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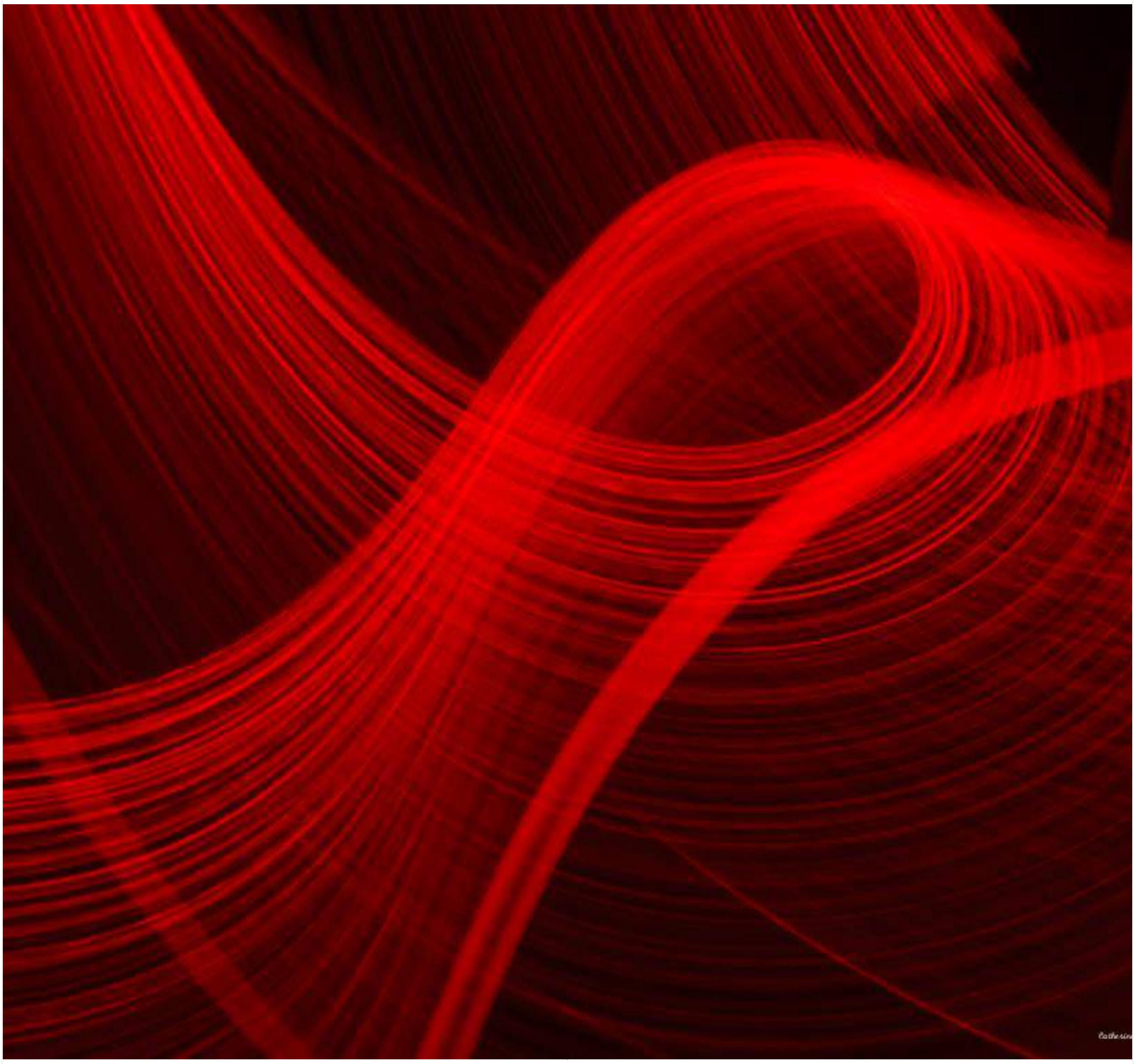

Practical guidelines for the registration and monitoring of serious traffic injuries

Deliverable 7.1

SafetyCube

Practical guidelines for the registration and monitoring of serious traffic injuries

Work package 7, Deliverable 7.1

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Executive summary

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

Work Package 7 is dedicated to serious traffic injuries, their health impacts and their costs. This deliverable (D7.1) focuses on the determination of the number of serious traffic injuries, defined as casualties with an injury level of MAIS ≥ 3 (MAIS ≥ 3 casualties).

BACKGROUND AND OBJECTIVES

Crashes also cause numerous serious traffic injuries, resulting in considerable economic and human costs. Given the burden of injury produced by traffic, using only fatalities as an indicator to monitor road safety gives a very small picture of the health impact of traffic crashes, just the tip of the iceberg. Moreover, in several countries during the last years the number of serious traffic injuries has not been decreasing as fast as the number of fatalities. In other countries the number of serious traffic injuries has even been increasing (Berecki-Gisolf et al., 2013; IRTAD Working Group on Serious Road Traffic Casualties, 2010; Weijermars et al., 2015).Therefore, 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).

To be able to compare performance and monitor developments in serious traffic injuries across Europe, a common definition of a serious road injury was necessary. In January 2013, the High Level Group on Road Safety, representing all EU Member States, established the definition of serious traffic injuries as road casualties with an injury level of MAIS ≥ 3. The Maximum AIS represents the most severe injury obtained by a casualty according to the Abbreviated Injury Scale (AIS).

Traditionally the main source of information on traffic accidents and injuries has been the police registration. This provides the official data for statistics at national and European level (CARE Database). Data reported by police usually is very detailed about the circumstances of the crash particularly if there are people injured or killed. But on the other hand police cannot assess the severity of injuries in a reliable way, due, obviously to their training. Therefore, police based data use to classify people involved in a crash as fatality, severe injured if hospitalised more than 24 hours and slight injured if not hospitalised. Moreover, it is known that even a so clear definition as a fatality is not always well reported and produces underreporting. This is due to several factors such as lack of coverage of police at the scene or people dying at hospital not followed by police (Amoros et al., 2006; Broughton et al., 2007; Pérez et al., 2006).

Hospital records of patients with road traffic injuries usually include very little information on circumstances of the crash but it does contain data about the person, the hospitalisation (date of hospitalisation and discharge, medical diagnosis, mechanism or external cause of injury, and interventions). Hospital inpatient Discharge Register (HDR) offers an opportunity to complement police data on road traffic injuries. Medical diagnoses can be used to derive information about severity of injuries. Among others, one of the possible scales to measure injury severity is the Abbreviated Injury Scale (AIS).

The High Level group identified three main ways Member States can collect data on serious traffic injuries (MAIS ≥ 3):

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

Once one of these three ways is selected, several additional choices need to be made. In order to be able to compare injury data across different countries, it is important to understand the effects of methodological choices on the estimated numbers of serious traffic injuries. A number of questions arise: How to determine the correction factors that are to be applied to police data? How to select road traffic casualties in the hospital data and how to derive MAIS ≥ 3 casualties? How should police and hospital data be linked and how can the number of MAIS ≥ 3 casualties be determined on the basis of the linked data sources?

Currently, EU member states use different procedures to determine the number of MAIS ≥ 3 traffic injuries, dependent on the available data. Given the major differences in the procedures being applied, the quality of the data differs considerably and the numbers are not yet fully comparable between countries. In order to be able to compare injury data across different countries, it is important to understand the effects of methodological choices on the estimated numbers of serious traffic injuries.

Work Package 7 of SafetyCube project is dedicated to serious traffic injuries, their health impacts and their costs. One of the aims of work package 7 is to assess and improve the estimation of the number of serious traffic injuries.

The aim of this deliverable (D7.1) is to report practices in Europe concerning the reporting of serious traffic injuries and to provide guidelines and recommendations applied to each of the three main ways to estimate the number of road traffic serious injuries.

Specific objectives for this deliverable are to:

- Describe the current state of collection of data on serious traffic injuries across Europe
- Provide practical guidelines for the estimation of the number of serious traffic injuries for each of the three ways identified by the High Level Group
- Examine how the estimated number of serious traffic injuries is affected by differences in methodology.

METHODS USED

The practical guidelines for the determination of the number of serious traffic injuries were developed using:

1) A survey carried out among experts in EU Member States
2) Current practices and experiences from a number of countries
3) Specific analysis in which different procedures were applied to the same data.

A survey was carried out among experts in EU Member States in order to provide an overview of the data and procedures that are applied for estimating the number of MAIS ≥ 3 casualties across Europe. The questionnaire was inspired by the a survey that had been conducted by FERSI (Auerbach and Schmucker, 2016). The 72 questions of the survey were clustered in six groups: (1)

Prime contact in the country; (2) General information on collection practices and responsibilities; (3) MAIS ≥ 3 methodology and planned changes; (4) Detailed information on hospital data; (5) Detailed information on applied method; (6) Concrete figures: fatalities and serious injuries police / MAIS ≥ 3.

Current practices and experiences from some countries allowed to explore the following topics:

- Methods to apply correction factors have been explored using data from Belgium, France and Austria
- Inclusion and exclusion criteria have been defined using Hospital Discharge Data based from Spain and the Netherlands. It includes a sensitivity analysis of the impact of using different inclusion/exclusion criteria.
- A sensitivity analysis has been carried out to assess the impact of obtaining MAIS ≥ 3 using different methods, either coding AIS directly or recoding from ICD diagnosis with a conversion tool. We used data from Spain, Belgium, the Netherlands and Germany.
- How to derive the number of serious traffic injuries using police and hospital record linkage has been explored with data from France, the Netherlands and Slovenia

Finally, a comparison of three methods proposed by the High Level Group to estimate the number of seriously injured (factors, hospital and record linkage) was carried out using data from the Netherlands.

MAIN RESULTS

State of data collection on serious traffic injuries across Europe

As of June 2016, 17 of the 26 countries that responded to the survey had either delivered MAIS ≥ 3 estimates to DG-MOVE – or had reported that they would be in the position to do so shortly. In the remaining 14 countries, the process for estimating the number of MAIS ≥ 3 traffic injuries appeared to be only in a very early stage or had not even started yet. One of the central problems in these countries, due to privacy regulations, was to get access to hospital discharge data.

The methods for estimating the number of MAIS ≥ 3 casualties differ between the countries. Most of the countries (9) use only hospital data, whereas two countries apply corrections to police data and four countries use a linkage of police and hospital data. France and Germany apply a combination of methods: in France a generalization based on the Rhone Trauma Register and Germany a generalisation based on GIDAS in depth data and data from the German Trauma Register DGU. Several countries plan to modify their method in the future, the majority of them towards linking police and hospital data.

As of June 2016, 13 of the 26 countries that responded to the survey had MAIS ≥ 3 estimates for 2014 readily available. The ratio of MAIS ≥ 3 casualties and fatalities differs considerably between these countries, from 0.6 MAIS ≥ 3 casualties per fatality in Poland to 13.2 MAIS ≥ 3 casualties per fatality in the Netherlands. This difference illustrates the considerable differences between the methodologies used and also indicates that extreme care should be taken in comparing national estimates on MAIS ≥ 3 at this stage.

Application of correction factors to police data

Basically, the first method proposed by the High Level Group estimates the actual or the registered number of MAIS ≥ 3 casualties on the basis of the number of casualties that is registered by the police.

Both previous research and current practices show that correction factors vary substantially between countries. This variability is due to the variation between police registrations, hospital registrations and the distribution of traffic injuries across countries. Thus, correction factors are country specific and it is strongly recommended not to apply the correction factors used in one country to another country.

In order to determine the correction factors on police data, it is imperative to have access to at least a sample of hospital data. Such a sample could be from part of the country routine data (e.g. as is currently the case in France and Germany) and/or for a limited time period (like in Belgium). Using such correction factors starts from the assumption that there is relative stability in both police and hospital registrations of casualties over time. However, as shown by the comparison of the three methods using Dutch data, the accuracy of police and hospital registration may change over time. Therefore, correction factors need to be validated and updated on a regular basis.

Since the accuracy of police registrations differs between road user groups (age, gender, transport mode) and accident types (single vs. multi-vehicle, place of occurrence, etc.), it is necessary to derive and apply different correction factors for different groups of road users. A first useful step to determine such correction factors is to model the effects of a series of variables (such as year, type of road user, age, gender…) on the ratios of police/hospital registrations. This step allows to identify which variables significantly affect these ratios and consequently it is possible to determine a series of correction factors on police data in order to predict the number of hospital registrations

Using hospital data

The availability of hospital data is essential for the determination of the number of serious traffic injuries. When such data is available all over a country and can be accessed easily and timely, it can be used to determine the number of MAIS ≥ 3 traffic injuries.

The main source for hospital data is the Hospital Discharge Register (HDR) that includes all hospitalisations for diseases and injuries from all or some public and/or private hospitals of the country. Hospital data is not always accessable for institutions that are responsible for the determination of the number of serious traffic injuries. Such data is indeed often highly protected by privacy legislation because it includes very sensitive information such as individual health information. However, practice from different countries shows that it is possible to anonymize the data in such a way that it is not possible to identify a particular person, and hence such data can be made available and accessible for research or statistical purposes. At national level it is advised to establish inter-sectorial collaboration between the health and the transport or interior ministries in order to facilitate the access to HDR data in view of calculating the MAIS ≥ 3 numbers. At European level, it is recommended to reinforce institutional collaboration between the European Commisison (DG MOVE), Eurostat, OECD-IRTAD and WHO to facilitate and improve reporting serious road traffic injuries in Europe.

Recording and handling systems of the HDR differ by country so the data should be compared with caution. Moreover, MAIS ≥ 3 road traffic casualties should be selected from the hospital data. This can be done in several ways and also this process influences the estimated number of serious traffic injuries. In this report we analysed (1) the effects of applying different in- and exclusion criteria to select road casualties from hospital data, and (2) the difference between direct AIS coding and the use of various recoding tools for the determination of MAIS.

In- and exclusion criteria to select road casualties from hospital data

All methods used for estimating the number of serious traffic injuries (MAIS ≥ 3) are in one way or another based on a selection of hospital records. So it is important to have clear criteria for inclusion or exclusion of hospital records in order to establish the population of people injured in traffic.

Hospital discharge registers use the International Statistical Classification of Diseases (ICD) to codify the main diagnosis, or reason for the hospital admission. Currently, hospital data in Europe are coded with either ICD-9 or ICD-10. It is on the basis of these codes that traumatic injuries can be identified. According to the ICD9-CM (clinical modification) specification codes 800 to 959 refer to injuries. When using ICD10 the range S00-T88 relates to injuries.

Since not all injury patients admitted to the hospital are road traffic casualties, one also needs to know the injury mechanism in order to properly identify traffic injuries. This can be done on the basis of the codes for external causes (the E-codes) that are part of the ICD nomenclature - provided that such a code has been allocated (which is not always the case). When identifying traffic injuries, it is recommended to include records with the following E-codes: E810-E819, E826, E827, E829 and E988.5 and excluding E828.

For non-motorized vehicles, the ICD9 coding scheme does not make a distinction between "Traffic accident" (any vehicle accident on a public road) and "Non-traffic accident" (any vehicle accident occurring entirely somewhere other than on a public road). There is a specific code to designate the place of occurrence of the event (E849) but usually it is not reported. Thus, on the basis of the E-codes alone, the number of traffic casualties may be somewhat overestimated. In order to avoid this, one may use other codes for casualties (if available) and/or weight or correct for non-public traffic accidents.

It should be noted that several countries suffer from incomplete specification of external causes in their hospital injury records. In Belgium for example, despite the compulsory registration of E-codes in hospitals, E-codes are missing for almost 20% of all casualties (although the percentage of missing causes for traffic injuries is probably lower). This leads to an underestimation of the number of traffic injuries. Some countries look for other variables to identify traffic injury cases like the insurance company that pays the hospitalisation (vehicle insurance).

Persons who die within 30 days after the accident should be excluded from the hospital records, as they are counted as a fatality. Another group to exclude from the numbers are the readmissions, in order to avoid duplicates. On the basis of data from Spain and the Netherlands, we estimate that the inclusion of fatalities within 30 days results in an overestimation of the number of serious injuries of about 5% and that inclusion of readmissions results in an overestimation of about 3%. To account for these differences, weighting factors can be applied.

It should finally be noted that not all MAIS ≥ 3 traffic casualties end up being hospitalized. Based on data from France, it appears that the exclusion of non-hospitalized MAIS ≥ 3 casualties results in an underestimation of the number of serious traffic injuries of roughly 5%.

