% of the sample encounter an impairment of at least 1% (PMI1+), 5.5% an impairment of at least 5% (PMI5+) and 1.6% an impairment of at least 10% (PMI10+).

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[3] Detailed description of the literature search methodology may be found in Weijermars, Wijnen, Bos, & Wijlhuizen, (2014), section 4.1.

[4] In the original literature review, different combinations of keywords were used in Pubmed and in TRID. In current review, all these combinations were used in Google Scholar as well as in Pubmed.

Amongst the ESPARR cohort (France), considering only the severely injured, Nhac-Vu and colleagues found that at one year post-accident 91.6 % of the casualties had a medical impairment, measured by the Injury Impairment Scale (IIS, States & Viano, 1990) . Of those the majority suffered slight impairment only (IIS=1: 57.3%), but 4% suffered major medical impairment (IIS=5 or 6) (H.-T. Nhac-Vu et al., 2012).

More recently, Berg and colleagues (2016) assessed Permanent Medical Impairment based on a national representative database of car accidents that occurred in Sweden (Swedish Traffic Accident Data Acquisition (STRADA)) for the year 2013. From the 42,823 road traffic casualties in 2013[5], 4,737 (11.1%)[6] suffered from a Permanent Medical Impairment of at least 1% (PMI1+). Stigson (2015) concluded on the basis of a similar study that 11.8% of a sample of 36,743 car occupants, injured in crashes that occurred in Sweden between 1995 and 2011 suffered from a PMI 1%.

3.2.2 Activity limitations and participation restrictions

Compared with the literature on impairments, more studies have investigated the consequences of traffic crash injuries in terms of activity limitations and participation restrictions. Consistently, research evidence shows that a significant proportion of crash survivors experience functional limitations on the long term, but there is little agreement about the prevalence of disability(Ameratunga, Norton, Bennett, & Jackson, 2004). Indeed, depending, amongst other things, on methodology, research design, outcome measurement tools and sample, prevalence was shown to differ widely across studies (Kendrick et al., 2011).

In a systematic literature review based on 19 studies, Ameratunga et al. (2004) noticed that prevalence of disability varied between 2% and 87%. More specifically for casualties admitted to hospital after the crash (8 studies), the authors noticed that the proportion reporting long term issues varied between 21% and 57%. A more recent literature review conducted by Weijermars et al. (2016) , concluded that the reported proportions of casualties experiencing long term consequences/disabilities varied between 11% and 80%, depending on the types of road users, the duration of the follow-up and the type of disabilities that were taken into account. Despite these differences a consistent picture emerged, suggesting that the most severely injured patients are not fully recovered 12 to 18 months post injury (Holbrook, Anderson, Sieber, Browner, & Hoyt, 1998, 1999; Michaels et al., 2000), and even amongst less severely injured patients, 45% are not fully recovered 12 months post injury (Mayou & Bryant, 2001). Furthermore, functioning may deteriorate in the longer term for some of those with severe injuries (Kendrick et al., 2011). From the results of their literature review, Ameratunga and colleagues (2004) also noted that in general, recovery from physical limitations in general trauma populations[7] reaches a plateau at about 12 months, while the trajectory relating to adverse psychosocial effects is less clear (see Section 3.4 for more details).

Besides general prevalence, some studies considered the domains of functioning where complaints were more frequent or persistent. In a study (Haukeland, 1996) based on a large Swedish sample of casualties admitted to an emergency department after a crash, 47% of the adult respondents (16 years old or older) still reported complaints 6 months after the crash. For children or adolescent (0 to 15 years old), this figure only yielded 16%s. Complaints mostly concerned physical health (less

[5] Data from this study are based on information about each person injured in a traffic accident received from about 97% (2013) of the emergency hospitals in Sweden. While the study sample was in fact 41,444 subjects, estimation of the number of injured subjects in Sweden for the years was calculated based on the formula 'Total sample size * 1/0.9678'.
[6] Among them, 2,142 were cyclists (45.2%), 1,576 car occupants (33.3%), 535 Motorbike/moped drivers (11.3%), 246 pedestrians (5.2%) and 213 other road users (e.g. bus passenger; 4.5%).
[7] Not only those injured in traffic crashes

mobility, about 70%; fatigue, about 30%), daily activities (household chores difficulties, about 30%) and social life (less social contact, 12.5%; less enjoyment during leisure time, 33%). In a study conducted in the Netherlands (Weijermars, Stipdonk, Aarts, Bos, & Wijnen, 2014), 76% of the respondents still reported complaints after 2.5 months (N=553) and 59% after 9 months (N=422). The most common complaints were about limitations of daily activities (66% after 2.5 months) and about pain/discomfort (respectively 66% and 67% after 2.5 months). However, complaints about limitations to daily activity rapidly decreased across time (37% after 9 months) while complaints about pain/discomfort remained quite persistent (50% after 9 months). Complaints about cognitive functioning were less frequent but they were found to be the most persistent (23% and 19% respectively for 2.5 months and 9 months follow-up).

In a cohort study conducted in Australia and based on a sample of casualties hospitalised after a traffic crash, Fitzharris et al. (2007) observed that 82% reported to have recovered full autonomy regarding daily activities between 6 and 8 months after the accident. However, for the majority of the dimensions considered in the study, the scores were still significantly lower at the 6-8 month follow-up than before the accident (i.e. for the following dimensions[8] : Physical function, Role-physical, Bodily pain, General health, Vitality, Social function, Role-emotion, Mental health).

A large cohort study conducted in France (the ESPARR study : Hours et al., 2013; Nhac-Vu et al., 2011, also see Chapter 4) showed that the most persistent complaints one year after the crash concerned physical health (pain), psychological reaction (PTSD), sequelae impairing everyday life or occupational functions and disturbed affective and social life, and this was particularly the case of the more seriously injured (MAIS3+).

In a recent nationally representative study conducted in Spain (Alemany, Ayuso, & Guillén, 2013), the authors explored prevalence of long term disability (lasting at least one year) as a consequence of road traffic injury for 26 functional and sensory domains. They found that the most prevalent ones were: between 50% and 60% of the sample reported major difficulties walking or moving outside their home unaided or undertaking daily housework activities ; between 40% and 50% faced major problems when travelling as a passenger on means of transport without any help or supervision or had major difficulties changing their body posture without help or supervision or had major difficulties avoiding dangers of daily life without any help or supervision ; between 30% and 40% had major difficulties maintaining the body in the same position or faced major problems when driving a vehicle. Based on the 26 domains explored, the authors also investigated dependence – which refers to the need of support of a third person in daily life - and found that 57.7% of the sample had was at least moderately dependent (meaning that they require help from a third person at least once a day).

Alghnam et al. (2014) conducted a longitudinal study – including adult participants aged <18 - from seven panels (2000–2007) of the Medical Expenditure Panel Survey (MEPS[9]). Of the 62,298 individuals included in the study who were evaluated at 5 rounds over a two years period (4-5 months between every two rounds), 993 participants reported traffic-related injuries during the follow-up period either at round 3 or 4. Pre-crash (round 2) vs. post-crash (round 4) comparison based on self-reported physical and mental health showed that participants display on average a significant loss (2.7 points on a 100 points scale) in their physical health while mental health rating

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[8] As measured by the SF-36 (Ware & Sherbourne, 1992)

[9] The Medical Expenditure Panel Survey (MEPS) is a nationally representative, longitudinal survey of health care use, expenditures, sources of payment, and insurance coverage of the US civilian non-institutionalized population. Every year, the MEPS selects a new probability sample of approximately 15,000 households, representing one panel, which is then followed longitudinally. Each longitudinal survey includes five rounds of interviews spaced 4–5 months apart during two full calendar years.

remain unchanged. In another study also based on the MEPS, but only from two panels (2000-2002), Alghnam and colleagues (2015) followed 30,576 participants over a two years period and observed that those having reported traffic injuries (590) displayed deficits in all domains assessed (mobility, pain/discomfort, self-care, usual activity and depression/ anxiety) at first follow-up and in all domains except self-care at second follow up (1 ≥ year after the crash). Deficits in mobility and activity were the strongest.

Palmera-Suárez et al. (2015) conducted a community based cross-sectional study and found that disability due to traffic accident (443 subjects) as compared to other source of disability (20,425 subjects) caused greater disability in terms of mobility (OR[10] = 3.1), a greater need for health/social services (OR = 1.5), and more problems with private transportation (OR = 1.6), moving around outside the home (OR = 1.6) and changes in economic activity (OR = 2.4).

In the EU funded REHABIL-AID project (Chliaoutakis et al., 2016), road traffic casualties from Greece (N=38), Germany (N=20 and Italy (N=35) were followed for 12 months. 12 months post-crash, pain was the most affected aspect of the of the SF-36 aspects, followed by energy/fatigue and general health.

3.2.3 Consequences of injury as a function of its type, location and severity

A number of studies investigated medical and/or functional consequences of injury (i.e. impairment of body function or structure, activity limitation and participation restriction) as a function of the injury type and location and/or its severity. Data on injury location and type typically rely on diagnoses made by physicians/professionals, often using well-established assessment tools such as the WHO's International Classification of Disease (ICD). More rarely, data about injury type and location are gathered by other means, for example self-reports made by the casualties themselves (Ameratunga et al., 2006). For investigating injury severity, studies usually make a distinction between different injury severity levels using for example the (M)AIS scale (e.g. Bull, 1985; Hours et al., 2013; Malm et al., 2008)[11]. However, when medical data assessing injury severity are lacking, some studies used other criteria as a proxy for assessing injury seriousness, for example patients staying more than 10 days in hospital (Grattan & Hobbs, 1980) or receiving a minimal amount from insurance companies as compensation (Cornes, 1992).

Type/location

Several studies investigated the consequences of injury as a function of the injury type and/or location. Studies consistently found that injuries to the lower extremities relatively often resulted in impairment and disabilities (Bull, 1985; Fort et al., 2011; Haagsma et al., 2009; Haukeland, 1996; Polinder et al., 2007; Chliaoutakis et al., 2016). Other injuries leading to serious/long term disabilities included spinal cord injuries (Haukeland, 1996; Laursen & Møller, 2012; Polinder et al., 2007), complex/multiple injuries (Haukeland, 1996; Laursen & Møller, 2012), injuries to the head (Bull, 1985; Fort et al., 2011) and hip fractures (Polinder et al., 2007). Based on a wide population-based study conducted in Sweden (N= 36,743 injured car occupants), it appeared that cervical spine injuries

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[10] The OR (Odds Ratio; Cornfield, 1951) is a measure of association between an exposure and an outcome. The OR represents the odds that an outcome will occur given a particular exposure (in this case, disability due to road traffic crash), compared to the odds of the outcome occurring in the absence of that exposure (in this case, other source of disability). An OR of 3.1 for mobility in this study suggest that the probability of sustaining a mobility related disability is 3.1 times higher in road traffic crash than in other source of disability.

[11] For a detailed inventory of such scales, see Nuyttens N. & Van Belleghem, G. (2014). *How severe are the injuries of casualties of road traffic accidents - Analysis of the MAIS severity scale for injuries suffered by casualties of road traffic accidents hospitalized in Belgian hospitals between 2004 and 2011* (Research report No. 2014-R-13S-EN). Brussels, Belgium. Belgian Road Safety Institute – Knowledge Center.

(70.5%) followed by head injuries (16.4%) were among the most common severely impairing ones (PMI10+) (Stigson et al., 2015).

Severity

Studies quite consistently demonstrated that the risk of impairment and/or of long term consequence increases as a function of injury severity (e.g. Bull, 1985; Haukeland, 1996). Haukeland (1996) observed that the proportion of casualties with persistent complaints and disability at 6 month follow-up was higher with increased AIS score. Similarly, Bull (1985) noticed that only 2% of the mild injuries (AIS1) led to disability, and that this figure increased with an increasing AIS score. In a similar vein, the results from a Swedish nationally representative study (Berg et al., 2016) showed that 8.4% of MAIS1 injured casualties – involved in road traffic crashes - suffered from PMI1%, while this percentage increased up to 59.6% and 98% of the MAIS3+ and MAIS5+ casualties, respectively. In contrast, in Malm et al.'s study (2008) the proportion of AIS1 injuries that led to permanent impairment was higher (10%). In the ESPARR study (Hours et al., 2010; Hours et al., 2013; Nhac-Vu et al., 2011), 1,168 road casualties treated in a hospital in the Rhône region (France) were followed during 5 years. In the 6 month follow up study, 32% of the sample reported that their health condition was the same as before the accident (Hours et al., 2010) while 37% reported they were fully recovered at the one-year follow up study (Hours et al., 2013). However, the authors noticed that prevalence rates of full recovery were drastically lower for severely injured casualties (MAIS3+: 20% full recovery after one year) as compared to mildly or moderately injured casualties (MAIS<3: 45% full recovery after one year) (Martine Hours et al., 2013; H.-T. Nhac-Vu et al., 2011). At two years post-accident, the difference of recovery still persisted between severe casualties (about 25% had recovered) and slight to moderate casualties (about 55%) (Tournier et al., 2014).

Although less serious injuries are less likely to lead to permanent impairments, some of the mild injuries may have very large consequences for individual casualties. With this respect, strain injuries to the spine – rated as a AIS1 'mild' injury - should be considered irrespective of severity threshold (MAIS3+ or 2+) as they relatively often lead to loss of health (Krafft, Kullgren, Tingvall, Boström, & Fredriksson, 2000) even in the very long term (5 years follow-up Tournier, Hours, Charnay, Chossegros, & Tardy, 2016) and show relatively high prevalence among road traffic casualties (e.g. 46% in Casey et al study, 2015). Moreover, one has to consider that mild injuries are much more frequent than serious injuries. Malm (2008) indeed showed that the proportion of light to moderate injuries (AIS1 and AIS2) was so high as compared to more severe injuries in their sample, that they caused the majority of permanent impairments (Malm et al., 2008). This is consistent with other studies that showed that the vast majority of nonfatal injuries leading to medical impairment are slight (AIS 1) injuries (Bohman, Stigson, & Krafft, 2014; Gustafsson, Stigson, Krafft, & Kullgren, 2015). With this respect, the relation between injury severity and permanent impairment is more complex and less direct than what we could intuitively expect. Indeed, severe injury may not necessarily lead to permanent impairment while permanent impairment may also arise from mild and/or moderate injury.

Most studies focusing on injury severity and using the MAIS scale used the MAIS3+ threshold to define serious injuries[12]. However, as Tingvall et al. (2013) have shown, a target set on MAIS3+ injuries and fatalities would result in a potential risk for neglecting problems that might lead to impairments. In a study, based on the Swedish national system for road traffic injury data collection (STRADA), these authors (Tingvall et al., 2013) indeed observed that MAIS 3+ injuries only address a small portion (14%) of predicted impairments (Risk of PMI1+). MAIS 2+ injuries, on the other hand, were shown to cover over 60% of all long-term consequences while long-term consequences result

[12] While in the majority of EU countries injuries are considered as severe using the MAIS≥3 threshold, some countries used a lower threshold as for example, the Netherlands with a threshold of MAIS2+ (see Gennarelli, Wodzin, 2005).

from AIS 1injuries in 37% of the cases. Polinder et al. (2015) also compared MAIS2+ and MAIS3+ severity cut-off points but with Disability Adjusted Life Years (DALYs) as outcome (see section 3.7 for more details on global burden of injuries) and showed that these two thresholds respectively captured 54% and 80% of all DALYs.

Type, location and severity

Fewer studies investigated the risk of impairment or long term consequences as a function of both the injury type/location and its severity. Malm et al. (2008) demonstrated, for example, that AIS1 injuries that were most at risk for leading to permanent impairment were nerve injuries in the neck or upper or lower extremities injuries. Similarly, Stigson (2015) showed on the basis of Swedish data that AIS 1 cervical spine injuries accounted for more than 50% of all traffic injuries leading to long-term consequences. On the contrary, abdominal and thoracic injuries were found to be less likely to lead to permanent impairment. This was true no matter the AIS score (Malm et al., 2008).

3.2.4 Consequences as a function of transport mode

Many studies focused only on one or a limited number of transport modes, for example, the patterns of injury associated with being a vehicle driver or passenger (Tunbridge, Everest, Wild, & Johnstone, 1988), motorcyclist (Clarke & Langley, 1995; Tunbridge et al., 1988), a cyclist (Jacobson, Blizzard, & Dwyer, 1998) (Jacobson et al., 1998; Kingma, Duursma, & Jan ten Duis, 1997; Rivara, Thompson, & Thompson, 1997; Stutts & Hunter, 1999; Tunbridge et al., 1988) or a pedestrian (Atkins, Turner, Duthie, & Wilde, 1988; Kliger & Sporty, 1993; Kong et al., 1996; Stutts & Hunter, 1999). Much fewer are those that aimed at a more extensive comparison of the consequences of traffic injuries across various road user types (Bull, 1985; Mayou & Bryant, 2003). From this literature, it appears that the proportion of casualties suffering short or long term medical consequences is likely to differ between transport modes.

Weijermars et al. (2014)showed a high proportion of severely injured casualties amongst pedestrians and motorcyclists. Similarly, Mayou and Bryant (2003) further reported that these (pedestrians and motorcyclists) were the road users who suffered the most severe injuries directly after the crash and were more likely to report continuing physical problems, use of medical care, and disability at both a 3 month and 1 year follow-up assessments. At 3 years follow up, they rated their health as only 'fair' or 'poor' (Mayou & Bryant, 2003).

Other studies further support the idea that motorcyclists are more likely, as compared to other road users, to report disabilities/persistent functional limitation (Bull, 1985; M Hours et al., 2010) and display a lower recovery rate (at 9 months after the crash in Weijermars, Stipdonk, et al., 2014).

As for pedestrians, those with serious injuries were, in Mayou and Bryant's study (2003) more likely to be admitted to a hospital and to undergo surgery, and to stay longer in hospital than other road users (Mayou & Bryant, 2003).Cyclists, on the opposite, were found to suffer less severe injury - particularly head, face, arm and leg injuries (Mayou & Bryant, 2003), often reported better recovery (e.g. at two-year follow-up in Tournier et al., 2014), and were less likely to report persistent functional limitation (Bull, 1985).

Finally, car occupants (both drivers and passengers) were particularly likely to suffer neck, chest and leg injuries and to report pain and short and long term-impairments, mainly attributed to neck and other muscular-skeletal complaints (Mayou & Bryant, 2003; Weijermars, Stipdonk, et al., 2014).

3.2.5 Key findings

- Impairments:

    - The vast majority of impairments resulting from traffic crash injuries are considered as slight or moderate.
- Activity limitations and participation restrictions:
    - Prevalence was shown to differ widely across studies, e.g. between 2% and 87% according to Ameratunga et al. (2004) and between 11% and 80% according to Weijermars et al. (2016).
    - A large part of the casualties were not fully recovered 12 months post injury and this was the case even for less severely injured casualties (e.g. amongst the less severely injured patients, 45% had not fully recovered at 12 months Mayou & Bryant, 2001).
    - The most frequent impacted functional domains were physical health (mobility, fatigue, pain/), discomfort) mental health, daily activities and social life.
- Consequences of injury as a function of its type, location and severity:
    - Injuries leading to serious/long term disabilities included lower extremities injuries, spinal cord injuries, injuries to the head and complex/multiple injuries
    - The risk of impairment and/or of long term consequence increases as a function of injury severity, but
    - The vast majority of nonfatal injuries leading to medical impairment are slight or moderate injuries (because of their very high prevalence as compared to more severe injuries), and
    - Some less severe injuries (AIS1) involve a high risk of permanent impairment: cervical spine injuries upper or lower extremities injuries.
- Consequences as a function of transport mode:
    - Higher proportions of severely injured casualties and of long term complaints are usually found amongst pedestrians and motorcyclists.
    - Cyclists were found to suffer less severe injury, to report better recovery and to be less likely to report persistent functional limitation.

3.3 PSYCHOLOGICAL CONSEQUENCES

Physical injuries can also lead to psychological disorders. The traumatic impact of physical injuries – and especially unexpected and unintentional ones - has long been recognized. It is therefore important to understand the psychological impact of surviving a traffic crash (O'Donnell, Creamer, Pattison, & Atkin, 2004). Indeed, existing reviews (Blaszczynski et al., 1998; Haagsma et al., 2011; Michaels et al., 1999; O'donnell, Bryant, Creamer, & Carty, 2008) suggested that the prevalence of psychological consequences post injury is high and that these may be associated with poorer functional and occupational outcomes. However, as shown in an early review of psychiatric morbidity after motor vehicle collisions (Blaszczynski et al., 1998) wide variations in prevalence rates have been found in the literature for most commonly reported disorder: depression (21% to 67% across studies), anxiety (4% to 87% across studies),driving phobia (2% to 47% across studies) and Post Traumatic Stress Disorder (PTSD) (0% to 100% across studies).

Psychological consequences have also been found to be the most persistent consequence, while recovery from physical limitations generally reaches a plateau at about 12 months after the accident (Ameratunga et al., 2004). In this respect, Mayou and Bryant (2003) suggested that as time passes, the most adverse consequences of road crash disability and distress, increasingly become psychologically and socially determined. For example, in a sample of mildly or moderately injured traffic casualties, Kenardy et al. (2015) observed that participants consistently reported mental health scores below population norms and that these scores did not improve significantly between 6, 12 and 24 months post-crash. On contrary, in a relatively small study in Greece, Germany and Italy, Chliaoutakis et al (2016) found that depression and subjective stress seemed to have a good recovery compared to pain and physical disability.

It is also worth noting that psychological sequelae tend to develop not immediately after the traumatic event but rather tend to 'crystallise' after several weeks or months. As an example, in a study from O'Donnell (2004) an increased prevalence of psychiatric conditions was observed in the 3 and 12 month follow-up as compared to immediately after the crash. This was true for various psychiatric conditions such as anxiety, depression, and substance abuse as well as for comorbid diagnoses[13]. Finally, it appears that the psychological and social consequences of road traffic trauma are not always directly proportional to the severity of the physical injury: Even relatively minor injuries can have profound psychosocial effects (Andersson, Bunketorp, & Allebeck, 1997; World Health Organization, 2008).

There is a growing amount of literature concerning the likelihood of developing a number of mental disorders following crash involvement and their evolution after the crash. From this literature, the most common (and most investigated) psychological consequences from crash involvement appear to be major depressive disorders, anxiety, Specific Driving Phobia and trauma-related stress disorders such as PTSD or Acute Stress Disorder (ASD) (Blaszczynski et al., 1998; Harrison, 1999; Mayou, Bryant, & Duthie, 1993; O'donnell et al., 2008).

3.3.1 Trauma/stress-related disorder: Post Traumatic Stress Disorder (PTSD) and Acute Stress Disorder (ASD)

Post-Traumatic Stress Disorder (PTSD) and Acute Stress Disorder (ASD) can develop after a person has experienced a traumatic event such as a road traffic crash or violence and are classified as "trauma- and stressor-related disorders" in the DSM-5. Symptoms of PTSD include reliving the traumatic event, attempting to avoid trauma-related cues and increased arousal. These symptoms last for more than a month after the event and causes dysfunction in life or clinical levels of distress. Acute stress disorder (ASD) results in similar symptoms, but these last for less than a month (yet more than 2 days) after the event.

Studies have revealed that PTSD is one of the most prevalent categories of mental illness, with road traffic accident emerging as the single leading civilian cause of PTSD (Blanchard & Hickling, 1997). A recent literature review conducted by Haagsma et al. (2011) concluded that 21% of the casualties of unintentional injury (not necessarily due to traffic crash) presenting at the emergency department and 30% of those treated at the hospital still suffer from PTSD three months after the injury was sustained, tapering down to 4% and 6% respectively after 12 months. Higher prevalence is generally observed in studies investigating PTSD prevalence rates following traffic crashes specifically, although these rates have been shown to vary widely across studies. For example, the prevalence of PTSD between 2 and 6 months follow-up has been variously estimated as 17.5% (Shalev et al., 1998), 23.1% (Ehlers, Mayou, & Bryant, 1998), and 42% (Michaels et al., 1999). Nishi et al. (2013) found even lower prevalence rates at 6 months follow-up (7.5%), but the authors acknowledge some issues regarding methodology (instruments used) and sample representativeness. PTSD prevalence rates at 12 months show an even greater variation, with studies from various countries reporting 1.9% (Schnyder, Moergeli, Klaghofer, & Buddeberg, 2001), 11% (Mayou et al., 1993) 16.5% (Ehlers et al., 1998), 16% (Mayou & Bryant, 2003) and 33% (Mayou & Bryant, 2001).

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[13] O'Donnell and colleagues (2004) proposed several hypotheses for explaining these slowing developing conditions. It may be that, within the acute hospital setting, psychological symptoms remain underdeveloped as the patient may see the hospital as a "safe, caring and supporting" environment. Furthermore, this is a time where the focus of recovery is on the physical self, which may impede or delay focus on the psychological self. Finally, some psychological symptoms may not yet have developed because of a lack of exposure to trauma triggers due to the overprotecting environment provided by in hospital setting.

In a recent literature review, Heron-Delaney and colleagues (2013) examined PTSD prevalence rates by time point amongst adult road traffic casualties. They reported estimates; ranging from 8% to 45% at one month (median = 27.0), 8–30% (median = 16.5) at three months, 6–28% (median = 18.0) at six months and 7–26% (median = 14.0) at twelve months post-crash. These ranges demonstrated an overall decreasing trend in PTSD prevalence estimates over time, which may reflect a natural remission in PTSD symptoms between 1 and 12 months post-crash, consistent with previous research (Yaşan, Güzel, Tamam, & Ozkan, 2009). Similarly, single studies that have investigated PTSD prevalence across multiple periods and/or longer follow-up periods also consistently showed a decrease of prevalence with the time elapsed since the crash (e.g. Mayou & Bryant, 2001).

Comparing data from several countries, Matsuoka et al. (2008) suggested that cross-cultural and population differences might explain some of this variation in PTSD prevalence, as this has previously been shown to be the case in depression research (Simon, Goldberg, Von Korff, & Üstün, 2002). Similarly, authors have explained the variation in prevalence by various factors, for example the country (O'Donnell et al., 2004), the instruments used for assessing PTSD (Nishi et al., 2013), the age of the casualties (de Vries et al., 1999; Mehta & Ameratunga, 2012), or their gender (Olff, Langeland, Draijer, & Gersons, 2007) (see Section 3.5 for further details).

A second trauma-related diagnosis, 'Acute Stress Disorder' (ASD) is highly similar to PTSD but describes acute 'pathological' responses directly following the trauma. Indeed, while PTSD tends to point at persistent traumatic suffering (for at least 30 days); ASD depicts a transitional period that occurs within the first 30 days of an event for at least 2 days but less than 4 weeks (American Psychiatric Association, 2000). Compared to PTSD, which has been extensively investigated, few studies to date have reported acute stress disorder prevalence rates following involvement in road crashes. Amongst the few studies that have investigated it, the reported prevalence of ASD varied between 16–42% (Bryant & Harvey, 1995, 1996; Harvey & Bryant, 1999; Mayou et al., 1993; Ozaltin, Kaptanoğlu, & Aksaray, 2003; Yaşan et al., 2009).

3.3.2 Other disorders: depression, anxiety, phobia

While the traumatic aspect of crash injury makes PTSD the most common psychological consequence of it, other psychological syndromes may also be present. However, most research has only focused on post-traumatic stress disorder (PTSD), with only a few studies investigating other disorders (O'Donnell et al., 2004). Less frequently investigated disorders such as depression, anxiety and specific phobias, substance abuse, and insomnia have nevertheless all appeared to be implied in the psychological aftermath of road traffic accidents (Blaszczynski et al., 1998; Mayou et al., 1993; Schnyder et al., 2001; Shalev et al., 1998).

The prevalence of depression was reported in only a few studies. However, the rates for this condition also vary. In the early period after the traumatic event (not necessarily road traffic crash) the rates of depression have been reported as 8% (Mellman, David, Bustamante, Fins, & Esposito, 2001), 9.4% (Nishi et al., 2013), 19% (Shalev et al., 1998), and 60% . (Holbrook et al., 1998). While 6–12 month post-injury the observed prevalence varied between 8.5% (Schnyder et al., 2001), 10% (in Richard Mayou et al., 1993 and in O'Donnell et al., 2004) and 31% (Holbrook et al., 1998).

The reported prevalence of other anxiety disorders includes rates for travel anxiety (e.g. 15% in Mayou et al., 1993 ; 18% in Mayou, Simkin, & Threlfall, 1991 ; 28 % in Mayou & Bryant, 2001 ; and about 50 % in Andersson et al., 1997); as well as panic disorder (e.g. 6% in Mellman et al., 2001 ; 3% in O'Donnell et al., 2004), generalised anxiety disorder (e.g. 4% in Mellman et al., 2001 ; 1-2 % in O'Donnell et al., 2004), and simple phobia (e.g. 4% in Mellman et al., 2001). Finally, very few studies have investigated substance abuse, amongst others the one of O'Donnell et al. (2004) indicated a prevalence rate of 8% and 6.5% respectively 3 and 12 months after the injury.

3.3.3 Comorbidity

Few studies have examined psychiatric comorbidity in an injured population. It is well established that some mental disorders, particularly in more chronic forms, rarely occur alone and are routinely associated with other psychiatric conditions (O'Donnell et al., 2004). Shalev et al. (1998) found that of the 18% of injury survivors with PTSD, 43% had a comorbid major depressive episode. Mayou and colleagues (1993) found that 74% of those with PTSD also reported comorbid anxiety disorders (O'Donnell et al., 2004). Moreover, this study also suggested comorbidity of psychiatric diagnoses with continuing medical problems and with all types of social problems (work, leisure, and financial). ASD has also been showed to be associated with high rates of persistent psychiatric complications and comorbidity in particular with anxiety, depression, phobic travel anxiety and/or PTSD (Mayou et al., 1993).Taken together, these findings highlight the importance of investigating comorbid diagnoses when assessing individuals after a trauma. The high prevalence of comorbid disorders following injury may have important implications for expected outcomes of treatment (Shalev et al., 1998).

3.3.4 Consequences for different types of road users

Few differences have been identified concerning the psychological outcomes of crash involvement depending on the type of transport used by the casualty (Peden et al., 2004), with the exception of passengers having poorer outcomes than other road users. This seems especially true regarding travel anxiety. In a representative study, Mayou and Bryant (2003) indeed found that car passengers were in general more likely than drivers and other road users to develop travel anxiety, a figure that also appears to be influenced by gender (as above mentioned): 34% for female passengers, 17% for female drivers, 16% male passengers and 7% male drivers. Overall, travel anxiety was more frequently experienced by passengers (28%) as compared to motorcyclists (20%), cyclists (17%), pedestrians (13%) and drivers (12%). While the authors didn't provide interpretation for this tendency, it may reflect the fact that passengers – more than drivers – may have experienced a total loss of control during the crash. Differences have also been observed in the nature of the travel anxiety, differences which reflected the accident experience (Mayou & Bryant, 2003): passengers were particularly concerned about being vehicle passengers, whilst pedestrians were worried about crossing the road in situations similar to those of the accident. At three years follow-up, the authors also found poorer outcomes for passengers, as compared to the other groups, regarding PTSD and anxiety (Mayou & Bryant, 2003). Recently, a study conducted by Chossegros et Al. (2011) suggested that users of two-wheel motor vehicles were less at risk of developing PTSD 6 months after an accident than users of four-wheel vehicles. It is important to note that the road user 'effect' has to be considered with caution as some studies didn't show that the transport mode predicted psychological outcome (Ehlers et al., 1998; Mayou et al., 1993; Mayou, Bryant, & Ehlers, 2001).

3.3.5 Key findings

- Psychological disorders have been found to be the most persistent consequences of involvement in traffic crashes.
- Even relatively minor injuries can have profound psychological effects.
- Psychological sequelae tend to develop not immediately after the traumatic event but rather tend to 'crystallise' after several weeks or months.
- The most common (and most investigated) psychological outcomes from crash involvement appear to be trauma-related stress disorders (such as PTSD and ASD), major depressive disorders, anxiety, and specific driving phobia.
- Prevalence of psychological disorders as a consequence of traffic crash widely differs across studies (e.g. ranging between 9.5% to 60% for depression).

- Comorbid psychiatric diagnoses are quite frequent in road traffic injuries.
- Few differences have been identified between transport modes, although passengers appear to report poorer outcomes than other road users (in particular for PTSD).

3.4 SOCIO-ECONOMIC CONSEQUENCES

Although this aspect is still far from being fully understood, a growing body of evidence suggested that the consequences of injuries are not only likely to affect the casualties' health and mental health but may also have a major impact on the patient's social, family and occupational life (Chossegros et al., 2011; Holbrook, Hoyt, & Anderson, 2001).

3.4.1 Social and relational consequences

In the European Union, more than 40,000 people are killed and more than 150,000 disabled for life by road traffic crashes each year. As a result, nearly 200,000 families annually are newly bereaved or have family members disabled for life (Peden et al., 2004). In a study on how families and communities cope with injured relatives, the most frequently reported coping strategy was reallocation of work within the family, with at least one family member having to take time off from their usual activity to help the injured person or to carry on that person's tasks. About a third of the individuals who adapted their work patterns for that reason lost income. In some cases, the injury of a family member caused children to stay away from school (Mock, Gloyd, Adjei, Acheampong, & Gish, 2003). The Fédération Européenne des Victimes de la Route (FEVR) conducted a comprehensive study in Europe investigating the physical, psychological and material damage suffered by traffic casualties and their families (FEVR, 1997). The results showed that 85% of the families of those disabled as a consequence of a traffic crash reported a significant permanent decline in their quality of life, and in half of the cases the consequences were especially severe (Fédération Européenne des Victimes de la Route, 1997).

In the ESPARR study, (Hours et al., 2013), more than half of the severely injured participants (MAIS3≥) reported that the accident had had an impact on the everyday life of their family. This was twice as many as in the mild-to-moderate injury group (MAIS1 or 2) - 55% vs. 22%. Most of the severely injured reported impact on leisure, projects (housing, marriage, children) and emotional life: 20% reported relational difficulties in their couple, 16% reported impaired sexual life, and the rate of separation was significantly higher than in the mild-to-moderate injury group (5% vs. 1%; $p < 0.001$). Andersson et al. (1997) showed that a third of their sample of randomly selected traffic casualties from the Traffic Injury Register in Göteborg (Sweden) still reported a reduction in leisure-time activities two years after their accident. More recently, Palmera-Suárez et al. (2016) observed that increase in the level of severity was significantly associated with increased probability of receiving aids, of family support and of moving home.

The repercussions of serious injuries on all the people who make up the casualty's social entourage are still not fully understood. A few studies have investigated the effect such injuries have within the casualty's family, essentially in cases of serious head injury. It was found that for these cases of cerebral trauma , one year post-crash, a third of close family relatives had a high level of anxiety and depression, and a quarter had reduced social contacts. The stress amongst close family members was higher if the casualty exhibited aggressivity, was dependant, or showed apathy (Marsh & Kersel, 2006; Marsh, Kersel, Havill, & Sleigh, 1998). In the same way, Brooks & McKinlay (1983) found that the stress suffered by the close family of a cerebral trauma casualty was related to that person's troubled cognition and altered mood. The most noteworthy effect on close family's daily life was the depletion of their leisure time. Verhaeghe et al. (2005) observed a high level of stress in families where one of the family members had suffered cerebral trauma, even ten or fifteen years later. It seems that it is not so much the severity, but rather the nature of these injuries that influences stress levels. Also, families experiencing financial difficulties, health problems, or lacking social support were most vulnerable.

3.4.2 Professional and economic consequences

Several studies have investigated the consequences of road traffic injuries on the casualties' employment and employability. In the ESPARR study, 87% of the 'worker' casualties reported time off work as a consequence of the crash while 56% of the 'student' casualties reported study interruption (Martine Hours et al., 2013). In Haukeland's study (1996), 75% of the traffic crash casualties who had received medical treatment after traffic accidents in Norway reported time off work after the crash and more than half of them still reported problems with their professional life 6 months after the crash. Of the whole sample, 9% had to change job, 4% had to reduce their working hours, and another 7% were declared unfit to work (Haukeland, 1996). Similarly, Andersson et al. (1997) found that 16% of employed individuals in their sample could not return to their ordinary jobs (Andersson et al., 1997). Based on insurance data from Norway, Lund & Bjerkedal (2001) observed that, for the period between 1992 and 1997, 21 per 100,000 capita (including people aged between 16 and 66) claimed incapacity benefits as a consequence of a traffic crash.

Studies also quite consistently report high prevalence of long periods of sick leave as a consequence of traffic crashes. Beckmann (2007), for example, reported 32% sick leaves of less than 3 months and 29% more than 3 months; Berecki-Gisolf et al. (2013) 32% more than 6 months sick leave; and Hours et al. (2010) 24% more than 6 months sick leave.

Other studies investigated mean time off work as a function of the injury severity. In a cross-sectional study conducted on Spanish community-dwelling participants (Rocío Palmera-Suárez et al., 2016), subjects sustaining moderate to more severe injuries as a consequence of road traffic crash had a fourfold higher probability of being retired or unfit for work as compared to the mildly injured. In the ESPARR study, the mean time off work was significantly longer in the severe injury group: 245 ± 158 days vs. 75 ± 104 days and 32% of the severe injury group who had stopped work had not returned at 1 year, compared to 5% of the mild-to-moderate injury group (Martine Hours et al., 2013). Fort et al. (2011) also investigated the amount of time off work as a function of the injury severity and showed that mean time off work was significantly longer in the severe injury groups (MAIS3 or higher): 46 days for the MAIS1 casualties, 90 days for the MAIS2, 167 days for the MAIS3 and 138 days for the MAIS4/MAIS5.

Besides these average tendencies, the authors also noticed that effective sick leave period widely differed from one person to another. Berecki-Gisolf et al. (2013) conducted a study (based on insurance data) among traffic casualties that suffered from orthopaedic and musculoskeletal traffic injuries and found that 32% of injuries resulted in work disability ≥6 months after the accident and that the duration of work disability increased markedly with the length of hospital stay. Considering the relative proportion of the total amount of time off work for the whole sample, they found that victims with no hospital stay (representing 41% of their sample) accounted for a substantial part (27%) of all work disability days. This figure was respectively 44% for those hospitalised for a short period (1 to 7 days; representing 44% of the sample) and 29% for those hospitalised for a longer period (>7 days; representing 15 % of the sample).

Differences in employability have also been shown as a function of psychological complications. For example, an Australian study indicated that road traffic accidents casualties who developed PTSD had more difficulty (as compared to those who hadn't developed the disorder) returning to work 8 months after the accident (Matthews, 2005).

Regarding the type of injury, Fort et al. (2011) observed that moderate and serious head injuries, serious lower extremity injuries and serious thoracic injuries were particularly likely to lead to extended sick leave.

To our knowledge, very few studies have investigated – at the same time - multiple predictors of socio-professional outcomes. As an exception, Gopiniath et al. (2015) showed on the basis of a longitudinal prospective study that not being admitted to a hospital, not having pre-injury chronic illness, better self-reported mental health at baseline were all associated with higher likelihood of returning to work after 24 months while younger age, better physical health and overall functioning were mutually independent predictors of returning to usual activities 24 months later.

Besides professional consequences, studies also illustrated economic issues as a consequence of a traffic crash. For example, in Mayou and Bryant's study (2003), over 40% of the sample (n = 368) reported financial problems at 3 months and 27% (n = 209) at 1 year as a result of the road traffic accident, with no differences according to the transport mode.

3.4.3 Consequences for different types road users

Professional and economic consequences of road traffic accidents have typically been investigated without distinguishing between road user types. As an exception, Mayou and Bryant (2003) found that pedestrians had on average the longest time off work. On the contrary, Tournier et al (2014) found no difference in terms of economic consequences at two years after the accident, across different road-user types, whilst pedestrians were found less likely than other user types to experience an occupational impact from the accident, after controlling for injury severity. Otherwise few differences have been observed in terms of effects on everyday activities between transport mode (Mayou & Bryant, 2003).

3.4.4 Key findings

- Social and relational consequences
    - Road traffic injuries often result in reallocation of work within the family/close relatives of the victims, with at least one family member having to take time off from their usual activity to help the injured person.
    - Increase in the level of severity is significantly associated with increased probability of receiving aids, of family support, of moving home, and of difficulties in day-to-day life (social, emotional and affective).
    - Road traffic injury is associated with higher level of stress and suffering (e.g. anxiety, depression) within the close family.
    - Families experiencing financial difficulties, health problems, or lacking social support are more at risk for developing difficulties as a consequences of the crash.
- Professional and economic consequences
    - A vast majority of road traffic injuries report time off work/studies after the crash with substantial part of them reporting long sick leaves (e.g. 32% more than 6 months sick leave in Berecki-Gisolf et al., 2013) or definitive leave (16% in Andersson et al., 1997).
    - Probability of long term leave or definitive leave increased with injury severity.
    - Differences in employability have also been shown as a function of psychological complications (in particular with PTSD).
    - Road traffic injuries may also have financial consequences (40% reporting financial difficulties at 3 months and 27% at one year in Mayou and Bryant, 2003).

3.5 ROLE OF PERSONAL AND ENVIRONMENTAL FACTORS

3.5.1 For physical health

A large body of literature have explored the potential predictors – or intervening factors – related to health condition. Evidence shows that many personal and environmental intervening factors are predictive of medical and functional consequences of traffic crash injuries. The main ones are : age, gender, mental health and psychosocial factors, comorbidity, socio-economic factors, the nature and the quality of treatment, the compensation process and the circumstances of the crash - e.g. being at fault (Gabbe et al., 2012; Haagsma et al., 2009; Polinder et al., 2007). While most studies have investigated the intervening role of personal or contextual factors separately, several studies focused on multiple predictors. For example, Gabbe et al. (2012) showed that younger age, male gender, injuries other than neurotrauma and higher education level were all predictors of better functioning 12 months after the crash. Kim (2011) showed that older age, male gender and lower level of education were associated with lower levels of functioning after a traumatic brain injury. Walton et al. (2013) observed that female gender and lower level of education were associated with more serious long term consequences – regarding pain and limitation – as a consequence of a Whiplash Associated Disorder.