The impact of different coding mechanisms on the number of MAIS ≥ 3 casualties
The AIS level of injuries can be determined in several ways. AIS coding can be direct, i.e. when traffic victims are registered, an AIS code is given for each of the injuries (or diseases) of the casualty. In Europe, such direct AIS coding is not very common however. In most countrues, AIS codes can be derived from other injury coding systems, like ICD. Currently the following conversion tools are available to derive AIS from ICD codes: ICDmap90[1], ICDpic[2], DGT[3], ECIP[4], AGU[5] or AAAM[6]. The use

[1] ICDmap90: Johns Hopkins University (1998). ICDmap90 and ICDMAP-90 user's guide. Baltimore.

of any of these conversions tools leads to the so-called ICD-derived AIS values. Some of these tools recode the ICD codes into the latest AIS© 2005/update 2008 codes, but other older tools recode ICD data into AIS codes that are based on previous versions of the AIS coding (AIS2005, AIS1998 or AIS1990). Recoding always has the disadvantage compared to direct coding, that some information gets lost or is not available so that a best match must be selected (in the recoding tool). This may have an effect on the severity that is assigned to a casualty and therefore also on the estimated number of MAIS ≥ 3 casualties.

Application of AIS1990/AIS1998 results in an overestimation of the number of MAIS ≥ 3 casualties by 12%. So in order to make data from different countries more comparable, the number of MAIS ≥ 3 casualties should be multiplied by a factor 0.89 when injuries are coded in AIS1990 or AIS1998 instead of AIS2005 or AIS2008.

In some cases, only a limited number of diagnoses is coded or available for analysis. The analyses conducted show that in case only 1 diagnosis is available, this leads to an underestimation of the number of MAIS ≥ 3 casualties of 22%; when only 3 diagnoses are available, the underestimation is around 5%. The principal diagnosis is not always the most severe, as also other criteria, like financial issues determine the principal diagnosis.

The estimated number of MAIS ≥ 3 casualties was compared for direct AIS coding and the ECIP conversion tool, using a small sample of German data. This analysis suggests that the ECIP recoding tool seems to result in reliable numbers of serious traffic injuries if codes are complete. The difference between the numbers generated by the different ICD9cm recoding tools is at most 7%. We were not able to investigate the difference between ICD9 tools and direct coding.

The majority of European countries now use a tool from AAAM ("Association for the Advancement of Automotive Medicine") that has been provided by DG-MOVE. It became obvious, however, that the US-based AAAM10 table does not yet provide satisfying transformation rates for the ICD versions currently being used in Europe. The conversion algorithm actually uses ICD10CM. As most European countries use an older version of ICD10 without clinical modification, this does not fit with European practice.

Due to hospital practice or privacy regulations, some countries use 4-digits injury codes instead of 5-digits codes. The effects of this truncation depend on the recoding tool that is applied. AAAM10 and ICDpic do not seem to be able to deal well with truncated codes. Countries that use AAAM10 in

[2] ICDpic: Clark, Osler, Hahn (2010). Stata module to provide methods for translating International Classification of Diseases (Ninth Revision) diagnosis codes into standard injury categories and/or scores. https://ideas.repec.org/c/boc/bocode/s457028.html.

[3] DGT: Directorate General de Trafico Madrid, Spain. SAS-algorithm. Available for this study. ICD9cm (version 1996) to AIS1998.

[4] ECIP: European Center for Injury Prevention, University of Navarra, Algorithm to transform ICD-10 codes AIS 90 (1998 update) and ISS, [version 1 for SPSS] [version 1.0 for STATA]. Pamplona, Spain 2006.with partial funding from the EU, DG SANCO Grant Agreement Nº 2004119 Project Apollo WP2.

[5] Agu: Schmitt KU, Baumgartner L, Muser M, Furter K, Scholz S, Lüber B, Thomas P, Simma A (2014) *Developing a scheme to report AIS-coded injury severity for Swiss traffic accident data*. IRCOBI Conference 2015. Berlin. 2014 Paper no. IRC-14-50. Schmitt KU, Baumgartner L, Muser M, Baudenbacher M, Simma A, (2015) *Improving the Swiss National Accident Statistics by Providing AIS Data to Classify Injury Severity*. 24th ESV Conference. Gothenburg. 2015. Paper No. 15-0323.

[6] AAAM9AAAM (2015). "Copy of aaam_icd9map_v1 0_Feb2015 read only.xls".
AAAM10 AAAM (2015). "Copy of aaam_icd10map_v1 0_Feb2015 read only.xls".
AAAM10-cm AAAM (2015). "Copy of aaam_icd10map_v1 0_Feb2015 read only.xls".

combination with truncated injury codes report fail rates of the ICD to AIS transformation of about 20%. In case other tools then ICDpic and AAAM10 are used, underestimation is between 3% and 10%.

Using linked/matched police and hospital data

A third method for estimating the actual number of MAIS ≥ 3 injuries is linking police data and hospital data. The main benefit of such a data linkage is that it leads to a maximal use of the available data sources. The process also provides insight in the completeness of police and hospital data and also allows to identify, and possibly to reduce, selection biases and underreporting. In this way, one could for example correct for missing or misspecified external causes (E-codes) in hospital data.

The linking process is based on one or more variables that are included in the records of both databases. Ideally this variable is a unique personal identification number, which allows to identify 1-to-1 linkages and apply a relatively easy and straightforward deterministic linking. However, this variable is often unavailable in one or both databases for privacy reasons. In the absence of a such unique identifier, it is possible to apply a so-called probabilistic or distance-based linking process based on several variables at once. Linking variables that are commonly used are date and time of the crash (and/or date and time of hospital admission), location of the crash, gender and date of birth (or age) of the casualty, mode of transport.

After the linking of hospital and police data has been completed, the number of traffic casualties recorded in hospital data but not identified as such can be estimated using the capture-recapture method. It is a method, which uses data linkage to estimate a total population. For example, by knowing numbers of casualties recorded by the police, by hospitals and by both (linked records), it is possible to estimate a lower bound of the number recorded by neither, and therefore to estimate the total number of casualties. To be valid, the capture-recapture approach must meet six conditions. Among them, three are particularly important: (i) the definition of the road casualty in the two data sources should be the same or included in one another; (ii) the two registrations are supposed to be independent; (iii) all subjects of interest should have the same probability of being registered by a given source. This third assumption is usually only valid within subgroups (e.g. mode of transport). These subgroups should therefore be taken into account by means of stratification or modelling.

Influence of the method on the estimated number of serious traffic injuries

Comparing the three methods proposed by the EC using data from the Netherlands illustrates that linking of police and hospital data has the potential to identify the highest number of serious traffic injuries, i.e. to have the lowest level of underreporting. Correction factors applied to police data identified the fewest MAIS ≥ 3 casualties in the Netherlands. In this case, this is due to a decrease in police registration level. Also in Austria, applying correction factors to police data resulted in lower number of serious traffic injuries than use of hospital data. This doesn't mean that applying correction to police data always results in underestimation of the number of MAIS ≥ 3 casualties. Crucial requirements for correction factors to lead to reliable estimates of MAIS ≥ 3 casualties are the quality of the variables recorded and the stability and consistency of both police and hospital registrations.

OVERALL CONCLUSIONS AND RECOMMENDATIONS

The adoption of a common definition for serious injuries has certainly given an impetus for the collection of data on serious traffic injuries in the EU-Member states. However, in many countries the process for estimating the number of MAIS ≥ 3 traffic injuries is still in a very early stage or has not even started yet. One of the central problems in these countries is the restricted access to hospital discharge data due to privacy regulations.

Hospital data are essential for determining the number of serious traffic injuries, defined as MAIS ≥ 3 casualties. Even when applying correction to police data, it is necessary at some point to have hospital data to derive the correction factors. When hospital data are properly anonymized in a way in which it is not possible to identify a person, they should be available for research or statistical purposes. Thus, more efforts are needed in Europe to make hospital data available in such a way that an accurate estimate of the number of serious traffic injuries can be made. This implies at least the availability of 4 diagnoses of injuries, no truncation of ICD codes, registration of E-codes, and the use of the latest version of AIS (2008). To this end, there should be more inter-sectorial collaboration between the health and the transport actors at national and international level.

The methods for estimating MAIS ≥ 3 vary considerably across countries, the differences seem to be heavily determined by the data available. The methods used clearly affect the estimated numbers of serious traffic injuries. Factors like in- and exclusion criteria applied, missing E-codes, AIS version, ICD-AIS recoding tool applied and the number of injuries taken into account when determining MAIS, can have a large influence on the estimated number of MAIS ≥ 3 casualties. It is important to discuss, report and interpret the estimation results taking also into account the different specific methodologies they are derived from.

For policy purposes, it is important to be able to monitor changes over time. For this purpose, it may be sufficient to use a method, which is less accurate i.e., is known under- or overreport the number of seriously injured. As long as any under/overreporting remains consistent across years it will still be possible to observe important trends in serious traffic injuries.

It is recognized that all three methods for estimating the number of serious traffic injuries – (1) applying correction factors to police data; (2) use of hospital data; (3) linking police and hospital data – have both advantages and limitations. Which method(s) to choose will depend on the context and constraints of each individual country. When using correction factors on police data, it is important to be assured of the stability of the police registration practice, and to have regular access to at least a sample of high quality hospital data. Also, it may be necessary to apply correction factors to hospital data, if there is evidence that some MAIS ≥ 3 traffic injuries are not identifiable as traffic victims within the hospital data. Whenever possible, an attempt should be made to link hospital with police data. This allows identifying road traffic casualties that are not recognisable as such in the hospital data and therefore provides a more accurate estimate of the number of serious traffic injuries.

Further harmonisation of methods over the next years is desirable in order to ensure that the estimated numbers of MAIS ≥ 3 road traffic injuries are comparable across Europe.

1 Introduction

This chapter describes briefly the SafteyCube project, a short description of the workpackage 7, and the background and objectives of this deliverable (D7.1)

1.1 SAFETYCUBE AND WORKPACKAGE 7

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

SafetyCube further 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.
2. Apply these methods to safety data to identify the key accident causation mechanisms, risk factors and the most cost-effective measures to prevent fatally and seriously injured casualties to occur.
3. Develop an operational framework to ensure the project facilities can be accessed and updated beyond the completion of SafetyCube.
4. 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 of 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.

Work Package 7 is dedicated to serious traffic injuries, their health impacts and their costs.

The main objectives of this work package are to:

1. Assess and improve the estimation of the number of serious traffic injuries
2. Determine and quantify health impacts of serious traffic injuries
3. Estimate economic and immaterial costs related to serious traffic injuries
4. Identify key risk factors related to serious traffic injuries and their health impacts

1.2 PURPOSE OF THIS DELIVERABLE D7.1

The aim of this deliverable is to report practices in Europe reporting serious injuries and provide guidelines and recommendations applied to each of the three main ways of estimate the number of road traffic serious injuries.

This deliverable is organised in several chapters: Chapter 1 describes the SafetyCube project, the objectives of WP7, and the aim of the deliverable. Chapter 2 includes the background and the rationale of the deliverable as well as the specific objectives. Chapter 3 describes briefly the methods used. Chapter 4 reports the current situation in Europe concerning the reporting of the number of serious injuries based on a survey to al Member States. Chapter 5 discusses how to estimate serious injuries defined as MAIS ≥ 3 applying correction factors. Chapter 6 adresses how to estimate traffic serious injuries using hospital data alone, specifies the selection criteria and the available tools to derive MAIS ≥ 3. Chapter 7 describes how to estimate serious injuries using police and hospital record linkage procedures. Chapter 8 describes other methods to estimate traffic serious injuries different from those identified by the High Level Group. Chapter 9 compares different methods to estimate serious injuries. In addition, the appendices include five experiences that focus on specific issues related to each method to report the number of serious injuries described in chapters 5 to 7 with data from several countries. Appendix I summarizes the main recommendations and will be used as a leaflet to communicate the key results of this Deliverable.

2 Background

This chapter discusses why serious traffic injuries are important as an additional indicator for road safety and why they are defined as MAIS ≥ 3 casualties. Moreover, it justifies the rationale of this deliverable and specifies the objectives.

2.1 SERIOUS TRAFFIC INJURIES AS AN ADDITIONAL INDICATOR FOR ROAD SAFETY PERFORMANCE

Traffic injuries are an important public health problem. Over 1.2 million people die each year on the world's roads, with millions more sustaining serious injuries and living with long-term adverse health consequences (World Health Organization, 2015). Road traffic injuries are currently estimated to be the ninth leading cause of death across all age groups globally, and are predicted to become the seventh leading cause of death by 2030 (World Health Organization, 2015). The total number of road fatalities in Europe declined by 42% overall between 2000 and 2013 within the 32 countries in the International Road Traffic and Accident Database (IRTAD) for which data are consistently available (Road Safety Annual Report 2015, 2015). Morover, in Europe it is estimated that for each traffic fatality there are 17,8 hospital admissions and 102,8 hospital outpatients (EuroSafe, 2014).

Traditionally the main source of information on traffic accidents and injuries has been the police. This provides the official data for statistics at national and European level (CARE Database). Only very recently other data sources such hospital data have been envisaged as usefull and necessary. Data reported by police usually is very detailed about the circumstances of the crash, date and place, mode of transport, other vehicles involved and drivers and passangers characteristics, particularly if there are people injured or deaths. But on the other hand police cannot assess the severity of injuries in a reliable way, due, obviously to their training (they are not health proffessionals). Therefore, police based data use to classify people involved in a crash as fatality, severe injured if hospitalised more than 24 hours and slight injured if not hospitalised.

On the other hand, hospital records of people attended due to traffic injuries usually include very little information on circumstances of the crash but it does contain data about the person (age, gender, municipality of residence), and hospitalisation (date of hospitalisation and discharge, medical diagnosis, mechanism or external cause of injury, and interventions). Hospital inpatient Discharge Register (HDR) is run for economic management and offers an opportunity to complement police data on road traffic injuries. Medical diagnoses can be used to derive information about severity of injuries. Among others, one of the possible scales to measure injury severity is the Abbreviated Injury Scale (AIS).

The principal indicator for monitoring road safety has been traffic fatalities. UNECE (United Nations Economic Commission for Europe) proposed as a common definition for traffic fatalities people dying at the scene of the crash or in the following 30 days. It is known that even a so clear definition as a fatality is not always well reported and produces underreporting. This is due to several factors such lack of coverage of police at the scene or people dying at hospital not followed by police (Amoros et al., 2006; Broughton et al., 2007; Pérez et al., 2006). It is well known that statistics of traffic injuries based only on police reporting are underestimated (Broughton et al., 2010; "Data considerations - European Commission," n.d.). Therefore, the registered number might differ from the "actual" number. Other data sources are then necessary.

Given the burden of injury produced by traffic, using only fatalities as an indicator to monitor road safety gives a very small picture of the health impact of traffic crashes, just the tip of the iceberg. Crashes also cause numerous serious traffic injuries, resulting in considerable economic and human costs. In addition, in several countries during the last years the number of serious traffic injuries has not been decreasing as fast as the number of fatalities. In other countries the number of serious traffic injuries has even been increasing (Berecki-Gisolf et al., 2013; IRTAD Working Group on Serious Road Traffic Casualties, 2010; Weijermars et al., 2015).Therefore, serious traffic injuries 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).

Ideally, traffic injuries of all severity levels should be reported. This would allow the assessment of the global burden of road traffic injuries. In practice, however, it is difficult to have reliable estimates of all road traffic injuries due to differences in the information systems, inclusion criteria, accuracy in reporting, etc. As a first step, consistent reporting of serious injuries could be used in order to obtain data for monitoring trends within countries and to compare rates and trends between countries.

To be able to compare road safety performance across Europe and to monitor developments in serious traffic injuries at European level, a common definition of a serious road injury was necessary. In January 2013, the High Level Group on Road Safety, representing all EU Member Sates, established the definition of a serious road injury as a road traffic casualty with an injury level of Maximum Abbreviated Injury Scale (MAIS) ≥ 3. It is recommended that all EU countries provide data for serious injuries according to this definition from 2014 on.

2.2 WHY SHOULD WE USE MAIS ≥ 3

Some of the main scales used to measure injury severity are the Abbreviated Injury Scale (AIS) and the MAIS (Maximum AIS). The Abbreviated Injury Scale (AIS) is an anatomical-based consensus derived, coding system created by the Association for the Advancement of Automotive Medicine to classify and describe the severity of injuries. The first version of the scale was published in 1969 with last updates in 2008 ("Association for the Advancement of Automotive Medicine," n.d.). The AIS provides standardized terminology to describe injuries and ranks injuries by severity. It represents the threat to life associated with the injury rather than the comprehensive assessment of the severity of the injury. The AIS provides a number of 7 digits which describes the body region (1), type of anatomical structure (2-3), specific anatomical structure (3-4), the level (5-6), and the severity scale (7). The severity is based on a 6-point ordinal scale, one being a minor injury and six being maximal (currently untreatable). 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. An AIS-Code of 9 is used to describe injuries for which not enough information is available for assessing its severity. The AIS scale is a measurement tool for single injuries. The MAIS (Maximum AIS) is the maximum of the AIS scores for each region of the body, and is frequently used for assessing overall severity. It does not necessary have a linear relationship with the probability of death.

Injury severity includes different dimensions such threat to life, disability, quality of life, injury burden, or cost (IRTAD Working Group on Serious Road Traffic Casualties, 2010). Hospital discharge establish threat to life injury, but fail to capture an important part of the disabilities, cost and burden generated by the injuries (IRTAD Working Group on Serious Road Traffic Casualties, 2010).To obtain data for international comparisons the most convenient choice is to use a measure of injury severity limited to the "threat to life" dimension, which can be derived from hospitalisation data for most countries. When using hospital discharge data for road traffic injury reporting, it is necessary to define serious injuries to prioritize "important" injuries and to control for bias. The probability of a case being identified as a serious injury should be independent of extraneous factors such of social, economic and demographic factors, as well as service supply and access factors (IRTAD Working Group on Serious Road Traffic Casualties, 2010).

IRTAD Working Group on Serious Road Traffic Casualties compared injury severity measures such MAIS, ICISS (ICD-based Injury Severity Score), LoS (length of stay at hospital), and Sentinel serious injury diagnoses according to some criteria. They concluded that MAIS ≥ 3 appeared to be the most appropriate definition.

The team of SafetyNet project working on underreporting of serious injuries (Broughton et al., 2010) investigated which type of definition of serious traffic injuries would me most suitable for Europe to monitor road traffic injuries. Broughton et al. investigated a definition of injury serverity based on LoS at hospital or a definition based on MAIS. They concluded that a definition based on MAIS would be more suitable because the LoS is influenced far more by clinical practices and the availability and organisation of hospital services than by the level of road safety. Therefore, according to Brougthon et al (2008), results based on MAIS are more likely to reliably monitor casualty and severity trends than results based on LoS. Moreover, Broughton et al. also discuss which MAIS range to include for the definition of a serious injury. The threshold could be 2 as AIS2 describes a moderate injury and there are appreciable number of cases of MAIS2 casualties that die. However, since it is not always possible to estimate MAIS1 and 2 separately with the data available in some countries, the minimum feasible value for the threshold appears to be 3 (Broughton et al., 2010). Moreover, AIS3 is referred to as a serious injury by the AIS.

Based on the recommendations of Broughton et al (2008) and IRTAD (2010), the High Level Group on Road Safety, representing all EU Member States, adopted MAIS ≥ 3 as the most appropriate definition of serious traffic injuries.

2.3 JUSTIFICATION AND OBJECTIVES OF THE DELIVERABLE

The High Level group identified in 2013 three main ways Member States can collect data on serious traffic injuries (MAIS ≥ 3):

- by applying a correction on police data,
- by using hospital data and
- by using linked police and hospital data.

That means, for any of the three ways to have access at some point to a hospital database with information on mechanisms and diagnoses that allow to derive MAIS. The main hospital data source in most European countries is the Hospital Discharge Register (HDR), which is basically an administrative dataset used for financial purposes of all hospitalisations for diseases and injuries (traffic and non-traffic) from the majority of hospitals. HDRs use the International Statistical Classification of Diseases published by the World Health Organization (WHO) to codify the main diagnosis, or reason for the hospital admission. Currently there are two main versions: ICD-9-CM (International Classification of Diseases, ninth revision, clinical modification); ICD-10 (the International Statistical Classification of Diseases and Related Health Problems, tenth revision). Reported diagnoses of injuries using either ICD9 or ICD10 allow to derive MAIS.

Currently, EU member states use different procedures to determine the number of MAIS ≥ 3 traffic injuries, dependent on the available data. Given the major differences in the procedures being applied, the quality of the data differs considerably and the numbers are not yet fully comparable between countries.

A previous study about reporting serious traffic injuries en Europe showed a low coverage of reporting and a high variability in the methods. The European Commission (DG MOVE) requested that the Forum of European Road Safety Research Institutes (FERSI) conduct a survey on the state of the art of MAIS ≥ 3 among its member countries. FERSI has partners from 21 European countries. The aim of that survey was to collect comparable information on MAIS ≥ 3 assessment in each country in 2014. (Auerbach and Schmucker, 2016). 15 of the 21 FERSI members answered the questionnaire. Many difficulties were reported concerning the assessment of MAIS ≥ 3. Moreover, 6 of the surveyed countries reported that they would not be able to report serious injuries for 2015 (Czech Republic, Greece, Hungary, Ireland, Russia and Slovenia). The greatest challenges reported by all the countries are shown in
Table 2-1. One of the main conclusions of the survey suggested that any interpretation of the national numbers of serious injuries has to carefully take into account the respective particularities and limitations of the method applied in each country and consider that the establishment of MAIS ≥ 3 will take time, maybe years in some countries.

Currently, Member States use different procedures to determine the number of MAIS ≥ 3. The procedure that is applied in a country is for a large part determined by the available data. Consequently, the quality of the data differs by Member State and the numbers may not be fully comparable. The impact of this heterogeneity on final estimations is unknown. Up to date, there are no clear guidelines on how to apply each method to report serious traffic injuries.

Once one of these three ways is selected, several additional choices need to be made. In order to be able to compare injury data across different countries, it is important to understand the effects of methodological choices on the estimated numbers of serious traffic injuries. A number of questions arise: How to determine the correction factors that are to be applied to police data? How to select road traffic casualties in the hospital data and how to derive MAIS ≥ 3 casualties? How should police and hospital data be linked and how can the number of MAIS ≥ 3 casualties be determined on the basis of the linked data sources?

Work Package 7 of SafetyCube project is dedicated to serious traffic injuries, their health impacts and their costs. One of the aims of work package 7 is to assess and improve the estimation of the number of serious traffic injuries.

The aim of this deliverable (D7.1) is to report practices in Europe reporting serious injuries and provide guidelines and recommendations applied to each of the three main ways of estimate the number of road traffic serious injuries.

Specific objectives for this deliverable are to:

- Describe the current state of collection of data on serious traffic injuries across Europe
- Provide practical guidelines for the estimation of the number of serious traffic injuries for each of the three ways identified by the High Level Group
- Examine how the estimated number of serious traffic injuries is affected by differences in methodology.

On the basis of the survey sent to all 28 EU member states as well as Iceland, Norway and Switzerland, the Deliverable discusses the current state of collection of data on Serious Injuries. Moreover, the deliverable discusses practical guidelines for each of the three ways to collect data on serious traffic injuries identified by the High Level Group (applying correction to police data, use of hospital data, linking police and hospital data). The guidelines are based on previous research as well as current practices and experiences from a number of countries and more detailed analyses done within SafetyCube. Finally, the deliverable examines how the estimated number of serious traffic injuries is affected by differences in methodology, by applying different methods to the same dataset.

Table 2-1 Greatest challenges with MAIS ≥ 3 reporting in FERSI countries. Country survey FERSI report, 2016.

	Data protection and corresponding restrictions to use hospital data		**Legal regulations (e.g. necessity of amendments)**		**Financing**		**Communication/ cooperation between institutions (e.g. police, hospitals, public agencies)**		**Other**		**There are/will be no challenges**	
Country	2014	In the long run	2014	In the long run	2014	In the long run	2014	In the long run	2014	In the long run	2014	In the long run
Austria	X	X	X	X								
Belgium		X		X			X	X				
Czech Republic										X[1]	X	
Finland							X					X
France		X		X	X	X		X		X[2]		
Germany		X		X		X		X	X[3]			
Greece	X	X			X	X	X	X				
Hungary	X	X		X	X	X		X				
Italy					X	X	X	X				
Ireland	X	X	X	X			X	X				
Nethelands									X[4]	X[4]		
Romania												
Spain											X	X
Sweden												
Republic of Slovenia	X	X					X	X				
Total	5	7	2	5	4	5	6	7	2	3	2	2

[1] Czech Republic: Implementation AIS coding to hospitals (hospital information systems)

[2] France: Implication of the ministry of health

[3] Germany: Development of statistical models

[4] NL: The quality of the police reporting is an issue. The external cause is no longer a required element in the medical register. This is necessary information to select patients after traffic crashes. The 4th digit in the V-code often specifies the patient as not resulting from a road traffic crash, but from a more generic transport accident, i.e. not a traffic crash. We have to see if that is true.

Source: Country survey FERSI report, 2016 (Auerbach and Schmucker, 2016).

3 Methodology

This chapter describes the process followed to develop the deliverable. Specific methods of analysis are described in the corresponding section

The practical guidelines for the determination of the number of serious traffic injuries were developed using:

1) A survey carried out among experts in EU Member States
2) Current practices and experiences from a number of countries
3) Specific analysis from in which different procedures were applied to the same data.

A survey was carried out among experts in EU Member States in order to provide an overview of the data and procedures that are applied for estimating the number of MAIS ≥ 3 casualties across Europe. The questionnaire was inspired by the a survey that had been conducted by FERSI (Auerbach and Schmucker, 2016). The 72 questions of the survey were clustered in six groups: (1) Prime contact in the country; (2) General information on collection practices and responsibilities; (3) MAIS ≥ 3 methodology and planned changes; (4) Detailed information on hospital data; (5) Detailed information on applied method; (6) Concrete figures: fatalities and serious injuries police / MAIS ≥ 3.

Current practices and experiences from some countries allowed exploring the following topics:

- Methods to apply correction factors have been explored using data from Belgium, France and Austria
- Inclusion and exclusion criteria have been defined using Hospital Discharge Data from Spain and the Netherlands. It includes a sensitivity analysis of the impact of using different inclusion/exclusion criteria.
- A sensitivity analysis has been carried out to assess the impact of obtaining MAIS ≥ 3 from different methods, either coding AIS directly or recoding from ICD diagnosis with a conversion tool. We used data from Spain, Belgium, the Netherlands and Germany.
- How to derive the number of serious traffic injuries using police and hospital record linkage has been explored with data from France, the Netherlands and Slovenia

Finally a comparison of three methods proposed by the High Level Group to estimate the number of seriously injured (factors, hospital and record linkage) was carried out using data from the Netherlands.

Full details of methods for each specific analysis is explained in the corresponding chapter and in the appendixes.

4 Reporting Road Traffic serious injuries in Europe

This section gives an overview on the state of play in the countries, on the methodologies used, the details of the national hospital data sets, the availability of estimations of MAIS ≥ 3 injuries and how these are/could be made comparable across the Union.

Since the adoption of the definition of serious traffic injuries as MAIS ≥ 3 in January 2013, the majority of countries have entered the process of jointly analysing crash-relevant police *and* hospital data, several of them for the first time in history.

As reported above, the first attempt to produce an overview of MAIS ≥ 3 data availability and estimation methodologies was carried out by FERSI (Auerbach and Schmucker, 2016) in cooperation with DG-MOVE in the years 2014-16 (see previous section). The project SafetyCube based its survey in 2016 on a modified version of the FERSI questionnaire and aimed at collecting data from all 28 EU countries as well as from Iceland, Norway and Switzerland.

The SafetyCube questionnaire was implemented as an MS Excel spreadsheet, prefilled with responses from three member countries of the project (Austria, Belgium, and the Netherlands). This simple setting allowed for respondents to assess how other countries had interpreted the questions and in what depth answers had been provided. This resulted in a swift response process. In total, stakeholders in 31 countries were contacted by email.

The 72 questions (see Appendix G) were clustered in six groups:

- Prime contact in the country
- General information on collection practices and responsibilities
- MAIS ≥ 3 methodology chosen and planned changes
- Detailed information on hospital data
- Detailed information on application of method 1 / 2 / 3
- Concrete figures: fatalities and serious injuries police / MAIS ≥ 3

4.1 AVAILABILITY OF MAIS ≥ 3 ESTIMATIONS ACROSS THE EU AND EFTA COUNTRIES

Responses to the SafetyCube questionnaire were received from SafetyCube partners as well as from FERSI and IRTAD members. In April 2016, DG-MOVE additionally sent the questionnaire to all CARE Experts. At the time of drafting this report, responses were received from 26 countries, resulting in a response rate of 84%.Table 4.1 merges responses to the SafetyCube questionnaire with information from DG-MOVE.

As of June 2016, 17 countries had either delivered MAIS ≥ 3 estimates to DG-MOVE – or had reported that they would be in the position to do so shortly.

In the remaining 14 countries, the MAIS ≥ 3 process was only in very early stages or had not even properly started yet. One of the central problems in these countries was for the transport sector, respectively the accident statistics sector, to get hold of hospital discharge data in the first place. Apparently the majority of the *New Members States* (i.e. the countries which joined the Union in or after 2004) are not yet in the position to deliver MAIS ≥ 3 data.

Table 4.1 Availability of MAIS ≥ 3 estimations across the EU and EFTA countries (including preliminary estimations as communicated in the CARE Experts Group). SafetyCube survey, 2016

	MAIS ≥ 3 estimations already dekivered or soon available?	For which years are MAIS ≥ 3 data available?
Austria	yes (2016)	2014
Belgium	yes (2015)	2011-2014
Bulgaria	no	-
Croatia	no	-
Cyprus	yes	-
Czech Republic	yes	2014
Denmark	no	-
Estonia	No (possibly from 2017)	-
Finland	yes (2015)	2010 & 2011, 2014
France	yes (preliminary figures)	2006-2012
Germany	yes (2015)	2014
Greece	no	-
Hungary	no	-
Ireland	yes (2015)	2005-2014
Italy	yes (2015)	2012-2014
Latvia	no	-
Lithuania*	no	-
Luxembourg	no	-
Malta*	no	-
Netherlands	yes (2015)	1993-2014
Poland	yes (2015)	2013
Portugal	yes (2015)	2010-2014
Romania*	no	-
Slovakia	no	-

	MAIS ≥ 3 estimations already dekivered or soon available?	For which years are MAIS ≥ 3 data available?
Slovenia	yes (2015)	2012-2014
Spain	yes (2016)	2000-2014
Sweden*	yes	2014-2015
United Kingdom	yes (2016)	1999-2011 (soon up to 2015)
Iceland	no	-
Norway	no	-
Switzerland	yes (2016)	2011-2014

** no detailed information on methodology yet available*

Source: SafetyCube questionnaire, information by DG-MOVE (CARE Expert Group).

4.2 METHODOLOGIES TO ESTIMATE THE NUMBER OF MAIS ≥ 3 INJURIES

The European Commission has identified three main ways for Member States to arrive at MAIS ≥ 3 estimates: 1) by applying a correction factor to police data, 2) by using hospital data alone and 3) by using linked/matched police and hospital data.

The survey made it obvious that the methodologies currently used vary between countries. Only two countries (BE, UK) used method 1 while nine countries (plus England) used method 2 and four used method 3. Another two countries used other or combined methods: France (generalisation based on the Rhône Trauma Register, and Germany (generalisation based on GIDAS in depth data and data from the German Trauma Register DGU®).

Several countries plan to modify their methodology in the future, the majority of them towards deterministic or probabilistic linking between police and hospital data. It goes without saying that deterministic linking requires the solving of privacy issues and therefore cannot be expected to be implemented in the short term. Table 4.2 gives an overview of the methods currently used and plans for modifications.

Table 4.2 Methods for MAIS ≥ 3 estimation currently in use and plans for future modification. SafetyCube survey, 2016

	1 Correction coefficient on police data	2 Use of hospital data alone	3 Using linked / matched police and hospital data	Other Methods	Changes planned?
Austria	(2015)	(from 2016)			Austria seeks to implement direct linking (mid-term)
Belgium	(from 2012)	(2009-2011)			Long term: probabilistic or deterministic linking
Bulgaria	-	-	-	-	-
Croatia	-	-	-	-	-
Cyprus	-	x	-	-	no
Czech Republic		x			Refinement of method
Denmark	-	-	-	-	-
Estonia	-	-	-	-	-
Finland			x		no
France				A model is constructed on linked casualties between the Rhône police data and the Rhone road trauma registry >> generalisation to France	Mid-term: extend the Rhône road trauma registry to a wider geographical coverage
Germany				In-depth accident data (GIDAS) and hospital data of very seriously injured RTC victims (Trauma Register DGU®) used to estimate the number of serious injuries >> generalisation to Germany	Ongoing optimisation
Greece	-	-	-	-	-
Hungary	-	-	-	-	-
Ireland		x			Refine current method;Mid-term: statistically match police and hospital data to estimate the level of underreporting (Source: FERSI Report).
Italy		x			no
Latvia	-	-	-	-	-
Lithuania	-	-	-	-	-

	1 Correction coefficient on police data	2 Use of hospital data alone	3 Using linked / matched police and hospital data	Other Methods	Changes planned?
Luxembourg	-	-	-	-	-
Malta	-	-	-	-	-
Netherlands			x		change from ICD9/AIS1990 to ICD10/AIS2008
Poland		x			improvement of reliability of methodology sought
Portugal		x			mid/long term: linking police and hospital data
Romania	-	-	-	-	-
Slovakia	-	-	-	-	-
Slovenia			x		no
Spain		x			no
Sweden		x			no
United Kingdom	UK (derived from hospital data from England)	England (Hospital data not available for rest of UK)			Work in progress. The methodology isn't finalised yet
Iceland	-	-	-	-	-
Norway	-	-	-	-	-
Switzerland			x		no

Source: FERSI & SafetyCube questionnaires

4.3 HOSPITAL DATA: THE DEVIL IS IN THE DETAILS

The reliability and comparability of the frequencies of MAIS ≥ 3 casualties depend on the way the number is registered – both in terms of the overall method and the details of the respective hospital data sets (Chapter 6). In some cases injury severity is assessed by means of the AIS scale, while in others use the International Statistical Classification of Diseases (ICD), both in its ninth or tenth version, and then a conversion tool is used such as AAAM ("Association for the Advancement of Automotive Medicine," n.d.) or icdpic (ICD Programs for Injury Categorization). Differences are also encountered in the way countries register their victims in Hospital Data Register (HDR), and the inclusion-exclusion criteria applied. Table 4.3 outlines the various differences between countries such as in/exclusion criteria as well as the number of available ICD digits and diagnoses.