Regarding age, studies consistently show lower prevalence of disability/handicap and/or long term consequences for younger casualties (Bull, 1985; Gabbe et al., 2012; Haukeland, 1996; Hours et al., 2010; Polinder et al., 2007). For example, Gopiniath and colleagues (2015) found that among individuals who sustained a mild/moderate injury following a vehicle collision at baseline, older ones (≥65) had a significantly lower physical functioning at 12 months and 24 months follow-up – than younger ones (18-64). This was observed after having adjusted for various factors as gender, pre-injury general health, pre-existing chronic illness. Conversely, no difference was found between the two groups for pain. Maraste et al. (2003), conducted a cohort study on 230 hospitalised traffic casualties (200 adults and 30 children below the age of 15) and reported that 38% of adults and 13% of the children still reported complaints (either on activity limitations, pain or anxiety) after one year. At the last follow-up (between 3.5 years and 4 years after the crash), long term consequences remained substantial for 23% of the adults and for 10% of the children. Using data from the National Health Interview Survey Disability Supplement, Shults et al. (2004) compared disability prevalence (encompassing functioning, activity limitation and participation restriction) among different age groups involved in a motor vehicle crash. In their sample, 1.2 million adults reported disability, and the highest prevalence being was observed among the 35-64 year old. As suggested by Forman et al. (2015), age effects may be explained as aging has profound effects on the morphology, geometry, and mechanics of tissues, from tissue growth and skeletal ossification in childhood and adolescence through osteoporosis and bone loss with advanced age. As a result, many recent efforts have focused on differentiating injury tolerances based on age to identify specialised injury prevention strategies (Forman et al., 2015).

In general, women appear to experience more disabilities resulting from injuries than men (Gabbe et al., 2012; Haagsma et al., 2009; Haukeland, 1996; Polinder et al., 2007; Walton et al., 2013) and this has also been shown for long-term outcomes – e.g. permanent medical impairment (Gustafsson et al., 2015). This may be partly due to whiplash associated disorders which has been found to be much more frequent among women than among men (Hours et al., 2014). An exception is however found for traumatic brain injuries, with men facing more severe functional long-term consequences (Kim, 2011).

As for potential interaction between age and gender regarding medical and functional consequences of road traffic crashes, studies remain scarce. However, several authors have suggested that age and gender may, to a certain extent, have some confounding effects regarding traffic crashes health/functional consequences (Forman, 2015). For example, some evidence suggested gender differences in age-related injury tolerances -e.g. given gender differences in the onset and progression of osteoporosis, as well as in musculature and anthropometry (Melton et al., 1997).

Other studies suggest that mental health and psycho-social factors may either be protective or detrimental in recovering physical and functional health after the crash. In a prospective cohort study conducted in a sample of 123 adults admitted to an intensive care unit (two thirds of which were admitted as a consequences of a traffic crash), data were collected prior to hospital discharge and 1, 6, 12, and 24 months post injury (Aitken et al., 2015). Results showed that optimistic perception of illness and greater self-efficacy were associated with better physical and functional health over time. Gopiniath and colleagues (2015) specifically investigated psychosocial predictors of traffic crash injury-related persistent pain (lasting until 2 years after the crash). They found that it was related to self-perceived physical functioning, pain-related work disability and pain catastrophizing[14]. According to the authors, this underscores the importance of considering patient subjective experience in rehabilitation settings for improving recovery and coping with persistent pain. Based on a longitudinal cohort design and on a sample of mildly or moderately injured traffic casualties (MAIS≤3), Kenardy et al. (2015)observed that, overall, physical health-related quality of life at 6, 12 and 24 months post-crash was consistently improved with higher expectations of returning to work, but was lower with age, increasing pain, expectations of persistent pain, heightened perceived threat to life, and the presence of PTSD or Major Depressive Episode.

Some evidence also suggested the potential role of comorbidity. From a 4-years follow-up study (SUN cohort study), Pons-Villanueva (2011) recorded pre-event self-reported health status (as measured by Short Form-36 scores) and subsequent traffic crash history. From the 3,361 participants included in the analysis, 64 had a motor vehicle crash and were shown to have had a worse health status at baseline (prior to the crash) as compared to those who would not subsequently have a crash. In a recent and extensive literature review, Yung and colleagues (Yung, Haagsma, & Polinder, 2014) observed that persons with pre-existing disability before the traffic crash had between 1.3 and 5.5 times more chance of sustaining an injury compared to persons without disability. Furthermore, Xiang et al. (2006) observed that child cyclists or pedestrians with previous disability[15] were more than five times more likely to have been hit by a motor vehicle. According to Weijermars (2014), these findings suggested that initial health status has not only to be considered as a comorbidity factor but also – and mainly – as increasing the risk for being involved in a traffic crash.

There is also some evidence suggesting a positive impact of socio-economic status (SES) and education level on health condition after a crash (Gabbe et al., 2012; Kim, 2011; Walton et al., 2013). For example, Nhac-Vu et al. (2011) observed that higher SES was related to better self-reported health status. According to Chliaoutakis et al. (2016) the marital status also affects rehabilitation; at 12 months, divorced and widows appear to have a slower rehabilitation compared to the single.

There is increasing evidence that compensation processes and prolonged exposure may have a negative effect on participants' longer term health and recovery (I. Harris, Mulford, Solomon, & Gelder, 2005), and that the 'time taken to deal with a claim' is associated with stress that may hinder recovery (Grant et al., 2014). Conversely, Casey and colleagues (2015) showed that higher disability and lower mental health ratings at the time of the claim introduction were significantly and independently associated with an increased time-to-claim closure. Altogether, this suggested a

[14] The concept of 'pain catastrophizing' is related to patient's catastrophic cognitions that may impede the individual's ability to cope with severe pain (Flor et al., 1993).
[15] Disability was defined as meeting the criteria of at least one of three disability measures: a yes answer to any of the national disability questions of Census 2000, meeting provisions in the Americans with Disabilities Act, or receiving special education (See Xiang et al., 2006, for further details).

vicious circle where more severely injured traffic casualties may be more likely to be exposed to claim compensation deleterious effects.

Several studies investigated whether admission to hospital – independently of injury severity – is likely to affect the long term consequences of accident involvement. From a study conducted on 218 injured car drivers, Ameratunga et al. (2006) noticed that among the casualties that report the most serious health issues, those that were not admitted to the hospital after the crash experienced poorer physical and mental health indicators than those who were admitted to the hospital. The authors consequently suggested that studies focusing exclusively on casualties treated in revalidation or trauma services are likely to underestimate the burden of injury caused by traffic crashes. While consequences generally appear to be more important for casualties that are admitted to a hospital and for casualties with more severe injuries (see for ex. Ameratunga et al., 2006; Berecki-Gisolf, Collie, & McClure, 2013; Polinder et al., 2015), this does not mean that those with less severe injuries or who are not admitted to a hospital do not encounter negative health impacts (Weijermars et al., 2016). Whiplash Associated Disorders (WAD) are especially relevant in this respect, since they are often considered minor injuries, yet make up almost 50% of these casualties report after-effects half a year or longer after the crash (Haukeland, 1996). The benefits of being treated in a more specialised medical centre – as compared to a standard medical centre - have also been shown. Gabbe et al. (2012) reported that patients treated at high quality trauma services had better functional outcomes 12 months after the crash than other patients presenting similar injuries but being treated in less specialised hospitals.

Finally, Gabbe at al. (2015) observed among a sample of 2065 adult orthopaedic trauma patients (injured in traffic crash) that those who were not at fault, or denied being at fault despite a police report of fault, experienced poorer outcomes at 12 months (functional recovery and return at work) than the at fault group (with the adjusted relative risk of reporting these problems being 1.20 to 1.35 times higher in the not at fault group).

3.5.2 For mental health

Some personal factors have been shown to have a substantial influence on the psychological outcomes that may follow a traffic accident. In their study, Mayou & Bryant (2001) found that several characteristics were predictive of later psychological complications one year after the accident. Among these were: negative emotionality/beliefs during convalescence, prior emotional problems, perceived threat to life associated with the accident, and feeling blameless. The authors suggested that these predictive variables could be easily assessed at first hospital attendance or during follow-up. This would allow the identification of casualties at risk for developing psychological sequelae and to offer them appropriate support.

Female casualties of traffic accidents seem more likely to experience psychological distress and to develop psychological symptoms than their male counterparts (Breslau, Davis, Andreski, Peterson, & Schultz, 1997; Holbrook et al., 2001; O'Donnell et al., 2004). Gender differences have indeed been found for several psychological outcomes. The female participants in Mayou and Bryant's study (2003) were twice as likely as males to develop travel anxiety one year after the crash. The same tendency was observed for mood disorders, but to a lesser extent (Mayou & Bryant, 2003). Women have also been found to be more prone to develop PTSD after involvement in a traffic crash than men are (Olff et al., 2007).

Regarding casualties' age, Mehta and Ameratunga (2012) conducted a literature review on PTSD among children and adolescents who survived road traffic crashes and reported prevalence between 12% and 46 % in the first 4 months following the crash and of 13 to 25% between the 4th and the 12th months following the crash. Although direct comparison between PTSD prevalence in children and adults remains difficult, an early study conducted on children traffic casualties and their parents (involved in the same crash) showed that 25% of the children suffered from PTSD compared to 15% of their parents (de Vries et al., 1999). This suggests a higher proneness to PTSD after traffic crashes amongst children as compared to adults. More recently, Gopiniath and colleagues (2015) compared older and younger casualties sustaining mild/moderate injury after a traffic crash and found no difference in psychological health – as rated by a general mental health measure[16] – neither at 12 nor at 24 months follow-up. To our knowledge, age effect as interfering with psychological consequences of traffic crashes injuries has not been investigated.

Psycho-social factors were also found to be associated with mental health outcomes over time. In Aitken's prospective study conducted over a 24 months period (2015), optimistic perception of illness, greater self-efficacy and perceived social support were associated with improved mental health over time (PTSD and psychological distress). Suliman and colleagues (2014) investigated clinical and neuropsychological predictors of PTSD among a sample of road traffic crash survivors. Neuropsychological impairment (on tests of information processing, executive functioning, verbal learning, and motor speed) and clinical symptoms of anxiety were found to predict PTSD severity. Initial symptoms, psychiatric diagnoses, disability, trait anxiety, perceived stress, negative cognitions, and sleep were also found to be associated with 3 and 6-month PTSD severity but causality (prediction) could not be established.

The literature also suggested that psychological outcomes may vary according to certain crash circumstances: for example, the fact that the road user was considered at fault or not; or whether or not the crash resulted in fatalities. Littleton et al. (2012) discussed the implication of being at fault in an accident that causes human damage and found that people who were not considered as being responsible for the accident experienced increased emotional and mental distress. In an early study conducted by Foeckler and colleagues (1978), 33 drivers were recruited through police records at 6 months to 11 years after having been involved in a traffic accident with fatalities. Their findings suggested that 33% exhibited disturbed thinking, depression and nightmares; 36% reported that they had difficulty talking about the accident; 12% reported being fearful of having another road traffic crash, whilst 48% feared that someone they loved might be hurt or killed in an accident. Although indicative, the study didn't provide any comparison data (e.g. car drivers involved in traffic accident without fatalities). In another study, Harvey and Bryant (1998) recruited 79 adult patients who sustained a mild traumatic brain injury following a motor vehicle accident. Of these, only 3 had been involved in a fatal crash and they were all diagnosed with ASD. Also, the feeling that one is not responsible for the accident appears to increase the risk of developing chronic PTSD and this has similarly been demonstrated in several other studies (Chossegros et al., 2011; Harris, Young, Rae, Jalaludin, & Solomon, 2008; Hickling, Blanchard, Buckley, & Taylor, 1999).

In general, the severity of the injury and/or the crash has been found to have little impact on psychological outcomes (Mayou et al., 1993, 2001). One exception is PTSD, whose occurrence has been observed to be associated with injury severity and the persistence of pain 6 months after the crash (Chossegros et al., 2011). Finally, the perception and memories of the accident as 'horrific' and 'frightening' have been found to be strong predictors of psychological disorders and of PTSD in particular (Mayou et al., 1993). Note that this is unlikely to occur if the person suffered brief unconsciousness after the accident. Moreover, several studies have shown that traumatic memories do not need to be either factual or real to contribute to PTSD (Bryant, Marosszeky, Crooks, & Gurka, 2000; Jones, Griffiths, Humphris, & Skirrow, 2001). Finally, post-traumatic amnesia was found to have a protective effect regarding PTSD (Gil, Caspi, Ben-Ari, Koren, & Klein, 2005) but this was not consistently evidenced in other studies (Chossegros et al., 2011; Mayou, Black, & Bryant, 2000).

[16] The mental component score of the Medical Outcome Study Short Form 12 (SF-12, Gandek et al. 1998)

Elbers et al. (2013) also showed that persons involved in an insurance compensation process reported more psychological complaints. O'Donnel and colleagues (2010) further observed that a difficult and stressful relations between the casualty and the insurance company was associated with increased anxiety at 24 months after the crash.

Finally, there is some evidence that lower socioeconomic status and lower education is associated with poorer outcomes on some psychological outcomes (in particular for PTSD) but this has not been observed for all psychological outcomes (Aitken et al., 2015; Ehlers et al., 1998; Suliman et al., 2014; Wrenger, Lange, Langer, Heuft, & Burgmer, 2008). As for ethnicity, studies provided mixed and inconsistent findings (Heron-Delaney et al., 2013; Suliman et al., 2014).

3.5.3 For socio-economic consequences

To our knowledge, intervening effects of personal and contextual factors regarding socio-economic consequences of road traffic injuries have rarely been investigated (with the exclusion of injury type, location, severity and of road user category, which have already been discussed; see section sections 3.2. and 3.4.3. for more details). As an exception, Buitenhuis et al. (2009) demonstrated that both age and concentration problems were important - but independent - predictors of long term professional consequences.

3.5.4 Key findings

- Many personal and environmental intervening factors are predictive of medical and functional consequences of traffic crash injuries
    - Increased risks have been shown to be associated with: older age, female gender, comorbid psychological conditions, medical comorbidity, lower quality of treatment, and prolonged exposure to compensation processes.
- Many personal and environmental intervening factors are also predictive of psychological consequences of traffic crash injuries
    - Increased risk has been observed for female gender, younger age (children/adolescents as compared to adults), negative emotionality/beliefs during convalescence, prior emotional problems, perceived threat to life, perception and memories of the accident as 'horrific' and 'frightening'.
- Intervening factors for socio-economic consequences have rarely been investigated, with a few exceptions (e.g. older age and concentration problems being associated to increased professional consequences, in Buitenhuis et al. 2009)

3.6 THE BURDEN OF INJURY

The burden that traffic injuries represent to society can be expressed by means of Disability Adjusted Life Years (DALYs) (Murray & Acharya, 1997). DALYs are considered to be a useful health indicator for road traffic crashes and have been applied in several previous studies (e.g., Bhalla et al., 2014; Dhondt, Macharis, Terryn, Van Malderen, & Putman, 2013; Dhondt, Pirdavani, Macharis, Bellemans, & Putman, 2012; Holtslag et al., 2008; Lapostolle et al., 2009; Polinder et al., 2007, 2015; Weijermars et al., 2016). The burden of injury (expressed in DALYs) integrates mortality, expressed in Years of Life Lost (YLL), and disability, expressed in Years Lived with Disability (YLD) associated with one type of injury or medical condition.

From the Global Burden of Disease Study 2013 (GBD 2013, Haagsma et al., 2016), it appears that road traffic injuries account for 64.1 million YLL and 8.6 million YLD worldwide. This means 903 YLL and 120 YLD per 100 000 inhabitants. the burden of injury due to road traffic injury has decreased significantly between 1990 and 2013 (-15.7%)[17] (Haagsma et al., 2016). This decrease is however quite small as the global burden of injury worldwide showed a decrease of 30.9% over the same period. With this respect, road traffic injury remain a leading cause of DALYs lost (tenth in 2010, Murray et al., 2013) and is the major cause of injury death and disability (29.3% of all injury DALYs are caused by road injuries, Haagsma et al., 2016).

In their study, Weijermars et al. (2016) focused on the health burden specifically for serious injuries (MAIS2+) due to traffic crashes in the Netherlands. They found that the majority of the health burden of serious traffic injures was attributed to disability following injuries (38,000 YLD for MAIS2+ road traffic injuries as compared to 25,000 YLL for fatalities). As this Deliverable focuses on non-fatal injuries, the remainder of this section will focus on the non-fatal burden of injury (expressed in YLD).

3.6.1 Burden of non-fatal road traffic injuries

Only a few studies report general figures on the burden of (non-fatal) road traffic injuries. Tainio and colleagues (2014) estimated the average burden of injury (YLD) that an injured person suffers in a traffic crash in Sweden, using data from the STRADA database and the GBD classification and weight factors. They make a distinction between injuries resulting in lifelong consequences and injuries resulting in a temporal disability. Tainio et al. found that the average burden per injured person was 14.7 YLD for lifelong injuries and 0.012YLD for temporal injuries. Moreover, YLDs due to road traffic injuries in Sweden, are mainly caused by lifelong consequences. Of all injuries, only 2% caused lifelong health consequences, but these lifelong injuries caused 96% of the total burden of injury (YLD). Weijermars et al. (2016) report an average of 2.1YLD per MAIS2+ casualty in the Netherlands, an average of 8.4YLD for lifelong consequences and an average of 0.2YLD for short term consequences. Furthermore, according to Weijermars et al. (2016), the main part (90%) of the burden of injury (YLD) of MAIS2+ casualties in the Netherlands is due to lifelong consequences and were experienced by only 20% of all serious road traffic injuries (those sustaining lifelong consequences). Holtslag et al. (2008) considered the burden of injury for people being severely injured (ISS>15) in an area of the Netherlands and found an average burden of 11.5YLD per patient. Dhondt et al. (2013, 2012) estimated the burden of injury of road traffic accidents in Flanders and Brussels and found that 15% of all casualties encountered lifelong consequences and that 91% of the burden of injury was due to lifelong disability.

Several studies compared the burden of injury for different transport modes. Dhondt et al. (2013) and Holtslag et al. (2008) compared YLD *per distance travelled* for different transport modes. According to Dhondt et al., the average YLD per distance travelled is highest for motorcyclists (253.66 temporary YLD and 3110.22 permanent YLD per 10^9 km travelled) and cyclists (109.25 temporary YLD and 874.26 permanent YLD per 10^9 km travelled) and lowest for motor vehicles with four or more wheels (4.27 temporary YLD and 41.78 permanent YLD per 10^9 km travelled). Holtslag et al. (2008) conclude that the burden of injury per distance travelled is highest for motorized two-wheelers. A higher burden of injury per distance travelled can be due to a relatively high risk of being injured, a relatively high burden of injury per casualty, or a combination of both. Tainio et al (2014) and Weijermars et al. (2016) compared the burden of injury (YLD) *per casualty* for different transport modes and thus excluded the influence of the risk of being injured in a crash. Tainio et al (2014) found that the average YLD per person for lifelong injuries was highest for car occupants and lowest

[17] However, the picture is quite heterogeneous worldwide with the decrease being largely predominant in high- income regions (50,6% decrease in central Europe) while the reverse trend occurs in a number of low-income and middle-income countries (worst evolution found in South sub-Saharan Africa with 35.2% increase). This increase is partly due to growth in motorisation and traffic density in developing countries but also to a lack of comprehensive road safety laws in those countries (Haagsma et al., 2016).

for pedestrians. The average YLDs per person for lifelong injuries for pedestrians, cyclists and car occupants were 9.4, 12.8 and 18.4, respectively. Weijermars et al. (2016) included both the temporal and lifelong burden of injury and found that pedestrians, mopeds and motorcycles showed the highest burden of injury per casualty (respectively 2.76YLD, 2.70YLD and 2.31 YLD per casualty). Cyclists injured in a crash without a motor vehicle showed the lowest average burden of injury per casualty (1.73YLD). Also in the study of Weijermars et al., the lifelong burden of injury per casualty was highest for occupants of motorized vehicles (respectively 10.91YLD for mopeds, 10.45YLD for cars and 10.17YLD for motorcycles).

Dhondt et al. (2013) also compared the burden of injury per distance travelled for men and women and for different age groups. For most travel modes, the burden of injury per distance travelled was higher for men than for women. The only exception was the lifelong YLD/km for cyclists, which was slightly higher for women than for men. Regarding age, pedestrians and cyclists showed the highest burden of injury per distance travelled (YLD/km) among 0-14 year olds, whereas for motor-vehicles YLD/km was highest among 15-24 year olds and for motorcyclists YLD/km was highest amongst the 25-34 year olds. Lapostolle et al (2009) estimated the burden of injury for the Rhone region in France and compared the YLD rate (YLD per inhabitant) for men and for women and for different age groups. They found that YLD rates were higher for men (191 per 100,000 compared to 73 per 100,000 for women). For both genders the maximum value was observed for the 15-24 year-old age group (551 per 100,000 for men and 166 per 100,000 for women). Weijermars et al. (2016) compared YLD values per casualty for different age groups and found that the average YLD per casualty decreased with age as a result of a decreased life expectancy.

Lapostolle et al (2009), Tainio et al (2014) and Weijermars et al. (2016) also provide information on the burden of injury for different types of injuries. According to Lapostolle et al. and Tainio et al. intracranial injuries, spinal cord injuries and fractures account for the largest burden of injury (YLD). Weijermars et al. (2016) used another classification of injuries and found that concussion, 'other skull-brain injury', fractures in knees, lower legs and ankles, and spinal cord injuries were the major contributors to the burden of injury. Noteworthy, the share of spinal cord injuries in the total burden of all serious road traffic injuries was of about 9% while less than 1% of all casualties had spinal cord injuries.

Polinder et al. (2012) investigated the relation between injury severity and DALYs in the Netherlands by comparing the respective contribution of several groups of patients – based on injury severity – to the global burden of injury and concluded that mild injuries (only treated by a physician outside the hospital or at an emergency department) accounted for 37.3% of the overall burden of injury (expressed in DALY). When expressed in YLDs, the authors also observed that patients only treated by a general practitioner accounted for only 2% of the total amount of YLDs, patients treated only in emergency services accounted for 32% and that permanent limitations of hospitalised casualties accounted for more than half of the total amount of YLDs. More recently, Polinder et al. (2015) assessed the burden of road traffic injuries in terms of DALYs both by hospitalization status and by MAIS cut-off point (severity) in the Netherlands. The largest proportion of DALYs was related to fatalities (37%), followed by admitted MAIS 2 injuries (25%), Emergency department treated injuries (not admitted to hospital afterwards, 16%) and admitted MAIS 3+ injuries (18%) while admitted MAIS 1 injuries only accounted for 4% of DALYs. The burden was the highest among cyclists with 39% of total DALYs. More than half of all bicycle related DALYs were MAIS 2+ injuries while car occupants were responsible for 26% of all DALYs, primarily caused by fatalities (66%). Polinder et al. (2015) concluded that only 54% of all DALYs are captured in case only MAIS3+ casualties and fatalities are taken into account. They stated that, from a burden of disease perspective, hospital admission MAIS 3+as cut-off to define serious road traffic casualties is not recommended.

Although studies consistently showed that traffic crash injuries lead to a substantial loss of health, Weijermars and colleagues (2014) noted that psychological outcomes, such as PTSD, are typically not included in the calculation of the burden of injury which may lead to its underestimation. According to Haagsma and colleagues (Haagsma et al., 2011), considering PTSD would indeed lead to an increase of 53% in the burden of injury.

3.6.2 Key findings

- Road traffic injuries are a major cause of injury death and disability
- The majority of the health burden of serious traffic injuries in the Netherlands can be attributed to non-fatal injuries. YLDs account for more than 60% of all DALYs. MAIS3+ injuries account for about one fifth of the DALYs. Worldwide the burden of injury is much larger for fatal injuries than for non-fatal injuries.
- The majority of the burden of non-fatal injuries is due to lifelong disability
- The burden of (non-fatal) injury varies by transport mode, age, sexe and type of injury:
    - The burden of injury per distance travelled is highest for motorized two-wheelers and the lifelong burden of injury per casualty is highest for occupants of motorized vehicles
    - For most transport modes, the burden of injury per distance travelled is higher for men than for women
    - The YLD per casualty decreases with age as a result of a decreased remaining life expectancy
    - Intracranial injuries, spinal cord injuries and fractures account for the largest burden of injury (YLD).
- Psychological consequences, such as PTSD are typically not included in the calculation of the burden of injury, which may lead to its underestimation.

3.7 CONCLUSION

The literature review shows that road traffic injuries can have large functional, psychological, and socio-economic consequences for casualties and that they also create a burden to society as a whole. According to the Global Burden of Disease Study 2013 (Haagsma et al., 2016), 29.3% of the burden of injury (expressed in Disability Adjusted Life Years (DALYs)) is caused by road injuries. Worldwide, road traffic injuries account for 64.1 million Years of Life lost (YLL) and 8.6 million Years Lived with Disability (YLD).

Consequences for individual casualties relate to all levels of the human functioning (impairments, activity limitations and participation restrictions) distinguished of the ICF and may also lead to psychological disorders. Reported functional consequences include pain, fatigue, mobility problems and problems carrying out daily activities. The most common psychological consequence of being involved in a crash appears to be Post Traumatic Stress Disorder (PTSD). Other common psychological consequences are major depressive disorders, anxiety, Specific Driving Phobia and Acute Stress Disorder (ASD). Socio-economic consequences include an impact on the everyday life of the family, leisure activities and social life, as well as sick leave and employment and employability.

Reported (long-term) impairments and other types of disabilities differ considerably between studies, depending on the characteristics of the casualties (e.g. injury severity, admitted vs. emergency care), the duration of the follow-up and the type of disabilities that are taken into account. Reported prevalence of medical impairment (observed problems in body function or structure, see Chapter 2) varies for example between 11% and 92% whereas self-reported prevalence of disabilities (self-reported impairments, activity limitations and/or participation restrictions) varies between 11% and 80% according to the most recent review. Reported prevalence of PTSD one year post crash varies between 2% and 33%. Prevalence of sick leaves of 6 months or more varies between 24% and 32%.

Types of injuries that are relatively often related to long term disabilities and a high burden of injury include injuries to the lower extremities (fractures), head injuries (intracranial injuries), spinal cord injuries, hip injuries (fractures) and complex/multiple injuries. Travel modes that are linked to a relatively high prevalence of long-term disabilities are pedestrians and motorcyclists. Other personal and environmental factors that have an effect on health impacts are

- Age: prevalence of physical health impacts is lower for younger casualties,
- Gender: women experience more physical and psychological consequences than men),
- Mental and psycho-social factors:
- Comorbidity:,
- Socio-economic status and education level:

In addition, compensation process, treatment in the hospital, and crash circumstances are mainly relevant for psychological consequences.

Finally, studies quite consistently show that the risks of functional, psychological and socio-economic consequences increase as a function of the injury severity, although severity of injuries appears to have only little impact on psychological consequences. However, minor injuries, like strain injuries to the spine, may also have large long-term consequences. Moreover, as less severe injuries are much more common than severe ones, they are responsible for a high percentage of disabilities and consequently represent a large share in the burden of injury. Polinder et al. (2015) showed that in the Netherlands, only 54% of all DALYs are captured in case only fatalities and MAIS3+ casualties are included.

4 Case studies

Health impact of serious road traffic injuries in a number of EU countries

This chapter discusses information on health impacts based on six additional case studies. None of the case studies described offers a perfect overview of the consequences of different types of road traffic injuries on human functioning. However, each of them provides some useful insights.

Some of the SafetyCube partners have access to additional studies/data on impacts of injuries obtained in road traffic crashes. This chapter discusses the results of these studies. Please note that the data was collected within the framework of studies – national or international – that have been conducted independently of the SafetyCube project and that have been made available for use within this project. The budget and duration of SafetyCube did not allow the collection of additional data.

4.1 SPAIN

The Spanish study on Health Impacts of Road traffic crashes is a nationwide household survey, specifically focussed on disability caused by road traffic collisions in Spain. The objective of this study is to describe disabilities and impairments (and to estimate the Years Lost for Disability) due to road traffic accidents. This section summarizes the main health impacts of traffic injuries, regardless of the type or seriousness of the injury. These analyses have been done specifically for SafetyCube.

4.1.1 Study design

The Spanish study on Health Impacts of Road traffic crashes is a cross-sectional study using the Spanish National Disability Survey 2008 (EDAD 2008) as a data source. The EDAD 2008 survey was based on a two-stage, stratified sampling design, with the first-stage units being census sections and the second-stage units being main family dwellings. The data was self-reported through a personal interview. One member of each household was interviewed as the main informant.

A sample size of 96,075 households was established (out of 18 millions). Response was obtained from 91,846 households (overall response rate of 97%), on 213 626 subjects, including 22,795 disabled persons, 473 of whom were disabled due to a traffic crash. Post-stratification weights were used in order to extrapolate the results to the Spanish population.

Participants included in the study

Respondents who participated reported some kind of disability caused by a road traffic collision (N=473 over the age of 5 years; 47% are women).

EDAD does not collect any information about the type of crash, the vehicle or the circumstances of the collision. All types of injury are included in the study; no data were obtained to specify type and severity of injuries.

Instruments for determination of consequences

Disability is defined as an important limitation to carrying out everyday activities that have lasted, or are expected to last, for more than one year, and whose origin is impairment. And **impairment** is understood to be any loss or anomaly of an organ, or of the function of that organ, including psychological impairments.

The EDAD questionnaire was used and the results were related to the ICF model.
Apart from questions about socio-demographic characteristics, each person answered a catalogue of 44 questions over eight domains: 1. Vision; 2. Audition; 3. Communications; 4. Learning and application of knowledge and performance tasks; 5. Mobility; 6. Self-care; 7. Domestic life; 8. Interaction and interpersonal relationships. Moreover, they were asked about medical conditions, diagnoses, professional life, education, discrimination, social contacts, accessibility and main caregivers.

4.1.2 Results

According to the EDAD questionnaire, in 2011, 473 reported having a disability due to traffic crash. Post-stratification weights were used in order to extrapolate the results to the Spanish population. **78,692 residents in Spain older than 5 years (0.17% of the population) had impairments caused by road traffic collision (traffic impairment)**; 42,481 were men and 36,211 were women. Table 4-1 shows the distribution of these men and women according to their age group.

Table 4-1 Men and women who reported having an impairment caused by road traffic collision according to age group (N=473. Post-stratification weights were used)

	Men		Women		Total	
Age	**N**	**%**	**N**	**%**	**N**	**%**
6 - 18 years	491	1.2	123	0.3	614	0.8
19-34 years	7,164	16.9	4,897	13.5	12,062	15.3
35-64 years	27,764	65.4	19,887	54.9	47,651	60.6
More than 65 years	7,061	16.6	11,303	31.2	18,364	23.3
Total	**42,481**	**100**	**36,211**	**100**	**78,691**	**100**

Respondents aged from 35 to 64 years presented the highest percentage of people impaired because of road traffic collision, for both men and women. The percentage of men having traffic-caused impairment is higher than that of women in all the age groups, with the exception of those older than 65 years.

Impairment can be caused by several reasons (congenital, work accident, traffic accident, etc.) and can cause several limitations in different domains (vision, audition, mobility, etc.). Table 4-2 shows the number of disabilities (or limitations) caused by road traffic injuries to each impaired men and women. Only participants with impairments caused by traffic have been selected. Table 4-3 shows the type of disabilities (or limitations) caused by road traffic injuries.

Table 4-2 Number of disabilities presented in men and women who reported having an impairment caused by road traffic collision. (N=473. Post-stratification weights were used)

	Men		Women		Total	
Number of disabilities	N	%	N	%	N	%
1 or 2	10,382	30.3	8,448	35.3	18,830	32.4
3 to 5	8,434	24.6	6,956	29.1	15,389	26.5
6 to 9	6,722	19.6	5,611	23.5	12,333	21.2
10 to 13	2,980	8.7	1,657	6.9	4,637	8
14 or more	5,718	16.7	1,228	5.1	6,946	11.9
Total	**34,236**	**100**	**23,899**	**100**	**58,135**	**100**

Table 4-3 Types of disabilities presented in men and women who reported having an impairment caused by road traffic collision. (N=473. Post-stratification weights were used)

	Men		Women		Total	
Type of Disability	**N**	**%**	**N**	**%**	**N**	**%**
Vision	4,285	12.5	1,296	5.4	5,582	9.6
Audition	2,977	8.7	1,174	4.9	4,151	7.1
Comunication	6,160	18	1,570	6.6	7,730	13.3
Mobility	26,765	78.2	19,408	81.2	46,173	79.4
Selfcare	12,730	37.2	8,154	34.1	20,884	35.9
Home life	17,039	49.8	16,346	68.4	33,385	57.4
Relationships	4,160	12.2	1,301	5.4	5,462	9.4
Total	**34,236**		**23,899**		**58,135***	

* One person can have disabilities from more than one type, which is the reason why this is not equal to the addition of each type of disability

Most of disabled men and women presented more than one or two limitations (70%; 65%). It is remarkable how 24.6% of men and 29.1% of women reported between 3 and 5 limitations, and how more than 16% of men presented more than 14 limitations. In both men and women disabilities related to mobility and home life are the most prevalent between people impaired because of road traffic collision. One person could have more than one disability of the same type (vision) and also disabilities of different types. Table 4-4 shows this information in more detail.

Table 4-4 Types of disabilities presented in men and women who reported having an impairment caused by road traffic collision(N=473. Post-stratification weights were used)

	Men		Women		Total	
Type of Disability	**N**	**%**	**N**	**%**	**N**	**%**
Only Vision	1,605	4.7	593	2.5	2,198	3.8
Only Audition	0	0	0	0	0	0
Only Comunication	1,083	3.2	0	0	1,083	1.9
Only Mobility	7,513	21.9	5,198	21.7	12,711	21.9
Only Selfcare	480	1.4	217	0.9	698	1.2
Only Home life	726	2.1	2,343	9.8	3,070	5.3
Only Relationships	0	0	0	0	0	0
More than one disability	22,828	66.7	15,547	65.1	38,375	66
Total	**34,236**		**23,899**		**58,135***	

* One person can have disabilities from more than one type, which is the reason why this is not equal to the addition of each type of disability

About two third of the people impaired because of road traffic accidents presented disabilities related to more than one domain. In both men and women, around 21% presented only disabilities related to mobility.

According to the EDAD questionnaire 47,414 persons reported only one impairment while 6,710, 2,932 and 1,079 persons reported two, three or four impairments caused by road traffic injury, respectively. Table 4-5 shows the total impairments of each type reported by men and women who reported having limitations due to road traffic.

Table 4-5 Impairments reported by men and women who reported having limitations caused by road traffic collision(N=473. Post-stratification weights were used)

	Men		Women		Total	
IMPAIRMENT	**N**	**%**	**N**	**%**	**N**	**%**
Profound and severe intellectual impairment	312	0.7	134	0.5	446	0.6
Moderate intellectual impairment	641	1.4	0	0.0	641	0.9
Mild intellectual impairment	371	0.8	0	0.0	371	0.5
Borderline intelligence	155	0.3	0	0.0	155	0.2
Dementia	255	0.6	925	3.3	1,180	1.6
Mental illness	1,216	2.7	0	0.0	1,216	1.6

Other mental and behavioural disorders	2,445	5.3	355	1.3	2,800	3.8
Total blindness	602	1.3	97	0.3	699	0.9
Poor eyesight	3,948	8.6	1,392	5.0	5,340	7.2
Postlocution deafness	122	0.3	0	0.0	122	0.2
Hard of hearing	1,759	3.8	1,174	4.2	2,933	4.0
Balance disorders	420	0.9	0	0.0	420	0.6
Muteness (not through deafness)	0	0.0	0	0.0	0	0.0
Difficult or incomprehensible speech	2,553	5.6	277	1.0	2,830	3.8
Head	0	0.0	0	0.0	0	0.0
Spinal column	6,475	14.1	8,107	28.9	14,582	19.7
Upper limbs	4,965	10.8	3,979	14.2	8,944	12.1
Lower limbs	10,229	22.3	7,126	25.4	17,355	23.5
Paralysis of an upper limb	685	1.5	210	0.7	895	1.2
Paralysis of a lower limb	307	0.7	273	1.0	580	0.8
Paraplegia	2,949	6.4	1,325	4.7	4,274	5.8
Tetraplegia	2,324	5.1	254	0.9	2,578	3.5
Motor control and/or muscular tone disorders	1,806	3.9	1,138	4.1	2,944	4.0
Other impairments of the nervous system	729	1.6	836	3.0	1,565	2.1
Respiratory system	92	0.2	0	0.0	92	0.1
Genitourinary system	192	0.4	294	1.0	486	0.7
Haematopoietic system and immune system	0	0.0	194	0.7	194	0.3
Impairments not classified elsewhere	306	0.7	0	0.0	306	0.4
Total	**45,860**	**100.0**	**28,087**	**100.0**	**73,947**	**100**

* One person can have more than one impairments caused by a RTC.

PHYSICAL AND PSYCHOLOGICAL CONSEQUENCES

Table 4-6 to Table 4-14 describe some different physical and psychological consequences suffered by men and women with impairments due to road traffic injuries. These negative consequences are related to three different domains: health status, discrimination and care conditions.

Health

Table 4-6 Self perceived health status reported by men and women who reported having limitations caused by road traffic collision(N=473. Post-stratification weights were used)

	Men		Women		Total	
Self-perceived health status	**N**	**%**	**N**	**%**	**N**	**%**
Very good	909	2.7	217	0.9	1,126	1.9
Good	12,122	35.4	8,013	33.5	20,135	34.6
Regular	13,692	40	9,105	38.1	22,796	39.2
Bad	6,571	19.2	5,539	23.2	12,110	20.8
Very bad	943	2.8	1,026	4.3	1,968	3.4
Total	**34,236**	**100**	**23,899**	**100**	**58,135**	**100**

Table 4-7 Impairments reported by men and women who reported having limitations caused by road traffic collision(N=473. Post-stratification weights were used)

	Men		Women		Total	
Chronic Conditions	**N**	**%**	**N**	**%**	**N**	**%**
Yes	25,755	75.2	17,938	75.1	43,693	75.2
No	8,482	24.8	5,961	24.9	14,442	24.8
Total	**34,236**	**100**	**23,899**	**100**	**58,135**	**100**

Table 4-8 Impairments reported by men and women who reported having limitations caused by road traffic collision(N=473. Post-stratification weights were used)

	Men		Women		Total	
Chronic depression or anxiety	**N**	**%**	**N**	**%**	**N**	**%**
Yes	4,878	14.2	3,848	16.1	8,726	15.0
No	29,358	85.8	20,051	83.9	49,409	85.0
Total	**34,236**	**100**	**23,899**	**100**	**58,135**	**100**

More than 50% of men and women reported having regular, bad or very bad health status. More than 24% of disabled men and women reported having at least one chronic condition and around 15% reported having chronic depression or anxiety.

Discrimination

Table 4-9 Discrimination suffered by men and women who reported having limitations caused by road traffic collision(N=473. Post-stratification weights were used)

	Men		Women		Total	
Discrimimination	**N**	**%**	**N**	**%**	**N**	**%**
Never	28,006	81.8	19,037	79.7	47,043	80.9
Sometime	4,389	12.8	3,102	13	7,491	12.9
Many times	781	2.3	1,288	5.4	2,069	3.6
Constantly	1,061	3.1	472	2	1,532	2.6
Total	**34,236**	**100**	**23,899**	**100**	**58,135**	**100**

Table 4-10 Problems report by men and women who reported having traffic-caused limitations when they travelling by public transport(N=473. Post-stratification weights were used)

	Men		Women		Total	
Problems travelling in Public Transport	**N**	**%**	**N**	**%**	**N**	**%**
Yes	5,957	17.4	5,126	21.5	11,084	19.1
No	28,279	82.6	18,772	78.5	47,052	80.9
Total	**34,236**	**100**	**23,899**	**100**	**58,135**	**100**

Table 4-11 Problems reported by men and women who reported having traffic-caused limitations when they travel in public space(N=473. Post-stratification weights were used)

	Men		Women		Total	
Problems walking through the street	**N**	**%**	**N**	**%**	**N**	**%**
Yes	15,320	44.7	10,870	45.5	26,190	45
No	18,917	55.3	13,029	54.5	31,945	55
Total	**34,236**	**100**	**23,899**	**100**	**58,135**	**100**

Table 4-12 Men and women who reported having limitations caused by road traffic collision that had to change their working situation because of their disabilities(N=473. Post-stratification weights were used)

	Men		Women		Total	
Modification of working situation	**N**	**%**	**N**	**%**	**N**	**%**
Yes	22,567	65.9	7,339	30.7	29,906	51.4
No	11,021	32.2	16,236	67.9	27,257	46.9
No answer	648	1.9	323	1.4	972	1.7
Total	**34,236**	**100**	**23,899**	**100**	**58,135**	**100**

Table 4-9 shows that 3% of men and 2% of women reported being constantly discriminated because of their disabilities. Moreover, 15.1% and 18.4% reported having been discriminated some or many times. More than 17% and 21% of disabled men and women presented any problem of accessibility when travelling by public transport, and around the 45% presented any problem of accessibility when travelling in public space. It is remarkable how about two third of men had to change their working activity or occupation as a consequence of the disability.

Care conditions

Table 4-13 Disabled men and women who reported to receive some personal care because of their limitations (N=473. Post-stratification weights were used)

	Men		Women		Total	
Personal care	**N**	**%**	**N**	**%**	**N**	**%**
Yes	14,275	41.7	12,539	52.5	26,814	46.1
No	19,962	58.3	11,360	47.5	31,321	53.9
Total	**34,236**	**100**	**23,899**	**100**	**58,135**	**100**

Table 4-14 Daily hours of care received by men and women who reported having limitations caused by road traffic collision(N=473. Post-stratification weights were used)

	Men		Women		Total	
Daily hours of care (media)	**N**	**%**	**N**	**%**	**N**	**%**
Zero	192	1.3	0	0	192	0.7
1 to 3 hours	5,214	36.5	5,077	40.5	10,291	38.4
4 to 6 hours	1,344	9.4	872	7	2,215	8.3
More than 6 daily hours	7,525	52.7	6,590	52.6	14,115	52.6
Total	**14,275**	**100**	**12,539**	**100**	**26,814**	**100**

Almost the half of the respondents impaired by traffic injuries reported that they need some help in their self-care. The majority of those needing some help received more than 6 hours of daily care.