The majority of countries now use the AAAM as converter tool as provided by DG-MOVE. It becomes obvious, however, that the US-based AAAM table does not yet provide satisfying transformation rates for the ICD versions currently being used in Europe. This is the case especially in those countries for which only one diagnosis and only four ICD digits are available from the hospital data, where the fail rate can be around 20% (see the poor rates in column "Share of failed transformations ICD > MAIS" in Table 4.3 for Austria and Poland).

Table 4.3 MAIS-relevant details in hospital data. SafetyCube survey, 2016

	Hospital data include …									
	Outpatients (non-hospitalised patients)	Day care patients (no overnight stay)	Re-admissions	Scheduled (non-urgent) admissions	Fatalities within 30 days	ICD version used	How many ICD digits are used to derive AIS?	Number of diagnoses available	Conversion algorithm	Share of failed transfor-mations ICD > MAIS
Austria	no	yes	no	yes	no	ICD10	4	1	AAAM	19%
Belgium	no	no	no	yes	no	ICD9-CM	5	All	AAAM	0.4%
Bulgaria	-	-	-	-	-	-	-	-	-	-
Croatia	-	-	-	-	-	ICD10	-	-	-	-
Cyprus	yes	yes	no	no	n/a	ICD9 upgrade	6	4	AAAM	n/a
Czech Republic	no	no	*	yes	no	ICD10	4	1	AAAM	unknown
Denmark	yes	yes	y/n	yes	yes	ICD10	-	-	AAAM	-
Estonia	-	-	-	-	-	ICD10	-	-	-	-
Finland	yes	yes	yes	yes	no	ICD-10	5	All	AAAM	unknown
France	yes	yes	no	no	no	Direct coding to AIS	n/a	n/a	n/a	n/a
Germany	no	no	no	no	no	Direct coding to AIS	n/a	n/a	n/a	n/a
Greece	-	-	-	-	-	ICD9	-		-	-
Hungary	no	no	yes	yes	yes	ICD10	5	?	-	-
Ireland	no	no	no	no	no	ICD10-AM	4	All	AAAM	26.2.%
Italy	no	no	No	no	no	ICD-9-CM (2002)	5	1	AAAM	8%
Latvia	-	-	-	-	-	-	-	-	-	-
Lithuania	-	-	-	-	-	-	-	-	-	-
Luxembourg	no	no	yes	yes	yes	ICD10	4	All	AAAM	unknown
Malta	-	-	-	-	-	-	-	-	-	-
Netherlands	no	yes	no	yes	no	ICD10	5	10	ICDmap90	~0%
Poland	no	yes	yes	Yes	no	ICD10	4	1	AAAM	21%

	Hospital data include ...									
	Outpatients (non-hospitalised patients)	Day care patients (no overnight stay)	Re-admissions	Scheduled (non-urgent) admissions	Fatalities within 30 days	ICD version used	How many ICD digits are used to derive AIS?	Number of diagnoses available	Conversion algorithm	Share of failed transfor-mations ICD > MAIS
Portugal	no	no	yes	no	no	ICD9-CM	4	All	AAAM	0%
Romania	-	-	-	-	-	-	-	-	-	-
Slovakia	-	-	-	-	-	-	-	-	-	-
Slovenia	no	yes	no	yes	yes	ICD10	4	20	AAAM	unknown
Iceland	-	-	-	-	-	-	-	-	-	-
Norway	-	-	-	-	-	-	-	-	-	-
Spain	no	no	no	no	no.	ICD9-CM	5	14	AAAM	1.6%
Sweden	no	yes*	no	no	-	ICD10	-	All	-	-
Switzerland	no	Yes*	no	no	no	Direct coding to AIS	-	All	-	-
United Kingdom	no	yes	no	no	no	ICD10	5	All	AAAM	6%

** only readmissions between hospitals. Readmissions between departments of one hospital are not included.*
*** if first admitted to an emergency room*
Source: SafetyCube questionnaire

4.4 EXTERNAL CAUSES: IDENTIFYING TRAFFIC INJURIES AMONG ALL INJURIES

The ICD nomenclature provides codes for external causes (e.g. ICD 10-Chapter XX) which allow the identification of road traffic injuries in all-injury hospital databases. As listed in Table 4.4, the set of codes used to filter the respective databases (from E-Codes for ICD9, from V-Codes for ICD10) vary between countries. This is likely to have an influence on the total number of traffic injuries identified from hospital data (Chapter 4). In addition, several countries suffer from incomplete specification of external causes; e.g. for more than a third of all injuries, no specified external causes are given in Austrian hospital data.

Table 4.4 Determination of injuries from road traffic crashes (external causes).

	ICD external causes	Proportion of unknowns with respect to external causes among all injuries
Austria	Austria-specific codes for external causes: only two codes for all traffic accidents (work or non-work-related: U11, U12)	35%
Belgium	E810-E819, E826, E827, E829	16%
Bulgaria	-	-
Croatia	-	-
Cyprus	-	-
Czech Republic	V01-V89	unknown
Denmark	-	-
Estonia	-	-
Finland	external causes in the hospital data are not used to determine involved in road traffic accidents	undetermined
France	n/a	n/a (would be 80% if hospital database were used)
Germany	n/a	n/a
Greece	-	-
Hungary	V00-V89	5%
Iceland	-	-
Ireland	V01-V89 excluding all 'non-traffic' codes, 'collision with railway' codes, V80.0, V81, V82	0.5%
Italy	E800-E819, E826	unknown
Latvia	-	-
Lithuania	-	-
Luxembourg	V00-V89	unknown
Malta	-	-
Netherlands	Conversion V00-V89 back to ICD9 and selection E810-E816, E818-E819 + E826, E827, E829	5%
Norway	-	-
Poland	V02-V04, V09, V12-V14, V20-V79, V82-V87, V89	38%
Portugal	E810-E819, E826	unknown
Romania	-	-

	ICD external causes	Proportion of unknowns with respect to external causes among all injuries
Slovakia	-	-
Slovenia	V00 - V89	0% (coding external causes is mandatory)
Spain	E810-E819, E826	17.5%
Sweden	n/a	n/a
Switzerland	n/a	n/a
United Kingdom	V01 to V89, excluding V81	unknown

Source: SafetyCube questionnaire

4.5 REPORTING THE NUMBER OF SERIOUS INJURIES MAIS ≥ 3

As outlined above, MAIS ≥ 3 assessment is still a work in progress for several countries, and some have not even started the process yet. Although it was agreed in the High Level Group on Road Safety that by 2015 all Member States and associated countries would provide MAIS ≥ 3 data for 2014, by June 2016 only 16 countries have provided first estimates to DG-MOVE (some only for earlier years than 2014). The Commission stated, however, that the available estimates (as of March 2016) would cover 80% of the EU population.

Table 4.5 provides an overview of the wide spread in the proportion of MAIS ≥ 3 injuries between countries. As of September 2016 16 countries (of the 26 who responded to the SafetyCube questionnaire) had MAIS ≥ 3 estimates for 2014 readily available.

The ratio of serious injuries, according to the MAIS ≥ 3 definition among fatalities varies substantially between the Member States. The lowest proportion of MAIS ≥ 3 injuries was currently estimated for Poland (0.6 MAIS ≥ 3 injuries per fatality), the highest for the Netherlands (13.5 MAIS ≥ 3 injuries per fatality). The variation between countries, is not only due to the various differences in data quality and assessment methodologies but also to differences between the transport systems, such as the modal share: The high proportion of cyclists in the Netherlands for example most probably contributes to the high Dutch proportion of serious injuries.

Table 4.5 Number of fatalities and MAIS ≥ 3 injuries and proportion between them.

	Fatalities 2014	Serious Injuries MAIS ≥ 3 2014	Proportion between MAIS ≥ 3 injuries and fatalities
Austria	430	1410	**3.3**
Belgium	727	2979	**4.1**
Bulgaria*	901		
Croatia	308		
Cyprus	45	83	**1.8**
Czech Republic	688		
Denmark	182		
Estonia	78		
Finland	229	519	**2.3**
France[1]	3650	25500	**7.0**
Germany	3377	14645	**4.3**
Greece***	879		
Hungary	626		
Iceland	4		
Ireland	193	343	**2.0**
Italy	3381	14943	**4.4**
Latvia	212		
Lithuania	267		
Luxembourg	35		
Malta**	13		
Netherlands	570	7500	**13.2**
Norway	147		
Poland[2]	3357	1859	**0.6**
Portugal	638	2046	**3.2**
Romania	1818		
Slovakia***	321		

	Fatalities 2014	Serious Injuries MAIS ≥ 3 2014	Proportion between MAIS ≥ 3 injuries and fatalities
Slovenia	108	213	**2.0**
Spain* **	1680	6613	**3.9**
Sweden	270	1192	**4.4**
Switzerland	243	2899	**11.9**
United Kingdom	1854	5070	**2.7**

**2009, **2010, ***2013, [1]MAIS ≥ 3 estimation for 2012, [2]MAIS ≥ 3 estimation for 2013. Source: SafetyCube questionnaire, CARE database.*

5 Applying correction factors to police data

This chapter describes how to estimate the number of serious injuries - defined as MAIS ≥ 3 - by applying correction factors.

The application of correction factors to police data is one of the three options proposed by the EC to estimate the number of MAIS ≥ 3 victims in a EU country: *"The first possibility would be to apply national coefficients to the data currently collected by the police to allow for mis- and under-reporting, thereby arriving at a truer estimate of the number of people seriously injured under the common EU definition.* "The two other options are the use of hospital data, and the linking of police with hospital data respectively.

Correction factors are used to obtain estimates that are as close as possible to actual figure(s) in a population by taking into account the completeness or biases in available data. In other words, correction factors are mathematical adjustments made to an estimation in order to correct it for deviations based either on the sampling or measurement method.

5.1 CLARIFYING THE CONCEPT OF "CORRECTION FACTORS"

The calculation of correction factors applied to police data is not completely independent of the two other options proposed by the EU, namely: the use of hospital data and the linking of police with hospital data. Indeed, in order to correct police data for underreporting, it is necessary to evaluate the magnitude of this underreporting. This cannot be done without access to some reference/comparison data, considered to be a more reliable reflection of the quantity to be estimated, such as hospital data. This does not necessarily require having continuous access to hospital data over time, because – provided that some conditions are met - it is possible to use the data for a given time period and extrapolate to a longer time period. However, in the absence of hospital data, a country has no benchmark to define its correction factors. Their calculation is difficult, if not impossible.

This said, it is important to bear in mind that hospital data are also unlikely to provide a perfect estimation of the actual number of MAIS+3 victims in traffic. In many countries, the observed numbers of road casualties (and MAIS ≥ 3 victims) within hospital data- is an underestimation of the actual number of road casualties (and MAIS ≥ 3 victims). The reasons for this are multiple. For example, flaws in the hospitals' own registration systems: under some circumstances, no E-code is assigned to the victim (preventing its identification as a "traffic victim"); or no diagnosis code is provided (preventing the calculation of any AIS score); or the victim's injuries are incompletely recorded. Another reason for underreporting in hospital data is independent of the quality of the hospitals' registration system and relates to the fact that not all casualties go to the hospital after involvement in a road crash.

Therefore, hospital databases will never perfectly cover the total number of road casualties. However, they can nevertheless be considered to provide a better estimate than police data, if only because the police cannot assess injury severity based on medical diagnosis. Some countries, like Spain apply procedures to improve the selection of traffic victims in hospital files and the estimates of the numbers of MAIS ≥ 3 victims in the hospital (See Chapter 6). France and the Netherlands, apply procedures to improve the estimates of the numbers of MAIS ≥ 3 victims based on both police, hospital data and a dataset in which records from both files have been linked (see Chapter 7). They use the "capture-recapture" method in order to arrive at a more correct estimate of the total numbers of injured in traffic (all severity levels and not only MAIS ≥ 3). The proportions of MAIS ≥ 3 is then estimated – taking accident characteristics into account - and applied to the previously corrected police data (see Chapter 7). This should be considered the reference method for the calculation of correction coefficient and it should be applied whenever possible. Chapter 6 of these guidelines provides more detailed information on the limits of hospital data and about the procedures that can be applied correct for them.

For now, it is important to bear in mind that three types of hospital-based correction factors need to be distinguished when considering the correction factors that can be applied to improve police data: one based on "raw" hospital data; another one based on hospital data corrected for registration flaws and improved for the selection of traffic casualties; and a third one based on hospital data matched/linked with police data. The differences consequently lie mainly in the "standard" or "reference" population/sample that is used to correct the number of serious injuries recorded by the police. The correction factors themselves are obtained by establishing the *ratio between the number of severe injuries in the reference sample/population and the number of severe injuries in the data to be corrected for-the police data in the present case*

The different types of correction factors are illustrated in Figure 5-1.

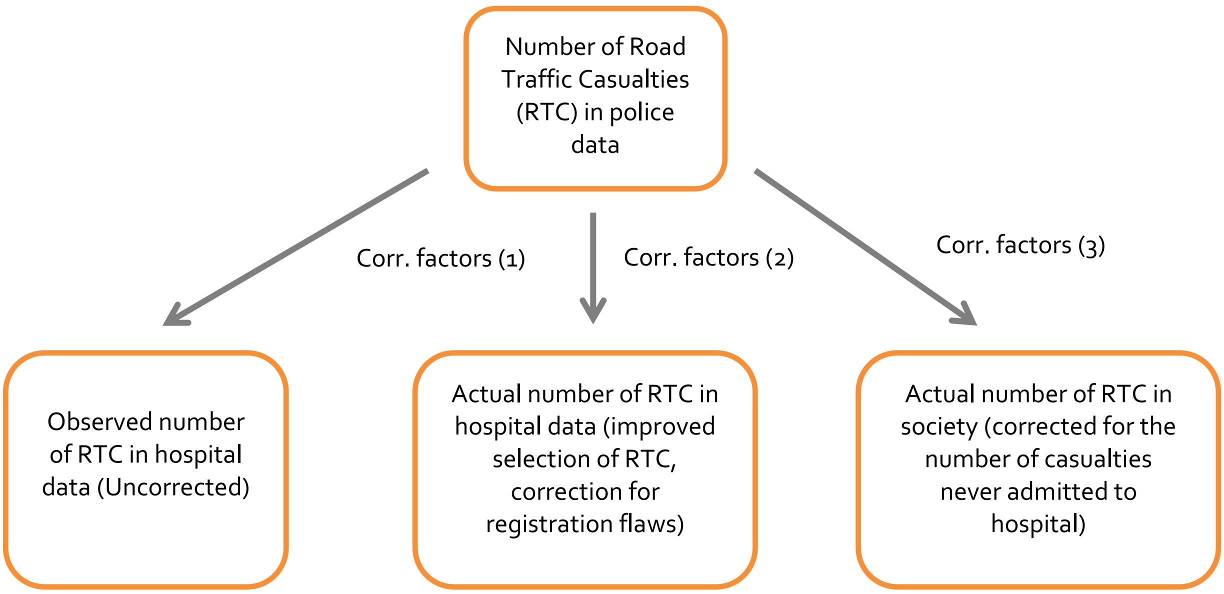

Figure 5-1 Types of correction factors

5.2 EMPIRICAL EXPERIENCES

In this section, we briefly review and discuss the main conclusions from the seminal work on the correction of police data conducted 10 years ago in the framework of the SafetyNet project. We also summarize the procedures applied in 4 experiences conducted in Belgium, France and Austria in order to correct the number of serious injuries registered in police data. These experiences are presented in detail in Appendix D of this deliverable.

5.2.1 SafetyNet

The first attempt to deal with underreporting and the estimation of the real number of severely injured with an international coverage dates back to ten years ago (2004-2008), with the integrated EC project "SafetyNet"(Broughton et al., 2008). The objectives of this project were:

(1) The estimation of the under-reporting level of road casualties in police data by developing a uniform methodology and applying it in seven EU countries (UK, CZ, FR, EL, HU, NL, ES)
(2) The estimation of the number of MAIS ≥ 3 casualties per country by applying correction factors to police accident statistics

The methodology of SafetyNet was entirely based on the ability of a country to link police and hospital data. All eight countries performed probabilistic linking between these two data sources: two countries made this link at national level; all others made it on regional level. No personal identification numbers were used to match the data from the two databases.