4.1.3 Conclusions

In 2011 an estimated number of 78,692 persons in Spain had an impairment due to road traffic collision, which represents 0.17% of the Spanish population older than 5 years. The age group 35 to 64 years presented the highest percentage of people impaired because of road traffic collision; although the percentage of impaired women older than 65 years is also relatively high. Most impaired people reported they had only one impairment (loss or anomaly of an organ or its functionality) due to road traffic collision but more than 2 limitations in different domains (vision, audition, mobility, etc.). Most of impairments reported were related to limbs and locomotion system and the consequent limitations reported are related to mobility and home life.

One in four impaired persons had a bad or very bad self-perceived health status. Almost half of the disabled men and women reported accessibility problems when travelling in public space. The impact of the impairments on the working activity is strong, mainly among men, where about two third had to change their working activity or their occupation after sustaining the disability. Care is needed by half of the disabled men and women.

4.2 FRANCE

The ESPARR study is a prospective cohort follow-up study that aims to determine long term health impacts of road traffic crashes. Road traffic casualties that seek medical care in health facilities in the Rhône administrative area are followed up to five years. Study results have been published in several journal articles (Fort et al., 2011; M Hours et al., 2010, 2013, 2014, Khati et al., 2013, 2014; Nash et al., 2014; H. T. Nhac-Vu et al., 2011, 2012, 2014; Tournier et al., 2016). This section summarizes the main health impacts, focussing on MAIS3+ casualties.

4.2.1 Study design

The ESPARR prospective cohort follow-up study is based on the Rhône administrative area Registry of Road Traffic Casualties, which records all casualties seeking medical care in public and private health facilities in the Rhône administrative area after a crash, including all modalities and whatever their seriousness and age. The study was not designed to be representative for France.

The inclusion criteria of the cohort are those of the Registry:

- having been in a road traffic crash involving at least one mechanical means of transport;
- the crash having occurred in the Rhône administrative area (population of 1,6 million inhabitants);
- having been admitted to one of the area’s hospital emergency departments;
- Being a resident in the Rhône area.

At baseline, all crash casualties were asked to agree to a face-to-face interview with a psychologically trained interviewer. Medical data were collected from the medical records, each lesion was then coded using the AIS by the medical doctor of the Rhône Registry for road casualties in order to obtain a complete description of the lesions, and to characterize the severity of the accident with the MAIS, NISS, and IIS .

At follow-up (six month, one year, two years, three years and five years) a postal auto-questionnaire was sent to all casualties; when possible it was filled out during a face to face interview, during the medical examination for the most severe injured casualties (MAIS 3+). In case of non-response (either by postal way or by face to face interview), phone interviews were done.

Participants included in the study

Persons (N=1168) over the age of 16 years including 320 serious injured persons (MAIS ≥3; 77.5% male) were included and also 204 persons under the age of 16 years, including 113 with serious injury (MAIS ≥3; 69.6% male). The response rate varies between different follow ups (61% at six month, 85 % at one year, .82 % at two years, 72% at three years, 67% at five years)

Instruments for determination of consequences

The following instruments were used to collect data on the following domains: Subjective health, Subjective evaluation of Pain, Sequelae, Functional impact in everyday life, Complications post-accident, Duration of stay at hospital or rehabilitation ward, Post-concussion syndrome, impact on family and everyday life, Impact on work and Interruption of studies.

1. WHOQOL-bref to evaluate the impact on the quality of life (for children aged 14-15 years and adults) and the Child Health Questionnaire—Parents Form 50 (CHQ-PF50) for children < 14 years))
2. Post-Traumatic CheckList Scale (PCLS) (for the evaluation of PTSD) at six months and one year after the accident:
3. General Health Questionnaire (12 items) (GHQ-12) (measure of depression)
4. *Only for AIS3+ or AIS on Head 2+ : medical examination*
   - ✓ ASIA impairment scale (AIS3+)
   - ✓ Functional independence measure (FIM) for MAIS3+
   - ✓ Glasgow Outcome Scale (GOS)
   - ✓ Neurobehavioral Rating Scale-Revised (NRS-R) and trail making test (psychocognitive evaluation)
5. *Only for whiplash adults :*
   - ✓ Neck Pain and Disability Scale (NPDS).

For more information on these instruments, see Appendix A.

4.2.2 Results

Results of the study are presented for persons aged 16+ who sustained serious injury (MAIS3+). Sample size varies from 194 respondents after six months[18] to 276 respondents after a year.

Table 4-15 shows recovery, residual pain and persistence of sequelae for different time intervals.

Table 4-15 Proportion of adults (16+) with MAIS3+ injuries that fully recovered, that report residual pain and that report persisting sequelae

Follow-up period	% fully recovered	Residual pain	Persistence of Sequelae (pain excluded)	Post Traumatic Stress Disorder (PTSD)
At six months (n=194)	10.8 %	89.2%	75.3%	27.3%
At one year (n=276)	19.6%	84.9%	75.3%	20.3%
At three years (n=266)	25.9%	75.3%	64.1%	Not available
At five years (n=254)	34.6%	65.9%	Not available	Not available

[18] Response rate is relatively low after six months because routine reminders have not been sent out for this follow-up.

In general, the health impacts of road crashes decrease over time. Five years after the crash, about one third of the MAIS3+ casualties is fully recovered and almost two out of three MAIS3+ casualties report residual pain. Residual pain is reported more often than other sequelae and then Post Traumatic Stress Disorder (PTSD). Pain also influences everyday activities. About 20% of MAIS3+ casualties report impairment related to pain, three years after the crash.

Table 4-16 Proportion of adults (16+) with MAIS3+ injuries that fully recovered, that report residual pain and that report persisting sequelae

Quality of life	1 year (n=254)	3 years (n=231)	5 years (n=214)
Bad or very bad general Quality of life	14.5%	6.5%	7.0%
Unsatisfied health satisfaction	35.9%	19.9%	15.4%
Physical domain[19] (score, max=100, mean (SD))	64.3 (22.2)	72.0 (20.5)	71.6 (20.5)
Mental domain[20] (score, max=100, mean (SD))	62.4 (18.9)	67.4 (17.2)	66.5 (17.9)
Social domain[21] (score, max=100, mean (SD))	69.8 (19.3)	73.5 (18.8)	72.9 (17.6)
Environmental domain[22] (max=100, mean (SD))	65.3 (17.5)	71.5 (16.2)	69.8 (15.5)

The tendency of a further improvement over time was also observable from the reduced proportion of persons reporting (very) bad overall quality of life; 14.5% reported a bad or very bad overall quality of life one year after the crash, compared to 6.5% three years post-crash (Table 4-16). Between three and five years this percentage did not further improve. An improvement was also observed between one and three years follow-up for specific domains of quality of life (physical, mental, social, environmental), without further improvement after 3 years. When the scores from the different domains are compared, scores appear to be lower for the mental domain, indicating that respondents encounter slightly more mental problems.

The ESPARR study also included persons with minor injuries (MAIS <3). For those who sustained minor injuries, 67.5% were fully recovered after three years; almost twice as many as those with MAIS3+. Moreover, these casualties less often report residual pain (37.0% compared to 65.9% 5 years post-crash) and persistence of sequelae (28.8% compared to 64.1% five years after the crash). Quality of life improves over time and is always better among the less seriously injured group. The difference between the two groups is particularly substantial in the physical domain. The mean health score for casualties MAIS<3 five years after the crash was 78.0 compare to 71.6 for MAIS3+ casualties.

[19] Physical capacities such as pain, restriction of mobility, sleep, energy
[20] Psychological capabilities such as self-esteem, depression
[21] Social relations such as friends, sexuality, social support
[22] Financial resources, safety and environmental concerns, proximity of healthcare settings.

Table 4-17 comparison for adults (16+) with MAIS1-2 and MAIS3+ injuries at five years after the accident

		Social and familial impact at five years				
		MAIS1-2		MAIS3+		
		N=554		N=214		p
familial status	NR	1	0%	0	0%	ns
	Single	152	27%	65	30%	
	Common law, married	332	60%	119	56%	
	Separated, divorced, widowed	69	12%	30	14%	
Impact on family life and emotional stability						p<0,0001
	NR	25	5%	11	5%	
	No	461	83%	129	60%	
	Yes	68	12%	74	35%	
financial difficulties						p=0,003
	No	493	89%	181	85%	
	Yes	28	5%	25	12%	
need human help for daily life						p=0,01
	NR	4	1%	1	0%	
	fully independent	545	98%	203	95%	
	partial assistance	4	1%	7	3%	
	total assistance	1	0%	3	1%	
need material support						
	crutches	12	2%	17	8%	p<0,0001
	Wheelchair	1	0%	6	3%	p=0,004

At five years after the crash, 10% of seriously injured people are considered unable to work and 7% is retired before the legal age (see figure 4-1). A high percentage of MAIS3+ injured people says that their affective and family life is impacted by the accident. One out of ten MAIS3+ casualties has financial problems (

Table 4-17).

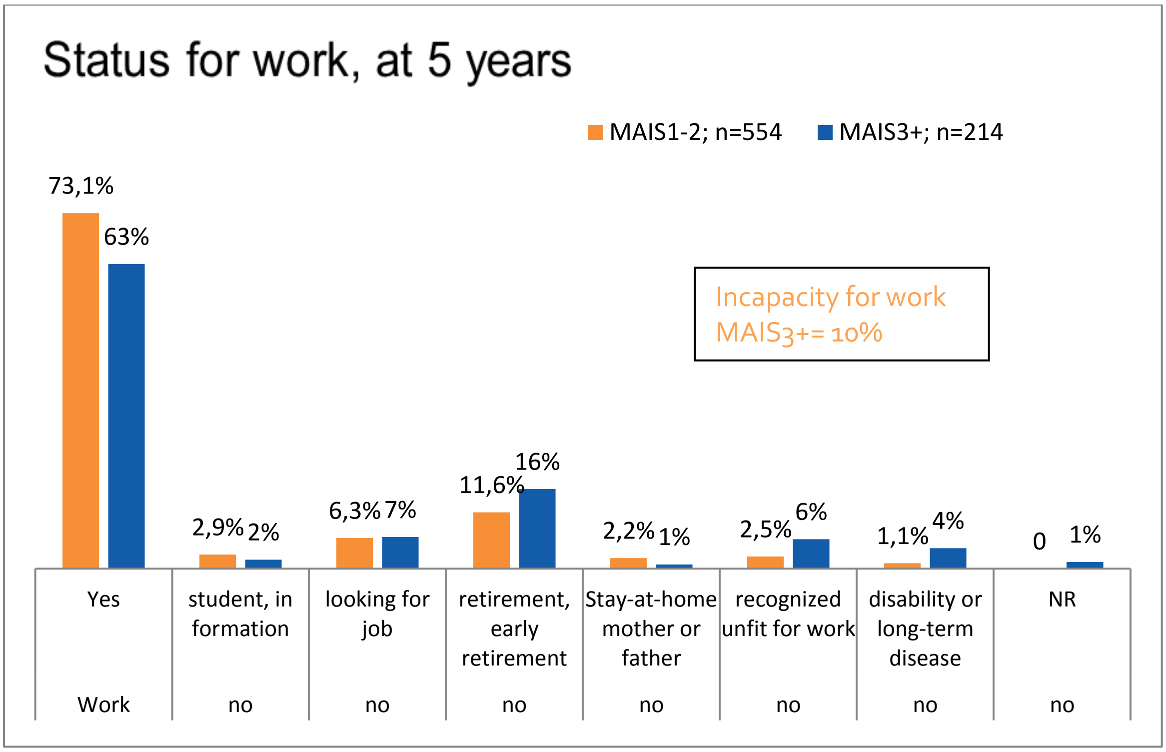

Figure 4-1 status for work, at 5 years after the accident; Proportion of adults (16+) with MAIS3+ injuries and MAIS1-2 injuries what do you mean by student, information (second category)? And what does the no mean on the x-axis? No retirement? Not looking for job?

Analysis by traffic mode

At one year post-crash, there is a significant difference ($p < 0.001$) between the different types of road? users regarding the presence of a post-traumatic stress disorder: four-wheeled motor vehicle users and pedestrians (including inline skaters and push scooters) suffered more frequently from PTSD than two-wheeled motor vehicle users, or bicyclistsbicyclists.

Whereas the percentage of casualties that recovered one year after the crash did not differ in a statistically significant way between traffic modes one year after the crash, there were significant differences between traffic modes two and three years after the crash. A higher proportion of pedestrians (followed by powered two-wheelers (2RM) were not recovered after three years.

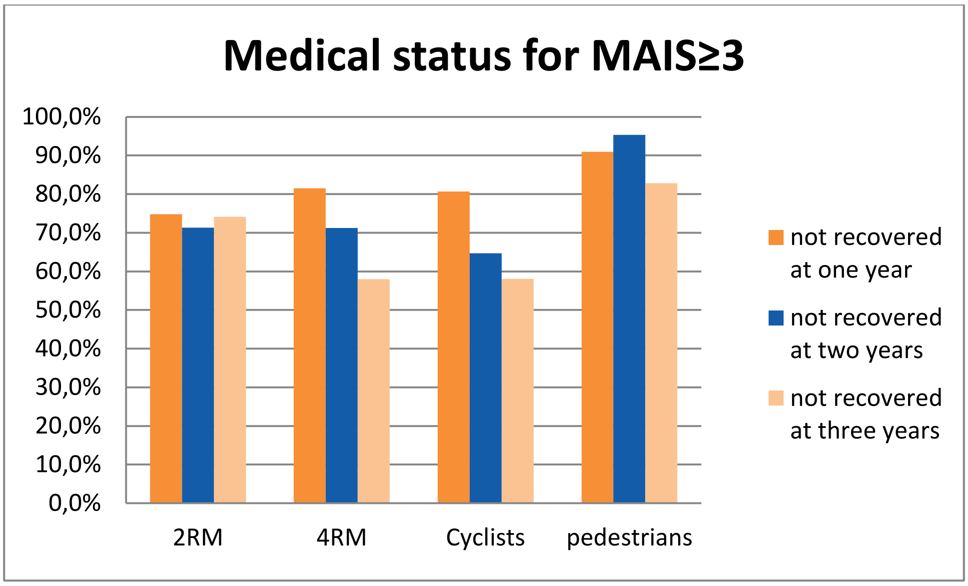

Figure 4-2 Recovery by transport mode one, two and three years post crash.

Traumatic brain injuries

Special attention was paid to compare the outcome of those who sustained severe traumatic brain injury (TBI), mild TBI or no TBI but other serious injuries after one, three and five years on several indicators of long term consequences including depression. Table 4-18 shows the results.

Table 4-18 Proportion of persons who sustained severe traumatic brain injury (TBI), mild TBI or no TBI but other serious injuries after one, three and five years and their scores on several indicators of long term consequences including depression.

Information on health	Severe TBI	Mild TBI	Other severe injuries
Presence of PTSD at one year	31.3%	23.6%	14.3%
At 3 years (n^1= 131;n^2=51;n^3= 46)			
Fully recovered (ns)	34.7%	31.4%	32.1%
Motor sequelae	28.6%	37.3%	38.9%
Psychocognitive sequelae	32.7%	27.5%	10.7%
Other neurological sequelae (except sensory sequelae)	22.4%	9.8%	9.2%
Depression (GHQ12-likert, mean(SD))	10.6 (2.5)	10.3 (4.3)	11.1 (4.4)
At 5 years (n^1= 131;n^2= 51;n^3= 46)			
Depression (GHQ12-likert, mean (SD))	10.1 (5.6)*	12.8 (6.0)	11.4 (4.8)

*p<0.01 with severe MAIS without TBI

For severe casualties (MAIS3+) at three years follow up, severe TBI are essentially suffering from cognitive and neurological sequelae, whereas severe casualties without TBI have essentially motor sequelae; the severe casualties with mild brain injury have both cognitive and motor sequelae. Severe TBI leads more frequently to bad (or very bad) QOL at three years or an unsatisfied health, but the difference is not significant (lack of power). At five years, based on the mean of the GHQ score, depression affects more severe casualties without TBI or with mild TBI than severe TBI.

4.2.3 Conclusions

The ESPARR study is a prospective cohort follow-up study that aimed to determine long term health impacts of road traffic crashes in the Rhône administrative area in France. From the study, it can be concluded that about one third of the MAIS3+ casualties are fully recovered five years after the road traffic crash. This implies that 2 out of 3 MAIS3+ casualties experience some health problems as a consequence of their injuries. Pain is more often reported than other sequelae and than PTSD. Three years post crash, three out of four MAIS3+ casualties report residual pain and one out of five casualties reports comprised impairment related to pain.

Most of Quality of life domains improve over time; generally within the first three years. Three years after the crash, 7% of the MAIS3+ casualties report a very bad or bad quality of life and 20% is unsatisfied with his or her health. Reported quality of life is a little lower on the mental health? domain than on the physical, social and environmental domain.

For severe casualties (MAIS3+) at three years, severe TBI is essentially suffering from cognitive and neurological sequelae, whereas severe casualties without TBI have essentially motor sequelae; the severe casualties with mild brain injury have both cognitive and motor sequelae. At five years, depression affects more severe casualties without TBI or with mild TBI than severe TBI.

The ESPARR study also included persons with minor injuries (MAIS <3). For those who sustained minor injuries, 67.5% was fully recovered three years after the crash; almost twice as much as those with MAIS3+. However, this implies that also for MAIS<3 casualties, one out of three casualties is not fully recovered three years after the crash.

4.3 UNITED KINGDOM

To understand the health impacts of road traffic crashes in the UK two separate data analyses were conducted. The first considers data collected as part of the PhD research thesis 'An Exploratory Study of Road Crash Survivors: Injury Outcomes and Quality of Life' (Barnes, 2006). This PhD research aimed to examine real effects of injury on survivors of road crashes and any effects on the family. The thesis consisted of a number of studies. One study was a follow-up of 50 participants who were seriously injured in road accidents and admitted to hospital because of their injuries.

The second uses data collected as part of the Impact of Injury study(Kendrick et al., 2011). This is a multi-centre study exploring the impact of unintentional injuries, including but not exclusively road traffic accidents.

Neither data set is fully representative nationally, but together they provide a useful insight into the impacts on quality of life of road users seriously injured in road crashes.

4.3.1 Study design

An Exploratory Study of Road Crash Survivors: Injury Outcomes and Quality of Life

Participants were recruited from two hospitals in the UK Midlands and were approached in the hospital to ask for consent for them to be included in the study. The main inclusion criteria were as follows:

- Participant had to have been admitted to the hospital after an injury was sustained in a road traffic collision;
- The participants had to be a vehicle occupant or a vulnerable road user;

- The collision had to have occurred on a public road undertaking normal everyday activities;
- Participants had to be aged between 18 and 70 years at the time of the collision;
- Participants were an in-patient when visited by the researcher;
- Participants needed to have telephone access for follow-up interviews.

The initial 30-40 minute baseline interview was then undertaken at the bedside, which asked for some background information related to areas such as home life, pre-existing conditions, education, employment, salary and the type of road user they were. Follow-up telephone interviews were conducted at three, six and twelve months, using the same interview layout as the baseline interview.

As shown in Table 4-19, a total of 50 participants were recruited over a five month period (39 male, 11 female) and the baseline interviews were usually conducted within 3 days of admission, although some were conducted after a greater number of days due to the serious nature of the injuries sustained.

Table 4-19 Age range and number of male and female participants in the study.

	MAIS <3	MAIS 3+	Total
Mean age (years)	41.5 (20-68)	34 (18-63)	
male	11	28	39
female	3	8	11

The participants' ages ranged from 18 to 68. From these 50 participants, 36 had a MAIS of 3 or greater. None of the participants stated they had pre-existing impairments of any kind.

The following instruments were applied in this study:

- EQ-5D+ cognition problems experienced across health domains (cognition, anxiety, pain, activities, self-care, mobility)
- SF-36v2 – Health Dimensions (physical function, role physical, bodily pain, general health, vitality, social function, role emotional, mental health)
- CES-D inventory for assessing depression. Assess symptoms from four factors (depressed affect, positive affect, somatic & retarded activity, interpersonal).

In addition to these, issues such as effect on employment, sick days, self-claimed impairment, insurance and litigation, financial burden and other major effects were considered at each follow-up.

Impact of Injury study

For this study, sampling criteria included being admitted to hospital, having no significant head injury (i.e. GCS15), age 16-70 years and consented within 3 weeks of their injury.

Participants initially completed a baseline questionnaire regarding pre-injury and injury quality of life (on the day of first recruitment) and then follow-up questionnaires were completed at 1, 2, 4 and 12 months to identify if and how they were still affected by their injury (e.g. pain/discomfort, recovery factors, time off work, litigation/compensation, health/social care use). Standardised tools were used at each follow-up including the following , Impact of Event Scale, Trauma Screening Questionnaire, Change In Outlook Scale, the Crisis Support Scale, List of Threatening Events and a visual analogue pain scale to understand the impact of the injuries even further (see Kendrick et al., 2011 for a complete list of measures).

Participants were recruited from hospitals in four locations in the UK. The total number of participants was 668, of which 200 people sustained injuries on the road with 114 recorded as traffic injuries occurring on the road (age range from 17 to 70 years). Table 4-32 shows the split of these 114 participants according to the seriousness of their injuries; with 38 (33%) participants having a MAIS 3+ injury.

Table 4-20 Age range and number of male and female participants with road traffic injuries

	MAIS < 3 (n=76)	MAIS 3+ (n=38)	Total
Mean age (sd)	40 (sd 16.6)	44 (sd 17.3)	
Male	52 (68%)	25 (66%)	77 (68%)
Female	24 (32%)	13 (34%)	37 (32%)
Total	76	38	114

4.3.2 Results

Please note that the results of both studies are only indicative because of the small sample sizes.

An Exploratory Study of Road Crash Survivors: Injury Outcomes and Quality of Life

This section outlines the main results of this study for the 50 road accident casualties who participated in the study. Results are presented separately for the 36 casualties with MAIS3+ injuries (mean age 34.3 SD 12.3; males n= 28; females n=8) and the 14 with MAIS injuries of 1 and 2 (mean age 41.5 SD 15.5).

Table **4-21** shows how many questionnaires were completed at each follow-up by each original participant. After 12 months, 76% of the original participants completed a questionnaire. Little difference was found between those still filling out a questionnaire at 12 months who sustained MAIS<3 injuries and those who sustained more serious (MAIS3+) injuries (78% compared with 71%).

Table **4-21** Follow up - valid completed questionnaires at each time point.

	Baseline	3 months	6 months	12 months
MAIS<3	14	13	13	10
MAIS3+	36	33	30	28
Total	50	46	43	38

Table 4-22 shows the distribution of the respondents over travel mode. Over three quarters (78%) of the 50 participants were in a motor vehicle when they sustained their injuries. Motorcycle riders are a much larger proportion of the sample when considering serious injuries only (MAIS 3+) (33%) compared to when only minor injuries only are considered (14%).

Table 4-22 Mode of travel of participant at the time of the road traffic collision

Mode of travel	MAIS<3	MAIS3+	Total
driver	5	10	15
passenger	3	7	10
Motorcycle rider	2	12	14
cyclist	1	2	3
pedestrian	3	5	8
Total	14	36	50

When considering only participants with serious injuries (MAIS 3+), physical impairments were still being experienced by 67% of participants after 3 months, with this number dropping to 50% after 1 year (Table 4-23).

Table 4-23 Pain and impairment follow up time points (participants with MAIS3+ injuries only)

	Physical Impairment	Sensory Impairment	Pain
3 months (n=33)	25	11	27
6 months (n=30)	24	8	26
12 months (n=28)	18	4	17

For sensory impairments, the numbers drop from 30% at 3 months to 11% at 12 months. The drop appears to be greater between 6 and 12 months than it is between 3 and 6 months.

When considering recovery in general, 5 out of 10 MAIS<3 casualties, considered themselves to be fully recovered at 12 months, whereas 7 out of 28 of participants with MAIS 3+ injuries were considered completely recovered.

Using the CESD inventory for assessing depression and assessing symptoms from four factors (depressed affect, positive affect, somatic & retarded activity, interpersonal), scores were calculated at baseline (i.e. on first contact with the participant in the hospital) and then a 3, 6 and 12 months follow-up). The scores appeared to peak at the 3 month follow-up and then started to fall again until at the 12 month follow-up, where the score was found to be slightly lower than what it was at baseline (Table 4-24). A cut off score of 16 or above is used as an indicator / at risk of depression; higher scores indicate a higher clinical risk.

Table 4-24 Mean CESD depression scores at each follow-up

	MAIS <3	MAIS 3+
CESD score at baseline	19 (sd 10.5)	20.5 (sd 8)
CESD score at 3 months	24 (sd 12)	22 (sd 9)
CESD score 6 months	21 (sd 9)	21 (sd 8)
CESD score at 12 months	18 (sd 8)	18 (sd 8)

Also, it is interesting to note that the mean CESD score was greater at 3 months for those with less serious injuries (MAIS<3) than those with more serious (MAIS 3+) injuries. This may indicate possible frustration for those with less serious injuries who think they will recover from them quicker than they do compared with those with more serious injuries who expect their injuries to take some time to recover from.

To measure quality of life at baseline and each follow-up, the EQ-5D health questionnaire was used to measure problems experienced across five health domains (anxiety/depression, pain/discomfort, activities, self-care, and mobility). The ratings given across these five areas were combined to give a single utility summary score and the results are shown in Table 4-25 below. Ratings closer to '0' mean that participants have extreme problems across these areas, whereas ratings closer to '1' mean very few or no problems are experienced.

Table 4-25 EQ5D scores at various stages of follow-up

	MAIS <3	MAIS 3+
EQ5D score baseline* on day of interview not state prior to injury	0.44 (sd 0.21)	0.45 (sd 0.21)
EQ5D score 3 months	0.63 (sd 0.30)	0.52 (sd 0.23)
EQ5D score 6 months	0.70 (sd 0.25)	0.66 (sd 0.19)
EQ5D score 12 months	0.74 (sd 0.21)	0.72 (sd 0.21)

In general, the mean overall score was found to increase (i.e. get closer to 1) at each follow-up, with only minimal differences found between those with minor injuries and those with serious injuries (Table 4-25). For example, scores went up quicker with MAIS<3 injuries than withMAIS3+ (i.e. at 3 months), but by 12 months the scores were similar. However, some individual scores were still found to be low even at 12 months in both categories there was a significant difference between the EQ5D UK population norms and the EQ5D 12 month scores (t-test statistic -5.137, df 37 p<.001).

The SF-36v2 health survey involves asking participants a series of questions to measure their functional health and well-being in eight health domains (physical function, role physical, bodily pain, general health, vitality, social function, role emotional, mental health). These eight scales can be aggregated into two summary measures: the Physical (PCS) and Mental (MCS) Component Summary scores. The MCS and PCS are UK normalised scores with a mean of 50 and sd 10 with scores below the mean indicative of worse health than the general population and those above the mean having better health. The scores for these two measures in this study are outlined in **Table 4-26**. The PCS scores indicate that physical health was worse for the sample overall however MAIS3+ cases had a worse PCS at 12 months compared to the MAIS<3. In general the MCS was higher than expected for all injury severity categories although higher at baseline for the MAIS<3 compared to 12 months.

Table 4-26 PCS and MCS scores at baseline and after 12 months.

Column title	MAIS <3	MAIS 3+
PCS baseline	45 (sd 12)	45 (sd 12)
PCS 12 months	47 (sd 9)	40 (sd 14)
MCS baseline	58 (sd 7)	50 (10)
MCS 12 months	51 (sd 11)	52 (9)

Impact of Injury study

This section outlines the main results of this study for the 114 participants with road traffic injuries. Results are categorised by injury severity for the 38 casualties with MAIS3+ injuries and the 76 with MAIS injuries of 1 and 2.

Table 4-27 shows how many participants returned questionnaires at each follow-up point. At 12 months post injury, 60% of participants completed a questionnaire, with more participants with MAIS 3+ injuries completing the 12 month questionnaire than those with MAIS<3 injuries (68% compared with 55%).

Table 4-27 Completed questionnaires at each time point

	MAIS <3 (n=76)	MAIS 3+ (n=38)	Total
Baseline	76	38	114
1 month	55 (72%)	28 (74%)	83 (73%)
2 months	48 (63%)	28 (74%)	76 (67%)
4 months	47 (62%)	26 (68%)	73 (64%)
12 months	42 (55%)	26 (68%)	68 (60%)

One third of the 114 participants were in a motor vehicle at the time of their injury. The remainder mainly comprised motorcycle riders (30%) and vulnerable road users (i.e. cyclists and pedestrians, 27%). Motorcycle riders comprise the largest proportion of participants who sustained serious injuries (MAIS 3+) in the sample (34% of those with MAIS 3+ injuries).

Table 4-28 Mode of travel of participant at the time of injury.

Mode of travel	MAIS <3 (n=76)	MAIS 3+ (n=38)	Total
Driver	22 (29%)	6 (16%)	28 (25%)
Motorcycle rider	21 (27.6%)	13 (34%)	34 (30%)
Vehicle passenger	7 (9%)	2(5%)	9 (8%)
Cyclist	9 (12%)	7 (18%)	16 (14%)
Pedestrian	12 (15.8%)	3 (8%)	15 (13%)
Other road user	0 (0%)	1 (3%)	1 (1%)
Not known	5 (6.6%)	6 (16%)	11 (9%)
Total	76	38	114

When considering recovery in general, of those completing 12 month questionnaires, half (50%) of all participants with MAIS<3 and MAIS 3+ injuries considered themselves to have made a better recovery than they expected at 12 months. The distribution of recovery expectations was similar across the groups with MAIS<3 and MAIS 3+ injuries.

Table 4-29 Recovery expectations at 12 months follow-up

	MAIS <3 (n=42)	MAIS 3+ (n=26)
Recovery at 12 months – better than expected	21 (50%)	13 (50%)
Recovery at 12 months – as expected	8 (19%)	4 (15%)
Recovery at 12 months - unknown	3 (7%)	2 (8%)
Recovery at 12 months – worse than expected	10 (24%)	7 (27%)

Pain was measured at each follow up time point and at 12 months only 3 people in each of the MAIS severity groups stated they had no pain at the time of questioning.

The Hospital Anxiety and Depression Scale (HADS) is a fourteen item scale (a subscale with 7 items for depression and a subscale with 7 items for anxiety) used to measure symptoms of anxiety and depression. Table 4-30 shows the HADS subscale scores at each follow up time point. Cases of depression and anxiety were defined as a score >= 11 on each subscale respectively. Borderline depression and anxiety were defined as a score 8-10 on each subscale respectively.

Cases of anxiety and depression and borderline cases were most common one month post injury in both injury severity groups. The prevalence of anxiety and depression reduced over time, but had not reached baseline levels by 12 months post injury in either injury severity group.

Table 4-30 Prevalence of Hospital Anxiety and Depression Scale scores of >=8 at follow up time points

HADS	MAIS <3		MAIS 3+	
HADS Anxiety	**Case >=11**	**Borderline 8-10**	**Case >=11**	**Borderline 8-10**
Baseline (n=76 MAIS<3;38MAIS3+)	1 (1%)	3 (4%)	1 (2.6%)	4 (10.5%)
1 month (n=55 MAIS<3; 28 MAIS3+)	10 (18%)	11(20%)	6 (21%)	6 (21%)
2 month (n=48 MAIS<3; 28MAIS3+)	7 (8.5%)	7 (14.6%)	4 (14%)	5 (18%)
4 month (n=47 MAIS<3; 26 MAIS3+)	4 (8.5%)	7 (15%)	2 (8%)	5 (19%)
12 month (n=42 MAIS<3; 26MAIS3+)	3 (7%)	6 (14%)	5 (19%)	3 (11.5%)
Depression				
Baseline (n=76 MAIS<3; 38 MAIS3+)	0 (0%)	1 (1%)	0 (0%)	0 (0%)
1 month (n=55 MAIS<3; 28 MAIS3+)	10 (18%)	14 (25.5%)	5 (18%)	5 (18%)
2 month (n=48 MAIS<3; 28 MAIS3+)	4 (8%)	6 (12.5%)	4 (14%)	4 (14%)
4 month (n=47 MAIS<3; 26 MAIS3+)	2 (4%)	6 (13%)	3 (11.5%)	3 (11.5%)
12 month (n=42 MAIS<3; 26 MAIS3+)	1 (2%)	2 (5%)	2 (8%)	2 (8%)

The EQ-5D health questionnaire was also used to measure problems experienced across five health domains (anxiety/depression, pain/discomfort, usual activities, self-care, mobility), reported as the utility index score combining responses across the five domains. The EQ-5D questions were asked in relation to the day of questionnaire completion for follow up questionnaires and for the day prior to injury for the baseline questionnaire.

Table 4-31 Mean EQ5D scores follow-up time points.

EQ5D utility score	MAIS <3	MAIS 3+
EQ5D utility score baseline prior to injury (n=114)	0.94 (sd .16) (n=76)	0.96 (sd .09) (n=38)
EQ5D score 1 month (n=83)	0.39 (sd 0.35) (n=55)	0.42 (sd 0.27) (n=28)
EQ5D score 2 months (n=76)	0.56 (sd 0.3) (n=48)	0.45 (sd 0.3) (n=28)
EQ5D score 4months (n=73)	0.68 (sd 0.22) (n=47)	0.67 (sd 0.22) (n=26)
EQ5D score 12 months (n=68)	0.76 (sd 0.19) (n=42)	0.71 (sd 0.24) (n=26)

Table 4-31 shows that the greatest reductions in the EQ-5D score were seen at one month post injury in both injury severity groups. Scores increased over time in both injury severity groups, but did not reach baseline values by 12 months post injury. EQ-5D scores were similar between injury severity groups across the follow up time points.

4.3.3 Conclusions

Both studies have a limited sample size and therefore only limited conclusions can be drawn from them. The rate of attrition was high in the PhD study compared to the Impact of Injury Study which had a 60% road traffic patient response rate at 12 months. The data for the IIS were extracted from the large sample population whose results are currenlty beign published in a number of journals focussing on various aspects of health outcomes. What both studies show however are that a significant proportion of people with serious road traffic injuries continue to experience problems at 12 months post injury. Of note were the psychological problems, continued pain and a reduced quality of life 12 months after injury with 27% (IIS) considering their health state to be worse at 12 months follow up than before their injury.. Also evident was the changing health over the 12 month follow up period indicating certain time points for example at 3 months where there were noticable psychological and health problems (PhD study). Moreover, it cannot be ignored that MAIS<3 casualties also experience physical and psychological problems from their injuries with a quarter of them rating themselves to be in a worse health state at 12 months compared to baseline (IIS 24%). MAIS <3 injuries tend to be higher frequency casualties with health consequences that will impact on health providers and cannot be ignored in road safety policy.

4.4 GERMANY

The Accident Research Unit of Medizinische Hochschule Hannover (MHH) started to collect information on long term consequences of road accidents by a brief questionnaire that has been circulated amongst all casualties of accidents of the Hannover subset of the GIDAS data base since 2013.

4.4.1 Study design

The Hannover team of GIDAS (Otte, Krettek, Brunner & Zwipp, 2003) collects accidents in as a representative sample in the Region of Hannover. In this 2,291 square metres large region there are 1.1 million people living. Approx. 10% of the region is urban area what is comparable to Germany. Also the distribution of roads over different road types (urban, rural, highway etc.) in the region of Hannover is comparable to Germany in general. This is important to facilitate a representative data collection for Germany. The data collection takes place in two alternating shifts every day in order to address all weekdays, and all times of the day in the same way.

Since 2013 all people being involved in any of the collected accidents in the Hannover area who declared their informed consent for the collection of personal data are approached approx. one year after the accident by a one page interview sheet sent by post, see Figure 4-3. The questionnaire could be answered either by paper version or online version. In addition there was the possibility to answer by phone. The questionnaire is designed as a very short questionnaire on purpose in order to increase the number of returns. It is planned to contact the people with reported long term consequences later with a more comprehensive questionnaire. This data collection has not been started yet.

It has to be noted that since 2014 the written consent was collected directly at the scene when possible. Before, it was collected by return mail. The step towards collecting the consent at the accident scene increased the number of returns and thus for this study the number of people being included in the study.

According to the GIDAS accident collection requirements the inclusion criteria for the long term consequence study are:

- having been involved in a road traffic accident (according to the German definition of road traffic accidents involving at least one moving vehicle on a public accessible road) with at least one person being injured;
- the crash having occurred in the Hannover Region (population of 1,1 million inhabitants);
- informed consent available of the receiver of the questionnaire

After increasing the number of responses it is planned to ask the people with reported long term consequences for more details. 270 of the 381 respondents with documented long term consequences gave their informed consent for follow-up studies (people without any problem were not explicitly asked for their consent).

Participants included in the study

Out of 7118 people that were involved in a crash, 2457 were approached – of them 1110 answered so far. The majority of the respondents was MAIS 1 injured or uninjured. By comparing the distribution over MAIS levels and transport modes between the group of respondents and the entire population of people involved in crashes in the Hannover Region included in GIDAS, it was checked whether the sample of respondents is representative. This comparison showed a sufficient comparable distribution over both injury severity and transport mode.

VerkehrsUnfallForschung
Medizinische Hochschule Hannover

Medizinische Hochschule Hannover
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no.	question	duration	
1.1	How long did you suffer from the accident?		months
1.2	How long did you receive a sick certificate resulting from the accident		weeks

no	question	yes	slow restart	no
2.1	Were you able to return to your old job (or school etc.) completely after termination of your sick certificate?			
2.2	Were you able to follow your old hobbies and private task in the same amount as before the accident?			
2.3	Was it necessary to move house or to modify your home as a result of the accident?			
2.4	Do you take medications as a result of the accident?			
	Which ones			

Do you suffer today as a result of the accident of:

no.	Question	yes	no
3.1	pain?		
3.2	reduced exercise possibilities?		
3.3	other physical disturbance?		
3.4	deficiency in concentration?		
3.5	fears?		
3.6	reduced capabilities in the job, in school etc.?		
3.7	reduced capabilities in the daily tasks?		
3.8	reduced capabilities in sports and hobbies?		
3.9	Reduced mobility (e.g. because of avoiding specific modes of transports, road, weather conditions etc.)?		
3.10	Social problems with friends, relatives, neighbours etc.?		

Disability

no.	question	yes	no	degree of disability
4.1	Had you got a proven disability?			
4.2	Have you got a new proven disability or a change of degree of disability as a result of the accident?			

In case you answered one of the questions of question block 3 with „yes" or question 4.2 with „yes" or question 2.2 with „no" we would be very grateful if you would sign the attached informed consent declaration. This declaration would allow us to approach you in the future for more detailed studies regarding long term consequences. However, if you do not agree that we contact you later on again, your answers would help today anyway to gain more insight into the topic.

Figure 4-3: Translation of the questionnaire used for the German case study

4.4.2 Results

When analysing the results it needs to be considered that it is expected that the number of returns is considerably higher for people with long term consequences than for those without. However, there is also a relatively high number of returns without reported long term consequences. For this study percentages are calculated by comparing the number of positive answers with the total number of answers. This could result in an overestimation of the risk for long term consequences. However, by comparing the number of positive answers with the number of approached people the risk for long term consequences would be considerably underestimated.

The data allows for analyses by mode of transport and injury severity. In the following the data is mainly analysed by the mode of transport. However, if special results depending on the injury severity are important for further understanding of long term consequences, these are presented in parallel.

625 people reported that they were suffering from their injuries, corresponding to 57.1% of the respondents. Vulnerable road users such as user of Powered Two Wheelers (PTW), cyclists or pedestrians were suffering relatively often from their injuries compared to car, HGV, and public transport users, see Table 4-32. In average people that were suffering reported of a suffering time of 137 days. Interestingly 13% of the accident involved people that were uninjured according to the GIDAS data reported of suffering with a median duration of suffering of 14 days. These people could have either recognised their injury later and are therefore officially uninjured although they sustained an injury or they are suffering from psychological burden following the accident although being uninjured. For the MAIS 2+ injured people the median suffering time was almost the complete observing year.

Table 4-32 Average duration of suffering of accident participants that reported about suffering

mode of transport	duration of suffering [days]	no. of people with reported suffering time	no. of responses	percentage of people with reported suffering time related to no. of responses
car	111	251	622	40.4
Heavy Goods Vehicle (HGV)	102	13	38	34.2
Powered two-wheeler (PTW)	199	88	100	88.0
bicycle	131	211	257	82.1
pedestrian	182	55	62	88.7
other	179	7	16	43.8
all	137	625	1095	57.1

Sick leave was reported by 36.5% of the respondents with an average duration of sick leave of 52 days, see Table 4-33. Especially users of Powered Two Wheelers (PTW) followed by users of Heavy Good Vehicles (HGV) show a long duration of sick leave. Approximately 7% of the respondents were unable to return to their old job following the accident (Table 4-34). Some more were able to return after sick leave, but needed a slow restart (progressive increase of working hours per day up to the number of working hours before the accident). Especially for pedestrians a considerable high percentage of RTC were unable to return to their old job. It needs to be noted for this analysis – comparable for the analysis of sick leaves – that not all RTC had a job or went to school or university etc. Comparable to the suffering but with a lower share 5% of initially uninjured reported about sick leave with a median duration of sick leave of 3 days.

Table 4-33 Average duration of sick leave of accident participants that reported about sick leave

mode of transport	duration of sick leave [days]	no. of people with reported sick leave	no. of responses	percentage of people with reported suffering time related to no. of responses
Car	46	165	626	26.4
HGV	68	13	38	34.2
PTW	73	74	101	73.3
Bicycle	46	110	248	44.4
Pedestrian	48	33	56	58.9
Other	7	1	15	6.7
All	52	396	1084	36.5

Table 4-34 Return to old job etc. possible?

Mode of transport	yes	No	slow restart needed	no. of responses	percentage of people not being able to return to old job related to number of responses
Car	560	28	25	613	4.6
HGV	34	1	3	38	2.6
PTW	69	10	22	101	9.9
Bicycle	189	21	26	236	8.9
Pedestrian	34	14	9	57	24.6
Other	14	2	0	16	12.5
All	900	76	85	1061	7.2

In order to analyse whether or not injuries to specific body parts influenced the ability to return to the old job the frequency of known injuries for each body region are compared for the respondents that were not able to return to their old job with the respondents that were able to return to their old job, see Figure 4-4. In general people that were not able to return to their old job after a road accident are more often injured than all people being involved in road accidents. Therefore it is expected that the percentage of people with injuries amongst those not being able to return to their old job is larger than for all others. From these expected trends there are two important deviations. On the one hand there are much more people with leg and abdomen injuries not being able to return to their old job than expected meaning that especially leg and abdomen injuries are associated with a larger risk to not be able to return to the old job. On the other hand neck injuries are considerably underrepresented amongst those people not being able to return to their old job.