After linking, the data could be subdivided in three groups: "linked data", "police only data" (namely data reported by the police but absent in the hospital data) and "hospital only data" (cases recorded in the hospital data but not in the police data).Before calculating the correction factors, the assumption was made that "police only data" were unlikely to correspond to an injury severity of MAIS 3 or more (i.e., it is unlikely that someone suffering from such severe injuries would not attend the hospital). MAIS ≥ 3 casualties were therefore considered plausible only in the "linked data" or in the "hospital only data", but not in the "police only data".

Two correction factors were then calculated and applied to the numbers of injured people reported by the police: one for the seriously injured; and another for the slightly injured. The calculation method of both factors is rather complicated but is elaborately described in Broughton et al. (2008).

Table 5.1 displays the two correction factors for all seven EU countries. The number of MAIS ≥ 3 in the UK Scotland for example is achieved by multiplying the number of seriously injured people reported by the police with correction factor 0.20 and the number of slightly injured reported by the police with correction factor 0.01. Most EU countries have more specific correction factors by road user type, but other variables influencing the probability of a victim to be reported by the police are not accounted for.

Table 5.1 Correction factors to be applied to police reported casualties in order to arrive at the best possible estimate of the number of MAIS ≥ 3 casualties[7]

	Correction factor / serious	Correction factor / slight
Czech Republic	0.21	0.02
France	0.68	0.06
Greece	0.46	0.12
Hungary	0.48	0.04
Netherland	0.39	0.016
Spain	0.26	0.02
UK Scotland	0.20	0.01

(Broughton et al., 2008)

Some important lessons were learned from the SafetyNet project which are still very relevant for the estimation of the number of MAIS ≥ 3 casualties.

Firstly, the correction factors to be applied to police reported serious injuries range from 0.20 to 0.68. In part, this is due to the fact that both the police and the hospital registration process varies widely between countries. In case of hospital it depens on the particular ICD and AIS version used, on the number of diagnoses recorded, on the quality and completeness of hospital registration, etc. Furthermore, the injured populations themselves are also likely to differ from country to country. Given these huge differences, it appeared impossible to generalize correction factors from one country to another. They should be considered as country-specific. The only satisfactory approach would be to carry out comparable studies in as many countries as possible.

Secondly, SafetyNet also showed that correction factors can change over time, as police and hospital accident reporting practices evolve. Therefore, studies need to be repeated regularly in order to update these factors. From these results, we can generally conclude that *correction factors are neither temporally, nor geographically constant and should be recalculated if the time or location parameters change*.

5.2.2 Current practices

The different practices presented in this Chapter and Appendix D further illustrate the various ways in which correction factors can be defined and applied. The 4 practices differ on a variety of other aspects, such as the way road traffic casualties (RTC) victims are selected out of Hospital Discharge Register (HDR) or the way the (M)AIS scores are calculated, but these aspects won't be covered in this chapter, as they are discussed in other parts of this deliverable. We focus instead on those

[7] A total of eight countries took part in this project, but the results presented in this table cover only 7 of them. This is because no MAIS score could not be calculated for Autsria – where only the mian diagnosis (per patient) was available at the time. Therefore, no correction factor could be computed for this country.

aspects that are essential to the application of correction factors to police data, namely: the "reference" used to establish the correction ("raw" or corrected hospital data, linked police and hospital data), the way the correction factors are derived, and the extent to which potential geographical and temporal variations of the coefficients is covered.

Correction factors derived from hospital data – the Belgian and Austrian practices:

Both experiences presented for Belgium are based on Hospital Discharge Data covering admissions in all Belgian hospitals (including outpatients). The data used for the first study covered the period extending from 2004 to 2011, but were available in aggregate format only (aggregation over years). The data used for the second study extended from 2009 to 2011, and were available in disaggregate format (hospital stay). The information they contained was also much more detailed than the one available for the first study.

One main difference between both experiences lies in the way hospital data were used to develop correction factors. In the first study, the correction factors corresponded to the *observed* ratios of severly injured in hospital records to severly injured in police records. These were calculated separately for 4 different road user categories. The observed ratios were then directly applied to (multiplied with) the number of severly injured recorded in police data for the different road user categories.

In the second study, the ratios of hospital/police severe injuries were first modelled by means of a multiple regression, and the estimated ratios were subsequently applied to police data for the correction. The model used to predict the ratios included the casualties' age, gender, and transport mode, as well as the date (year) of the accident and the fact it involved a motorized vehicle or not. In line with the conclusions derived from the SafetyNet results, transport mode, age, gender and the presence of a motorized vehicle appeared to be associated with significant variations of the ratio of hospital to police records. The modelled ratios were then applied to the corresponding variables categories in police data.

The Austrian study involves hospital data for the years 2001 to 2011. RTC were selected from these data on the basis of the medical diagnose and of registration of the external cause (U-codes). Estimations were made of the proportions of casualties with an "unspecified accident" code that were likely to actually be RTC and of RTC without AIS code that were likely to be MAIS ≥ 3 casualties. The numbers in these two categories of observations were corrected on the basis of these proportions. In a next step, the proportions of MAIS ≥ 3 and MAIS1-2 victims among RTC was then calculated. The assumption is made that this proportion is the proportion of MAIS ≥ 3 casualties among the severly injured recorded by the police. The so estimated numbers of MAIS ≥ 3 are considered as an indicator only.

Correction factors derived from linked police and hospital data - France:

The "reference" used in France to develop the correction factors are linked police and hospital data for the Rhône County (see Chapter 0 for more details about the linking procedure and estimation of its efficiency).

The correction of police data takes place in two stages. First, correction factors are defined for all MAIS1+ casualties. A multiple regression model (multivariate multinomial logit model) is used to predict the probability for an observation to have been registered (1) both by police and hospital services (i.e., tho be part of the "linked" subset of data); (2) by hospital services only, or (3) by police services only. Several predictors were entered in the model, which affect the probability of a victim to be reported by the police (these variables are described in Chapter 0 as well as in Appendix D of this deliverable). The correction factors obtained were applied to the police data in order to obtain a more accurate estimation of the number of injured traffic victim, *whatever the level of severity of their injuries*.

In a second stage, the casualties identified as common to the police and hospital files were used to build a model predicting *the proportion of MAIS ≥ 3 casualties among all severity casualties.* This model included predictors such as the type of area in which the crash occurred, the severity of the crash (fatal or not), whether it involved one vehicle or more, the victim's transport mode…: all predictors being considered likely to affect the probability of registration by the police. The probabilities estimated from this model are then applied to the national police data, corrected as described in the first step.

5.3 NUMBER OF CORRECTION FACTORS AND VARIABLES ACCOUNTED FOR

The ratio of hospital registered MAIS ≥ 3 victims (MAIS ≥ 3) to the total number of injured or seriously injured registered by the police (seriously injured) varies substantially according to road user type, age, gender, year etc. In the majority of EU countries, the ratio "MAIS ≥ 3 / seriously injured by police" is for example much higher for cyclists than for occupants of motorized vehicles. This means that an overall ratio of the total number of MAIS ≥ 3 to the total number of seriously injured is actually masking a wide range of much lower and much higher ratios, according to the values (e.g. cyclist) of the variables taken into account (e.g. road user type).

To the extent that it is technically possible to calculate one ratio "MAIS ≥ 3 / seriously injured by police", it is possible to calculate just one correction factor to estimate the total number of MAIS ≥ 3. However, it would be incorrect to apply this "general correction factor" to a given subgroup of road casualties in the police data. Applying such a general correction factor to the number of seriously injured cyclists recorded by the police for example, would result in a substantial underestimation of MAIS ≥ 3 victims among cyclists.

Ideally, a correction factor should be defined for each value of a variable- or for each combination of variable values – that appear to significantly influence the level of underreporting in police data (e.g.: road user type, age…).

Table 5.2 provides a list of variables that are likely to impact the probability of a victim to be reported by the police and Table 5.3 the number of correction factors to estimate MAIS ≥ 3 and variables accounted for, in each study and in SafetyNet. This list is probably not exhaustive, but it does contain the variables with most influence. The variables with the highest impact are mentioned in the first part of the list, although the order of presentation is not an exact reflection of their order of importance. Besides, it is very likely that the magnitude of the influence of each variable varies across countries.

Table 5.2 Type of variables affecting the probability of victim recording by the police

Variable	Explanation
Road user type	Cyclists, and to some lesser extent pedestrians, are less often recorded by the police than occupants of motorized vehicles
Severity of the accident	Accidents causing slightly injured casualties only are less often recorded than accidents resulting in severely or fatally injured casualties
Number of vehicles involved	Accidents with only one vehicle involved are less often recorded
Motorized vehicle involved: yes/no	Accidents with no motor vehicle involved are less often recorded
Road type (motorways, regional or provincial roads, local roads)	Accidents on local roads are less often recorded than accidents on highways
Age	Very young and older casualties are less often recorded
Gender	In some countries the reporting rate between men and women can be slightly different
Year	In some countries the reporting rate fluctuates over years (A frequent situation is an annually improving hospital registration along with a rather stable registration by the police, which affects the annual ratio between these two measures).

Note that in order to be able to define correction factors that are specific for these variables values, it is necessary for them to be registered in both hospital and police data. Most EU countries will therefore not be able to define correction factors for all the above-mentioned variables, because they will not all be available in both police and hospital data. Besides, not all variables will be equally important in all countries.

It is therefore recommended to account for those variables

(1) that have the most diverse impact on hospital/police ratios (the impact of road-user type, for example, differs widely depending on the particular road-user category considered: the ratio will be moderate for powered-two-wheelers, very high for cyclists, but low for car occupants). Of all variables listed above, "road user type" is probably one of the most significant and most frequently available variables.

(2) with values combinations that also result in significant variation in correction factors (e.g.: transport mode*age).

Table 5.3 Number of correction factors to estimate MAIS ≥ 3 and variables accounted for, in each study and in SafetyNet

Study	Variables	Number of correction factors calculated
Austria		1 general correction factor
Belgium 1	Road User Type (4 values)	4
Belgium 2	Road User Type (5 values) Motorized accident: Yes/No (2 values) Age (107 categories, unknown included) Gender (3 categories, unknown included)	Approx. 2000
France *	Mode of transport, Vehicle opponent, Accident severity, severity, type of road, type of police, year	About 300
SafetyNet	Road User Type (5 values)	5

* Correction factors to estimate MAIS1+

5.4 SUMMARY

The practical guidelines considering applying correction to police data that follow from SafyNet and the SafetyCube experiences are summarized in Table 5.4

Table 5.4 Guidelines for deriving and applying correction factors

- **The calculation of correction factors requires access to reference/comparison data, which are considered to be a more reliable reflection than police data of the quantity to be estimated. In the present time, hospital data are considered to provide better estimates of the number of seriously injured traffic victims. *It is therefore strongly recommended that access should be obtained to hospital data, or to a sample of it*. Without such access, no benchmark will be available upon which to base correction factors. This makes their calculation very difficult, if not impossible.**

- **Given the crucial role of hospital data in the calculation of the correction coefficients, it is *also advised to ensure that they are of optimal quality*. It might be necessary, in some cases, to apply correction factors to hospital data as well (see Chapter 4).**

- **Whenever possible, an attempt should be made to link hospital with police data, following the procedure described in Chapter 5. This allows obtaining (1) more accurate estimates of the number of casualties (all level of injury severity) and (2) to apply the estimated proportion of MAIS ≥ 3 casualties to these estimates.**

- **Multiple correction factors are necessary: There is no single, general correction factor which should be applied. It is more appropriate to apply several correction factors because the ratios of hospital/police registrations vary as a function of the characteristics of the victims (age, gender, transport mode) and of the accident (single- vs. multi-vehicle accident, place of occurrence…).**

- **Correction factors are variable: They are likely to vary over time and place. *Correction factors should therefore be updated on a regular basis*. When applying correction factors estimated for one-time period to another one, it is necessary to check first that police registration methods have not changed from one time point to the other. Besides, police registration, but also the distribution of different types of crashes vary widely between countries. Hospital registration is also likely to be different accross countries (ICD version, AIS version, number of diagnoses, quality and completeness of hospital and police registration, etc.). Correction factors will consequently vary according to these differences. *It is therefore strongly recommended that countries do not directly apply correction factors estimated in other countries*.**

- **It is useful to *model* the effects of various variables (such as year, type of road user, age, gender…) on the ratios of police/hospital registrations as a first step. This allows the determination of the variables that significantly affect these ratios and consequently the correction factors.**

6 Using only hospital data

This chapter describes how to estimate serious injuries defined as MAIS ≥ 3 using hospital data alone.

6.1 DATA SOURCES

The main hospital data source in most European countries is the Hospital Discharge Register (HDR), which is basically an administrative dataset used for financial purposes. The HDR includes all hospitalisations for diseases and injuries (traffic and non-traffic) from all or some public or private hospitals of the country. HDR contains data on age, sex, dates of hospitalisation and discharge, and diagnoses. Recording and handling systems of the HDR differ by country so the data should be compared with caution (EUROSTAT, 2015). HDR is the most common database used; however, there are also countries which use health data from other registers.

HDRs use the International Statistical Classification of Diseases published by the World Health Organization (WHO) to codify the main diagnosis, or reason for the hospital admission. Currently there are two main versions: ICD-9-CM (International Classification of Diseases, ninth revision, clinical modification); ICD-10 (the International Statistical Classification of Diseases and Related Health Problems, tenth revision). The 11th Revision is expected by 2018.

ICD-9 is used to code causes of mortality found on death certificates until 1999. ICD-9-CM is a clinical modification of the World Health Organization's 9th Revision and was designed for the classification of morbidity and mortality information to be used for statistical purposes and for indexing hospital records by disease. ICD-9-CM is the official system of assigning codes to injuries and diseases diagnoses and procedures associated with hospital utilization. The ICD is periodically revised to incorporate changes in the medical field. The Tenth Revision (ICD-10) has been available since 1992, and differs from the previous one in several ways although the overall content is similar. European countries have implemented it progressively, and almost all the countries who responded the survey are already using ICD-10 coding.

6.2 ACCESS AND AVAILABILITY OF HOSPITAL DATA

HDR is the most common database used for health data in most European countries. However, it is not usually available for institutions responsible for data analysis of road traffic casualties (RTC). These organizations, such as ministries of transport or interior, do not have access to health care data, which is owned usually by the ministry of health. This data is highly protected by the privacy protection laws and person protection data because it includes very sensitive information such as individual health information. But on the other hand, if they are properly anonymized in a way in which it is not possible to identify a person, they are accessible just applying for these data for research or statistical purposes. Almost half of the countries that answered to the FERSI questionnaire, mentioned they expected data protection and corresponding restrictions regarding the use of hospital data.

In Spain, for instance, the institution responsible for road traffic injury data analysis is the National Traffic Authority (Dirección General de Tráfico, DGT) from the Ministry of Interior, which owns the police database. With the aim of estimating the number of serious injuries, DGT requests, through an application form, data about all hospitalizations due to road traffic from the Ministry of Health. The person/institution interested in obtaining the data should specify in this form which data are needed, for which objective, and how the results will be published or shared. As the HDR in Spain is a database created by a public administration (Minister of Health) each citizen could request access to the data contained in the Register, if it will be used for research or statistical purposes. There is a public website where this request can be made: http://www.msssi.gob.es/estadEstudios/estadisticas/estadisticas/estMinisterio/SolicitudCMBDdocs/Formulario_Peticion_Datos_CMBD.pdf. Although the data of the HDR are anonymized, the person/institution has to sign and accept a confidentiality agreement. In this way, through a public request, the National Traffic Authority of Spain obtains data from the HDR of the country in order to study RTC and their severity, without any specific agreement between the Ministry of Interior and the Ministry of Health.

In case hospital data is used for linkage with police data and/or other data sources, anonymization is often not possible. This is because identifying variables are needed for linking records from both data sources. Moreover, as a result of the linking of multiple data sources, it could be possible to identify persons. As a result, patient privacy can not be ensured during the linking process. In that case, additional measures should be taken to ensure privacy. Institutions that link police and hospital data should therefore make sure that they meet the necessary requirements for privacy protection as well. Alternatively, linking police and hospital data may be executed by an organisation which meets these requirements who will send the results in non-identifyable form or encrypted form to the organisations that are in need of these data. In many countries the national statistics agency is one of the organisations that meet all the criteria for privacy protection.

Another important issue is knowing which data is needed from the health care organizations when estimating the number of severe injured in road traffic collisions. A minimum dataset should include:

- Age
- Gender
- Date of hospitalization
- Date of discharge or Length of stay
- Type of admission (Urgent, Scheduled)
- Destination at discharge (Home, Hospital Referral, Deceased…)
- Injury/disease Diagnoses (ICD10 or ICD9 diagnoses as many as available)
- Codes of External causes (ICD10 or ICD9 codes)

6.2.1 Acces to hospital data through Eurostat

On the basis of a gentlemen's agreement established in the framework of the Eurostat working group on "Public Health Statistics", actually all EU countries submit HDR data to Eurostat (Figure 6-1). There are national “Focal Points for the Joint Data Collection on Non-Monetary Health Care Statistics” in all EU and EEA countries who are in charge of this joint Eurostat/OECD/WHO data provison and who might be contacted also for accessing the national HDR data (See Appendix F for a list of national HDR Focal Points).