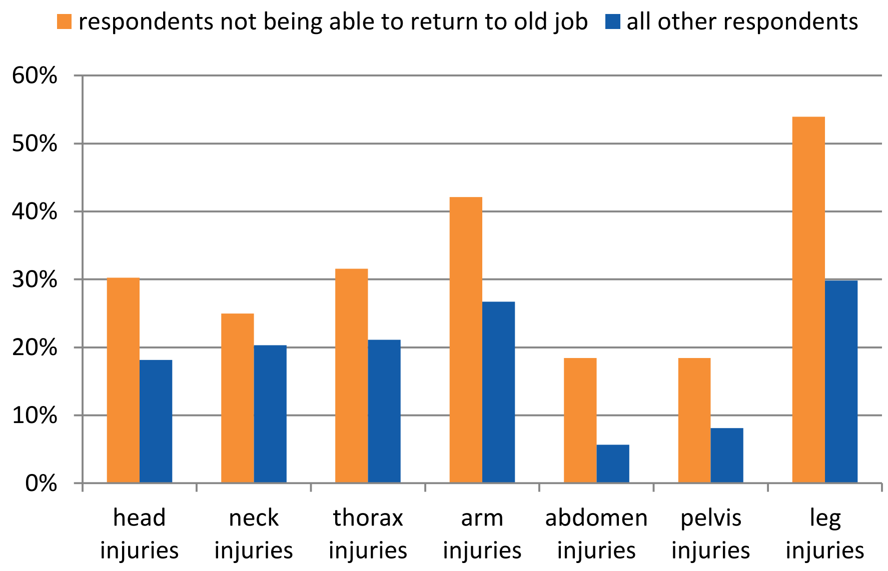

Figure 4-4 Injured body regions for people not being able to return to old job

Moving house or modifying the original home was necessary for 2.2% of all respondents in order to cope with the consequences of the accident, see Table 4-35. Again especially pedestrians show a considerable high percentage. The need to move house or to modify the house is larger for people with higher injury severity levels. However, even for 2.3% of the MAIS 1 injured it was necessary.

Table 4-35 Was it necessary to move house or to modify your home?

mode of transport	yes	no	no. of responses	percentage of people that needed to move or modify house related to number of responses
Car	9	620	629	1.4
HGV	0	37	37	0.0
PTW	2	101	103	1.9
Bicycle	6	249	255	2.4
Pedestrian	6	58	64	9.4
Other	1	14	15	6.7
All	24	1079	1103	2.2

In order to analyse whether or not injuries to specific body parts influence the need to modify the house or move house the frequency of known injuries for each body region are compared for the respondents that reported about the need for modifying or moving house with all other respondents, see Figure 4-5. In general people who need to move or modify their house after a road accident are more often injured than all people being involved in road accidents. Therefore it is expected that the percentage of people with injuries amongst those needing to move or modify their house is larger than for all others. From these expected trends there are two important deviations. On the one hand there are much more people with head, abdomen, pelvis and leg injuries that needed to modify or move house than expected meaning that especially head, abdomen and leg injuries are associated with a larger risk for special houses. On the other hand neck, thorax and arm injuries are considerably underrepresented amongst those people that needed to modify or move house. It needs to be mentioned that the results for pelvis is slightly below 0.05 and for leg injuries slightly above 0.06 in a chi squared test.

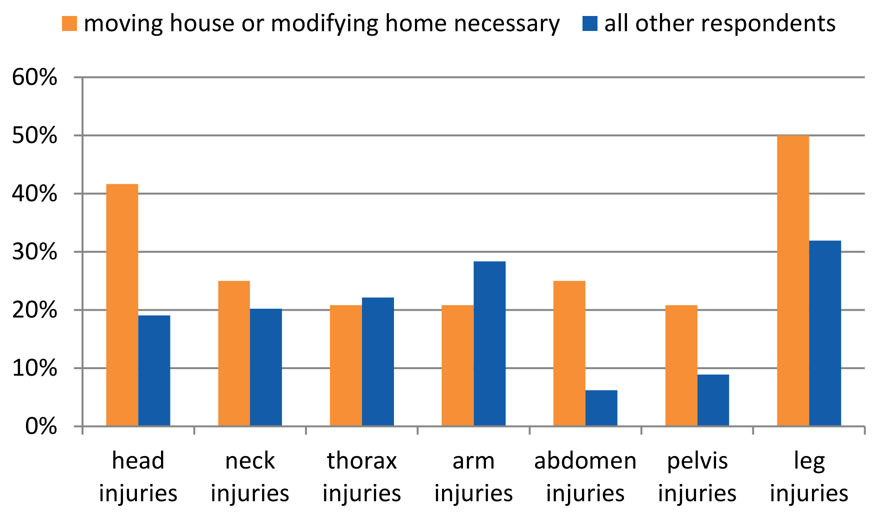

Figure 4-5 Injured body regions for people that needed to move house or modify their home

Any kind of medication was used in order to lower suffering from the accident by 8.7% in total. The use of medication is more often reported by pedestrian than other road user types, see Table 4-36. It was not yet analysed which type of medication (i.e., painkiller vs. ataractics) was used. The use of medication increases with injury severity level – 1% of the originally uninjured respondents reported of using medications.

Table 4-36 Use of medication to lower suffering from accident

mode of transport	Yes	no	no. of responses	percentage of people using medication to lower suffering in relation to responses
car	38	593	631	6.0
HGV	2	35	37	5.4
PTW	18	84	102	17.6
bicycle	22	232	254	8.7
pedestrian	17	45	62	27.4
other	1	13	14	7.1
all	98	1002	1100	8.9

Respondents suffered from pain (often and with high extend according to the questionnaire) one year after the accident in 130 cases (11.7%). Pain is observed again mainly for pedestrians, see Table 4-37.

Table 4-37 Reported pain as a result of the accident

mode of transport	Yes	no	no. of responses	percentage of people reporting pain in relation to responses
Car	44	588	632	7.0
HGV	4	34	38	10.5
PTW	22	80	102	21.6
Bicycle	37	221	258	14.3
Pedestrian	21	42	63	33.3
Other	2	14	16	12.5
All	130	979	1109	11.7

Reported pain is associated any kind of injury, see

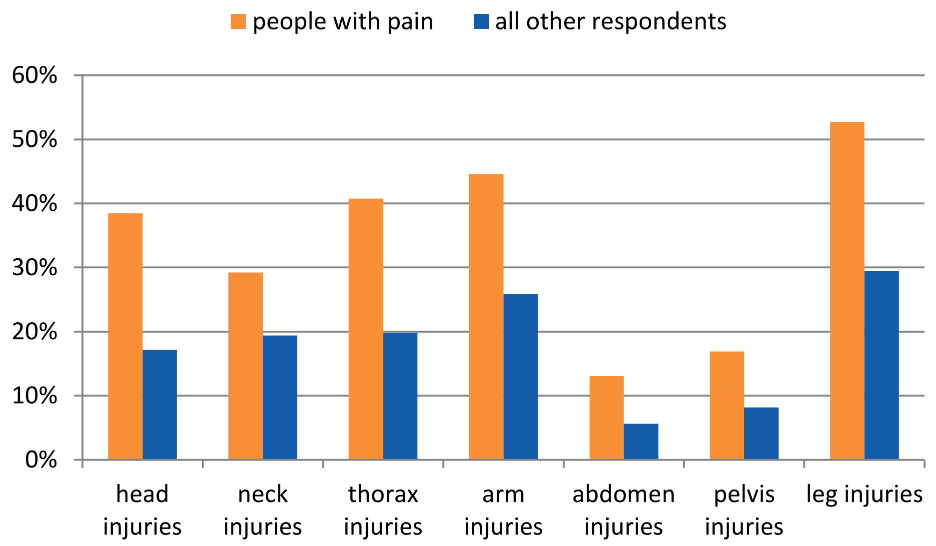

Figure 4-6. Differences for all body regions are statistically significant (p<0.001 chi square test).

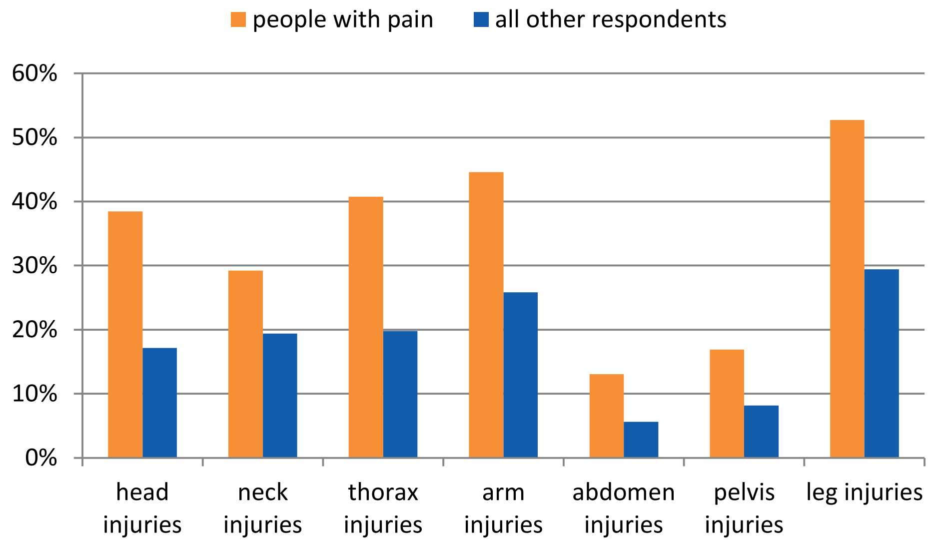

Figure 4-6 Injured body regions when pain is reported

Deficiencies in concentration were reported by 5.1% of the respondents in general and 17.2% of the pedestrians, Table 4-38.

Table 4-38 Reported deficiency in concentration

mode of transport	yes	No	no. of responses	percentage of people reporting deficiency in concentration in relation to responses
car	19	609	628	3.0
HGV	2	36	38	5.3
PTW	7	96	103	6.8
bicycle	17	241	258	6.6
pedestrian	11	53	64	17.2
other	1	15	16	6.3
all	57	1050	1107	5.1

Concentration deficiencies are reported highly significant more often for people with head, thorax, abdomen, pelvis and leg injuries ($p < 0.001$ chi square test), see Figure 4-7. For the other body regions differences are not significant.

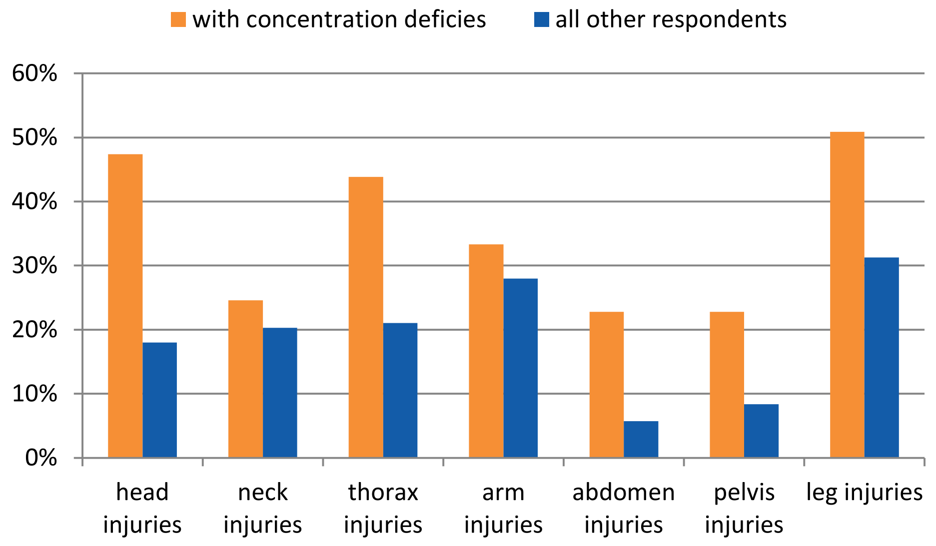

Figure 4-7 Injured body regions when concentration deficiencies are reported

Any kind of fears was reported by 19.3% of the respondents, with a considerable higher percentage for pedestrians (43.8%), motorcyclists (22.3%) and cyclists (22.0%), see Table 4-39. The analysis by injury severity level shows that even 6.4% of the originally uninjured respondents reported about fears resulting from the accident. However, generally people with injuries suffer more often from fears than those without, almost independent from the injured body region.

Table 4-39 Reported fears

mode of transport	Yes	No	no. of responses	percentage of people with fears in relation to responses
car	102	527	629	16.2
HGV	2	36	38	5.3
PTW	23	80	103	22.3
bicycle	57	202	259	22.0
pedestrian	28	36	64	43.8
other	2	13	15	13.3
all	214	894	1108	19.3

Reduced performance at work was reported by 7.3% of the respondents, see

Table 4-40 middle part. Reduced performance at daily routine tasks was reported by considerable more respondents than for reduced performance at work, see

Table 4-40 right part. Here it was 11.9%. Especially pedestrians and motorcycle riders reported often reduced performance. One possible explanation for the difference between reduced performance at daily routine and work might be that not all of the responders are working.

Table 4-40 Reduced performance

mode of transport	no. of responses	Reduced performance at work		Reduced performance at daily routine tasks	
		N	%	N	%
car	628	29	4.6	46	7.3
HGV	38	3	7.9	4	10.5
PTW	103	18	17.5	22	21.4
bicycle	258	21	8.1	37	14.3
pedestrian	62	9	14.5	19	30.6
other	16	1	6.3	3	18.8
all	1105	81	7.3	131	11.9

Especially head, thorax, arm, abdomen and leg injuries have a significant influence on reduced performance at work, see Figure 4-8. Significance levels for these body regions are all below 0.001. The situation is quite similar for reduced performance at daily routines and not shown here.

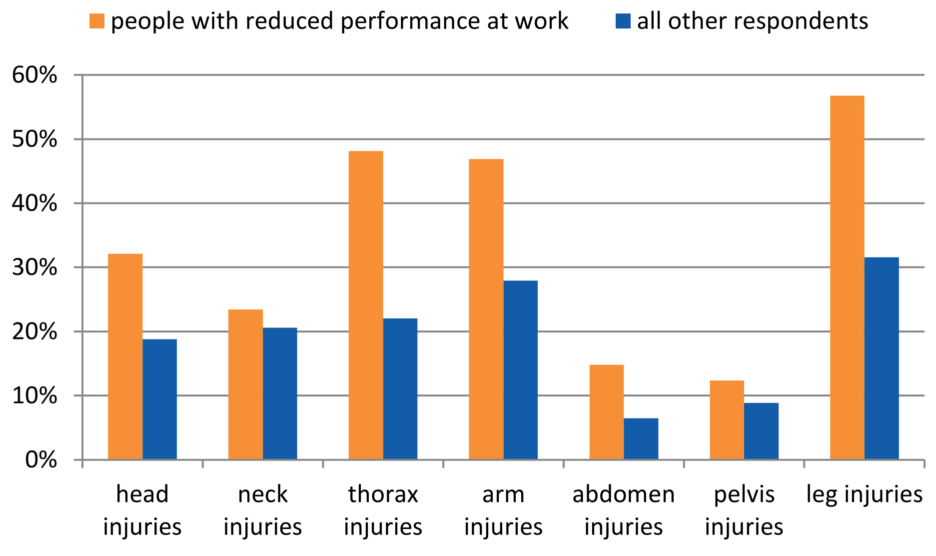

Figure 4-8 Injured body regions when reduced performance at work is reported

142 respondents (12.9%) reported a reduction in personal mobility as a result of the accident, Table 4-41. Further questions would be necessary in order to analyse the reason for the reduction in mobility (e.g., fears, physiological challenges etc.).

Table 4-41 Reduction in personal mobility

mode of transport	yes	no	no. of responses	percentage of people with reduced mobility in relation to responses
Car	55	569	624	8.8
HGV	4	34	38	10.5
PTW	21	82	103	20.4
Bicycle	42	215	257	16.3
pedestrian	19	44	63	30.2
Other	1	15	15	6.7
All	142	959	1101	12.9

Generally people with injuries suffer more often from reduced mobility option, almost independent from the injured body region, see Figure 4-9.

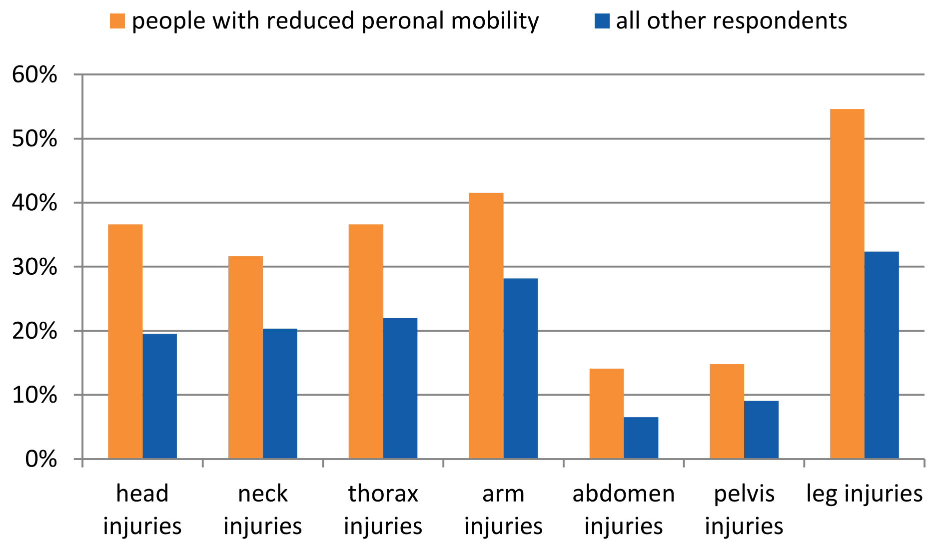

Figure 4-9 Injured body regions when reduced personal mobility

4.4.3 Conclusions

About 2,500 (35%) of the roughly 7,100 people that were involved in accidents collected for GIDAS in the Hannover area (Jan 2013 – October 2015) were approached one year after the accident with a short questionnaire asking for consequences of the accident. Of the approached people approx. 45% answered the questionnaire so far, resulting in approx. 16% responses (35%*45%) related to all RTC of the corresponding time.
In total more than half of the respondents (including uninjured people) reported they suffered from the accident. However, for the majority of people the duration of suffering was shorter than one year so that they did not report on long term consequences.

More than a third of the respondents reported a sick leave resulting from the accident with a median duration of 52 days. 8% of the respondents needed a slow restart for work and 7% were unable to return to their old job.

Several types of suffering from the accident were reported with a reasonable number of people reporting about problems although being uninjured or only MAIS 1-2 injured. The most frequently reported long term consequences were:

- pain (12% of the respondents)
- fears (19% of the respondents)
- reduced personal mobility (13% of the respondents)
- reduced performance at work (7% of the respondents)
- reduced performance at daily routine tasks (12% of the respondents)

When analysing the injury pattern – depending on the kind of problem – head, thorax, pelvis and legs are often significantly associated with individual problems.

For future studies regarding long term consequences it appears important not to restrict the study to RTC with high injury severity (e.g., MAIS 3+) because an important share of issues was also reported by people without injuries or low injury severity level.

4.5 MYLAC STUDY

The MyLAC study ('My Life After the Crash') is an international retrospective survey that aims to investigate consequences of road traffic crash injuries at various levels including medical, psychological, social and economic consequences. Eligible participants for the study were adults (16 year and older) who were ever been injured as a consequence of a road traffic crash. The study was coordinated by the Belgian Road Safety Institute (BRSI) and the European Federation of Road Traffic Victims (FEVR). The survey has been disseminated in 20 EU countries with the collaboration of relevant partners in each participating country (e.g. road casualties associations, medical/trauma patient associations, road/road safety organizations with emphasizes on casualties support or on post-crash response). The survey was translated into 16 languages and was open to response over a 4 months period (mid-May until mid-September 2016).

4.5.1 Study design

Participants included in the study

Out of the 830 participants that did start the survey online, 75 completed the first survey page only (socio-demographic data) and were considered as providing insufficient information for being included in the analyses. From the remaining 755 subjects, 208 did not complete the survey until the end but were nonetheless included in the analyses as they provided partially exploitable information.

In total, about forty organisations disseminated the survey in twenty EU countries: Belgium, France, Luxembourg, United Kingdom, Ireland, Denmark, Finland, The Netherlands, Germany, The Czech Republic, Bulgaria, Romania, Spain, Portugal, Italy, Slovenia, Croatia, Greece, Malta and Cyprus.

The sample size widely differs across participating countries (see Figure 4-10) because of noticeable differences between partners regarding, for example, the resources and time dedicated to the survey, the size of the organization, its implementation and visibility, the type of target audience, the quality of contact with members/affiliates, the dissemination/communication channel(s), etc.

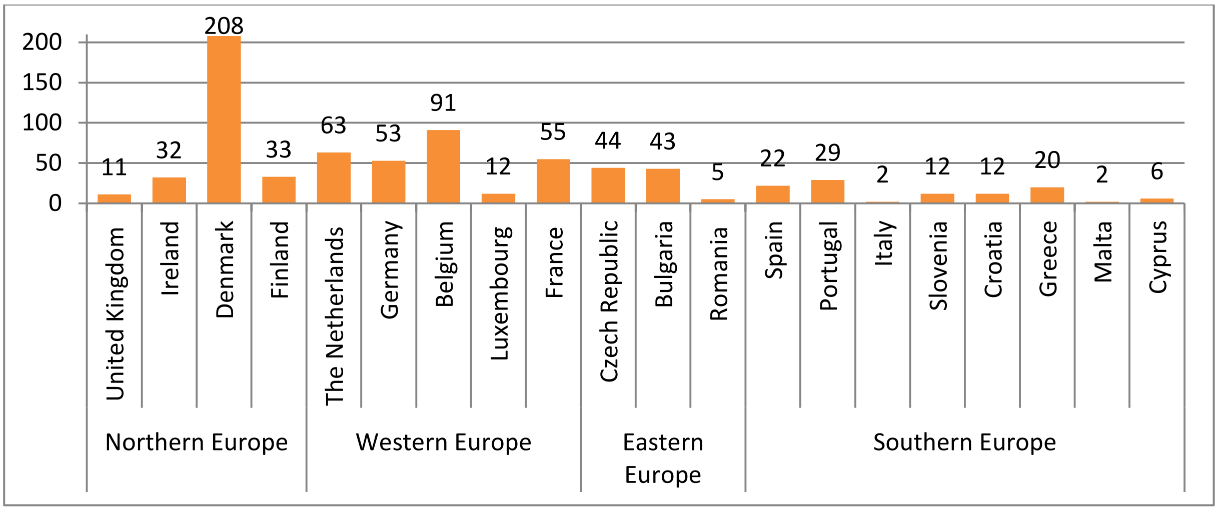

Figure 4-10 Sample size by countries

The total sample composition regarding gender, age, age at the time of the crash, time elapsed since the crash and road user category is presented in Table 4-42.

Table 4-42 Sample composition

		Number of subjects (% of total sample)
Gender	Female Male	413 (54.7%) 342 (45.3%)
Age	25 or less 26-45 46-65 More than 65	105 (13.9%) 355 (47.0%) 266 (35.2%) 29 (3.8%)
Age at time of the crash	25 or less 26-45 46-65 More than 65	292 (38.7%) 296 (39.2%) 149 (19.7%) 18 (2.4%)
Time elapsed since the crash	One year or less More than one year	101 (13.4%) 654 (86.6%)
Road user category	Four-wheeler Two-wheeler Cyclist Pedestrian	446 (59.1%) 121 (16.0%) 110 (14.6%) 78 (10.3%)

The total sample was divided following the four European regions delimited by the United Nations – Northern (N=284), Western (N=274), Eastern (N=92) and Southern (N=105) Europe – in order to compare these subsamples in terms of gender and age, age at the time of the crash, time elapsed since the crash and road user type categories. Chi-square tests showed significant differences in composition for gender, age, road user category but not for the age at the time of the crash and for the time elapsed since the crash. Although the representativeness of our sample may not be warranted, because, for example, of the wide differences in sample sizes and compositions between countries, the total sample size was judged to be sufficient to allow comparisons (e.g. between road user categories) on the topics covered by the survey.

Instruments for determination of consequences

The following instruments/measures were used in the analyses described in this section:

- Socio-demographics: age, gender
- Circumstances of the crash: time elapsed since the crash, age at the time of the crash, road user category
- Medical consequences :
    - Length of hospital stay and recovery
    - Injury type and location : the 39 EUROCOST injury groups (Suzanne Polinder, 2007) – submitted as a self-report questionnaire to the respondents - merged into the 6 broader categories : Head, face, abdominal and , thoracic, vertebral and spinal, upper extremities, lower extremities and other type injuries.
    - Functional health: EQ-6D (R. Brooks & The EuroQol Group, 1996; Hoeymans, Lindert, & Westert, 2005; The EuroQol Group, 1990) : Cognition, anxiety, pain, activities, self-care, mobility
- Psychological consequences :
    - PTSD: PCL-S 6-items short form (Lang et al., 2012; Weathers, Litz, Herman, Huska, & Keane, 1993). Items are rated on a 5 point-Likert scale. Total scores can range from a low of 6 to a high of 30 and scores of 14 or higher are indicative of PTSD diagnostic (see Lang et al., 2012, for details).
    - Anxiety disorder and Major depression: Hospital Anxiety and Depression Scale (HADS ; Zigmond & Snaith, 1983). Items are rated on a 5 point-Likert scale. For the two subscales (7 items each), scores can range from a low of 0 to a high of 21 and scores of 11 or higher are indicative of diagnostic.
- Impact on day-to-day, socio-emotional and family life
    - Consequences for socio-emotional life and on the ability to fulfil ones' responsibility (regarding household and work/studies) : 5 items taken from the subscales 'getting along with people' and 'life activities' of the WHODAS 2.0, 36-items version (Üstün et al., 2010) and 3 items newly developed[23].
    - Impact on family/household life and functioning (1 items)[24]
    - Impact on relatives' personal (3 items) and professional life (3 items)[25]
    - Impact on living situation
- Professional and economic consequences
    - Time off work/studies after the crash
    - Special adaptation(s) needed for getting back to work/studies
    - Financial income decrease

[23] As we used both existing and newly developed items, factor analysis - using oblimin rotation - was conducted in order to assess the measurement validity of the underlying factors. The two factors that emerged explained 74.64 % of the variance - with high loadings for all items and no cross-loading between the factors - and showed good reliability : socio-emotional life (6 items, $\alpha = .92$) and ability to fulfil ones' responsibility (2 items, $\alpha = .81$). Socio-emotional life items : Communicating with people, Maintaining friendships, Making new friends, Intimate relationships, Sexual activities, Dealing with people you don't know (1 : No difficulty at all – 5 : Extreme or cannot do). Ability to fulfil ones responsibility items : Taking care of your household responsibilities, Doing your day-to-day work/school (1 : No difficulty at all – 5 : Extreme or cannot do).

[24] "To what extent has the crash impacted on your family/household life and functioning ?" (1 : No impact at all – 5 : Extremely).

[25] Items were formulated as followed : "At least one of your relatives had to… to take care of you". Three items taps on professional life ("adapt work", "stop working", "alter career aspirations") and the three other on personal life ("adapt day-to-day life", "alter (reduce) social life" and "restrict emotional life")

Results

The purpose of the study was to explore the various consequences of traffic crash injuries covered by the survey, by comparing scores/prevalence between ***transport modes*** and according to ***severity level***. As the study only relied on self-report data (with no medical examination), standard severity measurement as AIS or ISS scores were not available. However, an aggregated measure of severity level of the injury was computed based on two underlying indicators of severity: the length of the hospital stay and the fact that the vital prognosis was engaged or not (based on self-report and according to what they were told from the medical staff)[26]. Based on these indicators, the severity score was dichotomized in two categories: 1). length of stay lasting 7 days or less AND vital prognosis not engaged (Grade I severity ; N=261), 2). length of hospital stay lasting more than 7 days OR vital prognosis engaged (Grade II severity ; N=399)[27]. Preliminary exploratory analyses showed that the proportion of more serious injury (Grade II) was significantly higher (p< .005) in less recent crashes (more than 1 years since crash[28]) than in more recent crashes (one year or less[28]) suggesting a potential confounding effect between recency and severity dimensions and, hence, potential biases. However, as the proportion of recent vs. less recent crashes were the same across road user categories (as assessed by a nonsignificant chi-squared test), these potential biases were implicitly and partially controlled for[29].

Table 4-66. Proportion of Grade I Vs. Grade II severity injuries as a function of the road user categoriestypes

N=755	Grade I severity	Grade II severity	
Four-wheeler	39.5%	60.5%	p <.001
Two-wheeler[30]	33.6%	66.4%	
Cyclist	59.0%	41.0%	
Pedestrian	19.7%	80.3%	

Table 4-66 showed proportions of road user categories as a function of injury severity. Proportion of grade II severity was the highest for pedestrians (about 80%) followed by four- and two-wheelers (about 60%) and was twice as high as for cyclists (40%).

[26] Standard severity score, such as AIS or ISS, are indeed implicitly based on four criteria : threat of life, permanent impairment, treatment period and energy dissipation (O'Keefe & Jurkovich, 2001).

[27] The terms grade I Vs. grade II severity were preferred to the distinction serious Vs. non-serious injury in order to avoid confusion – and erroneous comparisons - with other studies using standard injury severity scores (e.g. AIS, ISS).

[28] A one year time period since the crash was used as cutoff for distinguishing between recent vs. less recent crash. This is in accordance with existing literature that suggests that, in general, recovery from physical and functional limitations in general trauma populations reaches a plateau at about 12 months (Ameratunga et al., 2004).

[29] As comparisons between road user categories are based on the same proportion of recent Vs. less recent crash in each road user category, potential interference between these two aspects limited.

[30] Two-wheeler stands here for all motorized two-wheelers and includes motorcycles and moped bicycles.

Medical consequences

Table 4-67. Proportion of injuries reported[31] – by location and based on the EUROCOST injury groups – for each road user category and as a function of injury severity

N=660	Four-wheeler	Two-wheeler	Cyclist	Pedestrian		Grade I severity	Grade II severity	
Head	80.3%	37.2%	60.9%	62.8%	*p* <.001	46.4%	70.4%	*p* <.001
Face	22.9%	10.7%	20.9%	28.2%	*p* <.05	11.5%	32.6%	*p* <.001
Abdominal and thoracic	28.3%	25.6%	14.5%	24.4%	*p* <.05	9.2%	42.1%	*p* <.001
Vertebral and spinal	52.9%	32.2%	35.5%	35.9%	*p* <.001	50.6%	52.6%	*n.s.*
Upper extremities	39.0%	47.1%	43.6%	41.0%	*n.s.*	39.1%	52.4%	*p* <.001
Lower extremities	35.7%	48.8%	35.5%	55.1%	*p* <.001	27.6%	57.1%	*p* <.001
Other	56.5%	56.2%	75.5%	61.5%	*p* <.005	62.8%	71.9%	*p* <.005

Table 4-67 gives the proportion of injuries sustained – by location – respectively for each transport mode and for both seriously and less seriously injured casualties. The proportions of injuries differed between transport modes for all injuries expect injuries to upper extremities. Head injury was the most frequently sustained by four-wheelers (about 80%) and by pedestrians (about 60%) while other/unspecified injuries were most frequently reported by cyclists (75%) and by motorized two-wheelers (55%). With the exception of vertebral and spinal injuries, increased severity (grade II Vs. grade I) was associated with higher prevalence of each type of injury with the most noticeable differences observed for abdominal and thoracic injuries (+32.9%), lower extremities injuries (+29.5%), head injuries (+24.0%) and face injuries (+21.1 %).

Table 4-68. Functional loss[32] one month after the crash – as compared to pre-crash situation – based on EQ-6D scores and as a function of injury severity.

N=639	Grade I severity	Grade II severity	
Mobility	-1.47 (36.9%)	-3.07 (76.8%)	*p* <.001
Self-care	-1.14 (28.4%)	-2.93 (73.3%)	*p* <.001
Usual activity	-2.03 (50.7%)	-3.35 (83.6%)	*p* <.001
Pain[33]	2.06 (51.5%)	3.01 (75.3%)	*p* <.001
Mental health	-1.08 (26.9%)	-2.04 (51.0%)	*p* <.001
Cognitive functioning	-1.30 (32.6%)	-2.56 (63.9%)	*p* <.001

[31] Figures represent injury prevalence for each type injury separately without considering the possible occurrence of multiple injuries.

[32] Functional lost was calculated by making the difference between the ED-6Q scores before the crash and one month after the crash (as rated retrospectively by the respondents). ED-6Q scores are rated on a 5 points Likert scale (0. No/No problem – 4. Unable to/Extreme problem). Difference scores are expressed both in the original scale and as converted in percentage (the 0-4 scale being converted into a 0%-100% scale).

[33] Difference score for pain was reverted for reflecting increased difficulties (increased pain).

Overall the functional loss was largest for the usual activity dimension (-2.83/-70.8% for the total sample) followed by pain (2.64/66,0%), mobility (-2.44/61%), self-care (-2,23/55.8%), cognitive functioning (-2.06/51.5%) and mental health (-1.66/41.5%). While the functional loss for less severely injured casualties (grade I) was particularly evident for two dimensions (usual activity and pain with a functional loss of about 2 units/50%), four dimensions were specifically impacted in more seriously injured casualties (grade II): usual activity, mobility, pain, self-care (with a functional loss of about 3 units/75%).

Two-way ANOVAs were conducted for exploring differences in functional scores as a function of both severity and transport mode (see Table 4-68). Significant differences were observed for all EQ-6D scores as a function of severity. Most of these scores did not differ as a function of the transport mode used at the moment of the accident. The only exception concerns the Usual activity scale and the Cognitive functioning scale. For usual activity, post-hoc test showed that pedestrians had an increased functional loss as compared to four-wheelers (.43 corresponding to 10.8%). Powered two-wheelers additionally reported less functional loss as compared to four-wheelers and pedestrians. The analyses additionally revealed that users of motorized vehicles reported an increased usual activity functional loss as a consequence of grade II vs. grade I severity compared to vulnerable road-users (cyclists and pedestrians).

Psychological consequences

Table 4-69. Proportion of respondents reaching diagnostic threshold for Post Traumatic Stress Disorder (PTSD), Anxiety disorder and Major depression one month after the crash.

N=618	**Grade I severity**	**Grade II severity**	
PTSD	60.7%	63.9%	*n.s.*
Anxiety disorder	38.1%	50.9%	$p < .001$
Major depression	38.1%	69.1%	$p < .001$

Psychological disorders at one month after the crash (as retrospectively reported at the time of the survey completion) were reported by a substantial part of the sample. PTSD was the most frequently reported disorder (62.2% of the total sample reaching diagnostic criteria) followed by major depression (57.1%) and by anxiety disorder (46.0%). As for comorbid aspect, 40.9 % of the sample presented both PTSD and anxiety disorder, 43.1% both PTSD and major depression, 37.0 % both anxiety disorder and major depression and 33.0% presented the three disorders.
While PTSD was found to be the most frequent disorder among the less severely injured casualties (61% against 38% for anxiety disorder and major depression), the three types of disorders were reported by the majority of the more severely injured casualties (64% for major depression and PTSD and 51% for anxiety disorder).

Chi-squared tests were conducted for exploring differences in prevalence of psychological consequences as a function of both injury severity and transport mode (Table 4-69). No differences were found between transport modes. Regarding severity, significant differences were found for Anxiety disorder and for Major depression but not for PTSD.

Impact on day-to-day, socio-emotional and family life

Table 4-70. Impact on day-to-day, socio-emotional and family life as a function of injury severity.

N= 545	Grade I severity	Grade II severity	
Ability to fulfil ones' responsibility (mean score)	2.60	3.03	$p<.01$
Impact on socio-emotional life (mean score)	1.94	2.54	$p<.001$
Impact on family/household life and functioning (mean score)	2.30	3.13	$p<.001$
Impact on relatives' personal life (percentage reported impact)	34.3%	53.3%	$p<.001$
Impact on relatives' professional life (percentage reported impact)	17.9%	44.7%	$p<.001$

The three dimensions "Ability to fulfil ones' responsibility"[34], "Impact on socio-emotional life"[34], and "Impact Family/household life and functioning" were rated on a five point likert scales ranging from 1 (no impact at all) to 5 (extreme impact). For the total sample, slight (2-rating) to moderate (3-rating) impacts were reported by the casualties for these three dimensions. The highest impact was observed for "Ability to fulfil ones' responsibility" (2.87) followed by "Impact on family/household life and functioning" (2.82) and by "Impact on socio-emotional life" (2.31). As for the impact of the crash on the casualties' relatives, about 35% of the total sample reported impact on relatives' personal life and 46.1% report impact on their professional life.

Injury severity was associated with a higher reported impact on all three dimensions covering day-to-day, socio-emotional and family life (see table 4-70). It is noteworthy that a substantial part of the less severely injured casualties (grade I severity) also report impact on their life as a consequence of the crash. No difference was observed as a function of transport mode.

Table 4-71. Impact on living situation as a function of road user category and injury severity.

N=547	Four-wheeler	Two-wheeler	Cyclist	Pedestrian		Grade I severity	Grade II severity	
No change	62.1%	64.6%	85.7%	62.7%	$p<.01$	90.8%	51.2%	$p<.001$
Housing adaptation	15.3%	14.6%	4.8%	13.7%		4.8%	18.6%	
Had to Move	22.6%	20.8%	9.5%	23.5%		4.3%	30.2%	

Overall about one third of the sample (33.8%) reported that the crash had had an impact on their living situation either by requiring housing adaptations (13,4%) or moving to a place more adapted to their disabilities/handicap (20.4%). The impact of the crash on the casualties' living situation was shown to be lower for cyclists as compared to the other road user categories (Table 4-71). Indeed, while about 85% the cyclists reported no change (no housing adaptation, did not have to move to a more adapted place) this was only true for about 60% of the casualties in the other categories. Finally, injury severity was highly associated with increased changes in living situation: only 50% of

[34] Averaged score for multiple items.

severely injured casualties (grade II severity) reported *no* change as compared 90% of the less severely injured casualties (grade I severity).

Professional and economic consequences

Table 4-72. Time off work/studies as a function of the road user category and of the injury severity

N=494*	Four-wheeler	Two-wheeler	Cyclist	Pedestrian		Grade I severity	Grade II severity	
3 months or less	25.3%	33.7%	27.8%	18.2%	*p* <.05	48.9%	12.2%	*p* <.001
More than 3 months	46.3%	45.3%	60.8%	54.5%		42.6%	53.5%	
Stop working/studies	28.4%	20.9%	11.4%	27.3%		8.4%	34.3%	

* Including only respondents that reported a professional activity or being student at the time of the crash

About three quarters of the sample (73.5%) reported work/studies absenteeism either for a long period (more than three months, 49.2%) or definitely (24.3%).

The time period off work/studies significantly differs according to the transport mode (Table 4-72): While a higher proportion of cyclists and pedestrians reported long time period off work/studies (more than 3 months, about 55%), a larger proportion of the four-wheelers and of the pedestrians had to stop working or studying (about 30%) – as compared to the other road user categories. Injury severity was also associated with increased professional consequences with more than half of the severely injured casualties being off work/studies for a long time period and more than a third of them being constrained to stop working or studying. Even for less severely injured casualties, professional consequences were noticeable: more than half of them reported being off work/studies either for a long period or definitively.

Table 4-73. Adaptations needed for getting back to work/studies as a function of the road user category and of the injury severity

N=379*	Four-wheeler	Two-wheeler	Cyclist	Pedestrian		Grade I severity	Grade II severity	
Reorientation	45.8%	36.8%	35.7%	36.4%	*n.s.*	24.5%	53.8%	*p* <.001
Adapt work load	64.7%	55.0%	60.3%	72.7%	*n.s.*	54.5%	69.4%	*p* <.001
Special accommodations	50.0%	56.1%	57.1%	25.9%	*p* <.05	38.4%	59.0%	*p* <.001
No adaptation needed	25.4%	25.8%	20.3%	20.0%	*n.s.*	33.8%	16.9%	*p* <.001

* Excluding respondents who could not return to work/studies

Among the respondents who could - or were expected to - return to work/studies, additional questions were asked about potential adaptation(s) needed for getting back to active life (i.e. job/studies re-orientation, work load adaptation, special accommodations). Overall, the proportion of the casualties who needed adaptation did not differ between transport modes (about 20-25% did not request any adaptation). However, some differences were observed as to the type of adaption needed (see Table 4-73). Namely, pedestrians had to adapt work load more frequently while fewer of them requested special accommodation – as compared to the other transport modes.

Table 4-74. Financial income decrease as a function of the road user category and of the injury severity.

N=547	Four-wheeler	Two-wheeler	Cyclist	Pedestrian		Grade I severity	Grade II severity	
Same as before	44.0%	59.4%	63.1%	52.9%	*p* <.05	64.7%	41.6%	*p* <.001
200 – 1000 euros	35.4%	20.8%	22.6%	33.3%		24.2%	34.8%	
More than 1000 euros	20.6%	19.8%	14.3%	13.7%		11.1%	23.6%	

Finally, financial consequences were found to be non-negligible for a substantial part of the sample: 49.5% reporting a financial income decrease (monthly) of at least 200€ and more than 18.8% a financial income decrease (monthly) of more than 1000€. Financial income decrease was evident for all road user categories (see Table 4-74) with the highest consequences found for the four-wheelers : more than 55% of them facing a financial income decrease (monthly) of at least 200€ and more than 20% a financial income decrease (monthly) of more than 1000€. Injury severity was also consistently associated with higher financial income decrease.

4.5.2 Conclusions

The MyLAC study certainly has a number of limitations as, for example, the sample size/composition heterogeneity across countries (as discussed above). Another limitation is that the sample almost exclusively consists of people who were somehow related to the associations that took part to the dissemination of the survey (e.g. road casualties associations, trauma patient associations etc). As a result, the sample probably is biased towards casualties who experienced impacts and therefore cannot be assumed to be representative for all road traffic casualties. It should be noted also that the data were not collected at the same period post-injury which prevent accurate comparisons between respondents. Because of these limitations, conclusions have to be drawn with caution. The results remain nonetheless informative about how consequences of road traffic crash may vary as a function of the transport mode and of injury severity.

The MyLAC study provides insight into the magnitude of the consequences of road traffic crash with respect to various aspects of a casualty's life. As for the medical consequences, the injuries sustained were found to be associated with substantial functional loss and this was particularly evident for the usual activity and for the pain dimensions – whatever road user category or injury severity – but also for the mobility and the self-care dimension, in particular for the more severely injured casualties. A large part of the sample also suffered from psychological disorders as a consequence of the crash (one month after) with the most frequently reported disorder being PTSD (about 60% of the sample) followed by major depression (about 55%) and anxiety disorder (about 45%). Psychological comorbidity was also found to be important with, for example, 33.0% of the sample presenting the three psychological diagnoses. Prevalence of psychological symptomatology and comorbidity were quite high as compared to other studies (e.g. Mayou et al., 2001). While this may be due to the relative high prevalence of severely injured victims in our sample or to the fact that we could not control durations since crash – respondents that experienced the crash in a distant past may have blurry and exaggerated memories about how they felt in the past, – psychological morbidity may also have been overestimated as the respondents had to rate their mental state at one point time while most psychological disorders need to meet some duration criteria to reach diagnostic threshold (e.g. PTSD symptoms have to last for more than 1 month ;American Psychiatric Association, 2000). While impact on day-to-day, socio-emotional and family life was on average evaluated as slight or moderate, a substantial part of the sample (more than one third) reported that the crash had had consequences on at least one of their relatives' personal or professional life. Impact on living situation (housing adaptations or necessity to move) was also reported by a third of the sample. Regarding professional and financial consequences, about three quarter of the sample reported having been off work/studies either for a long period or definitely, and half of them reported a financial income decrease (monthly) of at least 200€.

Differences as a function of the ***transport mode*** were particularly evident for injury severity, type and location, the living situation and regarding the professional/financial consequences. While pedestrians in general faced the most drastic consequences as compared to the other road user categories, the financial impact appeared to be the highest for the four wheelers. No – or few - transport mode-related differences were found for the functional health (EQ-6D), for the psychological dimensions and for the day-to-day life (social and family life/functioning). With some few exceptions (i.e. PTSD and vertebral and spinal injury prevalence), ***injury severity*** was associated with more deleterious consequences and this was observed for all dimensions covered by the study.

It is also noteworthy that consequences were found to be substantial for all categories (transport modes and severity levels). Finally, although we could not rely on a standard measure for assessing injury severity (e.g. AIS or ISS), the injury severity score that was computed for our study purpose demonstrated good discriminant properties, for each dimension investigated in current research.

4.6 DISCUSSION

4.6.1 Added value of case studies

This chapter presented a number of case studies that described functional, psychological and socio-economic consequences of involvement road traffic collisions. Ideally, these studies together should describe consequences of (serious) road traffic injuries in all EU countries and in the EU in total and cover:

- different types of consequences, i.e. impairments, activity limitations, participation restrictions as well as psychological consequences, for
- different types of crashes and injuries, at
- different moments following crash occurrence.

Moreover, ideally, consequences should be measured using similar instruments, so results from different countries could be well compared to each other.

To be able to provide such information for a country, an ideal case study would meet the following requirements:

- Be representative on a national level
- Contain information on different types of crashes (e.g. transport mode, single/multiple vehicle crash)
- Contain information on different types of injuries and severity of the injury?
- Contain information on different consequences (impairments, activity limitations, participation restrictions as well as psychological consequences)
- Contain information about different, but fixed moments in time. This can be realized by doing a follow up study at which information is collected at a number of fixed moments following a crash, e.g. 2 months, 6 months, 12 months and 24 months post-crash.

None of the case studies presented in this chapter meet all of these requirements (Table 4-43). However, all studies are useful as they provide some information on consequences of serious road traffic injuries.

Table 4-43 Requirements met by case studies described in this Chapter.

Study	Nationally representative	Types of crashes	Types of injuries	Types of health impacts	Follow-up
Spain	Yes	No	No	Yes	No
France	No	Yes	Yes	Yes	Yes
UK	No	No	No	Yes	Yes
Germany	Yes (but small sample MAIS3+)	Yes	Yes	Yes	Yes (but so far only after 1 Year)
MyLAC study	No	Yes	Yes	Yes	No

The French ESPARR study meets almost all criteria. This prospective cohort study followed road crash casualties from the Rhone area for 5 years and provides information on different types of consequences, for different injuries (severity, type of injury) and for different groups of casualties (age, gender, transport mode). The study shows that self-reported quality of life improves over time; generally in the first three years after the crash. However, three years post-crash, about 75% of the MAIS3+ casualties are not fully recovered; 75% experience residual pain, whereas 64% report persistence of sequelae other than pain.

Also the German GIDAS follow-up study meets most of the criteria, although the sample size is much smaller and less information is collected than in the ESPARR study. Moreover, the sample size of MAIS3+ casualties is too small to draw conclusions for this specific group. In total about half of the respondents (including people who were initially classified as uninjured) reported that they suffered from the accident. Moreover, consequences of accidents appeared to be relatively large for vulnerable road users compared to car, HGV and public transport occupants.

Also both UK studies have small sample sizes, but provide some insight into consequences of road traffic injuries. From the impact of injury study for example, it can be concluded that consequences are largest one month post-crash, but improve from then on, but remain lower than the baseline level after 12 months.

The MyLAC study is interesting because it covers multiple countries. However, respondents only provide information concerning health impacts at one moment in time and the time elapsed after the crash differs between respondents. Moreover, the sample is probably biased towards casualties that experienced (large) impacts. The MyLAC study shows that road traffic injuries have physical, psychological, professional and financial consequences for a considerable part of the road traffic casualties and also affect the lives of their relatives. Besides, consequences appear to be largest for pedestrians and appear to be larger for more severe injuries.

The Spanish study on Health Impacts of Road traffic crashes provides information about the prevalence of impairments and disabilities due to road crashes among the Spanish population. In 2011, 0.17% of the Spanish population (older than 5 years) reported impairment(s) resulting from a road crash (including less severe injuries). Moreover, 74% of these people reported one or more disabilities resulting from a traffic crash.

4.6.2 General limitations of follow up studies based on self-response

Most of the case studies described in this chapter are follow-up studies that ask road traffic casualties about their (perceived) consequences. This kind of studies has one main limitation, namely that the percentages of casualties reporting negative consequences are based on casualties that responded to the questionnaire. It is not unlikely that casualties that are experiencing (more severe) negative consequences due to their road traffic crash are more inclined to respond to the questionnaire than people who are not experiencing negative consequences. This could result in an overestimation of the percentage of people facing negative consequences of road traffic crashes. This problem is probably more apparent in case of a low response rate. Response rate can be increased by contacting non-responders as was for example done in the ESPARR study.

Another issue that one should keep in mind when analysing results of these studies is that the reported consequences are based on self-report and therefore refer to self-perceived consequences. These are subjective and differ between persons based on their personal situation and perception. The advantage of using self-reports is precisely that it measures actual perceived consequences, and hence the subjective aftermath of the accident. The disadvantage is that it is not objective and possibly differs between different groups of road users. As a result, differences between groups of road users may not always be due to differences in objective crash outcomes but also due to differences in perception between groups of road users.

4.7 CONCLUSIONS

The case studies presented in this chapter show that (serious) road traffic injuries experience all kinds of functional, psychological and socio-economic consequences. The ESPARR study shows that three quarters of the MAIS3+ casualties is not fully recovered three years after the crash.

Most of the case studies also include less severe injured casualties. In the ESPARR study and the UK case studies it is possible to compare the consequences for serious road traffic injuries (MAIS3+ casualties) with consequences perceived by people that are less severely injured. This analysis shows that also MAIS<3 casualties quite often encounter negative consequences, although less often and less long lasting than MAIS3+ casualties do. The ESPARR study found that one out of three MAIS<3 casualties is not fully recovered three years after the crash. Therefore, less severe injuries are also relevant from a health impact perspective. A functional loss in usual activity was observed among all participants of the MyLAC survey, while mobility and self-care functional losses were reported more specifically by those participants who had also reported more severe injuries.

Pain is the most often reported consequence in the ESPARR cohort study. The Spanish case study shows that most disabilities that are reported by road traffic crashes (all severities) are related to mobility and home life. In the German study, pain (12%), reduced mobility (13%) and reduced performance at daily routine tasks (12%) are mentioned equally often. However, fear is reported by a higher percentage of respondents (19%). This might (partly) be due to the fact that fear is also reported by respondents that were not injured in the crash.

All case studies show that road crashes also affect mental health as well. In Spain, 15% of the people with impairments due to road traffic crashes report having chronic depression or anxiety. In the ESPARR study, 20% of the MAIS3+ casualties reported PTSD (post-traumatic stress disorder) one year after the crash. In the German case study, 19% of the respondents involved in crashes reported fears. The UK impact of injury study found that mental impacts are largest one month post-crash and reduce from then on. Finally, PTSD was reported by the majority (60%) of participants to the MyLAC survey, irrespective of self-reported injury severity. Anxiety and depression were reported by about half of the participants with more severe injuries. The MyLAC study is probably biased towards casualties that experience (more) consequences and is therefore not representative for all road traffic casualties.

The Spanish, French and German case studies as well as the MyLAC study show that road crashes also influence working activities and social life. In the French ESPARR study, 10% of the serious road traffic injuries reported that they were unable to work five years after the crash and 7% was reported having retired before reaching the legal age of retirement. Moreover, 12% of the MAIS3+ casualties reported financial problems and 35% reported that the road crash reported a negative impact on family life and emotional abilities. In Germany, 7% of the people involved in a crash reported that they were not able to return to their old job and almost the same percentage reported a slow restart. Moreover, 2% had to modify their home or to move. In Spain, about half of the respondents with impairments due to road traffic crashes had to change their working situation because of their disabilities. Moreover, almost half of the respondents reported to receive some care and about 20% reported to have been discriminated. One third of the respondents in the MyLAC study reported impacts of the crash on their housing situation. Moreover, about three quarter of the sample reported having been off work/studies either for a long period or definitely, and half of them reported a financial income decrease (monthly) of at least 200€.

The MyLAC study also provide information on the consequences of crashes for relatives of the road traffic casualties. More than one third of the casualties in the MyLAC study reported that the crash had had consequences on at least one of their relatives‘ personal or professional life.

Looking at different types of road users, consequences appear to be larger for pedestrians and motorized two-wheelers. The ESPARR study shows that a higher proportion of pedestrians, followed by motorized two-wheelers, did not fully recover three years after the crash. The German case study shows that vulnerable road users who were involved in crashes relatively often report that they have suffered from the crash than other road users. Moreover, a relatively high percentage of pedestrians was not able to return to their old job. The MyLAC survey pedestrians were globally observed to face the most drastic consequences as compared to the other road user categories, while the financial impact appeared to be the highest for the four wheelers. No – or few - transport mode-related differences were found for the functional health (EQ-6D), for the psychological dimensions and for the day-to-day life (social and family life/functioning).

5 Burden of (non-fatal) injury

This chapter determines the burden of injury for serious road traffic injuries for society, expressed in YLD (Years Lived with Disability), in five EU countries and one region in France.

We estimated the burden of injury of MAIS3+ road traffic injuries for the following countries/regions: Austria, Belgium, England, The Netherlands, the Rhone department in France and Spain. The results for the individual countries/regions are discussed in Appendix C. This Chapter summarizes the main results.

5.1 METHOD

For the calculation of the burden of injury we applied a method that is developed within the European INTEGRIS (Integrating of European Injury Statistics) study and that is described by Haagsma et al. (2012).

As mentioned in Chapter 2, the burden of injury can be expressed in DALYs and integrates mortality, expressed in Years of Life Lost (YLL) due to early death, and morbidity, expressed in Years Lived with Disability (YLD) attributed to a given condition in a population. Since this Deliverable focuses on non-fatal injuries, only YLDs will be discussed.

The INTEGRIS study estimated disability weights and proportions of injuries with lifelong consequences for the 39 EUROCOST injury groups (see Appendix B). This information on disabilities is combined with incidence data on serious road traffic injuries, using the EUROCOST injury classification.

5.1.1 INTEGRIS study

The INTEGRIS study provides disability weights (DWs) and proportions of casualties with lifelong consequences for each of the 39 EUROCOST injury groups. A disability weight reflects the impact of a health condition and has a value between 0 (full health), and 1 (entirely disabled or dead). Separate DWs are available for the acute phase (first year, acute burden of injury) and for lifelong consequences (remainder of someone's life for casualties that encounter lifelong consequences, lifelong burden of injury). Moreover, for the acute phase, separate DWs are available for 1) patients that are only treated at the Emergency Department and subsequently discharged to the home environment and 2) patients that are admitted to the hospital. Also the proportions of casualties with lifelong consequences are available both for patients only treated at the Emergency Department and for patients admitted to the hospital.

The DWs and proportions of casualties with lifelong consequences that are proposed in Haagsma et al (2012) are based on a study of functional outcomes in injury patients in the Netherlands (Polinder et al., 2007). In this study, data on health related quality of life was collected for a sample of over 8500 injury patients, aged 15 years or older. Respondents were asked to complete the EQ-5D questionnaire 2.5, 5, 9 and 24 months after they had attended the emergency department of a Dutch hospital. For some injuries, the disability weights were supplemented with disability weights from a different study (Haagsma et al., 2008).

A patient was assumed to have a long-term disability if, at the two year follow up, he or she still claimed to be experiencing injury-related health problems and also reported symptoms compatible with the injury suffered. For more information on the INTEGRIS method, see Haagsma et al. (2012). Appendix B shows the DWs and proportion of casualties with lifelong consequences provided by Haagsma et al. (2012).

5.1.2 Application of the INTEGRIS method

The application of the INTEGRIS method consists of the following steps:

1. Assign each road traffic casualty to one of the 39 EUROCOST injury groups
2. Calculate the burden of injury for each road traffic casualty by applying equation 1.
3. Sum the burden of injury of individual road traffic casualties to estimate the burden of injury for a group of road traffic casualties

Step 1: Assign each road traffic casualty to one of the 39 EUROCOST group

For this study only MAIS3+ casualties are selected, as this is the definition of serious road traffic injuries and serious road traffic injuries are the main topic of this study. As far as possible, the guidelines provided in Deliverable 7.1 *Practical Guidelines for the registration and monitoring of serious traffic injuries* are applied for the selection of cases. For the guidelines, see Pérez et al. (2016).

For all MAIS3+ casualties, ICD codes of injuries are translated into EUROCOST injury groups. In case of multiple injuries, the hierarchical scheme proposed by Polinder et al. (2008) is applied.

Step 2: Calculate the burden of injury for each road traffic casualty by applying equation 1

For each road traffic casualty assigned to one of the EUROCOST injury groups, the burden of injury can be estimated by means of equation 1.

$$B_i = DWa_{j(i)} + Pl_{j(i)} * DWl_{j(i)} * (LE_i - age_i - 1) \quad \text{(Equation 1)}$$

With:

B_i = Burden of injury of serious road traffic injury, $i=1 \ldots N$, with N=number of serious road traffic injuries
i = Serious road traffic injury, $i=1 \ldots N$, with N=number of serious road traffic injuries
$j(i)$ = EUROCOST injury group, $j=1 \ldots 39$ of casualty i
$DWa_{j(i)}$ = Disability Weight for disability during first year, for each EUROCOST group
$DWl_{j(i)}$ = Disability Weight for lifelong disability, for each EUROCOST group
$Plj_{(i)}$ = Proportion of cases with lifelong consequences, for each EUROCOST group
LE_i = Life Expectancy of casualty i given its age and gender.

Information on DWs and Pls are provided by Haagsma et al. (2012). We applied disability weights of admitted patients. For an overview of DWs and Pls for all 39 EUROCOST injury groups, see Appendix B. Information about the (remaining) Life Expectancy is taken from the Global Burden of Disease study (2013). The GBD study provides more specified Life Expectancies for many regions all over the world. The mean life expectancy of the region R10 Western Europe appeared to suit best to the countries in the case studies and to the EU28 countries in general. Therefore, we decided to use the Life Expectancy provided for that region for our study. http://ghdx.healthdata.org/global-burden-disease-study-2013-gbd-2013-data-downloads.

Step 3: Sum the burden of injury of individual road traffic casualties

By summing up the burden of injury of individual road traffic casualties, the burden of injury for a group of road traffic casualties can be estimated. Moreover, by dividing the burden of injury for a group of casualties by the number of casualties in that group, the average burden per casualty was estimated. We made a distinction between the acute burden of injury and the lifelong burden of injury. The acute burden of injury refers to disabilities during the first year after the crash, whereas the lifelong burden of injury deals with the burden after the first year. The lifelong burden is only determined for casualties that experience lifelong consequences, so the average lifelong burden per casualty is related to the number of casualties that experience lifelong consequences.

By combining the incidence data per EUROCOST injury group with the proportions of casualties with lifelong consequences, the proportion of serious road traffic injuries suffering from lifelong consequences was also determined.

5.2 ESTIMATED BURDEN OF INJURY OF SERIOUS ROAD TRAFFIC INJURIES

5.2.1 Overall estimates for six countries

Table 5-1 summarizes the general, most recent annual information on the burden of injury in the six countries. The average burden per MAIS3+ casualty varies between 2.4 YLD per casualty in Spain and 3.2 YLD per casualty in the Netherlands, with an average of 2.8 YLD per casualty for the six countries together. The average acute burden per MAIS3+ casualty varies between 0.1 YLD per casualty in Spain and 0.3 YLD per casualty in Austria, Belgium, England and the Netherlands. The lifelong burden per casualty for casualties who experience long-term consequences of their injuries varies between 8.7 YLD per MAIS3+ casualty in the Netherlands to 11.5 YLD per MAIS3+ casualty in Spain.

Table 5-1 Estimated Numbers of serious injuries (MAIS3+) and Burden of those injuries in 2014 in a number of countries.

Indicator	Austria	Belgium*	England*,&	Netherlands	Rhone (Fr)†	Spain
# MAIS3+	1 410	4005	7,807	7,691	5,140	7,610
Total burden MAIS3+ [YLD]	4 360	10,913	24,028	24,699	12,961	18,303
Burden pp [YLD]	3.1	2.7	3.1	3.2	2.5	2.4
Acute burden pp [YLD]	0.3	0.3	0.3	0.3	0.2	0.1
Lifelong burden pp [YLD]†	10.1	10.1	9.9	8.7	11.1	11.5
Lifelong burden [% of total]	91%	91%	91%	91%	91%	90%
Proportion casualties with lifelong disabilities [%]	28%	25%	28%	33%	21%	19%

*2010 estimate, & Hospital Episode Statistics (HES) inpatient database. *Copyright© 2016, Re-used with the permission of The Health and Social Care Information Centre and Department for Transport. All rights reserved,* †2004-2013
† for casualties with lifelong consequences.

The majority of the burden of injury is related to lifelong consequences; about 90% of the total burden of injury of MAIS3+ casualties is due to lifelong consequences. Percentages are very similar for the different countries. By applying the INTEGRIS method it is also possible to estimate the percentage of serious road traffic injuries that encounter lifelong consequences. On average this is 25% of all MAIS3+ casualties in the countries for which the burden of injury was estimated. However, differences between countries are quite large, varying from 19% of all MAIS3+ casualties in Spain and 33% of all MAIS3+ casualties in the Netherlands.

As the same disability weights have been applied to the incident cases of the different countries, differences in results between countries are due to differences in injuries encountered by the casualties (partly due to differences in distribution of casualties over transport modes) and the age distribution of the casualties. Differences in injuries are discussed in Section 5.2.3. Differences in age distribution are discussed in Section 5.2.5. Additionally, differences in the selection of MAIS3+ casualties, such as, AIS version and AIS recoding tool, might also play a role (see **Table 5-2** for a summary of methodological information). These differences mainly influence the number of MAIS3+ casualties and thus the total burden of injury and are expected to have only minor consequences for the indicators related to the burden of injury per person.

For some countries, data is available for a series of years. Indicators like average burden of injury per casualty and proportion of casualties that encounter lifelong consequences, appear to be quite stable over the years. As a result, it has been possible to determine that the total burden of injury shows a similar development in time as the number of serious injuries. For more details, see Appendix C.

Table 5-2 Main characteristics concerning the selection of MAIS3+ road traffic casualties in study countries.

	Austria	Belgium*	England*,&	Netherlands	Rhône (Fr)†	Spain
Most recent year	2014	2011	2010	2014	2004-2013	2014
Years in dataset	2005-2014	2009-2011	1999-2010	2000-2014	2004-2013	2010-2014
AIS rating	AAAM10	ICDpic	ECIP-Navarra	ICDmap90	direct	ICDpic
AIS-version	2008	2005	1998	1990	1990	2005
ICD-version	ICD10	ICD9	ICD10	ICD9	-	ICD9
Number of diagnoses	1	20	9	12	8+	14
Truncation	yes	no	no	no	no	no

5.2.2 Burden of injury for different transport modes

Table 5-3 shows the average burden per MAIS3+ casualty and the percentage of MAIS3+ casualties that experience permanent consequences for different modes of transport. According to the table, the average burden per MAIS3+ casualty is highest for car occupants and lowest for cyclists (in crashes without motorized vehicles). Moreover, on average, the percentage of MAIS3+ casualties that suffer from lifelong consequences is highest for pedestrians and lowest for car/van occupants and motorized two-wheelers.

Table 5-3 Average burden of injury for different transport modes for Belgium, England, The Netherlands, Spain and the Rhone region.

Transport mode	Burden per person [YLD] average (max, min)			% casualties lifelong
	Acute burden	Lifelong burden	Average burden	
Pedestrian	0.26 (0.28-0.25)	9.5 (10.8-8.4)	2.8 (3.4-2.4)	27% (30%-23%)
Cyclist (Be, Sp, Fr)	0.26 (0.29-0.24)	8.8 (10.2-6.8)	2.3 (2.3-2.3)	25% (30%-20%)
Cyclist in crash without motorized vehicle (Eng, Nl)	0.31 (0.33-0.29)	6.9 (8.3-5.4)	2.6 (2.9-2.4)	35% (37%-32%)
Cyclist in crash with motorized vehicle (Eng, Nl)	0.28 (0.29-0.26)	10.4 (10.7-10.1)	3.3 (3.4-3.1)	29% (31%-27%)
Motorized two-wheelers	0.24 (0.27-0.23)	12 (13-11.1)	3.0 (3.5-2.4)	24% (29%-17%)
Car/van	0.25 (0.29-0.22)	13.6 (16.4-10.5)	3.4 (5.8-2.3)	23% (33%-17%)

However, it should be noted that the results differ between the countries. In Spain and the Netherlands, the average burden per casualty was highest for car/van occupants, whereas in the Rhone region and Belgium, the average burden per casualty was highest for motorized two-wheelers and in England the average burden per casualty was highest for pedestrians. Regarding the lifelong burden per casualty, the results are more similar although the values differ between countries. In most countries, the lifelong burden per casualty was highest for car/van occupants and in general the lifelong burden of injury per casualty is lowest for cyclists and pedestrians. Moreover, in Belgium, Spain and the Rhone region, the percentage of MAIS3+ casualties that experience lifelong consequences is highest for pedestrians. In the Netherlands however, the percentage of casualties that experience lifelong consequences is highest for cyclists in crashes without motorized vehicles and in England, the percentage is highest for motorized two-wheelers. Differences related to the burden per person per transport modes are due to differences in types of injuries (distribution over EUROCOST injury groups) and differences in age distribution of the casualties.

We also estimated the total burden of injury per transport mode and the distribution of the total burden over the different transport modes. The total the burden of injury per transport mode is determined by the average burden per casualty and the number of casualties per transport mode. The results differ considerably between countries. For Belgium and England, the burden of injury is highest for cars/vans (resp. 36% and 26% of the total burden of injury of MAIS3+ casualties). For Spain and the Rhone region, the burden of injury is highest for motorized two wheelers (respectively 22% and 41%), although we should mention that in Spain the transport mode is unknown for a large part of the MAIS3+ casualties (38%). In the Netherlands, the burden of injury is highest for cyclists that are injured in a crash without a motorized vehicle (37% of the total burden of MAIS3+ casualties). The differences between the countries are to a large extent due to differences in the distribution of MAIS3+ casualties over the transport modes. In the Netherlands for example half of all MAIS3+ casualties are injured cyclists in a bicycle crash without a motorized vehicle being involved. In England, this is only 13% of all MAIS3+ casualties. These differences in distribution of casualties over transport modes are largely due to differences in modal split between the countries.

5.2.3 Burden of injury for different types of injuries

We also determined the burden of injury per EUROCOST injury group. First of all, we estimated the average burden per MAIS3+ casualty for each of the injury groups. The average burden per casualty is determined by the Disability Weights (DWs), Plifelong and by the ages of the casualties. As the same DWs and Plifelong are applied, differences between countries are only due to differences in age distribution of the casualties. For all six countries, the average burden per MAIS3+ casualty is by far the highest for spinal cord injuries; the average burden per spinal cord MAIS3+ casualty varies from 24.4 years lived with disability in the Netherlands to 30.0 years lived with disability in England. This high burden per casualty is caused by a very high percentage of casualties experiencing lifelong consequences (100%) and high disability weights (see Appendix B).

Second, we estimated the total burden of injury per injury group. This total burden is determined by the number of casualties and the average burden per casualty. Also the total burden of injury is relatively high for spinal cord injuries; on average 22% of the total burden of injury of MAIS3+ casualties is caused by spinal cord injuries. The total burden of injury is highest for the EUROCOST group 'other skull-brain injury' in most countries. On average 32% of the total burden of injury of MAIS3+ casualties is caused by 'other skull-brain injuries'. In Belgium, Austria, England and Spain other skull-brain injuries are the main contributor to the burden of injury of MAIS3+ casualties. In the Netherlands, spinal cord injuries are the main contributor to the burden of injury and in the Rhone region, fractures in knees and lower legs are the main contributor to the burden of injury of MAIS3+ casualties. Fractures in knees and lower legs are the third contributor to the total burden of injury in England and in Spain, but are responsible for only 3% of the burden of injury in the Netherlands. Also fractures in hips and factures in femur shafts have a high contribution to the total burden of injury is some of the countries and not in other countries. Hip fractures are the third contributor to the burden of injury of MAIS3+ casualties the Netherlands and Austria, but are responsible for only 6% of the burden of injury in the Rhone region. Femur shaft injuries are the second contributor to the burden of injury in Austria, but only account for 4% of the burden of injury in the Netherlands. **Table 5-4** summarizes the results for the injury groups discussed. The five EUROCOST injury groups in **Table 5-4** represent 91% of the total burden of injury in the six countries together.

Table 5-4 Five main injury groups (in top 3 of total burden in at least one of the countries), the burden per MAIS3+ casualty and the minimum, maximum and average share in the total burden of injury of MAIS3+ casualties

EuroCOST injury group	Average burden pp [YLD]	Total burden of injury (MAIS3+) [YLD]		
		Min	Max	Average
2 other skull-brain injury	3.3	27% (Rhone)	36% (Austria)	32%
9 spinal cord injury	27.7	13% (Rhone)	35% (Netherlands)	22%
22 fracture hip	2.6	6% (Rhone)	20% (Netherlands)	13%
23 fracture femur shaft	3.2	4% (Netherlands)	23% (Austria)	11%
24 fracture knee/lower leg	4.3	3% (Netherlands)	31% (Rhone)	13%

Differences in distribution of burden of injury over injury groups between countries are mainly due to differences in the distribution of MAIS3+ casualties over injury groups. These differences in distribution of MAIS3+ casualties also partly explain differences in the general burden of injury figures between the countries. The difference in the proportion of cases with lifelong consequences (Pl) between Spain and the Netherlands can for example partly be explained by a difference in the number of casualties with hip fractures. People with hip fractures relatively often experience lifelong consequences of their injuries (PI is 52%) and in Spain the number of casualties with hip fractures is low compared to the Netherlands. In Spain 8% of all casualties have hip fractures compared to 31% in the Netherlands. Hip fractures are a common injury in the Netherlands for elderly cyclists that are injured in a bicycle crash without a motorized vehicle being involved.

The distribution of injuries and burden of injury over the body can be visualised by the so-called burden of injury body profiles that were introduced by Weijermars et al. (2016). Figure 5-1 shows the burden of injury body profiles for the six investigated countries. Appendix D contains the data that are on the basis of these profiles.

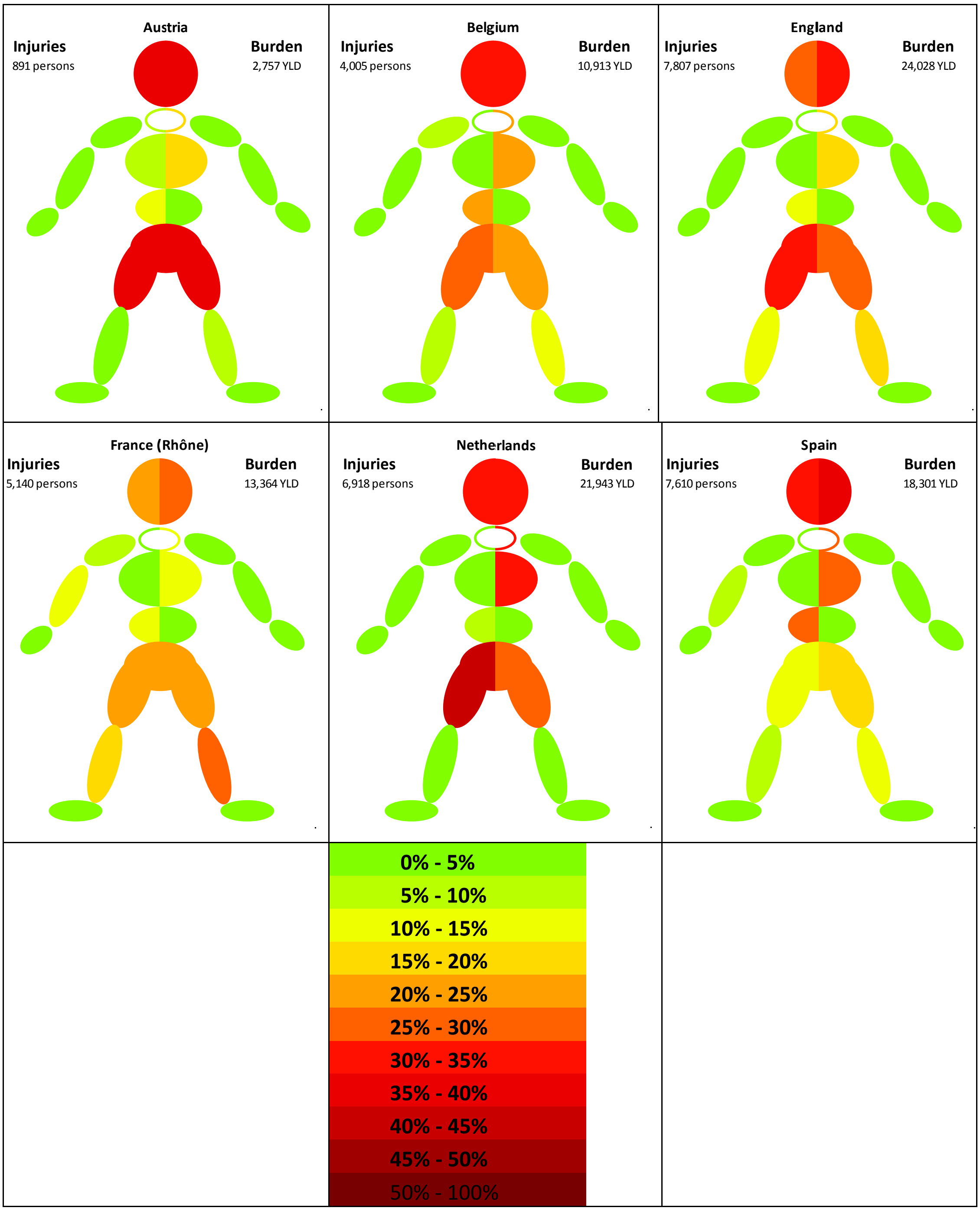

Figure 5-1 Burden of injury body profiles of the six countries. The left side of the body profiles shows the distribution of the casualties (prioritized EUROCOST injury group) over the body regions, the right side shows the distribution of the burden of injury.

The countries show some similarities, but also some differences. All six countries show a relative high share of head injuries in both the number of injured MAIS3+ road traffic casualties and in the burden of injury of those casualties, although the share is lower in the Rhone region compared to the other countries. Another body region with a relative high share in the number of MAIS3+ casualties and burden of injury are hip/upper legs, although these injuries appear to be less common in England and Spain. Back/chest injuries also appear to have a relatively high share in the burden of injury. Moreover, their share in the burden of injury is higher than their share in the number of casualties. This is due to spinal cord injuries that result in a high burden per casualty. On contrary, injuries to the abdomen have a higher share in the number of casualties than in the burden of injury. These injuries appear to be quite common in Spain, England and Belgium.

Differences in the burden of injury body profiles between the countries are partly due to differences in the distribution of casualties over transport modes. Section 5.2.2 showed that the distribution of casualties over transport modes differs between countries and the burden of injury body profiles differ between transport modes. **Figure 5-2** shows for example the body of injury profiles of different transport modes for the Netherlands. For cyclists who are injured in a crash without a motorized vehicle, the share of hip injuries in both the number of injuries and the burden of injury is very high, also compared to other transport modes. Car occupants show a relatively high share of back/chest injuries compared to other transport modes. For more information on injury profiles of different transport modes also see Aarts et al (2016).

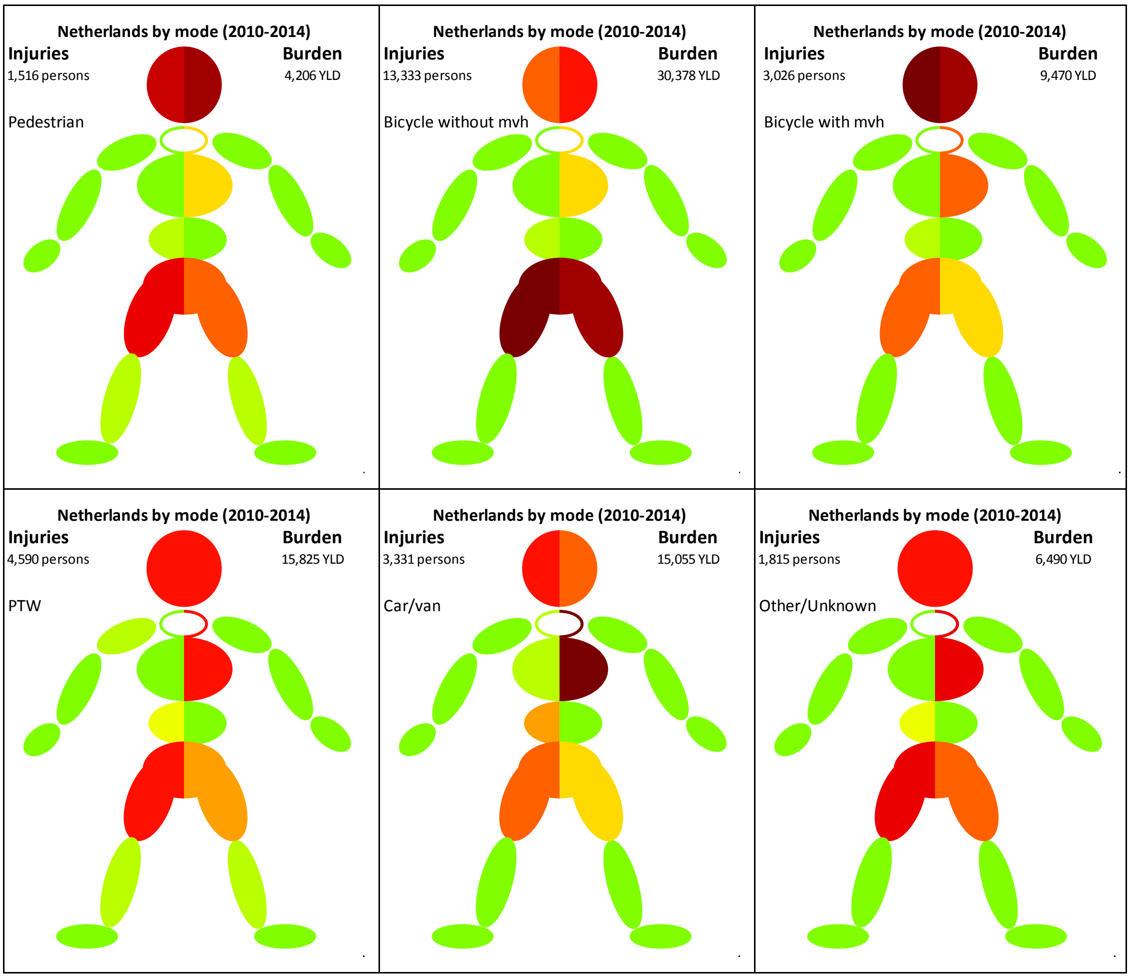

Figure 5-2 Burden of injury body profiles for different transport modes in the Netherlands. The left side of the body profiles shows the distribution of the casualties (prioritized EUROCOST injury group) over the body regions, the right side shows the distribution of the burden of injury. (mvh = motor vehicle)

5.2.4 Burden of injury for men and women

For all six countries, the number of MAIS3+ casualties is higher for men than for women. As a consequence, men have a higher share in the burden of injury in all six countries. On average, men also have a higher burden of injury per casualty (see **Table 5-5**). The results however vary between the countries; in Spain, the burden per casualty is higher for women than for men and in Austria, the average burden per casualty is comparable for men and women.

Table 5-5 Summary of information on burden of injury for men and women in six investigated countries.

Gender	% of total burden of injury Average (min, max)	Burden pp [YLD] Average (min,max)	Plifelong Average (min,max)
Men	72% (62% - 76%)	2.9 (2.4 – 3.3)	26% (18% - 33%)
Women	28% (24% - 38%)	2.8 (2.4 – 3.1)	31% (21% - 36%)

The percentage of MAIS3+ casualties that experience lifelong consequences in all countries appears to be higher for women than for men.

5.2.5 Burden of injury for different age groups

Figure 5-3 shows the distribution of the total burden of injury over different age groups. From the figure can be seen that young people have a very high share in the total burden of injury. There are two main reasons for that. First of all, young people have a lot of remaining life years and therefore have a relatively high burden of injury per person. Second, as is shown in Figure 5-4, young people have a relative high share in the number of serious road injuries as well.

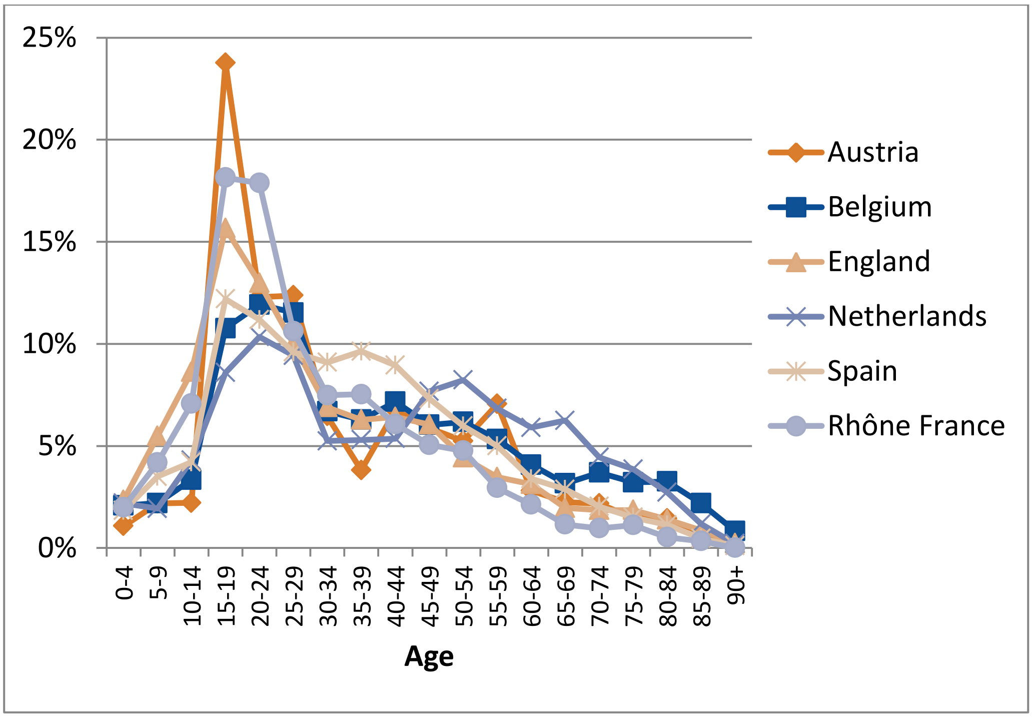

Figure 5-3 Age distribution of burden of injury in six countries.

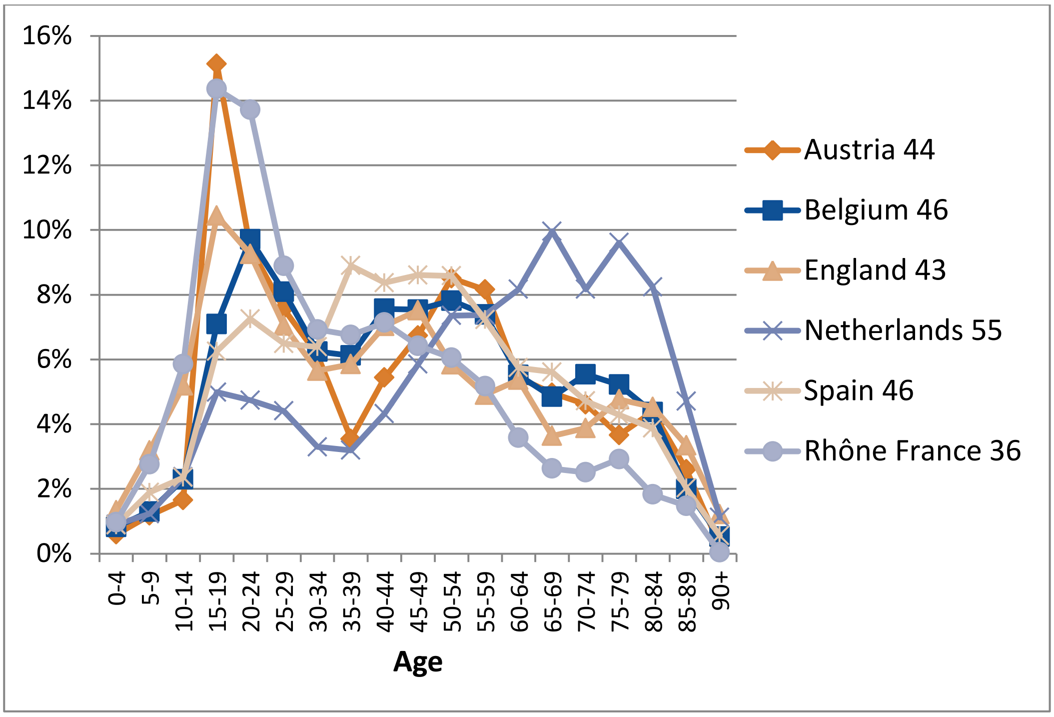

Figure 5-4 Age distribution of casualties in six countries. For each country, the average age of serious road injuries is mentioned in the legenda.