In principle, the aggregated HDR data set that is transmitted to Eurostat could be used also for a MAIS-3 calculation (Table 6.1). In practice, however, for most countries the truncation of ICD-10 diagnoses at a 3-digit level (Table 6.2 and Table 6.3) and missing external cause information do not allow for this kind of analysis. Other countries provide their HDR data not in ICD format but in the format of the International Shortlist for Hospital Morbidity Tabulation, ISHMT (Table 6.2).[8]

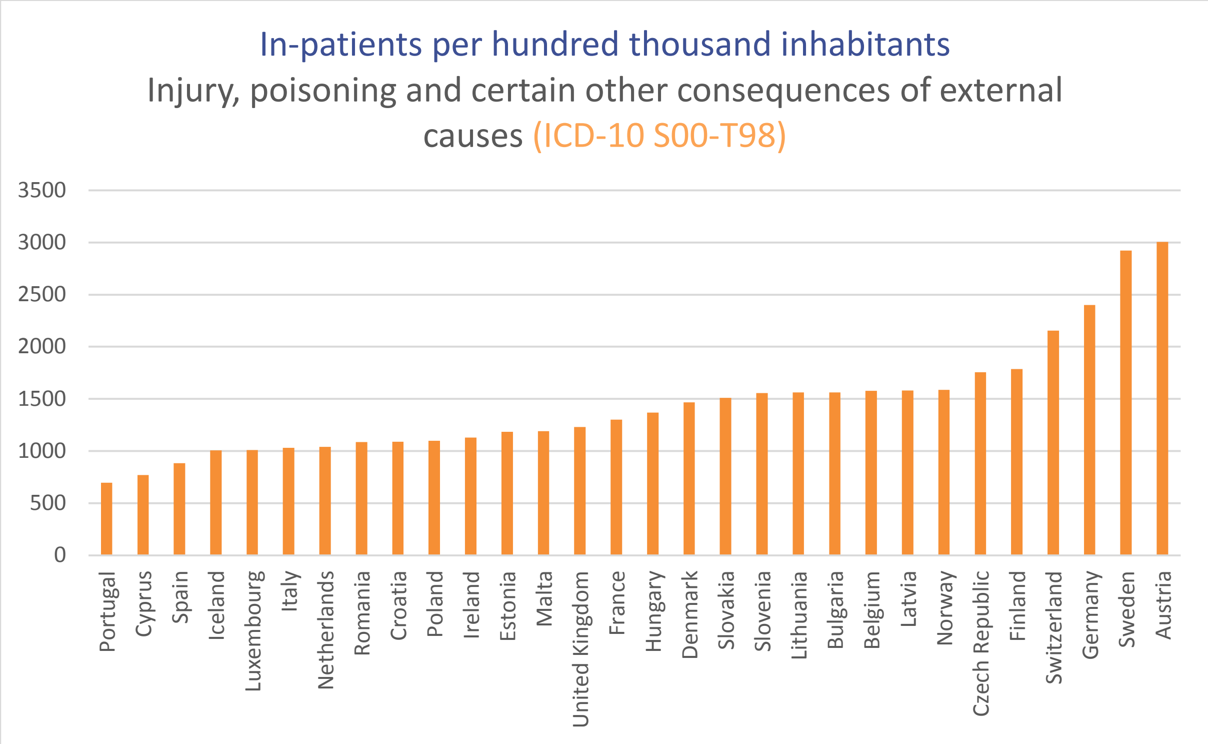

Figure 6-1 HDR data availability at the Eurostat level – ranking of in-patients with an ICD-10 injury diagnoses (S00-T98) 2013

As for the criteria for case selection that will be discussed in the next section, the Eurostat metadata for HDR data might be an interesting reference for a common understanding of the basic HDR concepts like hospital, hospital discharge, in-patient, day care patient or out-patient.[9]

Once defined and formally harmonized data will be available (to a certain degree at least) it would be important for the traffic safety sector to be able to participate in discussions about the specific implementation of measures for data collection in the EU public health statistics.[10] The aim would be to refine the HDR data provision in a way that enables AIS-assessment also on the basis of the aggregated HDR at Eurostat.

[8] http://ec.europa.eu/eurostat/web/health/health-care/data
[9] http://ec.europa.eu/eurostat/statistics-explained/index.php/Hospital_discharges_and_length_of_stay_statistics
[10] Regulation on Community statistics on public health and health and safety at work (EC) No 1338/2008

Table 6.1 Record layout of the HDR data set available at Eurostat

	Variable description	Type	Size in case of fixed field length
1. Country	Two-character country code (ISO 3166, www.iso.org). This field can be extended by adding a code for sub-national entities, thus allowing reporting at sub-national level6.	Character	25
2. Year	Year of discharge	Integer	4
3. Age	Code of age grouping	Integer	1
4. Gender	Code of gender	Integer	1
5. ICD version	Code of ICD version used to code diagnosis	Character	3
6. Diagnosis	Code of diagnosis or external cause (ICD-9 or ICD-10 code corresponding to above code of ICD version)	Character	5
7+3n. Discharges	Number of inpatient discharges (excluding day cases) with above diagnosis, by defined age groups	Integer	10
8+3n. Bed-days	Number of bed-days used for above diagnosis, by defined age groups	Integer	10
9+3n. Day cases	Number of day case discharges with above diagnosis, by defined age groups	Integer	10

Table 6.2 Code table for ICD Version used to code main diagnosis

Code	Classification System
94	ICD9 4 - Character list
103	ICD10 3 - Character list (most preferable)
104	ICD10 4 - Character list
HMT	Internationa Shortlist for Hospital Morbidity Tabulation (ISHMT)

Table 6.3 Classification system system used by countries for HDR data provision to Eurostat

Country	Classification system
Austria	shortlist
Belgium	ICD9
Bulgaria	shortlist
Croatia	ICD10 (3 digits)
Cyprus	ICD10 (3 digits)

Country	Classification system
Czech Republic	ICD10 (3 digits)
Denmark	ICD10 (3 digits)
Estonia	shortlist
Finland	ICD10 (3 digits)
France	shortlist
Germany	shortlist
Greece	No data
Hungary	shortlist
Ireland	shortlist
Italy	shortlist
Latvia	ICD10 (3 digits)
Liechtenstein	No data
Lithuania	ICD10 (3 digits)
Luxembourg	ICD10 (3 digits)
Malta	ICD10 (3 digits)
Netherlands	shortlist
Norway	ICD10 (3 digits)
Poland	ICD10 (3 digits)
Portugal	ICD9
Romania	ICD10 (3 digits)
Serbia	ICD10 (3 digits)
Slovakia	ICD10 (3 digits)
Slovenia	ICD10 (3 digits)
Spain	ICD9
Sweden	ICD10 (3 digits)
Switzerland	ICD10 (3 digits)
Turkey	No data for the two last data collection
United Kingdom	ICD10 (3 digits)

6.3 CRITERIA FOR CASE SELECTION / INCLUSION

In order to allow comparability across countries when identifying road traffic casualties some issues need to be considered. The influence and suitability of each will be described, and a final definition of road traffic injury with hospital data will be recommended. A study based on data from Spain and from the Netherlands describes these issues with more detail (See Appendix B).

6.3.1 General Criteria for case selection / inclusion

- First of all, it is necessary to determine whether **fatalities** from the in-patient database should be included or excluded. Police registers include road traffic fatalities up to 30 days after the collision. So in hospital databases it is important to assure that fatalities are not double counted (as injured and as fatality) with the police registers. Therefore, the general recommendation is that if a person is admitted to hospital but finally dies within 30 days after the admission he/she should be counted as a fatality (as in the police registers). But if the person dies after 30 days, he/she should be recorded as injured according to his/her severity, since they are not included in the fatalities statistics. Therefore, MAIS ≥ 3 casualties that die after 30 days should be included as a serious road injury.

- Secondly, it is also important to decide how to deal with admissions that are a second episode of an injury. These are known as **readmissions** and have been defined as one or more episodes due to the same reason for attendance in the same or in any other hospital. In order to avoid double counting the general recommendation is to exclude readmissions within a full calendar year. As it is not always possible to identify them, they are differently treated in the European countries. In some cases, as in Spain, it is only possible to identify readmissions within 30 days in the same hospital and to exclude them, but admissions within a full calendar year or from different hospitals due to the same reason from attendance are difficult to identify. In other cases, as in Netherlands, readmissions can be identified in the same hospital over a period of a full calendar year

- Hospital admissions can take place through emergency attendance or be **scheduled**. These scheduled admissions may be a second episode of a previous emergency injury or may not. Therefore, the way scheduled admissions are treated can also vary from one country to the other. The general recommendation is to avoid double counting. If readmissions are explicitly recorded and can be excluded from the database, it is not necessary to exclude scheduled admissions. If defined readmissions are not speicifcally recorded, then scheduled admissions they should be also excluded.

- Other criteria which should be standardized are **outpatients RTC** (day-care, non-hospitalized) and **short hospitalizations**. Their actual inclusion or not in the definition varies depending on the country; however, the general recommendation is to include them in the definition all traffic injury hospitalisations, even if they only generate short stays in the hospital.

6.3.2 ICD Codes Criteria for case selection / inclusion

Hospital Discharge Register (HDR) use the International Statistical Classification of Diseases published by the World Health Organization (WHO) to codify the main diagnosis, or reason for the hospital admission. Hospital data are coded with ICD-9 or ICD-10, and, based on those codes, road traffic injuries have to be identified. An effort to reach an agreement on the optimal definition of the ICD codes needed has been made.

- According to the **ICD9-CM** the definition of road traffic injuries includes **any traumatic injury** including codes from 800 to 959. These include fracture, dislocation, sprain, internal injury, open wound, injury to blood vessel, superficial injury, contusion, crushing, foreign body entering through body orifice, burns, and injury to nerves and spinal cord. Although it also includes late effects of injury and complications of physical trauma (905 to 909, 958 and 959) they automatically are excluded when obtaining severity.

- For those countries using **ICD10**codes for **traumatic injury these** include: S00-T88. According to ICD10, "A transport accident is any accident involving a device designed primarily for or being used at the time primarily for, conveying persons or goods from one place to another".

- In addition, there are codes to describe the **external cause of injury** (E-codes). Codes E810-819 ("Motor vehicle traffic accident") fulfil clear inclusion criteria, but it is not so clear whether E826 ("Pedal cycle accident") and codes E820-E825 should be excluded, as they would not fulfil police definition of "traffic accident", E827 "Animal-drawn vehicle accident", E828 "Accident involving an animal being ridden", E829 "Other road vehicle accident" and E988.5 "Injury by crashing of motor vehicle, undetermined whether accidentally or purposely inflicted". Finally, the general recommendation suggests including as E-codes: E810-E19, E826, E827, E829 and E988.5 and excluding E828.

- Frequently external causes are underreported. In Belgium, the registration of E-codes in hospitals has been compulsory since 2003. Yet, despite this obligation, they are not consistently recorded. However, registration improves year after year: in 2004 35% of hospitalized patients with a principal diagnosis within the range 800-959.9 had not received any E-code. Since 2008 this percentage has always been lower than 20% and in 2010 this figure was no more than 16%. This percentage covers all patients visiting a hospital because of an external cause. It is uncertain to what extent this overall percentage can be extrapolated to the whole subgroup of road victims (the Federal Public Service of Health – responsible for the maintenance of the hospital register data in Belgium - suggests this proportion could be lower for road victims). In Spain in 17% of records the E-code is unknown. It is therefore impossible to apply a correction factor adjusting for missing E-codes specifically among traffic victims.

- ICD10 distinguishes between "Traffic accident" (any vehicle accident on a public road) and "Non-traffic accident" (any vehicle accident occurring entirely somewhere other than on a public road), so it is possible to consider traffic injuries occurring on public roads, as has been proposed by international organizations, and to exclude non-traffic casualties. That information is explained in the external codes. General recommendations are to include codes V01-89 and/or weighting -correcting for non-public road- for non-traffic injury codes.

- E-codes from ICD9-CM do not allow identification of whether the collision occurred in a public road or not. The E-code 849 allows identification of this but may not be accurately collected. However, if the proportion of cases that occur away from a public road is known through any other data source, a weighting factor can be applied in order to avoid overestimation.

- Information about the code of external cause (E code) is frequently missing in many countries. That is the reason why some countries look for other variables to identify traffic injury cases. The **compensation payer company** is a variable that is considered in some countries, for example, in Spain which identifies 25.4% that were not identified in any other way (Appendix B). General recommendation suggests taking this issue into account and select cases when available.

6.3.3 Use of weighting factors to make data more comparable with other countries

Sometimes is not possible to have complete hospital data for a country. In that case **weighting factors** could be used to correct for data deviations in order to generate estimations that are better comparable to estimates from other countries.Table 6.4 shows weighting factors calculated for road traffic serious injured (MAIS ≥ 3) with the Spanish Hospital Discharge and with the Dutch Database from Hospital Discharge Register. For each 'deviation' from the ideal situation, we calculated the effect on the estimated number of serious traffic injuries. On the basis of these effects, weighting factors were derived. For example, in case it is not possible to exclude fatalities within 30 days, the number of MAIS ≥ 3 casualties would be overestimated by 5%, so a weighting factor of 0,95 should be applied. When these weighting factors are very close to 1, the in/exclusion criteria do not affect very much the estimated number of MAIS ≥ 3 casualties, therefore we decide not to consider it. This is for example the case regarding the inclusion of Ecodes E820-E825 and E929. Inclusion of these E-codes probably does nott affect the estimated number of MAIS ≥ 3 casualties much, at least this wasn't the case in Spain and the Netherlands. Inclusion of fatalities within 30 days has the largest effect on the estimated number of MAIS ≥ 3 casualties of the analysed factors and results in an overestimation of 5%.

This weighting factors could be used as an example for another country if no other hospital data are available. We recommend to only include weight factors that are 0.97 or smaller, as the other weight factors only have a very limited effect. Moreover, we should note that the weight factors are based on two countries only and therefore should be applied with caution. More detail about these weighting factors calculation methods are explained in Appendix B. Nontheless we need to have in mind that applying weighting factors make countries only a little bit more comparable. One of the biggest obstacles weakening the comparability between countries are missing external codes and it is not possible to calculate weighting factors for that because it is very country specific. So it we need to be cautious thinking that countries are comparable if only they apply the weighting factors mentioned here.

Table 6.4 Weighting factors among selection criteria for serious injured (MAIS ≥ 3) traffic hospital admissions in Spain and in the Netherlands. Spanish Hospital Discharge Register 2011 and Dutch Database from Hospital Discharge Register,1993-2013.

	Spain	the Netherlands	Average
Including deaths within 30 days	0.95	0.96	0,95
Including Readmissions	0.98	0.96	0,97
Including E929	0.99	1.00	1,00
Including E828	0.98	0.97	0,97
Including E820-825	0.99	0.98	0,99

In summary, Table 6.5 shows the criteria for selecting road traffic casualties from hospital data in a harmonized way.

Table 6.5 Summary of criteria for road traffic case selection from hospital data.

• If a person is admitted to hospital but finally dies within 30 days after the admission he/she should be accounted as a fatality. If the person dies after 30 days and has an injury severity MAIS ≥ 3, it should be counted as a serious injury • Exclude readmissions to avoid duplicates within a full calendar year (or within a month if it is not possible to identify through the full year) and exclude scheduled admissions when they are a second episode of a previous emergency injury but they are not defined as readmissions. • Include all traffic injury hospitalisations even those with short length of stay. • Include all cases with any injury diagnosis (ICD9CM: 800-999; ICD10: S00-T88) • Include external causes for road traffic injuries: (ICD9CM: E810-E819, E826, E827, E829, E988.5; ICD10: V01-89 for those codes for traffic injuries and/or weighting -correcting for non-public road- for non-traffic injury codes) • To compensate for missing E-codes, additional sources for the identification of traffic injuries as accident compensation payer could be used when available. • If it is not possible to meet all in- and exclusion criteria, weighting factors could be used to correct data deviations for specific criteria to make estimations between EU countries more comparable to each other.

6.4 HOW TO DERIVE MAIS ≥ 3

To determine the number of MAIS ≥ 3 casualties, MAIS ≥ 3 casualties have to be selected from the hospital data. MAIS ≥ 3 refers to the Maximum Abbreviated Injury Scale of 3 or more and reflects the highest AIS-level of all injuries a casualty obtained.

As it has been mentioned above AIS levels of the injuries of a casualty can be determined in several ways. AIS coding can be direct or can be derived from other injury coding systems, like ICD. Moreover, various conversion tools are available for recoding ICD codes into AIS codes, e.g. ICDmap90, ICDpic, European Center for Injury Prevention Algorithm (ECIP) and AAAM. Some of these tools recode the ICD codes into the latest AIS© 2005/update 2008 codes, but other, older tools transform ICD data into AIS codes that are based on previous versions of the AIS coding (AIS2005, AIS1998 or AIS1990). Also ICD has different versions and is subject to regular updates. All these elements (AIS version, ICD version and conversion tool) influence the AIS levels of the injuries and therefore the resulting number of MAIS ≥ 3 casualties.

In addition, for some countries the MAIS score is based on a limited number of injuries, whereas in other countries the MAIS is based on many more or even all injuries of an injured person. In case only a limited number of injuries are taken into account, not all MAIS ≥ 3 casualties might be selected and the number of serious traffic injuries might be underestimated. Finally, in some countries (e.g. Austria, Slovenia) the ICD10 injury code is truncated to four digits before it is recoded into AIS. This might lead to a different AIS level and therefore might influence the number of MAIS3 casualties.

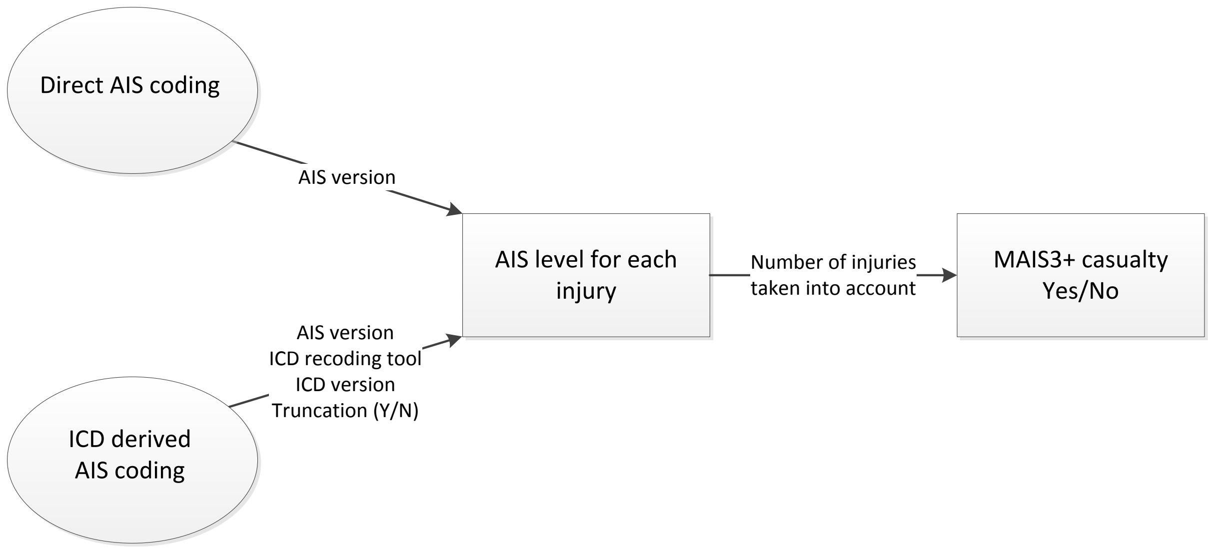

Figure 6-2 Issues related to deriving MAIS ≥ 3 that may influence the number of MAIS ≥ 3 casualties

Figure 6-2 summarizes the issues related to deriving MAIS ≥ 3. Ideally, MAIS ≥ 3 casualties are selected on the basis of directly coded AIS levels of all injuries of a casualty, based on the latest AIS coding instructions. However, in practice this is often not possible. By applying various ICD conversion tools, in combination with various versions of the coding instructions, we investigated how the estimated number of MAIS ≥ 3 casualties vary depending on the method that is applied. In a similar way, we investigated the effect of including a limited number of injuries and of using truncated injury codes. This section summarizes the results of these analyses. The analyses and results are described in more detail in, Appendix B Study 2

6.4.1 Direct coding versus various conversion tools

We searched for literature that compared (M)AIS levels resulting from direct coding to ICD-derived (M)AIS levels using recoding tools that are applied in Europe. We performed a search in the databases SCOPUS, ISI Web of Science and Pubmed. Only a very limited amount of literature appeared to be available. Both Di Bartolomeo et al (2010) and Greene et al (2015) compared severity levels generated by ICDpic with severity levels based on direct AIS coding. De Bartolomeo et al only compared ISS (Injury Severity Score) scores and conclude on the basis of 289 cases that agreement between scores based on ICDpic and scores based on direct coded AIS scores is poor. The main cause for this poor agreement is incomplete ICD9-CM coding. The study of Greene et al. (2015) had a much larger sample of over 40 000 patients and compared both AIS levels and ISS for ICDpic and direct AIS coding. They found that the performance of the ICDpic tool differs by body region; injury severity is reasonably well classified for thoracic and abdominal injuries, moderately well for head and neck injuries, but only fair for face and extremity injuries. However, ICDpic performs quite well in classifying AIS ≥ 3 injuries for each body region. Greene et al conclude that ICDpic may be a preferred tool in determining injury severity for large trauma datasets, but caution needs to be taken when examining smaller trauma sets. Therefore, based on this literature review, we conclude that ICDpic seems to be a reliable tool for our purpose.

We were able to do some analyses ourselves as well. First of all, in the German GIDAS database (direct coded AIS levels), during several years all 16,695 casualties were coded in AIS1998 as well as AIS2008. These data were used to examine the effect of different AIS versions. The results of this analysis are shown in line 1 of Table 6.6. Application of the AIS1998 version results in roughly 12% higher number of MAIS ≥ 3 casualties then the AIS2008 version. This is due to a more detailed specification of injuries in AIS2008 and improvements in trauma and medical care. As AIS2008 is considered to be the gold standard, a weight factor of 0,89 should be applied when AIS1990/1998 is used.

Second, some of the data from the German GIDAS database could be matched to patient information of the Medical School Hannover. For 209 trauma casualties, ICD10GM injury codes were available and within SafetyCube these injuries were recoded to AIS using various ICD10 recoding tools. This enables us to compare direct coding with ICD10-derived coding. Line 2 of Table 6.6 shows the results of this analysis. The ECIP tool provides a 13% higher number of MAIS ≥ 3 casualties compared to direct coding, but this difference can be fully explained by a difference in AIS version; ECIP uses AIS1998 whereas for the direct coding AIS2008 is used. Please note however that the sample size is very small (209 cases) and concern trauma cases with many and relatively serious injuries. Moreover, injuries are coded in the German version of ICD10 (ICD10GM). Therefore, although the number of MAIS ≥ 3 casualties estimated by ECIP is exactly equal to the number that results from direct AIS coding, it cannot be sure that ECIP results in a reliable estimation of the number of MAIS ≥ 3 casualties. We recommend to repeat the exercise with a larger sample and an ICD version that is used within the recoding tools. The AAAM10 and AGU tools underestimate the number of MAIS ≥ 3 casualties by respectively 20% and 14%.

Third, data from the Netherlands, Spain and Belgium have been used to compare the results for different recoding tools in combination with different AIS versions and different ICD versions (lines 3, 4, 5, and 6 in Table 6.6). Since it was not possible to compare ICD9 derived AIS with direct coding, it was not possible to determine which tool provides the best result. When taking into account a 12% difference between AIS1990/1998 and AIS2005/2008, ICDpic appears to result in the highest number of MAIS ≥ 3 casualties in all three countries. Moreover, the difference between the ICD9cm recoding tools is at most 7%. Regarding the ICD10 tools, also these analyses show that the AAAM10 tool results in a much lower number of MAIS ≥ 3 casualties than ECIP. This difference can only be partly explained by the difference in AIS version. As differences between tools that use ICD9 and tools that use ICD10 can only be investigated by converting ICD9 to ICD10 and vice versa and we don't know the effect of these conversions, it was not possible to make a good comparison between tools that use ICD9 and tools that use ICD10 to recode to AIS.

We conclude from our analyses that the AAAM10 tool appears to result in serious underreporting of MAIS ≥ 3 casualties. Looking into the AAAM10 conversion table in more detail shows that the conversion table actually uses ICD10cm and possibly the most recent version that is used in the USA. As most European countries use an older version of ICD10 without clinical modification, this does not fit with European practice. We recommend adapting the conversion tables for this tool to better fit to our needs, instead of applying a large correction factor.

Table 6.6 Estimated numbers of MAIS ≥ 3 casualties when applying different AIS versions and different conversion tools.

				ICD9-CM				ICD10		
N	Country	AIS 1998	AIS 2008	ICDmap90	DGT	ICDpic	AAAM9	ECIP	AAAM10	agu
				1990	1998	2005	2008	1998	2008	2008
1	GE	1 019 (112%)	909 100%							
2	GE		103 (100%)					116 (113%)	82 (80%)	89 (86%)
3	NL (1993-2013)			107738	109605	103747	102900			
4	NL (2012-2014)							14 384	8 391	
5	Belgium					19 143	18 381			
6	Spain					8 274	7 656			

6.4.2 Consequence of using a limited number of injuries per casualty

In some cases, only a limited number of injuries were coded or available for analysis. The consequence of this limitation was investigated by running the conversion tools taking into account 1, 2, 3 and all injuries and comparing the results. This analysis is done using Belgium, Spanish and Dutch data.

Table 6.7 shows the results.

On average, taking into account only 1 injury, results in an estimated number of MAIS ≥ 3 casualties which is 78% of the number that is estimated on the basis of all injuries. When 2 injuries are taken into account, 90% of the serious traffic injuries are identified and when 3 injuries are taken into account, on average 95% of the number of MAIS ≥ 3 casualties are identified. This results in the following weighting factors:

- Where only 1 injury is available per casualty, the estimated number of MAIS ≥ 3 casualties should be multiplied by 1.28
- Where only 2 injuries are available per casualty, the estimated number of MAIS ≥ 3 casualties should be multiplied by 1.11
- Where only 3 injuries are available per casualty, the estimated number of MAIS ≥ 3 casualties should be multiplied by 1.05
- Where 4 or more injuries are available, no correction is required.

Table 6.7 Estimated numbers of serious traffic injuries when taking 1, 2, 3, or all injuries into account and applying different conversion tools (upper half) and proportion of MAIS ≥ 3 casualties that is included when taking account 1, 2 or 3 injuries (all injuries is 100%). Consequences of limiting the number of injuries

	BE	NL	NL (ICD10 converted to ICD9cm)	ES	SUM	Average ICD9cm
	ICD9cm ICDpic	ICD9cm ICDmap90	ICD9cm ICDmap90	ICD9cm ICDpic	ICD9	(BE+NL+ES)/3
All	19,142	107,735	15,078	8,274	135,151	
3	17,900	105,728	14,766	7,753	131,381	
2	16,654	102,392	14,258	7,315	126,361	
1	13,678	91,159	12,489	6,357	111,194	
All	100%	100%	100%	100%	100%	
3	94%	98%	98%	94%	97%	95%
2	87%	95%	95%	88%	93%	90%
1	71%	85%	83%	77%	82%	78%

6.4.3 Consequence of truncated injury codes

Due to hospital practice or privacy regulations, some countries use 4-digits injury codes instead of 5-digits codes. ICD conversion tools differ on how they deal with these so called truncated codes. Some tools simply say that the injury is not detailed enough to assess the severity and return MAIS=0 or MAIS=9. Other tools, like AAAM, also provide a severity for the aggregated level, by taking into account the severities of the injuries underneath.

Table 6.8 shows the effect on the number of MAIS ≥ 3 casualties in case of truncation for various conversion tools. Most conversion tools, except from ICDpic and AAAM10 appear to be quite capable of dealing with truncated codes. ICDpic shows a large decrease in the number of MAIS ≥ 3 casualties when injuries are truncated. Therefore, we recommend not to use ICDpic for truncated codes. The AAAM10 tool shows a considerable increase in the number of MAIS ≥ 3 casualties in cases of truncated injury codes. We recommend repeating this analysis when the conversion tables are adapted for the European needs to have a closer look at how the tool deals with truncated codes.

Table 6.8 Estimated number of MAIS ≥ 3 casualties when using truncated codes compared to using full codes, % of underreporting when using truncated codes and weighted factors to correct for truncated codes. Overview of the effect of truncation on the estimated number of MAIS ≥ 3 casualties for different conversion tools

		Using full codes	Using truncated codes	%	Factor
ES	ICDpic	8,274	2,108	25%	3.9
BE	ICDpic	19,143	3,949	21%	4.8
NL	ICDmap90	107,735	101,549	94%	1.06
	DGT	115,380	109,039	95%	1,06
	ICDpic	109,373	17,454	16%	6.3
	AAAM9	108,509	97,660	90%	1.11
NL	ECIP	14,519	14,071	97%	1.03
	AAAM10	8,480	12,123	143%	0.70

Table 6.9 Summary about deriving MAIS ≥ 3

- **|n order to make data from different countries more comparable to each other, the number of MAIS ≥ 3 casualties should be multiplied by a factor 0.89 when injuries are coded in AIS1990 or AIS1998 instead of AIS2005 or AIS2008**
- **The ECIP recoding tool seems to result in reliable numbers of serious traffic injuries. It should be noted however, that this conclusion is based on a small sample.**
- **The difference in the estimated number of MAIS ≥ 3 casualties between the ICD9cm recoding tools is at most 7%. It was not possible to investigate the difference between ICD9 tools and direct coding.**
- **It is recommended to adapt the conversion tables for the AAAM10 tool to better fit European needs. In the current state the AAAM10 tool results in a clear underestimation of the number of MAIS ≥ 3 casualties. Moreover, truncation results in an increase in the number of MAIS ≥ 3 casualties**
- **The following weighting factors could be applied in cases where less than 4 injuries are taken into account for the determination of the number of MAIS ≥ 3 casualties**
    - **1.28 in cases of 1 injury**
    - **1.11 in cases of 2 injuries**
    - **1.05 in cases of 3 injuries**
- **Do not use the ICDpic tool in combination with truncated codes**
- **The following weighting factors could be used to correct for truncated codes:**
    - **1.06 in case of ICDmap90 or DGT**
    - **1.03 in case of ECIP**
    - **1.11 in case of AAAM9**

6.1 SUMMARY

This Chapter presents guidelines for determining the number of serious traffic injuries using hospital data. An important issue related to the use of hospital data is the access to hospital data by institutions that are responsible for the estimation of the number of serious injuries. If the data are properly anonymized, they should be accessible for research or statistical purposes. Alternatively, institutions that are responsible for the estimation of serious injuries should make sure they meet the necessary requirements for privacy protection.

We recommend to apply the following in/exclusion criteria:

- Exclude fatalities within 30 days, include MAIS ≥ 3 casualties that die after 30 days. Based on experiences from Spain and the Netherlands, it was estimated that inclusion of fatalities within 30 days results in an overestimation of 5% of the number of serious traffic injuries. So, in order to make data more comparable across Europe, a weighting factor of 0.95 could be applied in case fatalities within 30 days cannot be excluded
- Exclude readmissions if possible. Based on experiences from Spain and the Netherlands, it was estimated that inclusion of readmissions results in an overestimation of 3% of the number of serious traffic injuries. So, in order to make data more comparable across Europe, a weighting factor of 0.97 could be applied in case readmissions cannot be excluded
- Include all traffic injury hospitalisations even those with short length of stay.
- Include all cases with any injury diagnosis (ICD9CM: 800-999; ICD10: S00-T88)
- Include external causes for road traffic injuries: (ICD9CM: E810-E819, E826, E827, E829, E988.5; ICD10: V01-89 for those codes for traffic injuries and/or weighting -correcting for non-public road- for non-traffic injury codes)
- To take care of missing E-codes, additional sources for the identification of traffic injuries as accident compensation payer could be used when available.

Various issues related to deriving MAIS ≥ 3 were also analysed and the following conclusions were made:

- Application of AIS1990/AIS1998 results in an overestimation of the number of MAIS ≥ 3 casualties by 12%, so in order to make data from different countries more comparable, the number of MAIS ≥ 3 casualties should be multiplied by a factor 0.89 when injuries are coded in AIS1990 or AIS1998 instead of AIS2005 or AIS2008
- The ECIP recoding tool seems to result in reliable numbers of serious traffic injuries. It should be noted however, that this conclusion is based on a small sample.
- The difference in the estimated number of MAIS ≥ 3 casualties between the ICD9cm recoding tools is at most 7%. It was not possible to investigate the difference between ICD9 tools and direct coding.
- The AAAM10 conversion table appears to result in serious underreporting in MAIS ≥ 3 casualties and does not seem to fit to European practice. It is recommended to adapt the conversion tables for the AAAM10 tool to better fit European needs. In the current state the AAAM10 tool results in a clear underestimation of the number of MAIS ≥ 3 casualties.
- The following weighting factors could be applied in cases where less than 4 injuries are taken into account for the determination of the number of MAIS ≥ 3 casualties
    - 1.28 in cases of 1 injury
    - 1.11 in cases of 2 injuries
    - 1.05 in cases of 3 injuries
- It is recommended to not use the ICDpic tool in combination with truncated codes. Regarding other recoding tools, the following weighting factors could be applied in case of truncated codes:
    - 1.06 in case of ICDmap90 or DGT
    - 1.03 in case of ECIP
    - 1.11 in case of AAAM9

7 Using linked/matched police and hospital data

This chapter describes how to estimate serious injuries defined as MAIS ≥ 3 using hospital and police linked data.