The age distribution appears to vary considerably between the countries. Austria and England have relatively many young road traffic casualties compared to Belgium and especially The Netherlands. The average age of a serious road traffic casualty is lowest in the Rhone region of France (36 years old) and highest in the Netherlands (55 years old). In the Netherlands, the share of elderly is very high among serious road injuries. This is mainly due to a high number of elderly bicyclists that are injured in crashes without motorized vehicles being involved. The age distribution of the casualties other than cyclists without motorized vehicles is much more comparable to the other countries (see Figure 5-5).

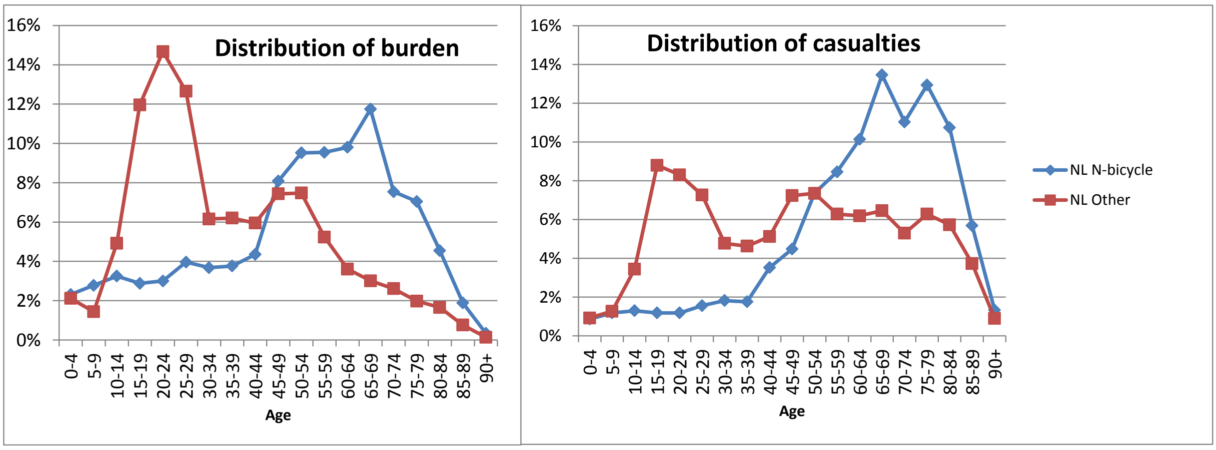

Figure 5-5 Age distribution of burden of injury and casualties of bicycle crashes without motorized vehicles being involved and all other casualties in the Netherlands.

Overall, the burden of injury per casualty decreases with age. The main reason for this is that older people have fewer remaining life years than younger people and consequently lower YLD due to permanent injury. When interpreting the results, one should be aware that we applied the same disability weights and proportions of casualties with lifelong consequences per EUROCOST injury group to all ages. In reality it is possible that a younger casualty with the same injury has a lower disability weight and a lower probability of permanent consequences than an older casualty. However, age dependent disability weights and proportions of lifelong consequences are not (yet) available.

Differences in age distribution also affect the total burden of injury and the average (lifelong) burden per casualty. As the average (lifelong) burden per casualty is relatively high for young casualties, a high number of young casualties results in a high average burden per casualty. The relatively high average lifelong burden per casualty in Austria and England, compared to Belgium and the Netherlands is probably caused by a relative young average age of the casualties[35].

Figure 5-6 shows the proportion of casualties that experience lifelong consequences for different age groups. In all countries, elderly road users show the highest proportion of casualties with lifelong consequences. Apparently, these casualties obtain more often injuries with relatively high proportions of lifelong consequences. As stated above, it is not unlikely that older casualties are more inclined to experience lifelong consequences given a certain injury compared to younger casualties. However, this is not taken into account in the method as it is now, as PIs of the EUROCOST groups are not age dependent.

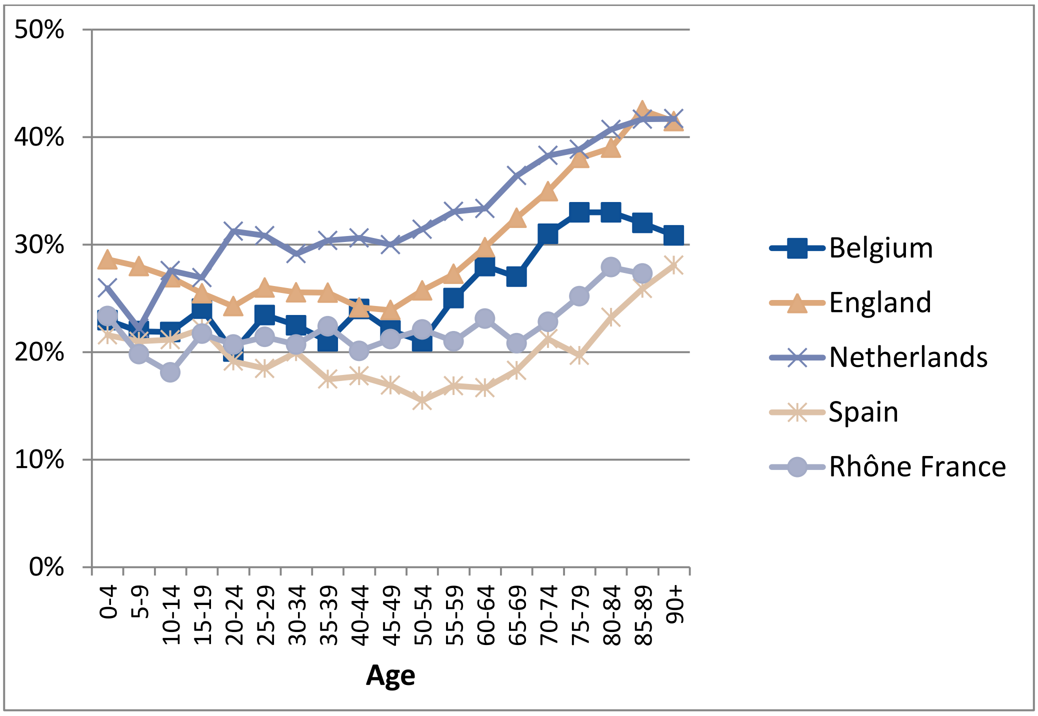

Figure 5-6 Proportion of MAIS3+ casualties with lifelong consequences for different age groups and different countries.

5.2.6 Burden of injuries of less severely injured road traffic casualties

All six countries also register less severe casualties that are admitted to the hospital. Also for these casualties the burden of injury has been determined. For all six countries, the average burden per casualty is lower for less severe injuries (see **Table 5-6**). Please note that the same disability weights were applied to different severity levels. Hence, differences in the average burden per person are

[35] The average burden per casualty is relatively low in England, but this is probably due to a relatively low proportion of people that experience lifelong consequences.

only due to differences in distribution of the casualties over the 39 EUROCOST injury groups and differences in the age distribution of the casualties.

Table 5-6 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%

Table 5-6 also shows that only part of the total burden of injury of hospitalized road traffic casualties is experienced by MAIS3+ casualties. The percentage differs between 22% and 58% and is relatively low for Austria. In Austria, only 9% of all hospitalized casualties in the sample has a MAIS3+ injury.

The Netherlands and the Rhone department 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, Polinder et al. (2015) estimated that casualties treated at the emergency department, are responsible for 26% of the total burden of injury in the Netherlands. So, MAIS3+ casualties are responsible for only about one third (48%*74%) of the total burden of injury in the Netherlands. For the Rhone department, almost 7% of all road traffic casualties that are treated at an Emergency Department or admitted to a hospital have a MAIS of 3 or higher. These MAIS3+ casualties are responsible for 26% of the total burden of injury of all treated road traffic casualties.

5.3 DISCUSSION

5.3.1 Limitations of the method applied

The INTEGRIS method, to our knowledge, appears to be the most appropriate method to calculate the burden of injury, given the information that is available for the countries. However, the application of the method has a number of limitations. First of all, the method itself has a number of limitations. First, psychological consequences are not really taken into account. According to Haagsma et al. (2011), the burden of unintentional injuries (including road traffic injuries) would be 53% higher if Post Traumatic Stress Disorder (PTSD) was also taken into account. Second, the method does not correct for a decrease in life expectancy due to trauma. Trauma patients are known to have a lower life expectancy (Davidson et al., 2011) which may also contribute to Years of Life Lost. However, there is not enough information to correct for this.

Also the application of the method results in a number of limitations. The main limitation is that the disability weights and percentages of casualties with lifelong disability that are applied are determined for a sample of injury patients that were admitted to a hospital. The sample also included less severely injured casualties (MAIS2, MAIS1-), and other injury causes.

The disability weights are estimated for hospital admitted patients in the different EUROCOST injury groups. The sample also includes admitted patients that have less severe injuries (MAIS2, MAIS1). It is quite possible that more severely injured casualties within a EUROCOST group are experiencing more disabilities from their injuries than less severely injured ones and therefore should have higher disability weights (DWs) and possibly also a higher percentages of casualties with lifelong disability (Pl). Should this effectively be the case, this would mean that the application of the current method leads to an underestimation of the burden of injury of MAIS3+ casualties.

The disability weights (DWs) and percentages of casualties with lifelong disability (Pls) are based on a sample of injury patients, including road traffic casualties, but also casualties of unintentional falls, sports accidents and other external causes. It is not clear to what extent DWs and Pls for road traffic injuries are comparable to injuries from other external causes. DWs and Pl could for example depend on someone's age, and the distribution of casualties within a EUROCOST group over age probably differs depending on injury cause. For the Netherlands we compared the average age of road traffic casualties with the average age of injury patients in general for a number of EUROCOST groups. The average age appeared to be lower for road traffic casualties. It is also possible that younger traffic casualties are more resilient than older ones, and consequently that the DWs and Pls should be lower for them. If that is indeed the case, the lower average age of road traffic casualties compared to other types of casualties would result in an overestimation of the burden of injury. On the other hand, MAIS3+ road traffic casualties are more likely to have multiple injuries. Multiple injuries might lead to higher disability weights. This would result in an underestimation of the burden of injury for road traffic casualties. So, the fact that disability weights and Pls are based on a broader sample of injury patients instead of road traffic injury patients could result in either an overestimation or an underestimation of the burden of injury.

Another limitation is that the DWs and Pls are based on a Dutch cohort study. DWs and Pls could be different for other countries. Moreover, the life expectancy is taken from the region S1-R10 Western Europe in the Global Burden of Disease study 2013. The life expectancy in individual countries could differ from this life expectancy table.

5.3.2 Transferability of results

Calculation of the burden of serious road traffic injuries in six countries/regions shows that the results differ considerably between countries. The average burden of injury per MAIS3+ road traffic casualty differs between 2.4 years lived with disability in Spain and 3.2 years lived with disability in the Netherlands. Moreover, the proportions of MAIS3+ casualties that encounter lifelong disabilities from their injuries vary between 19% in Spain and 33% in The Netherlands. Also the distribution of burden of injury over transport modes and the average burden per casualty per transport mode differs between the countries examined. The differences between countries are mainly due to differences in age distribution of the casualties and in the distribution of casualties over EUROCOST injury groups which are also influenced by differences in modal split.

As a consequence of the relatively large differences in burden of injury per person between the countries, one should be careful when applying the results from these countries to calculate the burden of injuries in another country or to calculate the burden of injury for Europe. As a first rough estimation of the burden of injury serious road traffic injury, one could multiply the number of MAIS3+ casualties with an average burden per casualty of 2.8 YLD. Depending on the age distribution and the type of injuries of the casualties, the actual burden could however be considerably higher or lower.

5.4 CONCLUSION

This chapter discussed the burden of injury of MAIS3+ road traffic casualties in the following countries/regions: Austria, Belgium, England, The Netherlands, the Rhone department in France and Spain. The burden of injury was calculated applying the INTEGRIS method. The application of this method has a number of limitations which were discussed in Section 5.3.

The average burden of injury per MAIS3+ casualty varies between 2.4 YLD in Spain and 3.2 YLD in the Netherlands, with an average of 2.8 YLD per casualty for the six countries together. About 90% of the burden of injury is due to lifelong disabilities that are encountered by 19% (Spain) to 33% (Netherlands) of the MAIS3+ casualties. The average lifelong burden per casualty who experiences lifelong consequences varies between 8.7 YLD (The Netherlands) and 11.5 YLD (Spain).

The average burden per casualty differs by injury type, transport mode, age and gender. Regarding injury type, the average burden per serious road traffic injury is by far the highest for spinal cord injuries (24.4 YLD – 30.0 YLD). This high burden per casualty is caused by a very high percentage of casualties experiencing lifelong consequences (100%) and high disability weights. Concerning transport modes, the results appear to differ between the countries. Overall, the average burden per serious road traffic casualty is highest for car occupants (3.4 YLD on average) and lowest for cyclists (2.3 on average for Belgium, Spain and the Rhone region). Overall, men have a higher burden of injury per casualty, although in Spain the average burden per casualty is higher for women than for men. Finally, the average burden per casualty decreases with age, because expected remaining life years and thus years lived with permanent disabilities decreases with age.

We also determined the distribution of the total burden of injury over transport modes, EUROCOST injury groups, gender and age. For all six countries, men have a higher share in the total burden of injury then women. Concerning transport modes, injury groups and age, results differ between countries, mainly as a result of differences in distribution of MAIS3+ casualties over these groups. Regarding the EUROCOST injury groups, the following five (out of 39) groups are responsible for roughly 90% of the total burden of injury:

- Other skull-brain injury
- Spinal cord injury
- Fracture hip
- Fracture femur shaft
- Fracture knee/lower leg

The burden of injury differ considerably between six countries/regions that were included in the analysis, mainly as a result of differences in age distribution of MAIS3+ casualties and in distribution of EUROCOST injury groups. Because of these differences, we recommend to be careful when applying the results from these countries to calculate the burden of serious road traffic injuries in another country or to calculate the burden of road traffic injury for Europe.

Finally, we also estimated the burden of injury for casualties that have less serious injuries. As expected, the average burden per casualty is lower for less severely injured casualties. However as there are relatively many MAIS<3 casualties, they have a high share in the total burden of injury in a country. Besides, there are even more road traffic casualties that are treated at an emergency department and discharged to the home environment. On the basis of data from the Netherlands and the Rhone region we estimated that MAIS3+ casualties are responsible for only 26% to 33% of the total burden of injury of all road traffic casualties.

6 Discussion, conclusions and recommendations

The literature review, case studies and burden of injury calculations show that (serious) road traffic injuries have large impact on the lives of individual casualties and on society as a whole. This chapter summarizes the main results and combines the results from the different chapters.

Serious road traffic injuries are increasingly being adopted as an additional indicator for road safety, next to fatalities. Reducing the number of serious traffic injuries is for example one of the key priorities in the road safety programme 2011-2020 of the European Commission. Non-fatal injuries can have a major impact on the quality of life of a crash survivor (and their families) and also pose a burden to society. As the consequences of injuries are very determinative for the costs of injuries for society, it is important to obtain information on these consequences. Besides, insight into consequences of (serious) road traffic injuries for different groups of road traffic casualties is very useful to further improve road safety policy.

This Deliverable discussed the consequences of serious road traffic injuries for the individual casualties (and their family members) as well as for the society as a whole. The consequences for individual casualties were investigated by means of a literature review and a number of additional case studies. The consequences for the society as a whole were also addressed in the literature review, and further examined by means of actual calculations of the burden of injury for a number of countries. Both the case studies and the burden of injury calculations have limitations. These are discussed in Section 6.1. Despite these limitations they provide useful insights on the variety and on the importance of the consequences traffic injuries. Section 6.2 presents the main conclusions of our research and Section 6.3 provides recommendations, both for policy-makers and for further research.

6.1 DISCUSSION

6.1.1 Consequences of road traffic injuries for individual casualties and their families

The long-term consequences of injuries on individual lives and their relatives are a very complex topic to investigate. Injuries have a wide range of potential consequences. According to the ICF, discussed in Chapter 2, road traffic injuries may influence human functioning at one or more levels: 1) problems in body function or structure (impairments), 2) activity limitations and 3) participation restrictions. The main body of the available literature deals with consequences on the levels of activity limitations and participation restrictions, impairments are discussed less often. The activity limitations and participation restrictions cover both functional limitations as well as socio-economic consequences. Moreover, the literature review also showed that road traffic injuries can also lead to different psychological disorders. The ICF framework and literature review also show that consequences may vary in time and from one casualty to the other, depending on for example the type and severity of injury, and personal and environmental factors

Ideally, one would like to have information about all kinds of consequences discussed above, at different moments in time, for different groups of casualties and about personal and environmental factors that influence consequences and development in time. However, none of the studies -

neither the studies found in the literature review, nor the case studies discussed in Chapter 4- provides a full picture of all consequences of road traffic injuries in Europe. The ESPARR study seems to be the most comprehensive study that is available for road traffic injuries. The sample size of road traffic casualties is quite large (1372 respondents), a large variety of outcomes are assessed at 0.5 years, 1 year, 2 years, 3 years and 5 years post-crash and the sample includes all kinds of road traffic casualties. However, the study is only representative for the Rhone region in France.

The studies discussed in the literature review (Chapter 3) and in Chapter 4 focus on different types of consequences, include different groups of casualties, and measure consequences at different moments in time. As a result of these differences, reported prevalence of disability as well as other reported consequences differs considerably between studies. Self-reported prevalence of disability varies for example between 11% and 80% according to the most recent review, whereas reported prevalence of PTSD vary between 2% and 60% and the proportion of casualties that report not being able to work for a long time varies from 10% (ESPARR study) to 75% (MyLAC study).

Many studies focussing on consequences of road traffic injuries concern follow-up studies in which road traffic casualties were asked to fill out a questionnaire on perceived impacts of sustained injuries. The main limitation of such questionnaires is that non-response is often quite high and might introduce a bias, overestimating the proportion of casualties that experience negative consequences. Besides, one should be aware of the fact that perceived consequences are for a (large) part subjective and are consequently influenced by a casualty's perception. This is not necessarily a problem. The advantage of using self-reports is precisely that it measures actual perceived consequences, and hence the subjective aftermath of the accident. However, one should be aware that perception might differ between different groups of road users and therefore, observed differences in consequences between groups of road users might not always be due to differences in objective crash outcomes but also due to differences in perception between groups of road users.

6.1.2 Calculation of the burden of injury

Calculation of the burden of injury of (serious) road traffic injuries enables us to compare the burden of traffic injuries to the health burden of other types of injuries and of diseases. Worldwide, road traffic injuries are a leading cause of DALYs (tenth in 2010, Murray et al., 2013) lost and is the major cause of injury death and disability (29.1%, Haagsma et al., 2016). Moreover, calculation of the burden of injury enables us to compare burden of fatal injuries with burden of non-fatal injuries. Finally, the burden of injury can be compared between different groups of road casualties, providing information on which groups of casualties could be given priority from a health perspective.

The YLD calculations presented in this deliverable result from applying the method developed within the European INTEGRIS study (Haagsma et al., 2012).Although this method, to our knowledge, seems to be the best available method, its application has a number of limitations. First of all, the INTEGRIS method itself has a number of limitations:

- As is also the case for other methods to calculate the burden of injury, psychological consequences are not really taken into account.
- The method does not correct for a decrease in life expectancy due to trauma.
- For some EUROCOST injury groups, there is no specific disability weight (DW) for patients that are admitted to the hospital. In those cases, we applied the DW of patients that were treated at the Emergency Department.

Second, the application of the INTEGRIS method to MAIS3+ road traffic casualties in various countries results in a number of limitations:

- The applied disability weights (DWs) and proportions of casualties with lifelong disabilities (PIs) are determined for a sample of injury patients that were admitted to a hospital. The sample also included less severely injured casualties (MAIS2, MAIS1-) and other injury causes. Possibly DWs and PIs of several EUROCOST groups should be higher for MAIS3+ casualties. Moreover, possibly DPs and PIs also differ between injury causes, for example as a result of differences in age distribution of the casualties.
- The DWs and proportions of casualties with lifelong disabilities are based on a Dutch cohort study and could be slightly different for other countries. Moreover, the life expectancy is taken from the region S1-R10 Western Europe in the Global Burden of Disease study 2013 and the life expectancy in individual countries is slightly different.

Calculation of the burden of serious road traffic injuries in six countries/regions shows that the results can differ considerably between countries, mainly due to differences in age distributions as well as in distributions of casualties over EUROCOST injury groups. As a consequence, one should be careful when applying the YLD estimates from these countries to calculate the burden of road traffic injury in another country or to calculate the burden of road traffic injury for Europe. As a first rough estimation of the burden of injury, one could multiply the number of MAIS3+ casualties with an average burden per casualty of 2.8 YLD. Depending on the age distribution and the injuries of the casualties, the actual burden can however be considerably higher or lower.

6.2 CONCLUSIONS

6.2.1 Consequences of (MAIS3+) road traffic injuries for individual casualties

According to the ICF[36], road traffic injuries can result in disabilities related to one or more levels of human functioning: 1) problems in body function or structure (impairments), 2) activity limitations and 3) participation restrictions. Activity limitations and participation restrictions deal with different aspects of human functioning, like mobility, self-care, domestic life, but also interpersonal interactions and relationships and community social and civic life. These latter consequences are treated separately in this report and are called socio economic consequences. The literature review in Chapter 3 showed that in addition to consequences on all three levels of human functioning, road traffic injuries can also lead to psychological disorders. These psychological disorders can be seen as an additional health condition in the ICF next to road traffic injury.

Both the literature review and the case studies from France, Great Britain, Spain, Germany and the MyLAC study show that road traffic injuries can have a substantial negative impact on the life of the casualties. Many people report negative consequences related to one of more levels of human functioning, up to five years after crashes. According to the ESPARR cohort study – a large follow-up study in the Rhone region in France- about three quarters of the MAIS3+ road traffic casualties are not fully recovered three years after the crash.

Impacts of road crashes that are reported include:
- **Functional consequences**: reported functional consequences include pain, fatigue, mobility problems and problems carrying out daily activities.
- **Psychological consequences**: reported psychological consequences include Post Traumatic Stress Disorder (PTSD), major depressive disorders, anxiety/fear, Specific Driving Phobia and Acute Stress Disorder (ASD). Reported prevalence of PTSD one year post crash varies between 2% and 33%.

[36] International Classification of Functioning, Disability and Health

- **Socio economic consequences**: reported social impacts include consequences on everyday life of the family, impact on leisure activities, and impacts on emotional life and (sexual) relationships. Economic impacts include sick leave from work or study, impact on employment and employability and financial problems as a result of the traffic crash.

Several studies compared the prevalence of various consequences, but the results are not consistent. According to the ESPARR study for example, pain is the most often reported consequence, whereas the MyLAC study reports that functional loss is largest for usual activities, followed by pain. The Spanish study shows that most disabilities are related to mobility and home life and in the German study, fear is reported most often.

According to the ICF framework, the extent to which an injury influences activities and participation of a casualty also depends on personal and environmental factors. This statement was supported by the literature we reviewed in Chapter 3. Personal and environmental factors that are reported to affect activity limitations, participation restrictions and/or psychological consequences are:

- Age; prevalence of functional impacts is lower for younger casualties)
- Gender; women experience more functional and psychological consequences than men
- Mental and psycho-social factors
- Comorbidity
- Socio-economic status and education level
- The compensation process
- Treatment in the hospital
- Crash circumstances.

Next to personal and environmental factors, also injury severity and type of injury (which are part of the health condition in the ICF) were found to have an effect on both functional and socio-economic consequences. In general, functional and socio-economic consequences appeared to be worse for more severe injuries. However, we should note that also less severe injuries, like strain injuries to the spine, *can* have major impacts on the life of casualties. The ESPARR study for example shows that one out of three MAIS<3 casualties are not fully recovered three years after the crash (compared to 74% of MAIS3+ casualties). Injury severity appeared to only have a small effect on psychological consequences. Types of injuries that are often linked to long-term disabilities include injuries to the lower extremities, head injuries, spinal cord injuries, hip injuries and complex/multiple injuries.

Looking at different transport modes, consequences appeared to be larger for pedestrians and powered two-wheelers. The ESPARR study shows for example that a relatively high proportion of pedestrians, followed by powered two-wheeler riders, did not fully recover three years after the crash. The German case study shows that vulnerable road users who were involved in crashes relatively often report that they have suffered from the crash and that a relatively high percentage of pedestrians were not able to return to their old job. The results from the case studies are consistent with results from the literature review.

6.2.2 Consequences of (MAIS3+) road traffic injuries for the society

Road traffic injuries also pose a burden to society. The burden of non-fatal traffic injuries can be expressed in Years Lived with Disability (YLD). According to the most recent figures of the Global Burden of Disease Study (GBD, 2013), road traffic injuries account for 8.6 million YLD worldwide, 120 YLD per 100 000 inhabitants (Haagsma et al., 2016). Road traffic injuries account for 29.3% of all injury DALYs (Haagsma et al., 2016).

Within SafetyCube we calculated the burden of injury of MAIS3+ road traffic casualties in Austria, Belgium, England, The Netherlands, the Rhone department in France and Spain, applying the

INTEGRIS method. The results appear to differ considerably between the countries/regions, mainly as a result of differences in age distribution of the casualties and in distribution of casualties over the EUROCOST injury groups.

The average burden of injury per MAIS3+ casualty varies between 2.4 YLD per casualty in Spain and 3.2 YLD per casualty in the Netherlands, with an average of 2.8 YLD per casualty for the six countries together. About 90% of the burden of injury is due to lifelong disabilities that are encountered by 19% (Spain) to 33% (Netherlands) of the MAIS3+ casualties. The average lifelong burden per casualty that experiences lifelong consequences varies between 8.7 (Netherlands) and 11.5 (Spain) YLD. The acute burden varies between 0.1 YLD and 0.3 YLD in the six countries. These results are consistent with most of the results that are described in literature. Only Tainio et al. (2014) found a clearly higher value for lifelong injuries (14.7 YLD) and a clearly lower value for temporal injuries (0.0012 YLD). Moreover, according to the study of Tainio et al., only 2% of the injuries caused lifelong consequences. The latter two can be explained by the fact that in the analysis of Tainio et al. less severe injuries were also included. Moreover, Tainio et al. applied the GBD method instead of the INTEGRIS method.

Regarding the burden of injury for different types of injuries, the average burden per serious road traffic injury is by far the highest for spinal cord injuries (24.4 – 30.0 YLD). Spinal cord injuries are also responsible for a large part of the total burden of injury, as are 'other skull-brain injury', fractures of hips, femur shafts and knee/lower legs. These five EUROCOST groups together are responsible for about 90% of the total burden of injury of MAIS3+ casualties in the six countries. These results are consistent with results in other studies.

Concerning transport modes, results appear to be less consistent between countries. In the Netherlands and Spain, the average burden per casualty was highest for car/van occupants, whereas in the Rhone region and Belgium, the average burden per casualty was highest for motorized two-wheelers and in England the average burden per casualty was highest for pedestrians. For the six countries together, the average burden per serious road traffic injury is highest for car occupants (3.4 YLD on average) and lowest for cyclists (2.3 on average for Belgium, Spain and the Rhone region). In most countries, the proportion of MAIS3+ casualties that encounter lifelong consequences is highest for pedestrians. The distribution of the total burden of injury over transport modes appeared to differ between countries, mainly due to differences in the distribution of MAIS3+ casualties over transport modes.

In most countries, men have a higher burden of injury per casualty. Moreover, men have a relatively high share in the number of MAIS3+ casualties in all countries and therefore also a relatively large share in the burden of injury. The average burden per casualty decreases with age, because remaining years to live and thus years lived with disability decreases with age.

Finally, the average burden per casualty appeared to be lower for less severely injured casualties. However, since the incidence of less severe injuries is much higher the share of burden of injury of these injuries is high. , On the basis of data from the Netherlands and the Rhone region we estimated that MAIS3+ casualties are responsible for only 26% to 33% of the total burden of injury of all road traffic casualties.

6.3 RECOMMENDATIONS

Serious road traffic injuries have only recently been considered as an additional indicator for road safety policy making. Moreover, research focussing on health impacts and the burden of road traffic injuries from a road safety point of view is a relatively new field of research. Over the longer term, this kind of research could substantially contribute to further road safety policy improvements.

We therefore recommend further discussion and exploration of the possibility of formulating road safety policies with an increased focus on the reduction of health impacts in addition to the reduction of the number of casualties. This could imply a different prioritization of transport modes, and increased focus on certain types of injuries, like spinal cord injuries. It should be further analysed which crash types and risk factors –related to road safety behaviour, infrastructure and vehicles- have relative large health impacts for individual casualties and/or contribute substantially to the burden of injury. Road safety measures could be (additionally) aimed at preventing or limiting the consequences of these crash types and risk factors.

Additionally, measures could be developed that would specifically aim at reducing the health impacts of crashes that already have occurred. An example would be the early detection and treatment of injuries that are known to have large long term impacts – although not necessarily being life-threatening. Another example would be measures aiming at improving social and professional re-integration. Cooperation with health care professionals and other relevant parties is essential in this respect.

In this respect, it should be noted that also less severe injuries are very relevant from a health burden perspective. MAIS3+ casualties are responsible for less than half of the total burden of non-fatal road traffic injury. We recommend countries that also have information about less severe injuries, to monitor developments and burden of injury for this group of casualties as well. Moreover, countries that do not yet have information on the incidence of less severe injuries could consider the options for registering less serious injuries as well.

Concerning further research, we recommend extending the burden of injury calculations to other European countries. This study showed that it is possible to apply the INTEGRIS method to serious road traffic casualties in different countries and that results differ between countries. Therefore, it would be interesting to repeat the calculations for more countries. Besides, additional analyses are possible, depending on the specific research question(s). One could for example construct burden of injury body profiles for different transport modes, different age groups, different genders or combinations of transport mode, age and gender.

Finally, for a European-wide application of the INTEGRIS method we recommend to overcome some of its limitations. The most important limitation is that disability weights and proportions of casualties are based on a broader sample of injury patients, including less severe injuries as well as injuries with other external causes[37]. We recommend developing serious road traffic injury specific disability weights and proportions of lifelong disability. This would require carrying out a large scale, European-wide follow up study specifically aimed at road traffic casualties. The French ESPARR cohort study and the Dutch follow-up study (Polinder et al, , 2007)that allowed the calculation of the disability weights determined in the INTEGRIS study could provide the methodological guidelines for such a follow-up study. The follow-up study could also be used to obtain a full picture on consequences of road traffic injuries for individual road users in a variety of EU countries.

[37] The broader group of injury patients probably has another age distribution and probably less often obtain multiple injuries.

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Appendix A: Instruments applied in ESPARR study

WHOQOL-BREF : The WhoQol instrument, driven by the World Health Organization was developed to qualify the quality of life through individuals' perception of their position in life in the context of the culture and value systems in which they live and in relation to their goals, expectations, standards and concerns. It has been developed collaboratively in several culturally diverse countries. It contains 100 questions and is organized into six domains: physical domain; psychological domain; level of independence; social relationships; c; spirituality/religion/personal beliefs. A shorter version has been further developed and tested (The WHOQOL-BREF); it is a 26-items self-report instrument which assesses four domains assumed to represent the Quality Of Life (QOL) construct: physical domain, psychological domain, social relationships domain and environment domain, plus two facets for assessing overall QOL and general health.

Child Health Questionnaire—Parents Form 50 (CHQ-PF 50): contains 12 scales: physical functioning; role social–emotional/behavioural (which assesses emotional/behavioural consequences of the accident for social activities); role social–physical (which assesses physical consequences of the accident for social activities); bodily pain; general behaviour; mental health; self-esteem; general health perceptions; parental impact–emotional; parental impact–time; family activities and family cohesion. These domains are summarized with 2 global scores: physical score and psychosocial score.

Post-traumatic Checklist Scale (PCLS): contains 17 items corresponding to the 3 PTSD dimensions: re-experiencing, avoidance and hyperactivity. The PCLS has shown good specificity in diagnosing PTSD; a score ≥44 indicates PTSD with disorder inevitably affecting the subject's life.

General Health Questionnaire (12 items) (GHQ-12): The general Health questionnaire is a psychiatric screening instrument. Several forms are used that differ in length (12 items; 28 items; 60 items); GHQ12 is considered as a useful tool for determine psychiatric illness in several populations.

ASIA impairment scale: grades the degree of impairment due to a spinal cord lesion; 5 levels are recognised (Complete spinal lesion; sensory incomplete; motor incomplete with more than half of muscles below the neurological level of injury have a muscle grade less than 3; motor incomplete with at least half of muscles below the neurological level of injury have a muscle grade > 3, Normal) (ASIA, 2000, 2008).

Functional independence measure (FIM): assesses independence on the motor, cognitive, psychological and behavioural dimensions by measuring limitation of activity and need for help. It comprises 18 function rubrics: 13 motor and 5 cognitive. Severity is assessed for each function on a 7-point scale, from 1 = dependence to 7 = complete independence. Total score thus ranges from 18 to 126.

Glasgow Outcome Scale (GOS): a global scale for functional outcome that rates patient status into one of five categories: Dead, Vegetative State, Severe Disability, Moderate Disability or Good Recovery.

Neurobehavioral Rating Scale-Revised (NRS-R): "The original NRS19 is a multidimensional rating scale that originated from the BPRS and was modified63 to increase its content validity with respect to the behavioural manifestations of TBI. The NRS consists of a semi-structured interview and brief cognitive tests used during the interview. It documents alertness, attention, fatigability, orientation, memory for recent events and delayed recall, conceptual organization, motor behaviour, expressive/receptive language functioning, attitude toward social environment, capacity for self-insight, motivation and long-range planning, disinhibitory behaviour or agitation, post concussional symptoms, and emotional state. " (Vannier et al., 2000)

the Trail Making Test : composed of two parts: In Part A, the subject is asked to connect as rapidly as possible, in ascending order, a set of 25 randomly distributed dots; in Part B, the subject is once again asked to connect dots, as quickly as possible and in ascending numerical and alphabetical order, through systematic alternation of a number and a letter (1-A-2- B-3-C. . .). It assesses mental flexibility and attention-switching capability.

Neck Pain and Disability Scale: is a 20-item scale measuring neck pain and related disability (neck movement) and the level of interference with daily lie activities.

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Appendix B Disability information

EUROCOST group	Disability Weights for acute phase	Proportion with lifelong consequences	Disability Weights lifelong consequences
1 concussion	0,100	21%	0,151
2 other skull-brain injury	0,241	23%	0,323
3 open wound head	0,209	-	-
4 eye injury	0,256	0	-
5 fracture facial bones	0,072	-	-
6 open wound face	0,210	-	-
7 fracture/dislocation/strain/sprain vertebrae/spine	0,258	0	-
8 whiplash, neck sprain, distorsion cervical spine	ND	ND	ND
9 spinal cord injury	0,676	100%	ND
10 internal organ injury	0,103	-	-
11 fracture rib/sternum	0,225	-	-
12 fracture clavicle/scapula	0,222	9%	0,121
13 fracture upper arm	0,230	10%	0,147
14 fracture elbow/forearm	0,145	8%	0,074
15 fracture wrist	0,143	18%	0,215
16 fracture hand/fingers	0,067	0	0,022
17 dislocation/sprain/strain shoulder/elbow	0,169	18%	0,136
18 dislocation/sprain/strain wrist/hand/fingers	0,029	0	-
19 injury of upper extremity nerves	ND	0	-
20 complex soft tissue injury upper extremities	0,190	15%	0,166
21 fracture pelvis	0,247	29%	0,182
22 fracture hip	0,423	52%	0,172
23 fracture femur shaft	0,280	35%	0,169

24 fracture knee/lower leg	0,289	34%	0,275
25 fracture ankle	0,203	35%	0,248
26 fracture foot/toes	0,174	39%	0,259
27 dislocation/sprain/strain knee	0,159	0	0,103
28 dislocation/sprain/strain ankle/foot	0,151	26%	0,125
29 dislocation/sprain/strain hip	0,309	30%	0,128
30 injury of lower extremity nerves	ND	0	-
31 complex soft tissue injury lower extremities	0,150	13%	0,080
32 superficial injury, including contusions	0,150	-	-
33 open wounds	0,093	-	-
34 burns	0,191	0	-
35 poisoning	0,245	0	-
37 foreign body	0,060	-	-
38 no injury after examination	-	-	-
39 other injury	0,212	-	-

Source: Haagsma et al., 2012

Appendix C Burden of injury in various countries

This appendix presents information on the burden of injury (expressed in YLD) for MAIS3+ casualties in a number of EU countries.

AUSTRIA

Estimation of the burden of injury

The number of MAIS3+ casualties in the tables below is based on an assignment of AIS values (MAIS1,2, MAIS3+ or undefined) to the 4-digit ICD-10 codes of the Austrian HDR data according to the "ICD-10 to AIS" lookup table provided by DG MOVE in 2015. As inclusion criteria, the definitions as in Deliverable 7.1 (Pérez et al., 2016) were followed.

The initial number of MAIS3+ casualties obtained this way in the Austrian HDR data ("Sample") is an underestimation of the "real" MAIS3+ count due the fact that:

1. a certain share of MAIS3+ traffic casualties is suspected within the group of unspecified accidents (25% of the initial number of MAIS3+ casualties in 2014),
2. a certain share of MAIS3+ traffic casualties is suspected within the group of cases "without an AIS score" (34% of the number of MAIS3+ casualties resulting from the correction in step 1; in 2014)

In order to account for these "suspected cases" an overall correction factor of 1.67 (= 1,25 x 1,34) was applied to the initial number of MAIS3+ casualties and to the initially calculated YLD as well (sample vs. estimated total).

YLD values and disability counts were derived from the Austrian HDR data according to the INTEGRIS procedure as described above: Unless specified differently, the MAIS3+ subset of the HDR data was used for the burden of injury analysis.

Burden of injury, main figures (2014)

Table C 1 Main burden of injury figures for traffic casualties with serious injuries (MAIS3+), Austria, 2014

	2014 sample	2014, estimated total
Number of MAIS3+ casualties	846	1 410
Total burden (all MAIS3+) [YLD]	2 616	4 360
Average burden per person (MAIS3+)	3.1	3.1
% of total burden (MAIS3+) due to lifelong consequences	91%	91%
% of MAIS3+ casualties with lifelong consequences	28%	28%
Average acute burden per person (all MAIS3+) *	0.28	0.28
Average lifelong burden per person with lifelong consequences (MAIS3+)	10.1	10.1

* including acute burden in the "lifelong group"; spread over all MAIS3+ cases)

In Austria, in 2014, a total burden of 4 360 YLD was estimated for 1 410 MAIS3+ traffic casualties. More than 90% of this burden is due to lifelong consequences. For all MAIS3+ casualties, the average burden is 3.1 years. For the group of MAIS3+ casualties with lifelong consequences the average burden is 10.1 years.

There was a decreasing trend in the average burden per road traffic casualty in the last years in Austria, which however, has been reversed in 2014. Temporary YLD are hardly influencing the overall YLD development (Figure C 1).

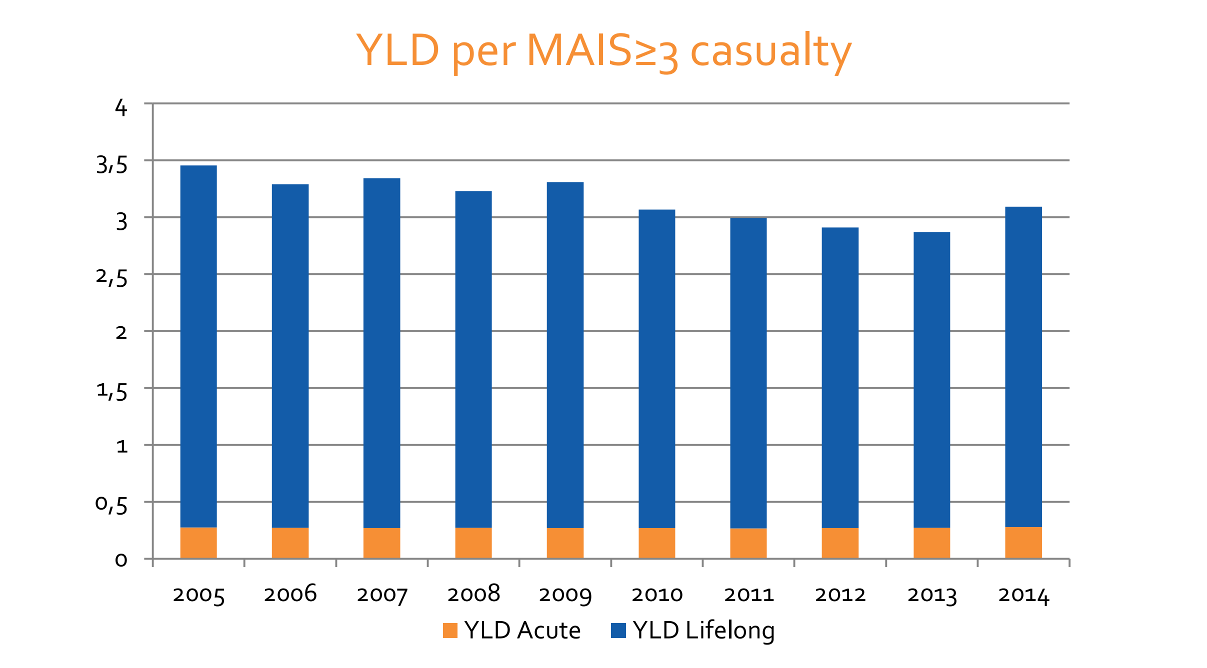


Figure C 1 Average temporary and lifelong burden for all MAIS3+ traffic casualties, for the period 2005-2014 in Austria.

Analysis per transport mode

Due to missing details in the ICD-10 codes of the Austrian HDR data, no distinction by mode of transport can be made of the MAIS3+ traffic casualty.

Analysis per EUROCOST injury group

Table C 2 Burden of injury figures per EUROCOST injury group, Austria, 2014

EUROCOST injury group	# MAIS3+ in sample	Burden of injury [YLD]				Plifelong
		acute p.p.	lifelong p.p.	Average p.p.	Total	
2 other skull-brain injury	286	0,24	3,1	3,3	946	23%
7 fracture/dislocation/strain/sprain vertebrae/spine	42	0,26	0	0,3	11	0%
9 spinal cord injury	15	0,68	28	28,7	430	100%
10 internal organ injury	88	0,1	0	0,1	9	0%
22 fracture hip	150	0,42	2,5	2,9	432	52%
23 fracture femur shaft	181	0,28	3	3,3	597	35%
24 fracture knee/lower leg	41	0,29	4,1	4,3	178	34%
31 complex soft tissue injury lower extremities	9	0,15	0,5	0,6	6	11%
34 burns	4	0,19	0	0,2	1	0%
39 other injury	30	0,21	0	0,2	6	0%
Total	846	0,28	2,8	3,1	2.616	28%

Only 10 out of the 39 Eurocost injury groups are responsible for the total burden of MAIS3+ traffic casualties. Almost 40% of burden is caused because of “other skull-brain injuries”. “Spinal cord injury” accounts for the highest average burden per person lifelong (Table C 2).

Analysis by age and gender

Table C 3 Number of MAIS3+ casualties, various YLD values and Plifelong for men and women in 2014, Austria

Gender	# casualties in sample	Burden of injury [YLD]				Plifelong
		YLD acute p.p.	YLD lifelong p.p.*	Average YLD p.p.	Total YLD	
Men	633	0,27	2,8	3,1	1.957	28%
Women	213	0,29	2,8	3,1	660	32%
Total	846	0,28	2,8	3,1	2.616	28%

*for casualties with lifelong consequences

As expected from fatalities, the analysis by gender confirms the high proportion of males, almost 75%, both for the MAIS3+ and the (total) YLD indicator. Gender specific YLDpp values are quite similar between the men and women (Table C 3).

In principal, the age distribution of the burden of injury seems to reflect the age distribution of MAIS3+ casualties; there is a sharp peak in the age group “15 to 19 years”, which is less prominent for acute than for lilelong consequences (Figure C 2).

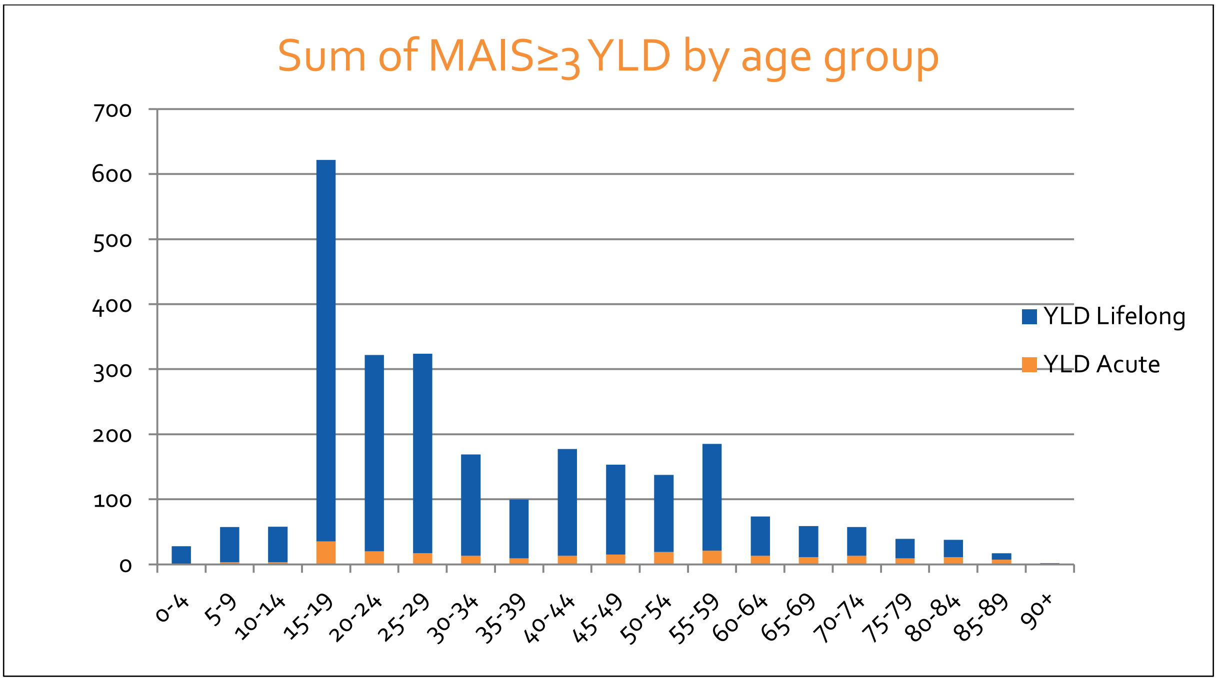


Figure C 2 *Acute and lifelong burden by age* group in 2014 Austria

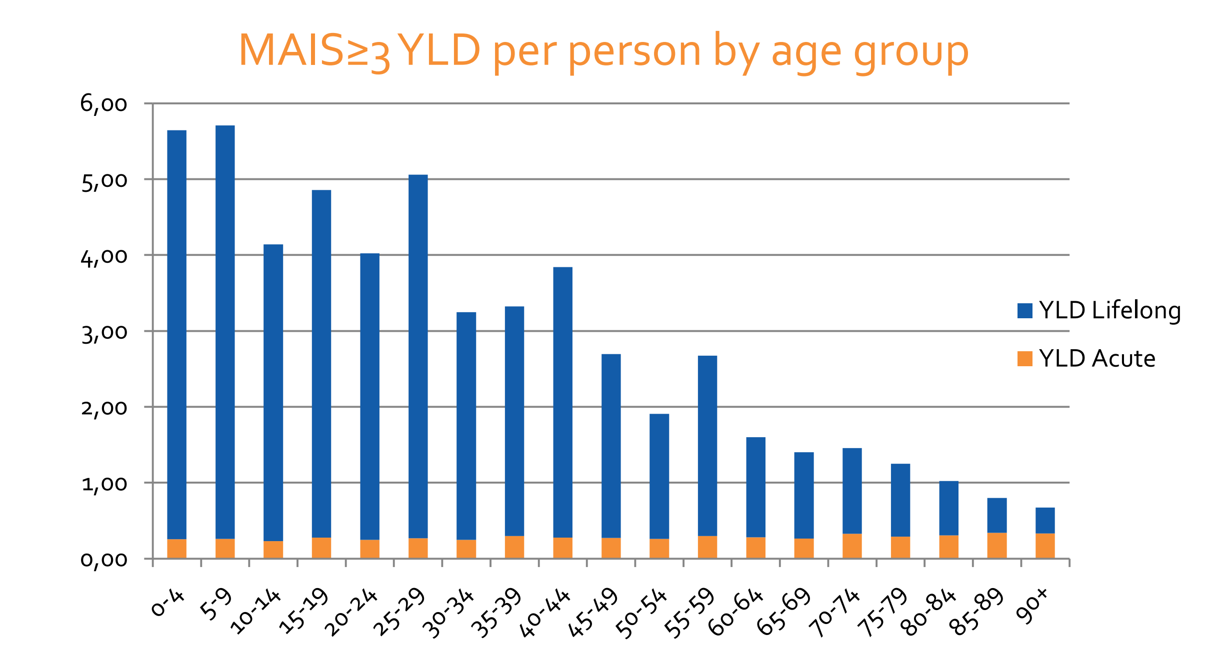


Figure C 3 *Acute and lifelong burden per person by age* group in 2014 Austria

Burden of injury for less severe injuries

In order to compare the burden of injury for less severe injuries with the one for MAIS3+ injuries, the indicators of Table C 1 were calculated also for MAIS1,2 injuries. Due to data restrictions, however, no correction factor was applied for MAIS1,2 injuries and only sample results are given.

Table C 4: YLD figures for less severely injured road traffic casualties (MAIS1,2), 2014, Austria

	MAIS1,2 2014, sample	**MAIS3+ 2014, sample**
Number of MAIS1,2 casualties	8 929	846
Total burden (all MAIS1,2) [YLD]	9 257	2 616
Average burden per person (MAIS1,2)	1.0	3.1
% of total burden (MAIS1,2) due to lifelong consequences	84%	91%
% of MAIS1,2 casualties with lifelong consequences (Plifelong)	10%	28%
Average acute burden per person (MAIS1,2)	0.16	0.28
Avearge lifelong burden per person with lifelong consequences (MAIS1,2)	8.6	10.1

Compared with MAIS3+ injuries, the burden of injury for traffic casualties with less serious injuries (MAIS1,2) is smaller when expressed per person (1.0 and 3.1 respectively). However, due to the 10 times larger number of less serious casualties in the sample, the total burden exceeds the burden of MAIS3+ casualties (Table C 4):

- a total of burden of 9 275 YLD was calculated for 8 929 MAIS1,2 traffic casualties (MAIS3+: 2 800 YLD for about 900 casualties)
- 84% of this burden is due to lifelong consequences (MAIS3+: 91%)
- the average burden is 1.0 years lived with disability (MAIS3+: 3.1 YLD)

- for the group of MAIS1.2 casualties with lifelong consequences the average burden is 8.6 years lived with disability (MAIS3+: 10.1 YLD)
- Average acute burden per MAIS1,2+ casualty is 0.16 YLD (MAIS3+: 0.28 YLD)

BELGIUM

Estimation of the burden of injury

In Belgium the number of MAIS3+ casualties is estimated on the basis of hospital discharge data. The burden is calculated for hospital admissions. Anonymised hospital discharge data covering the period 2009 to 2011 used in these analyses have been provided by the Federal Public Service of Health.

In order to identify road traffic casualties, patients have been selected who had been attributed one of the following E-codes: E810 till E819, E826, E827, E829, E929.0, E988.5. Of this original dataset, records corresponding to readmissions, fatalities within 30 days have been excluded. Additionally, among records for which an E-code indicating the place of occurrence of the accident (E849) was available only those with code E849.5 (indicating "street and highways" as accident place of occurrence) have been included in the analysis. All records with missing E849 code have however been included in the sample.

All diagnoses have been converted from ICD9 codes to AIS severity scores by means of the ICDPIC conversion table. Note that the MAIS3+ casualties numbers presented later on in this section have not been adjusted for missing E-codes, missing diagnoses, nor for patients who never attended the hospital. This is likely to have resulted in an underestimation of MAIS3+ casualties.

Burden of injury, main figures

Table C 5 Main burden of injury figures for traffic casualties with serious injuries (MAIS3+), Belgium, 2011

Figure	2011 sample
Number of MAIS3+ casualties	4005
Total burden (all MAIS3+) [YLD]	10913
Average burdenper person [YLDpp]	2.72
% of total burden due to lifelong consequences	91%
% of MAIS3+ casualties with lifelong consequences (Plifelong)	25%
Average acute burden per person [YLDpp]	0.25
Average lifelong burden per person with lifelong consequences [YLDpp]	10.1

Source: BRSI, on the basis of hospital admissions for the year 2011.

4005 MAIS3+ casualties have been registered in Belgium for the year 2011 on the basis of hospital data. Together, they represent a burden of injury of about 10 913 YLD, with an average of 2.72 YLD per person. Lifelong consequences account for 91% of the serious road traffic injuries burden. About one out of 4 MAIS 3+ casualty experience lifelong consequences as a result of the injuries sustained.

Analysis per transport mode

Table C 6 Burden of injury of MAIS3+ casualties for different transport modes in 2011, Belgium

Transport mode	# MAIS3+	Burden of injury				Plifelong
		YLD acute p.p.	YLD lifelong p.p.*	Average YLD p.p.	Total YLD	
Pedestrian	329	0.26	9.25	2.71	893	3278 %
Cyclist	1417	0.29	6.79	2.31	3,272	30%
Motorized two-wheeler	755	0.24	12.53	3.08	2,325	23%
Car/van occupant	1327	0.22	13.86	2.97	3,944	20%
Other	177	0.23	11.11	2.71	479	22%
Total	4005	0.28	10.08	2.72	10,913	25%

*for casualties with lifelong consequences

The burden per person and percentage of casualties with lifelong consequences differ between transport modes. The average burden per person is highest for car/van occupants and motorized two-wheelers. It is the lowest for pedestrians. The percentage of casualties encountering lifelong consequences is high for pedestrians and for cyclists compared to other transport modes.

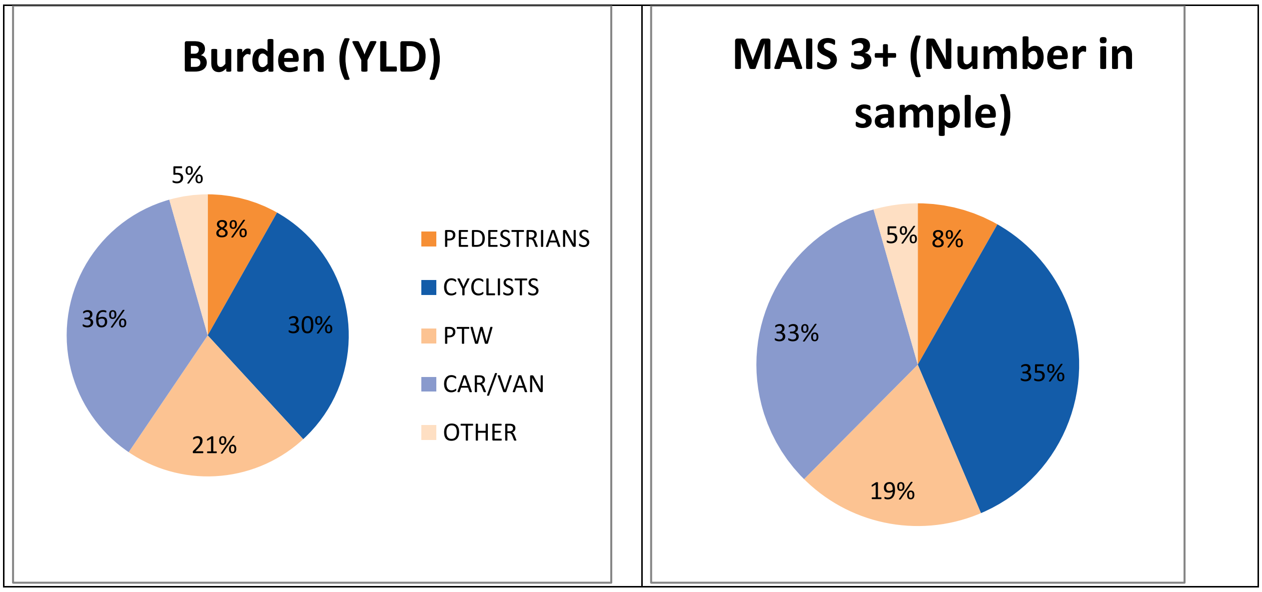


Figure C 4 Distribution of MAIS3+ casualties and burden of injury of these casualties over transport modes, Belgium, 2011.

Car/van occupants represent 30% of the MAIS3+ casualties in Belgium, but they make up 36% of the burden of injury, given their relatively higher average burden of injury. The same holds for powered two-wheelers. Pedestrians and cyclists, on the opposite, make up a larger share of the total number of MAIS3+ casualties than of the burden of injury because of their lower average burden of injury (see Figure C 4).

Analysis per EUROCOST injury group

Table C 7 Burden of injury figures per EUROCOST injury group, Belgium, 2011

EUROCOST injury group	# MAIS3+ in sample	Burden of injury [YLD]				Plifelong
		YLD acute p.p.	lifelong p.p.	Average p.p.	Total	
1 concussion	2	0.100	5.05	1.16	2	21%
2 other skull-brain injury	1218	0.241	12.57	3.13	3496	23%
5 fracture facial bones	4	0.072		0.07	1	0%
7 fracture/dislocation/strain/sprain vertebrae/spine	18	0.258		0.26	5	0%
8 whiplash, neck sprain, distorsion cervical spine	1			0.07	0	
9 spinal cord injury	92	0.676	27.02	27.70	2?548	100%
10 internal organ injury	706	0.103		0.10	73	0%
11 fracture rib/sternum	115	0.225		0.23	26	0%
12 fracture clavicle/scapula	272	0.222	4.40	0.62	168	9%
13 fracture upper arm	18	0.230	3.98	0.63	12	10%
14 fracture elbow/forearm	82	0.145	3.05	0.39	32	8%
15 fracture wrist	25	0.143	7.64	1.52	38	18%
16 fracture hand/fingers	1				0	
20 complex soft tissue injury upper extremities	8	0.190	7.78	1.36	11	15%
21 fracture pelvis	192	0.247	7.04	2.29	440	29%
22 fracture hip	558	0.423	3.79	2.39	1,336	52%
23 fracture femur shaft	254	0.280	8.33	3.20	1,811	35%
24 fracture knee/lower leg	342	0.289	11.53	4.21	1,439	34%
25 fracture ankle	37	0.203	8.89	3.72	812	35%
29 dislocation/sprain/strain hip	1	0.309	2.23	2.54	3	30%
31 complex soft tissue injury lower extremities	55	0.150	3.23	0.56	31	13%
34 burns	3	0.191		0.19	1	0%
39 other injury	1	0.212		0.21	0	0%
Total	4005	0.28	10.08	2.72	10913	29%

The injuries with the largest shares in the total burden of injury are: spinal cord injuries, 'other skull-brain injuries' knee/lower leg fractures, and hip fractures. Spinal cord injuries lead by far to the highest burden of injury per casualty and have permanent consequences for all casualties.

Analysis by age and gender

Table C 8 Number of casualties and burden of injury for men and women, Belgium, 2011

Gender	# casualties in sample	Burden of injury [YLD]				Plifelong
		YLD acute p.p.	YLD lifelong p.p.*	Average YLD p.p.	Total YLD	
Men	2,961	0.25	10.27	2.73	8072	24%
Women	1,044	0.26	9.56	2.72	2841	26%
Total	4,005	0.25	10.08	2.72	10,913	25%

*for casualties with lifelong consequences

The number of MAIS3+ casualties is much higher among men than among women. The average burden of injury per person is similar for men and women.

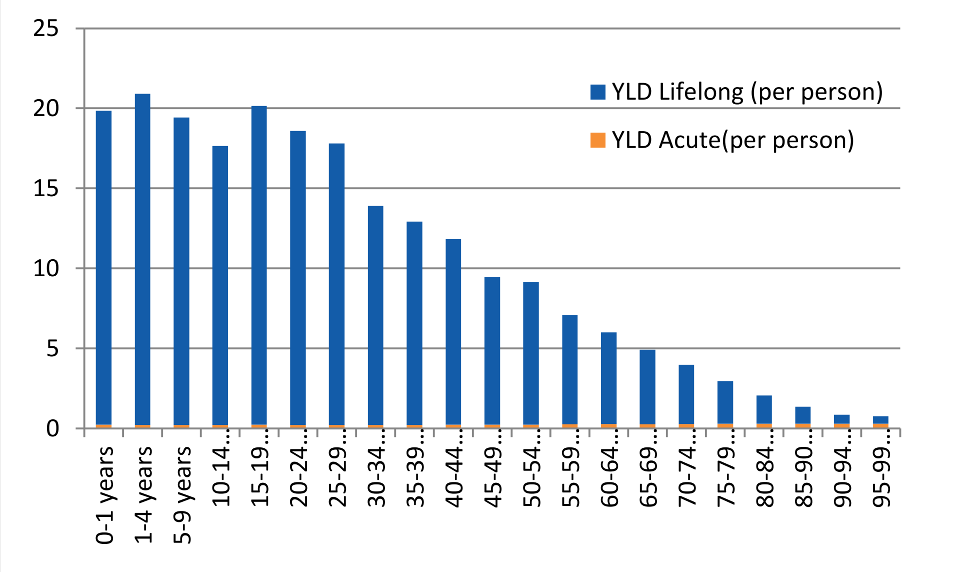


Figure C 5 *Acute and lifelong burden per person by age* group in 2011 Belgium

The burden of injury per person depends on someones' age. A younger person has a higher (remaining) life expectancy and therefore has a relative high lifelong burden of injury compared to an older person.

Burden of injury for less severe injuries

Table C 9 Main YLD figures for less seriously injured casualties (MAIS1,2) compared to MAIS3+ casualties, 2011, Belgium

Severity	N in sample	%	Burden [YLD]	%	Burden p.p.	Lifelong (number)	%
MAIS3+	4,005	22%	10,913	44%	2.72	982	40%
MAIS2	8,236	44%	12,844	51%	1.56	1340	55%
MAIS1-	2,197	12%	1,300	5%	0.59	135	5%
Total hospitalized	14,438	100%	25,057	100%	5,18	2,457	100%

ENGLAND

Estimation of the burden of injury

In England there were 2 possible methods to estimate the number of MAIS3+ injuries; one using linked police and hospital discharge data, the other using only hospital data. After looking at both datasets it was decided to use the hospital-only data, as this included significantly more casualties than the linked data. It is expected that our sample will not reflect the true number of injuries, for example there are likely to be some errors in the hospital recording, however we believe the figure to be close and at this time we are unable to accurately estimate the true number.

The hospital discharge data covers casualties in England, not the whole UK, and only includes casualties who were admitted to a hospital. Casualties treated only at the accident and emergency departments and not admitted to hospital are not included. Injury diagnoses are coded to the International Classification of Diseases, 10th edition (ICD-10), and the MAIS was derived using the method developed at the University of Navarra for the Apollo project. We have used 2010 data for our analysis, it is possible that more current estimates would be slightly different but we don't expect them to have changed drastically.

Before calculating the burden of injury the data was cleaned to exclude casualties not relevant for the analysis. We excluded; planned/scheduled admissions, re-admissions within 1 calendar year, patients who died within 30 days of hospital admittance, and patients who did not have an external cause of injury related to a road transport accident (on the basis of the 'V' codes). For each of the remaining casualties we attempted to calculate the burden of injury, although for a very small number of records this was not possible due to missing variables (e.g. no age recorded).

Burden of injury, main figures (2010)

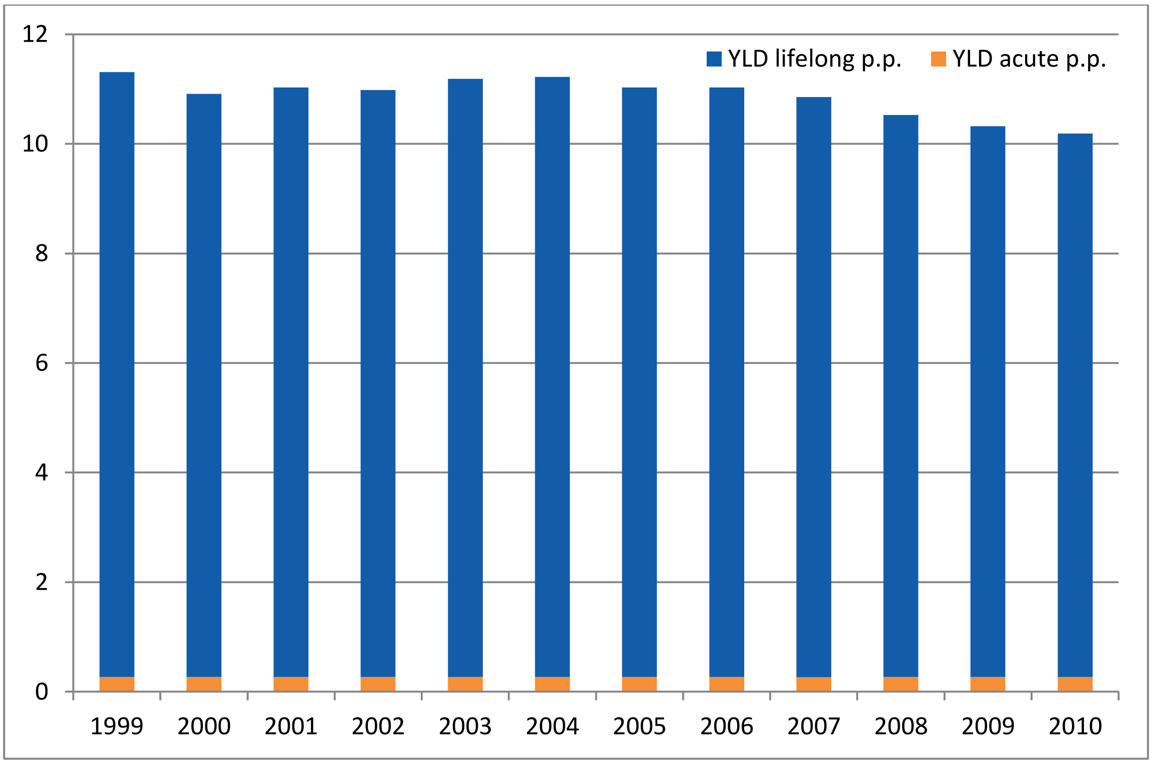
Table C 10 Main burden of injury figures for traffic casualties with serious injuries (MAIS3+), England, 2010

Figure	2010 sample
Number of MAIS3+ casualties	7,807
Total burden (all MAIS3+) [YLD]	24,028
Average burden per person [YLDpp]	3.08
% of total burden due to lifelong consequences	91.3%
% of MAIS3+ casualties with lifelong consequences (Plifelong)	28.3%
Average acute burden per person [YLDpp]	0.27
Average lifelong burden per person with lifelong consequences [YLDpp]	9.92

Source: Hospital Episode Statistics (HES) inpatient database.

In 2010 in England there were just over 7,800 recorded casualties admitted to hospital with serious road traffic injuries (MAIS 3+). These casualties had a total burden of injury of 24,028 YLD, an average of 3.08 YLD per person. Nearly a third of MAIS 3+ casualties are expected to have lifelong consequences from their injuries, and lifelong consequences are responsible for around 91% of the total burden of serious (MAIS 3+) road traffic injuries.

Development over time



The burden of injury per person has steadily decreased from 2004 to 2010.

Analysis per transport mode (2010)

Table C 11 Burden of injury of MAIS3+ casualties for different transport modes in 2010, England

Transport mode	# MAIS3+ in sample	Burden of injury [YLD]				Plifelong
		Acute p.p.	Lifelong p.p.*	Average p.p.	Total	
Pedestrian	1,638	0.27	10.78	3.39	5,560	29%
Cyclist in crash without motorized vehicle	1,041	0.29	8.31	2.93	3,050	32%
Cyclist in crash with motorized vehicle	443	0.26	10.65	3.14	1,390	27%
Motorized two-wheelers	1,547	0.25	11.10	3.02	4,665	25%
Car/van	2,006	0.26	10.52	3.07	6,156	27%
other	1,132	0.29	7.86	2.83	3,208	32%
Total	7,807				24,028	

*for casualties with lifelong consequences

The average burden per person is highest for pedestrians, followed by cyclists in collision with a motorised vehicle. There could be several reasons for this, for example both these groups show a larger proportion of child (age<15) casualties compared with PTW riders and car/van occupants.

Cyclists in crashes without a motorised vehicle have one of the lowest average burdens per person, however they are the most likely to encounter lifelong consequences compared with other road user groups.

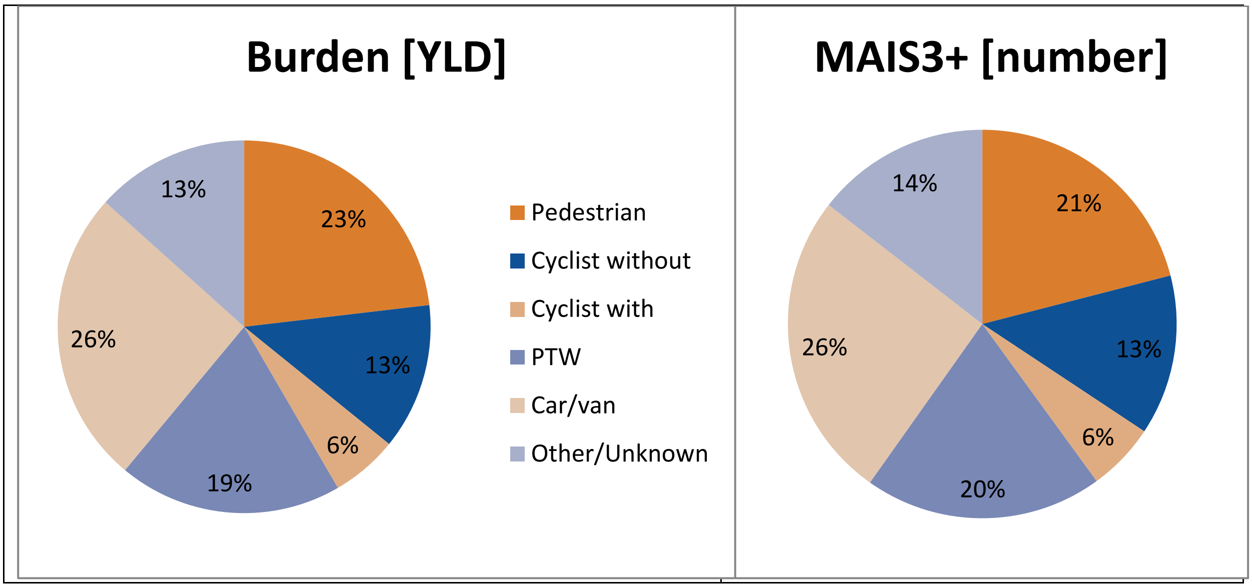


Figure C 6 Distribution of MAIS3+ casualties and burden of injury of these casualties over transport modes, England, 2010.

For most road user groups the proportion of total casualties is equal to their share of the total burden of injury. Pedestrians have a higher share of the burden relative to their total number, but the difference is only slight, and is likely due to the higher average burden of injury per person for this group.

Analysis per EUROCOST injury group (2010)

Table C 12 Burden of injury figures per EUROCOST injury group, England, 2010

EUROCOST injury group	# MAIS3+ in sample	Burden of injury				Plifelong
		YLD acute p.p.	YLD lifelong p.p.*	Average YLD p.p.	Total YLD	
2 other skull-brain injury	2,083	0.24	14.71	3.62	7,548	23%
5 fracture facial bones	2	0.07		0.07	0	0
7 fracture/dislocation/strain/sprain vertebrae/spine	101	0.26		0.26	26	0
9 spinal cord injury	133	0.68	29.32	30.00	3,989	100%
10 internal organ injury	902	0.10		0.10	93	0
11 fracture rib/sternum	12	0.23		0.23	3	0
12 fracture clavicle/scapula	351	0.22	4.56	0.63	222	9%
13 fracture upper arm	26	0.23	6.81	0.91	24	10%
14 fracture elbow/forearm	193	0.15	3.47	0.42	82	8%
15 fracture wrist	103	0.14	11.00	2.12	219	18%
16 fracture hand/fingers	6	0.07		0.07	0	0
18 dislocation/sprain/strain wrist/hand/fingers	15	0.03		0.03	0	0
20 complex soft tissue injury upper extremities	26	0.19	8.01	1.39	36	15%
21 fracture pelvis	313	0.25	7.14	2.32	725	29%
22 fracture hip	1,500	0.42	3.71	2.35	3,531	52%
23 fracture femur shaft	856	0.28	8.83	3.37	2,886	35%
24 fracture knee/lower leg	820	0.29	12.61	4.58	3,753	34%

EUROCOST injury group	# MAIS3+ in sample	Burden of injury				Plifelong
25 fracture ankle	171	0.20	12.59	4.61	788	35%
26 fracture foot/toes	3	0.17	6.22	2.60	8	39%
27 dislocation/sprain/strain knee	36	0.16		0.16	6	0
29 dislocation/sprain/strain hip	3	0.31	6.42	2.23	7	30%
31 complex soft tissue injury lower extremities	124	0.15	3.52	0.61	75	13%
32 superficial injury, including contusions	5	0.15		0.15	1	0
33 open wounds	4	0.09		0.09	0	0
34 burns	4	0.19		0.19	1	0
39 other injury	15	0.21		0.21	3	0
Total	7,807				24,028	

The injuries with the largest shares of the total burden of injury were 'other skull-brain injuries' (31%), 'spinal cord injuries' (17%), 'fracture to knee/lower leg' (16%) 'fracture to hip' (15%), and 'fracture to femur shaft' (12%). Together these injury groups represented 90% of the total burden; no other injury groups had more than 5% of the share.

Of the total number of MAIS3+ casualties in the sample, 12% were in the 'internal organ injury' group which has no lifelong consequences. The average burden per person was comparatively very high for 'spinal cord injuries', of which 100% of casualties suffer lifelong consequences.

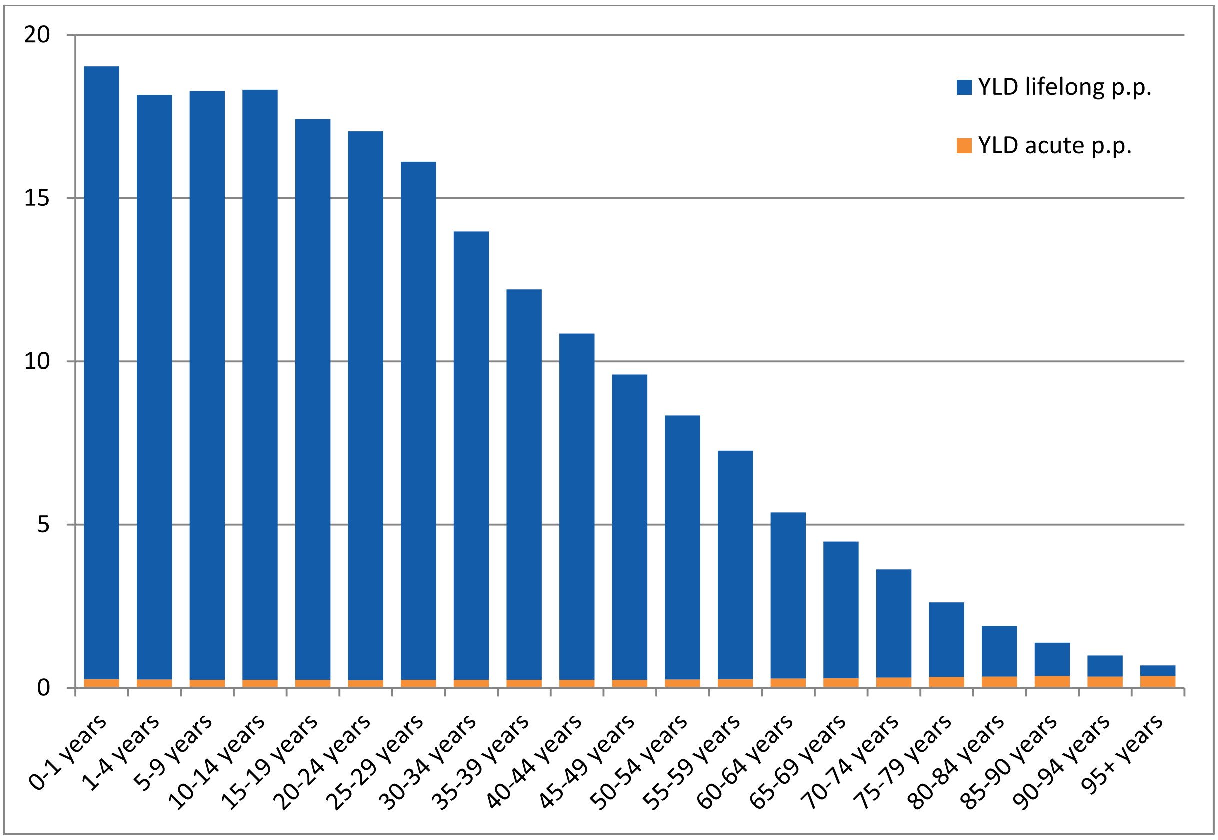
Analysis by age and gender

Table C 13 Number of casualties and burden of injury for men and women, England, 2010

Gender	# victims in sample	Burden of injury				Plifelong
		YLD acute p.p.	YLD lifelong p.p.*	Average YLD p.p.	Total YLD	
Men	5,478	0.26	10.79	3.16	17,283	27%
Women	2,329	0.29	8.19	2.90	6,745	32%
Total	7,807				24,028	

*for casualties with lifelong consequences

The number of males in the sample of MAIS3+ injuries is more than twice the number of females. The average burden per person is higher for men than women; however women are more likely to suffer lifelong injuries than men.



The acute burden of injury appears to gradually increase with age, perhaps reflecting that as people get older they can be more susceptible to injury and may recover more slowly than younger people. However, the lifelong and overall burden decreases with age which is expected as an older person has a lower remaining life expectancy so does not live with the injury for as long as a younger person.

Burden of injury for less severe injuries

Table C 14 YLD figures for less seriously injured casualties (MAIS1-,2) compared to MAIS3+ casualties, 2010, England

Severity	N in sample	%	Burden [YLD]	%	Burden p.p.	Lifelong (number)	%	% of N
MAIS3+	7,807	17%	24,028	34%	3.08	2,209	36%	28.3%
MAIS2	20,905	47%	43,000	60%	2.06	3,700	61%	17.7%
MAIS1-	15,962	36%	4,204	6%	0.26	191	3%	1.2%
Total hospitalized	44,674		71,232			6101		

THE NETHERLANDS

Estimation of the burden of injury

In the Netherlands, the number of MAIS≥3 casualties is estimated by linking police and hospital discharge data. The burden is calculated for serious road traffic casualties that are recorded in the hospital data. For several reasons, 11% of all MAIS≥3 casualties is not recorded as a road traffic casualty in the hospital. This is caused by missing/wrong external cause (known from linking) and by incompleteness of hospital reporting (known from the hospitals). For consistency reasons the patients recorded in ICD10 (gradually introduced in the Dutch hospitals since 2012) were converted to ICD9-cm and treated alike the patient records we have used in this study since 2000. Additional corrections were needed for the ICD10-records for differences in severity and cases that were falsely reported as 'not a traffic accident'. For each casualty, the burden was estimated, using weighting factors to compensate for these omissions. For the total burden of injury of all MAIS≥3 serious road traffic injuries, the calculated burden appears to be 13% higher than based on the sample. The indicators 'per person' and percentages related to lifelong consequences show only very small differences between the sample and the estimated true indicators.

Burden of injury, main figures

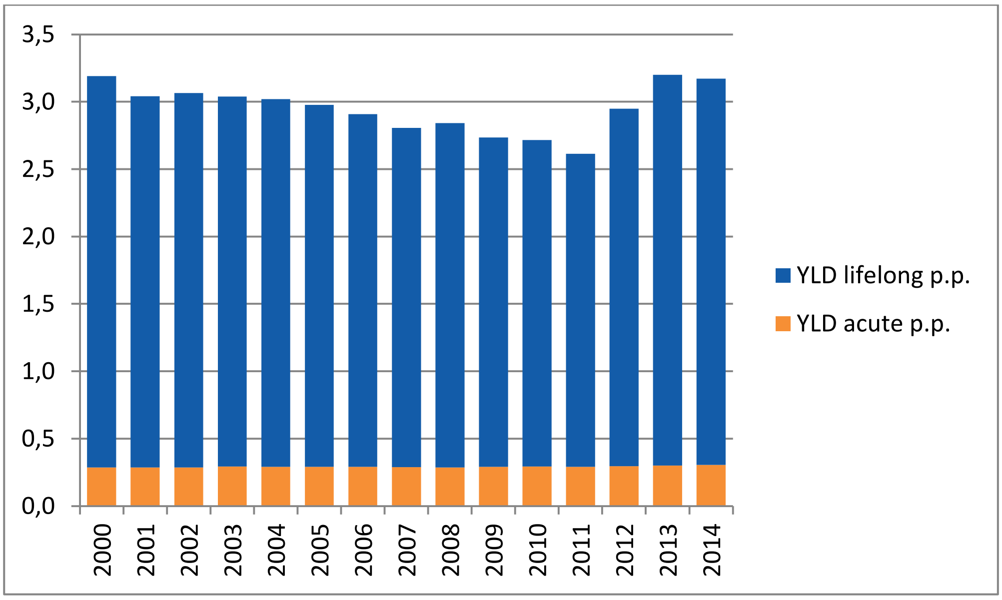
Table C 15 Main burden of injury figures for traffic casualties with serious injuries (MAIS≥3), Netherlands, 2014

Figure	2014 sample	2014, estimated total
Number of MAIS≥3 casualties	6,918	7,691
Total burden (all MAIS≥3) [YLD]	21,943	24,699
Average burdenper person [YLDpp]	3.17	3.21
% of total burden due to lifelong consequences	90%	91%
% of MAIS≥3 casualties with lifelong consequences (Plifelong)	34%	33%
Average acute burden per person [YLDpp]	0.31	0.30
Avearge lifelong burden per person with lifelong consequences [YLDpp]	8.40	8.74

Source: SWOV, on the basis of LBZ. The year of discharge was 2014, so this includes some patients that had their traffic accident late 2013, but excludes some patients that were hospitalised late 2014 but not yet discharged in 2014. For referencing please round numbers to hundreds.

In the Netherlands, we had almost 7,700 serious road traffic injuries (MAIS≥3) in 2014. These MAIS≥3 casualties together have a total burden of injury of about 24,700 YLD, on average 3.2 YLD per person. One out of three MAIS≥3 casualties is estimated to encounter lifelong consequences from its injuries. Lifelong consequences are responsible for about 90% of the total burden of injury of serious road traffic injuries.

Development over time



We see a decrease in the burden per person until 2011 and from then an increase that we cannot explain. It may be related to the gradual introduction of ICD10 in hospitals since 2012.

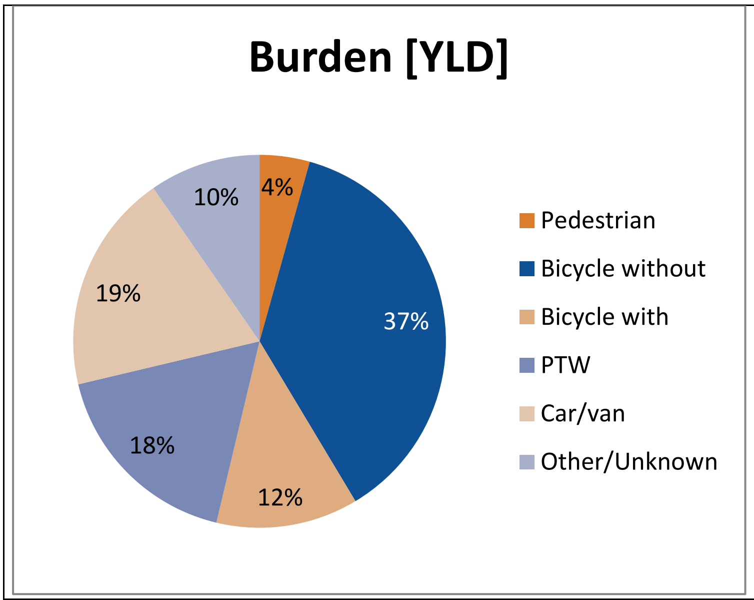
Analysis per transport mode (2014)

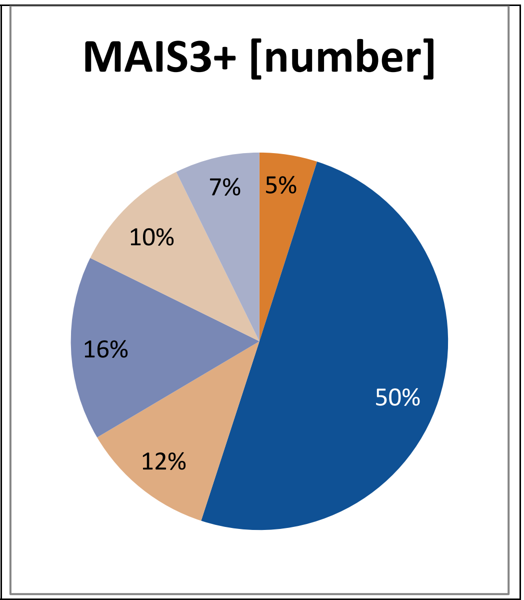
Table C 16 Burden of injury of MAIS≥3 casualties for different transport modes in 2014, Netherlands

Transport mode	# MAIS≥3 in sample	Burden of injury				Plifelong
		YLD acute p.p.	YLD lifelong p.p.*	Average YLD p.p.	Total YLD	
Pedestrian	342	0.28	8.39	2.79	953	30%
Cyclist in crash without motorized vehicle	3,463	0.33	5.41	2.35	8,131	37%
Cyclist in crash with motorized vehicle	795	0.29	10.07	3.40	2,705	31%
Motorized two-wheeler	1,092	0.27	11.41	3.53	3,854	29%
Car/van	723	0.29	16.43	5.78	4,181	33%
other	503	0.29	12.02	4.21	2,118	33%
Total	6,918	0.31	8.41	3.17	21,943	34%

*for casualties with lifelong consequences

The burden per person and percentage of casualties with lifelong consequences differ between transport modes. The average burden per person is highest for car/van occupants and lowest for cyclists in crashes without motorized vehicles. The latter probably has to do with the fact that the casualties in this group have a relative high average age. The percentage of casualties that encounter lifelong consequences is relatively high for cyclists that are injured in a crash without a motorized vehicle.





Half of the MAIS≥3 casualties in the Netherlands are cyclists that are injured in a crash without a motorized vehicle. Since these casualties have a relative low average burden of injury, their share in the total burden of injury is somewhat smaller (37%).

Analysis per EUROCOST injury group (2014)

Table C 17 Burden of injury figures per EUROCOST injury group, Netherlands, 2014

EUROCOST injury group	# MAIS≥3 in sample	Burden of injury				Plifelong
		YLD acute p.p.	YLD lifelong p.p.*	Average YLD p.p.	Total YLD	
1 concussion	2	0.100	8.42	1.87	4	21%
2 other skull-brain injury	2,350	0.241	11.52	2.89	6,795	23%
5 fracture facial bones	2	0.072		0.07	0	0%
7 fracture/dislocation/strain/sprain vertebrae/spine	3	0.258		0.26	1	0%
9 spinal cord injury	314	0.676	23.68	24.36	7,649	100%
10 internal organ injury	624	0.103		0.10	64	0%
11 fracture rib/sternum	9	0.225		0.23	2	0%
12 fracture clavicle/scapula	208	0.222	3.91	0.57	119	9%
13 fracture upper arm	12	0.230	6.43	0.87	10	10%
14 fracture elbow/forearm	47	0.145	2.71	0.36	17	8%
15 fracture wrist	11	0.143	7.47	1.49	16	18%
20 complex soft tissue injury upper extremities	8	0.190	7.88	1.37	11	15%
21 fracture pelvis	634	0.247	5.29	1.78	1,129	29%
22 fracture hip	2,125	0.423	3.19	2.08	4,421	52%
23 fracture femur shaft	335	0.280	7.07	2.76	923	35%
24 fracture knee/lower leg	196	0.289	10.51	3.86	757	34%
25 fracture ankle	1	0.203	6.15	2.36	2	35%
26 fracture foot/toes	1	0.174	5.28	2.23	2	39%
29 dislocation/sprain/strain hip	1	0.309	6.82	2.36	2	30%
31 complex soft tissue injury lower extremities	24	0.150	3.70	0.63	15	13%
34 burns	2	0.191		0.19	0	0%
39 other injury	9	0.212		0.21	2	0%
Total	6,918	0.306	8.41	3.17	21,943	34%

The injuries with the largest shares in the total burden of injury are: spinal cord injuries, 'other skull-brain injuries' and hip fractures. Spinal cord injuries lead by far to the highest burden of injury per casualty and have permanent consequences for all casualties.

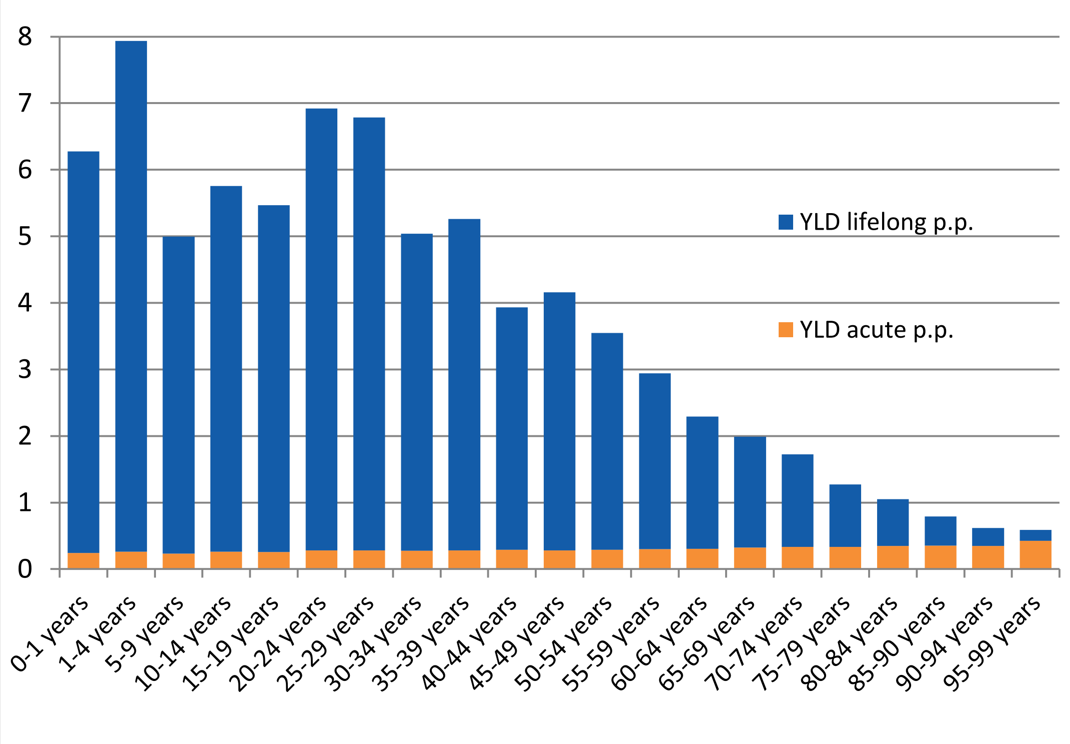
Analysis by age and gender

Table C 18 Number of casualties and burden of injury for men and women, Netherlands, 2014

Gender	# casualties in sample	Burden of injury				Plifelong
		YLD acute p.p.	YLD lifelong p.p.*	Average YLD p.p.	Total YLD	
Men	4,076	0.300	9.22	3.33	13,589	33%
Women	2,842	0.315	7.33	2.94	8,353	36%
Total	6,918	0.306	8.41	3.17	21,943	34%

*for casualties with lifelong consequences

The number of MAIS≥3 casualties is much higher among men than among women. Also the average burden of injury per person is higher for men than for women. This might have to do with the fact that female casualties are on average older than male casualties.



The burden of injury per person depends on someones age. A younger person has a higher (remaining) life expectancy and therefore has a relative high lifelong burden of injury compared to an older person. The relative low burden per person for 5 to 19 year olds might have to do with the types of injuries these casualties have.

Burden of injury for less severe injuries

The table below shows that MAIS≥3 casualties are responsible for almost half of the total burden of injury of all road traffic casualties that are admitted to the hospital. The average burden per person is clearly higher for MAIS≥3 casualties than for MAIS2 and MAIS1- casualties. Additionally, according to figures provided by Polinder et al (2015), casualties only treated at the emergency department, are responsible for 26% of all burden of injury in the Netherlands. So, MAIS≥3 casualties are responsible for only about one third (48%*74%) of the total burden of injury in the Netherlands.

Table C 19 YLD figures for less seriously injured casualties (MAIS1,2) compared to MAIS≥3 casualites, 2014, Netherlands

Severity	N in sample	%	Burden [YLD]	%	Burden p.p.	Lifelong (number)	%	% of N
MAIS≥3	6,918	26%	21,943	48%	3.17	2,359	50%	34%
MAIS2	13,098	50%	20,599	45%	1.57	2,151	46%	16%
MAIS1-	6,127	23%	3,359	7%	0.55	188	4%	3%
Total hospitalized	26,143	100%	45,901	100%		4,697	100%	18%

RHONE REGION IN FRANCE

Estimation of the burden of injury

In France, the number of MAIS3+ casualties is estimated from the Rhône Registry linked with police data using an extrapolation process, which is described elsewhere (cf. WP7.1). For the current analysis, that extrapolation process has not yet been used, due to practical reasons. The following results are hence drawn from the Rhône Registry alone, and so the total numbers are not country-wide but only for the Rhône department (basically the Lyon metropolitan area, 1.6M inhabitants). The registry includes all road accident casualties suffering from at least one AIS1 injury), hospitalized or not. All injuries were classified using AIS coding, then Eurocost injury groups have been assigned to each AIS injury by a medical doctor following the recommendations of the Apollo project (concerning ICD9 or ICD 10).

Burden of injury, main figures

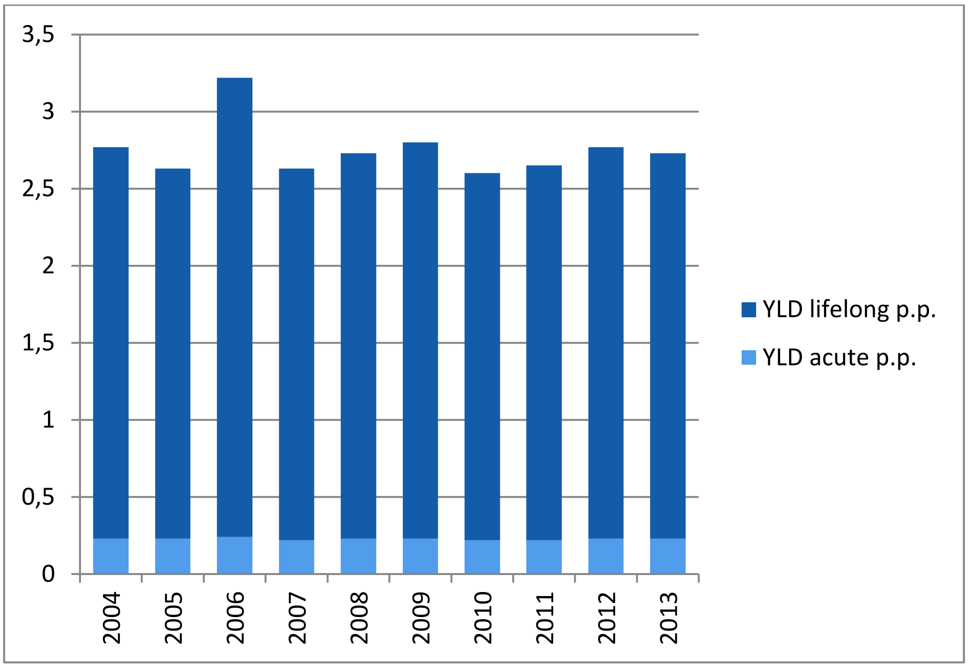
Table C 20 Main burden of injury figures for traffic casualites with serious injuries (MAIS3+), Rhone region, 2004-2013

Figure	Rhône 2004-2013
Number of MAIS3+ casualties	5,140
Total burden (all MAIS3+) [YLD]	12,961
Average burden per person [YLDpp]	2.52
% of total burden due to lifelong consequences	91%
% of MAIS3+ casualties with lifelong consequences (Plifelong)	21%
Average acute burden per person [YLDpp]	0.23
Average lifelong burden per person with lifelong consequences [YLDpp]	11.09

Source: Rhône Registry. The years of discharge were 2004-2013.

Based on 5,140 MAIS3+ hospitalized casualties, a total burden of injury of 12,961 YLD has been estimated, on average 2.6 YLD per person. 21% of MAIS3+ hospitalized casualties are estimated to encounter lifelong consequences from their injuries. Lifelong consequences are responsible for about 91% of the total burden of injury of serious road traffic injuries.

Development over time



The average YLD per person appears quite stable from 2004 to 2013, although higher in 2006 without clear explanation.

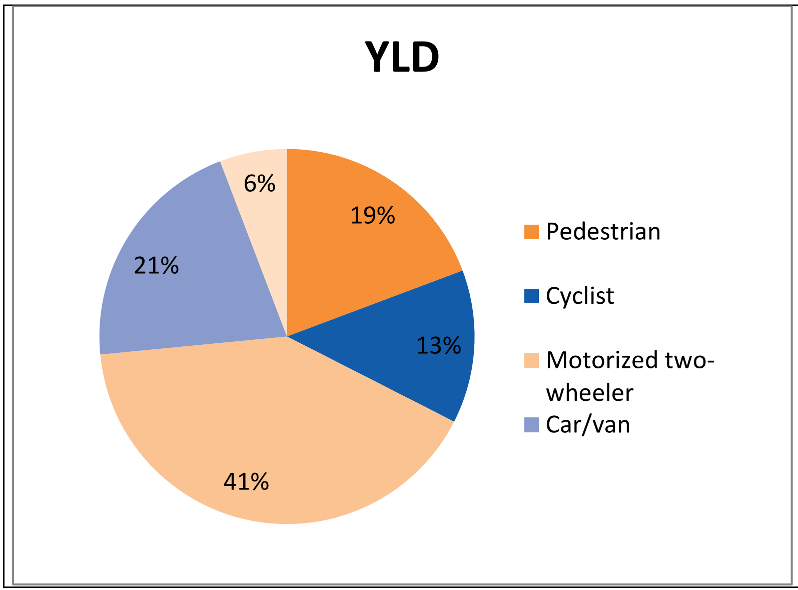
Analysis per transport mode

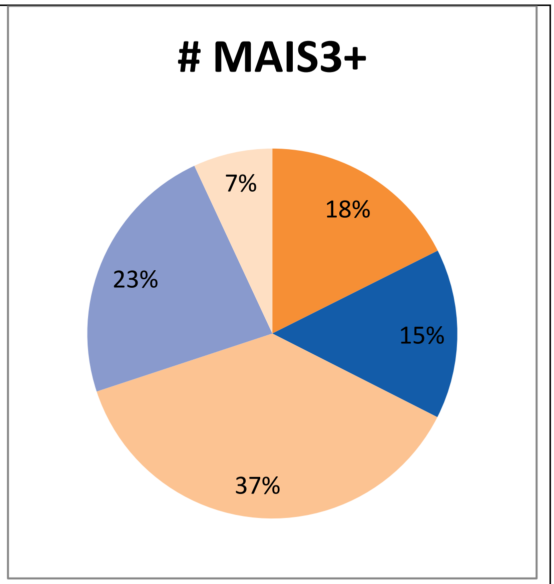
Table C 21 Burden of injury of MAIS3+ casualties for different transport modes in 2004-2013, Rhone region

Transport mode	# MAIS3+	Burden of injury				Plifelong
		YLD acute p.p.	YLD lifelong p.p.*	Average YLD p.p.	Total YLD	
Pedestrian	905	0.25	9.97	2.76	2500	25.2%
Cyclist	764	0.24	9.36	2.25	1716	21.5%
Motorized two-wheeler	1925	0.23	11.84	2.81	5414	21.8%
Car/van occupant	1190	0.22	12.39	2.16	2576	15.8%
Other	356	0.21	10.72	2.12	755	17.8%
Total	5,140	0.23	11,09	2.52	12,961	20.7%

*for casualties with lifelong consequences

In the Rhône department the total YLD is highest for motorized two-wheelers. Estimated average YLD per person is the highest for pedestrians and lower for car/van occupants.





Analysis per EUROCOST injury group (2014)

Table C 22 Burden of injury figures per EUROCOST injury group, Rhone region, 2004-2013

EUROCOST injury group	# MAIS3+ in sample	Burden of injury				Plifelong
		YLD acute p.p.	YLD lifelong p.p.*	Average YLD p.p.	Total YLD	
2 other skull-brain injury	954	0.24	14.67	3.62	3449	23%
3 open wound head	4	0.21	.	0.21	1	0
5 fracture facial bones	9	0.07	.	0.07	1	0
7 fracture/dislocation/strain/sprain vertebrae/spine	117	0.26	.	0.26	30	0
9 spinal cord injury	62	0.68	27.04	27.72	1718	100%
10 internal organ injury	839	0.1	.	0.1	86	0
11 fracture rib/sternum	77	0.23	.	0.23	17	0
13 fracture upper arm	276	0.23	6.55	0.88	244	10%
14 fracture elbow/forearm	816	0.15	3.47	0.42	345	8%
20 complex soft tissue injury upper extremities	9	0.19	6.18	1.12	10	15%
21 fracture pelvis	280	0.25	7.61	2.45	687	29%
22 fracture hip	240	0.42	4.91	2.98	715	52%
23 fracture femur shaft	489	0.28	8.41	3.22	1576	35%
24 fracture knee/lower leg	870	0.29	12.59	4.57	3976	34%
25 fracture ankle	14	0.2	10.66	3.93	55	35%
31 complex soft tissue injury lower extremities	80	0.15	3.6	0.62	49	13%
33 open wounds	2	0.09	.	0.09	0	0
34 burns	2	0.19	.	0.19	0	0
Total	5,140	0.23	11,09	2.52	12,961	20.7%

The injuries with the largest share in total burden are: 'other skull-brain injuries' (26.6%), fracture of knee/lower leg (30.7%), spinal-cord injuries (13.3%), femur shaft fracture (12.2%), pelvis fracture (5.3%) and hip fractures (5.5%). These six Eurocost groups account for more than 93% of the total of

YLD. These results should be considered as a consequence of the choices made in the Apollo project, concerning the building of the groups and the priorities defined between these groups. Spinal cord injuries lead to the highest burden of injury per casualty, by far, always having permanent consequences, but concern a small proportion of casualties.

Analysis by age and gender

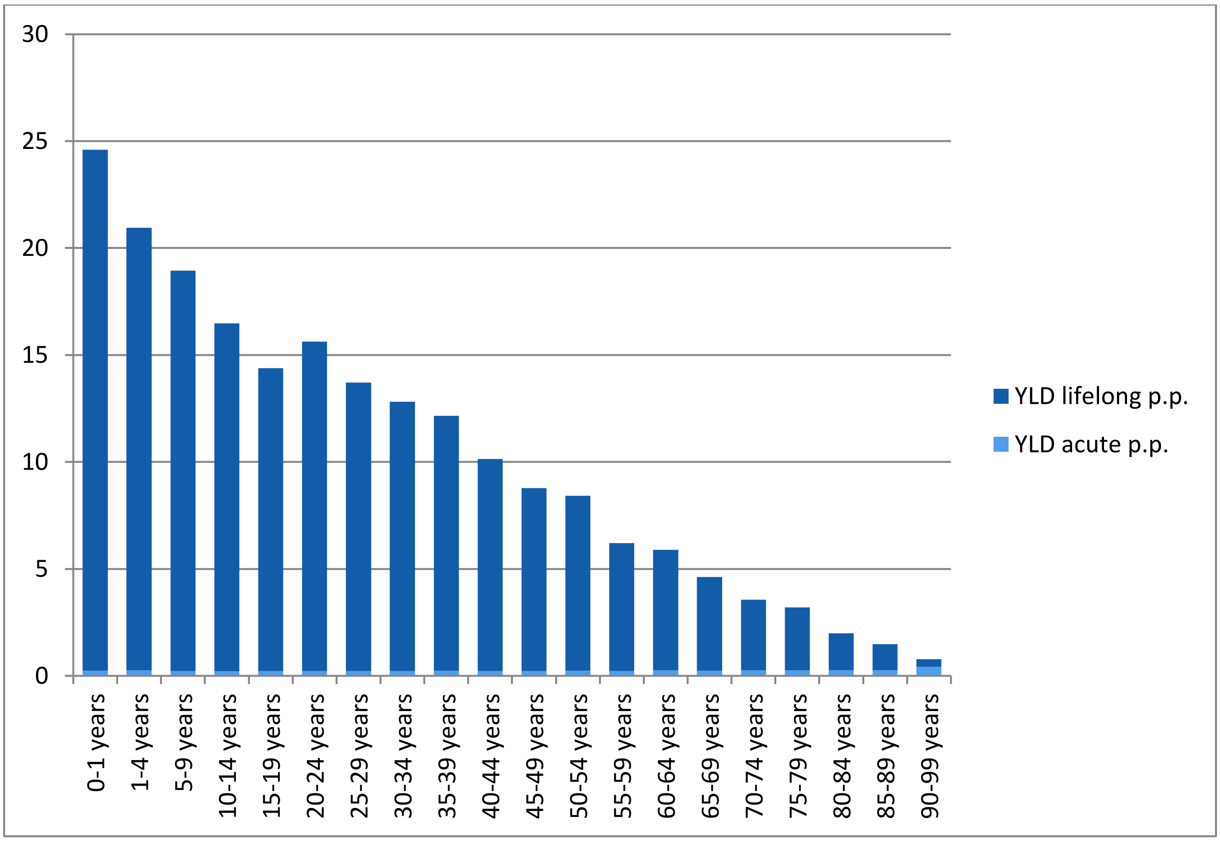
Table C 23 Number of casualties and burden of injury for men and women, Rhone region 2003-2014

Gender	# casualties	Burden of injury				Plifelong
		YLD acute p.p.	YLD lifelong p.p.*	Average YLD p.p.	Total YLD	
Men	3,824	0.23	11.30	2.56	9,798	20.7%
Women	1,316	0.23	10.47	2.40	3,163	20.8%
Total	5,140	0.23	11,09	2.52	12,961	20.7%

*for casualties with lifelong consequences

The number of MAIS3+ casualties is much higher amongst men than women, while the average burden of injury per person is slightly higher for men than for women.

Age: graph with acute and lifelong burden as a function of age



As expected, the YLD lifelong per person decreases as the age of the casualty increases.

Burden of injury for less severe injuries

Table C 24 YLD figures for traffic casualties that are admitted to a hospital, Rhone region 2003-2014

Severity	N	%	Burden [YLD]	%	Burden p.p.
MAIS3+	5,140	44.8%	12,961	59.0%	2.52
MAIS2	4,650	40.6%	8,784	37.3%	1.89
MAIS1-	1,675	14.6%	852	3.8%	0.51
Total hospitalized	11,465	100%	22,670	100%	

The table above shows that MAIS3+ casualties account for almost two thirds of the total burden of injury of all road-accident casualties that require hospitalization. The average burden per person for MAIS3+ casualties is higher than for MAIS2, and much higher than for MAIS1-.

The Table below shows the same information from all casualties, including emergency department out-patients, as well as those hospitalized. All in all, MAIS3+ casualties (of whom 5,140 were hospitalized out of 5,393 total = 95.3%), are responsible for 26% of total burden of injury in the Rhône department.

Table C 25 YLD figures for traffic casualties with less serious injuries, Rhone region 2003-2014

Severity	N	%	Burden [YLD]	%	Burden p.p.
MAIS3+	5,393	6.7%	13,402	26.1%	2.49
MAIS2	15,100	18.8%	24,568	47.8%	1.63
MAIS1-	59,657	74.4%	13,402	26.1%	0.22
Total road casualties	80,150	100%	51,372	100%	

When considering all road casualties, hospitalized or not, the part of burden of injuries (estimated in terms of YLD) is the highest for the MAIS2 group. The injury burden due to the MAIS1- group, which represents an eighth of the total, but virtually three quarters of the total number of casualties, is similar to the injury burden due to the MAIS3+ group.

SPAIN

Estimation of the burden of injury

In Spain, serious traffic injuries (MAIS3+) are identified from the National Hospital Discharge Register (HDR). Criteria for inclusion were to have E-codes for external causes of injury such E810-819, E826-829, E929, E988.5. When there is no information of external causes of injury (E-codes), information from insurance traffic companies allows identifying traffic casualties. Fatalities within 30 days after hospital admission as well as readmissions and scheduled admissions were excluded. MAIS has been derived with the *icdpic* module of Stata (Stata v11, StataCorp, College Station, TX). The period of study for this study is 2010 to 2014.

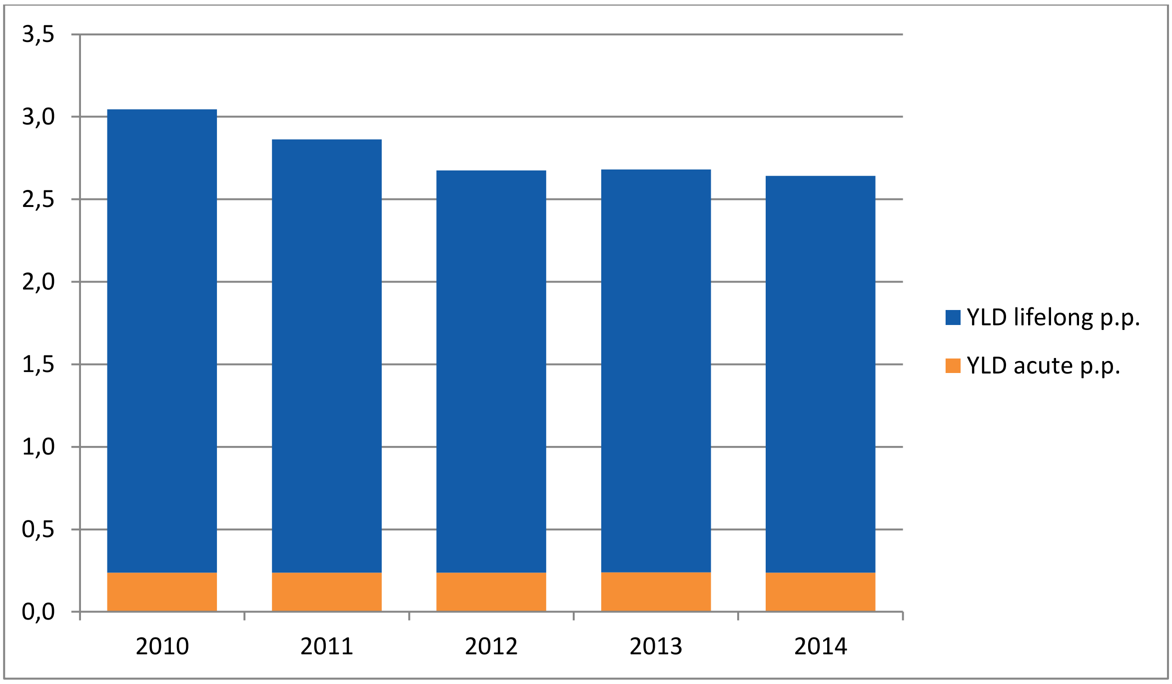
Burden of injury, main figures (2014)

Table C 26 Main burden of injury figures for traffic casualties with serious injuries (MAIS3+), Spain, 2014

Figure	2014, estimated total
Number of MAIS3+ casualties	7,610
Total burden (all MAIS3+) [YLD]	18,303
Average burden per person [YLDpp]	2.41
% of total burden due to lifelong consequences	90%
% of MAIS3+ casualties with lifelong consequences (Plifelong)	19%
Average acute burden per person [YLDpp]	0,10
Average lifelong burden per person with lifelong consequences [YLDpp]	11,54

In Spain, the total number of serious road traffic injuries (MAIS3+) rose to 7,610 cases in 2014. These MAIS3+ causalities have a total burden of injury of about 18,300 YLD; giving 2.41 on average burden per person (YLDpp). Lifelong consequences from serious injuries were about 90% of total burden. In terms of YLD per person the average lifelong burden was close to 11,54 years. 19% of all MAIS3+ casualties were estimated to suffer lifelong consequences from its injuries.

Development over time



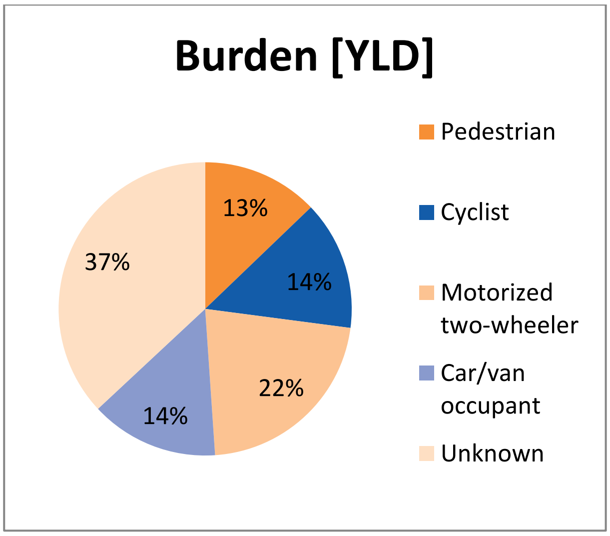
The five years evolution shows a small decline in the burden per person until 2012 with practically flat growth from this year.

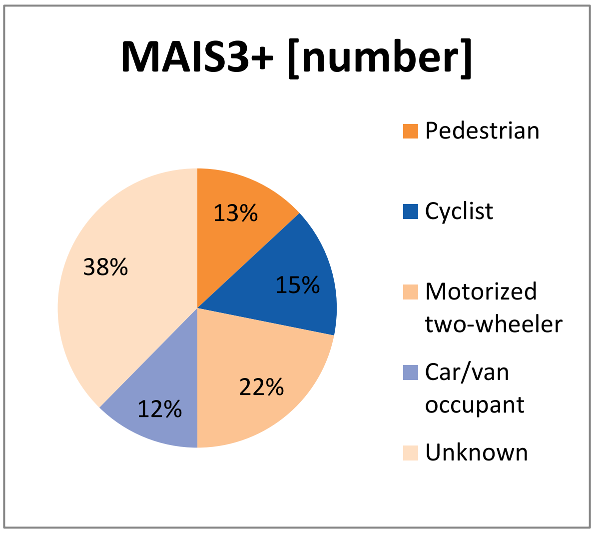
Analysis per transport mode

Table C 27 Burden of injury of MAIS3+ casualties for different transport modes in 2014, Spain

Transport mode	# MAIS3+	Burden of injury				Plifelong
		YLD acute p.p.	YLD lifelong p.p.*	Average YLD p.p.	Total YLD	
Pedestrian	996	0.25	9.10	2.36	2,348	23%
Cyclist	1,146	0.25	10.18	2.28	2,607	20%
Motorized two-wheeler	1,662	0.23	12.99	2.41	3,998	17%
Car/van occupant	943	0.24	14.94	2.74	2,588	17%
Other	2,863	0.24	11.41	2.36	6,761	19%
Total	7,610	0.4	11.54	2.41	18,303	19%

*for casualties with lifelong consequences





Transport mode for 38% of MAIS3+ casualties was absent. This was a result of lack of E-codes for external causes of injury taken from insurance traffic companies. Taking into account this limitation, the average burden per person of MAIS3+ casualties with lifelong consequences was highest for motorized vehicles and lowest for pedestrians/cyclists. In particular, this was 9.10 for pedestrians and 14.94 for car/van occupants.

Analysis per EUROCOST injury group (2014)

Table C 28 Burden of injury figures per EUROCOST injury group, Spain, 2014

EUROCOST injury group	# MAIS3+ in sample	Burden of injury				Plifelong
		YLD acute p.p.	YLD lifelong p.p.*	Average YLD p.p.	Total YLD	
1 concussion	168	0.10	6.12	1.38	233	21%
2 other skull-brain injury	2,051	0.24	12.64	3.15	6,456	23%

3 open wound head	3	0.21		0.21	1	0%
4 eye injury	4	0.26		0.26	1	0%
5 fracture facial bones	70	0.07		0.07	5	0%
6 open wound face	13	0.21		0.21	3	0%
7 fracture/dislocation/strain/sprain vertebrae/spine	184	0.26		0.26	47	0%
8 whiplash, neck sprain, distortion cervical spine	2	0.07		0.07	0	0%
9 spinal cord injury	183	0.68	27.26	27.94	5,112	100%
10 internal organ injury	439	0.10		0.10	45	0%
11 fracture rib/sternum	1,626	0.23		0.23	366	0%
12 fracture clavicle/scapula	67	0.22	4.48	0.63	42	9%
13 fracture upper arm	94	0.23	5.41	0.77	72	10%
14 fracture elbow/forearm	350	0.15	2.95	0.38	133	8%
15 fracture wrist	171	0.14	8.24	1.63	278	18%
16 fracture hand/fingers	37	0.07		0.07	2	0%
17 dislocation/sprain/strain shoulder/elbow	17	0.17	4.32	0.95	16	18%
18 dislocation/sprain/strain wrist/hand/fingers	3	0.03		0.03	0	0%
19 injury of upper extremity nerves	4	0.00		0.00		0%
20 complex soft tissue injury upper extremities	52	0.19	5.92	1.08	56	15%
21 fracture pelvis	77	0.25	6.88	2.24	173	29%
22 fracture hip	589	0.42	4.37	2.69	1,587	52%
23 fracture femur shaft	295	0.28	8.73	3.34	984	35%
24 fracture knee/lower leg	465	0.29	11.81	4.30	2,001	34%
25 fracture ankle	73	0.20	9.14	3.40	248	35%
26 fracture foot/toes	90	0.17	9.89	4.03	363	39%
27 dislocation/sprain/strain knee	29	0.16		0.16	5	0%
28 dislocation/sprain/strain ankle/foot	4	0.15	3.35	1.02	4	26%
29 dislocation/sprain/strain hip	1	0.31	5.59	1.99	2	30%
30 injury of lower extremity nerves	2	0.00		0.00		0%
31 complex soft tissue injury lower extremities	21	0.15	3.29	0.58	12	13%
32 superficial injury, including contusions	243	0.15		0.15	36	0%

33 open wounds	178	0.09		0.09	17	0%
39 other injury	5	0.21		0.21	1	0%
Total	7,610	0.4	11.54	2.41	18,303	19%

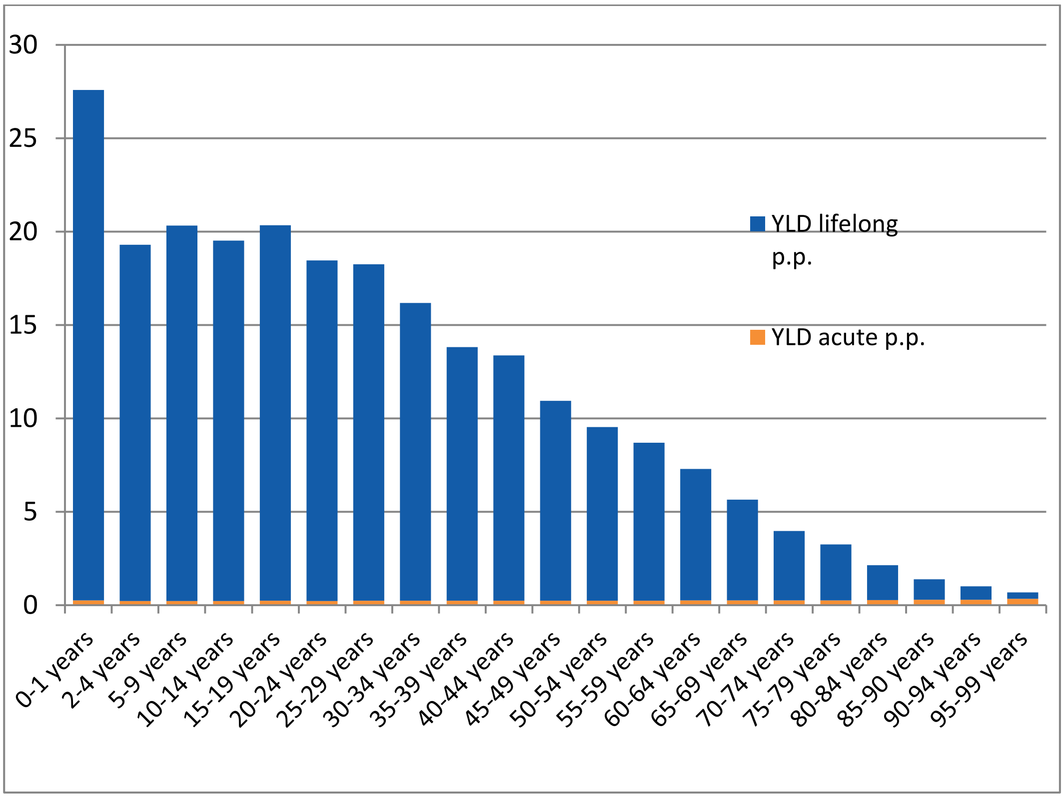
Analysis by age and gender

Table C 29 Number of casualties and burden of injury for men and women, Spain, 2014

Gender	# MAIS3+ in sample	Burden of injury				Plifelong
		YLD acute p.p.	YLD lifelong p.p.*	Average YLD p.p.	Total YLD	
Men	5,651	0.24	11.67	2.35	13,285	18%
Women	1,959	0.24	11.19	2.56	5,017	21%
Total	7,610	0.24	11.54	2.41	18,303	19%

*for casualties with lifelong consequences

The distribution by gender, shows slightly differences on average burden per person of MAIS3+ causalities. 11.67 for men and 11.19 for women.



Bearing in mind that the burden per person of MAIS3+ casualties with lifelong consequences depends, at least partially, on the remaining life expectancy, we have to make some notifications with respect to the age groups until 15-19 years old. First of all, the highest lifelong burden is in the population aged 0 and 1. After a significant drop in burden of disease in the next age group, this is followed by a steady rise until the 15 to 19 15-19 years old group. The subsequent evolution is almost consistently decreasing.

Burden of injury for less severe injuries

Number of casualties by severity in 2014, their number with lifelong consequences and burden of injury.

Severity	N in sample	%	Burden [YLD]	%	Burden p.p.	Lifelong (number)	%	% of N
MAIS1- / MAIS2	15,031	66%	20,016	52%	1.33	1,864	57%	12%
MAIS3+	7,610	34%	18,303	48%	2.41	1,430	43%	19%
Unknown	17	0%	3	0%	0.19	0	0%	0%
Total hospitalized	22,658	100%	38,322	100%	1.69	3,294	100%	15%

These results show that one out of three causalities are MAIS3+. However, these MAIS3+ causalities are responsible for nearly 50% of the burden of injury of hospitalized casualties.

Appendix D burden of injury body profiles

The Burden of Injury body profile (see section 5.2.3), displays the distribution of casualties over their most affected body region (left). Also the burden of that injury is displayed on the other (right) side of the body profile.

For each casualty the EUROCOST injury group is determined. In case of multiple injuries, the hierarchical scheme proposed by Polinder et al. (2008) is applied. Then the Burden of injury is calculated using:

$$B_i = DWa_{j(i)} + Pl_{j(i)} * DWl_{j(i)} * (LE_i - age_i - 1) \quad \text{(Equation 1)}$$

Each casualty counts in one of the 39 EUROCOST groups.
All casualties (and their burden) are now counted into 10 aggregated Body region, (depending on their EUROCOST group, see tables below. See appendix B for the descriptions of the EUROCOST groups).

Then numbers are calculated into fractions, so in Belgium 26% of the casualties have their most severe injury to the head and 33% of the total burden of injury is associated with these casualties. In order to construct the Burden of Injury body profile these fractions are transferred into a colour, from green (no casualties are injured, no burden) to red (more than 50% of all casualties are injured on that body region, or more than 50% of the total burden is associated with that body region).

In a body profile, constructed from ellipses, the colours are visualised. Note that this approach can be applied to all casualties, independent from the severity of their injuries. In this report it is applied to the national selections of MAIS3+ casualties.

Distribution of injuries over body regions

EUROCOST injury groups	Body region	**Belgium**	**Austria**	**England**	**Netherlands**	**Rhône**	**Spain**
1,2,3,4,5,6	1 Head	26%	34%	28%	34%	21%	30%
7,8,9	3 Thorax; back; spine	2%	7%	8%	5%	4%	5%
10,11	4 Rib; sternum; internal	17%	10%	20%	9%	13%	27%
21,22,23,29	5 Pelvis, hip; femur	37%	39%	7%	45%	21%	13%
12,13,17	6 Shoulder; upper arm	5%	0%	10%	3%	8%	2%
14,15,18	7 Elbow; forearm; wrist	3%	0%	4%	1%	14%	7%
16,20	8 Hand; fingers	0%	0%	6%	0%	0%	1%
24,25,27,28	9 Knee; lower-leg; ankle	8%	5%	7%	3%	17%	8%
26,31	10 Foot; toes	1%	1%	6%	0%	3%	1%
19,30,32,33, 34,35,36,37,38,39	11 Other	0%	4%	4%	0%	0%	6%