A third method for estimating the actual number of serious traffic injuries (MAIS ≥ 3) is by linking police data with hospital data. By this linking procedure, more information can be collected to correct for over- or underreporting in both the police and hospital data. For example, police records will probably miss out some injured road users of crashes. In hospitals, a certain proportion of injured people do not get any external cause (or sometimes a wrong one) and linking with police data enables to estimate their frequency.

7.1 METHODS FOR LINKING RECORDS

Linking data can only be based on variables that are included in both data sets. The most ideal variable would be a unique personal identification number. This would provide the greatest guarantee that the established link is accurate. However, this information is most likely not available for privacy reasons (Belgium recently succeeded in using a unique identification number to link two databases, i.e. hospital data and health insurance data and Swedish Traffic Accident Data Acquisition (STRADA) uses a unique ID for each casualty but still only matches about 80% of cases).

Alternatively, a set of other factors can be used to identify commonalities between police and hospital records. Such variables include gender, date of birth, date and time of the crash, location of the crash, severity of the crash (fatal vs non-fatal) and mode of transport. The greater the count of matching variables between a police and hospital case, the higher the probability that these records are for the same crash victim and should be linked.

If perfect linkage between the two sources is not possible or cannot be assumed (e.g. because of privacy issues or due to differences in variables and values) a distance based or a probability based linking method can be used as an alternative linkage method. Both alternative methods take into account missing data, coding differences and coding errors. More details on linking methods are given in the IRTAD report (OECD/ITF, 2011).

It is difficult to estimate the reliability of the outcomes if neither the police data nor the hospital data are complete. When using a probability based linkage method, the uncertainty of the data will be reflected in the outcomes. It is therefore always important to obtain as much information possible on the reliability and usability of the linked data. A selection of methods for estimating the reliability is presented below:

- By looking at the trends over time of subgroups and comparing them with the development of similar subgroups in other data sources, an indication of the reliability could be provided.

- A record linkage based on a test database including personal identification numbers can be performed to estimate the best set of linking variables. By comparing these outcomes with those of the method that is used on the actual dataset (for which no personal identification numbers are available), the optimal linkage technique can be determined.

- By replacing the year value of one dataset by the year of the other dataset one can obtain an idea of the distinctive character of the method. The number of links found is related to the discriminative power of the record linkage and/or data. Ideally, no record should be linked when the year value is replaced by another value.

- The same principle could be applied by condensing datasets of more years into one year and linking within them. Subsequently selecting and examining a (simple) random sample of linked and not-linked records would then allow assessing the precision and recall (using the manual review as a true record linkage). With the manual review results, one could compute evaluation measures like precision and recall with the clerical review as true record linkage. This is done with True Positives, False Positives, False Negatives, True Negatives and derived indicators such as Sensitivity, Specificity, Positive Predictive Value and Match Rate (see Appendix D).

7.2 OUTCOMES OF LINKAGE

When police data and hospital data use the same definition for a road crash casualty, it is possible to cross tabulate the two data sources. When the definition is "injured in a road crash whatever the injury severity", it results in the following cross table:

Table 7.1 Numbers of traffic casualties for any injury severity according to their recording in hospital data or police data.

		Hospital data	
		Yes	**No**
Police data	**Yes**	Common data	Unlinked police data
	No	Unlinked hospital data	Unobserved / missed

However, the definition often differs in the two data sources. A common case for many countries is that outpatients are not included in the hospital data. Police data often contains a variable hospitalised yes/no, but this variable is often not reliable recorded by the police, and should hence not be used to restrict the police data. Instead a number of injured persons recorded as non-hospitalized in the police data do match hospital discharges records.

As the objective is to estimate the number of MAIS ≥ 3, considering only hospital discharge data may lead to a small underestimation of the number of MAIS ≥ 3 (about 5% according to Rhône Trauma Registry in France). It is considered in the following that this underestimation can be neglected, or corrected afterwards.

The hospital data being now restricted to hospitalized casualties; we can first split them into recorded or not recorded in the Hospital Discharge Register (HDR) (Table 7.2).

The column named "Hospitalized and not in HDR" at the right end (in orange) in Table 7.2 can be excluded because the number of such casualties is believed to be very small.

Secondly the hospitalized and recorded in HDR can be split into MAIS ≥ 3 and MAIS2- (obtained from ICD conversion). The column "MAIS2-"(in grey) can be excluded because the aim is to estimate

MAIS ≥ 3. However, this may lead to possible issues when the MAIS level is not correctly estimated from ICD, these are discussed in Chapter 6. The main consequence of ignoring the MAIS2- column in the table is that the four remaining cells are restricted to MAIS ≥ 3, while no information is available about the MAIS level in the police data.

Thirdly the MAIS ≥ 3 column is split according to whether the "external cause" recorded indicates a road crash, another cause, or is simply missing.

Table 7.2 Distribution of hospitalized casualties depending on their recording in HDR, their severity (MAIS level from ICD) and indication of external cause, and according to their recording by police or not

	Hospitalized and in HDR			Hospitalized and not in HDR
	MAIS ≥ 3 (from ICD)		MAIS2- (from ICD)	
	External cause: Traffic casualty	Other or missing external cause		
in police data				
not in police data				

Table 7.3 shows the resulting table along with the meaning of the numbers calculated in the different cells.

Table 7.3 Distribution of MAIS ≥ 3 hospitalized casualties recorded in HDR depending on indication of external cause and according to their recording by police or not

	Hospitalized and in HDR MAIS ≥ 3 (from ICD)		
	External cause: Traffic casualty	Other or missing external cause	Total
in police data	Common linked data (1)	Common linked data (2)	
not in police data	Unlinked hospital data	Unidentified unlinked hospital data	
Total			Estimate of actual number of hospitalized MAIS ≥ 3

Linking hospital data with police data allows us to identify casualties as road casualties in the "Common linked data (2)" cell where external cause is inaccurate or missing.

The "Unidentified unlinked hospital casualties" are those missed by police and present in HDR but unidentified as road casualties because of inaccurate or missing external cause coding. Their number can be evaluated with capture-recapture method.

7.3 ESTIMATING THE UNOBSERVED SUBSET BY CAPTURE-RECAPTURE APPROACH

The capture recapture method is based on the availability of at least two registration sources of subjects of interest (e.g. list A and list B). The method is presented for two lists, but can be expanded to three or more lists. It can be displayed in the following way:

Table 7.4 Frequency distribution according to being present or absent in the two registrations

		List B		
		B	$\overline{B}$	
List A	*A*	n_{AB}	$n_{A\overline{B}}$	n_A
	$\overline{A}$	$n_{\overline{A}B}$	$n_{\overline{A}\overline{B}}$	
		n_B		n

Here, if one assumes that the probability of being registered in list A is independent of the probability of being registered in list B, this translates[11] into: $n_A/n = n_{AB}/n_B$. From this the intuitive Petersen estimate: $\hat{n} = \frac{n_A \times n_B}{n_{AB}}$ is obtained. It also happens to be the maximum likelihood estimator (MLE) [12]. It is the first "simple" estimator; it applies to the case where there are only 2 registration sources (also called the "2-list method"), and a simple pocket calculator is enough to calculate it.

The $\hat{n}$ is the estimated sum of the four cell frequencies, including the unobserved one.
This is applied to the Dutch data below; the obtained frequencies are those of the green cells.

Table 7.5 Distribution of hospitalized casualties depending on they are or not recorded in Hospital discharge register (HDR), their severity ((MAIS level from ICD) and according to they are recorded by police or not.
Example from Dutch data

	Hospitalized and in HDR MAIS ≥ 3 (from ICD)		
	External cause: Traffic casualty	Other or missing external cause	Total
in police data	1752	90	1842
not in police data	5417	278	5695
Total	7169		7537

[11] In probability theory, independence of occurrence of two events A and B is written P(A)=P(A/B), where P(A)= probability of occurrence of event A. Besides, by definition : P(A/B)= P(A and B) / P(B), so that we get : P(A)= P(A and B)/P(B). A probability can be estimated by the corresponding observed proportion, so that P(A) is estimated by n_A/n and P(A and B) /P(B) is estimated by $(n_{AB}/n)) / (n_B/n)$ which simplifies into n_{AB}/n_B. We hence get $n_A/n = n_{AB}/n_B$

[12] The maximum likelihood estimator is only asymptotically unbiased (i.e. unbiased for large samples size). Another estimator has hence been developed : the Nearly Unbiased Estimator (Wittes, 1972):

$$\hat{n} = \frac{(n_A + 1) \times (n_B + 1)}{(n_{AB} + 1)} - 1$$

Applying this linkage method to this example adds 5% of MAIS ≥ 3 to the hospitalized MAIS ≥ 3 observed in HDR. This small increase is due to the low proportion of missing external causes for Dutch data. If a country has a larger percentage of missing values for external causes, it may lead to a more substancial increase in the total estimated number.

The method can be elaborated, for instance by including some stratification (see further on, under the condition of homogeneity of capture). Also, explicit modelling has been developed to take more complex cases into account.

The capture-recapture approach is based on four key assumptions, and also on two implicit ones. The four key assumptions are (Hook and Regal, 1995; International Working Group for Disease Monitoring and Forecasting, 1995):

1) No entry or loss between the registrations (close population)
2) Perfect identification of subjects common to both registrations
3) Independence of recording between the registrations
4) Homogeneity of capture by a given registration

The two implicit assumptions are (Gallay et al., 2002):

5) Same geographical area and same time period
6) Perfect identification of the subjects of interest

We focus on three of them (nr 6, 4 and 3), a more complete discussion can be found in the IRTAD report (OECD/ITF, 2011).

- <u>Assumption n°6: perfect identification of the subjects of interest</u>

The criteria for defining a subject of interest must be very precise, and should be the same for the two (or more) registrations. This is the case for the first example shown above (Table 7.5) and for the French experienc (see study 4 in Appendix D).

When the definition of the subject of interest in one source is included in the definition of the other source, the most restricted definition hence applies. For the most frequent case described above (Table 7.5), the HDR definition is "hospitalized" which is included in the police definition (Injured whatever the severity). The outcome is then restricted to hospitalized.
We further restrict the HDR data of hospitalised to MAIS ≥ 3. This restriction being "included " in the definition of the police data, this leads to a restriction of the police data to MAIS ≥ 3.

- Assumption n°3: There should be independence between the registrations.

The subjects' probability of being registered in one source should be independent of the probability of being registered by the other source. This is the basic underlying assumption for establishing the Petersen estimator (as previously mentioned).
Coming back to the practical case shown above, the condition of independence means that the probability of a causalty having a correct or missing external cause in the HDR is independent of being registered or not by the police.

If there is a positive dependence, the obtained estimate of the number of road traffic hospitalized MAIS ≥ 3 has been shown (International Working Group for Disease Monitoring and forecasting, 1995) to be a lower bound of the real number.

- <u>Assumption n°4: There should be homogeneity of capture by a given source/registration.</u>

This means that all subjects of interest should have the same probability of being registered by a given source.

This is usually not the case. Many characteristics influence the reporting probability: the number of vehicles involved in the crash, the road user type (Derriks and Mak, 2007; Elvik and Mysen, 2007). Indeed, multi-vehicle crashes are more likely to be reported than single-vehicle crashes; injured cyclists are less likely to be reported than injured car occupants (all other things being equal).

In such cases, the homogeneity of capture is only valid within sub-groups (ex: within cyclist, within car occupants, etc.). It is however possible to account for this. The first way to do it is to stratify on these sub-groups, i.e. to stratify on the variable which is associated with the probability of registration, and which defines the sub-groups. More precisely, one should estimate the number of subjects of interest in each stratum, and then one should sum up the estimates obtained over the strata to get the total number of subjects of interest. The Netherland experience gives a good example of this stratification process (see study 4 in Appendix D).

This stratification approach can however in practice only deal with at most 2 or 3 variables associated with probability of registration. The strata are defined by the combination of the 2 or 3 variables (and hence the cell frequencies get smaller and smaller with the number of stratification variables, up to a point where the estimation would not be valid).

A better way to deal with heterogeneity of capture is in fact to use an explicit modelling and to include as covariates the variables that influence registration probability. The number of covariates one can take into account is hence higher. The French experience is an illustration of this kind of modelling (see study 4 in Appendix D).

7.4 SUMMARY

Table 7.6 Summary about record linkages

- **All available information should be used (Police+Hospital+Other sources)**
- **Linking data can only be based on variables that are included in both (all) data sets. The most ideal variable is a unique personal identification number (deterministic linkage), but this information is rarely available for privacy reasons**
- **In the absence of a unique identifier, probabilistic or distance based linkage is recommended. Commonly used linking variables are date and time of the crash (and/or date and time of hospital admittance), location of the crash, gender and date of birth of the casualty, mode of transport, etc.**
- **For most countries, MAIS ≥ 3 can only be assessed from hospital data. MAIS ≥ 3 casualties are mostly hospitalized and well reported in hospital data, but external causes derived from ICD are often missing or misspecified.**
- **Once the linkage is completed, the number of traffic casualties recorded in hospital data but not identified as such can be estimated by linking these data with police data and using capture-recapture method.**
- **The capture-recapture approach is based on six conditions, among them the three most important to keep in mind:**
    - **The definition of the road casualty in the two data sources should be the same or included into one another**
    - **Independence between the registrations: when this hypothesis is weak, estimation is biased downwards in case of positive dependence, upwards otherwise.**
    - **Homogeneity of capture by a given registration: homogeneity is usually only valid within subgroups (e.g. mode of transport). These subgroups should hence be taken into account by stratification or modelling methods.**
- **The estimate of Serious Injuries (MAIS ≥ 3) based on a linking between Police and Hospital files and complemented with a Capture Recapture estimate for missing/ miscoded data gives the best indicator for the true number of serious injuries.**

8 Other methods to estimate serious road traffic injuries

As a result, from the survey, we noticed that some countries do not use one of the three methods suggested by the High Level Group. In this section a brief description is provided of the method used in Germany

In Germany the number of Serious Road Traffic Casualties MAIS ≥ 3 is determined by two different methodological approaches. The first approach is based on data from the German In-Depth Accident Study (GIDAS). The second approach is based on hospital data from the German TraumaRegister DGU® (TR-DGU).

GIDAS data were used in order to learn which types of accident scenarios show a rather high (or low) probability for MAIS ≥ 3 injuries for a casualty, using the *decision tree* method. This method separates the dataset into smaller subsets with high or low number of MAIS ≥ 3 compared to the total number of hospitalized casualties. For each of the 35 subsets found –defined by a specific combination of 10 variables[13]– a fraction of the hospitalized casualties is determined that are seriously injured, or "MAIS ≥ 3".

Applying these fractions on the number of hospitalized casualties in the same subset definition from police data, allows to determine the number of MAIS ≥ 3 casualties – assuming that there is a similar reporting quality/completeness in GIDAS and Police data.

The GIDAS dataset (2011-2013) being used to extrapolate the number of German MAIS ≥ 3 in 2014 contains detailed accident and injury information of 1733 hospitalized persons, of which 348 MAIS ≥ 3 (20.1%).

The number of seriously injured road accident casualties (MAIS ≥ 3) in 2014 is estimated to be 14,645. These are 21.6 % of all 67,732 hospitalized persons. So the net result is a little higher than to the original 20.1%. This number is the sum of the subgroups that could be identified and also gives an accurate estimate of the number of MAIS ≥ 3 casualties in each of these groups. Whereas the number of passenger car fatalities makes about 50% of all road traffic fatalities, passenger car users only account for about 35% of seriously injured road casualties. PTW and cyclists cover about 50% of seriously injured road traffic casualties.

The second approach, used as a plausibility check on the GIDAS based estimate, uses data from Intensive Care departments of Trauma centers. Taking into account severe injuries (ISS16+) and several factors and assumptions (the number of cases MAIS ≥ 3 is 2.2 times bigger than the group of

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[13] mode of traffic participation, age group of casualty, gender of casualty, kind of accident, type of accident, time of day, location of accident, number of road users involved, weekend accident, opponent.
Each variable has been disaggregated down to binary distributions before entering the decision tree method. This means that e.g. "number of road users involved" is not a multinominal distribution (category 1=one, 2=two or 3=more) but consists of 3 binary distributions: Category1 Yes/No, Category2 Yes/No and Category3 Yes/No.

ISS16+, 51.9% of the patients is from a road traffic accident, 10% underreporting) this approach results in a 15% higher number. Given the uncertaincies in assumptions and the factors applied, this roughly confirms the number of MAIS ≥ 3 as determined by the GIDAS decision tree.

Actually, the German approach seems to be a special case of applying correction to police data. However, the correction is done in a very specific and sophisticated way. Like other cases of applying correction to police data, it is possible to apply the method to derive correction factors also in other countries, but transfer of the injury severity distribution in the subgroups of the decision tree may be difficult, as across the borders the completeness of injury reporting by the police and judgement of hospitalization is likely to be different.

9 Estimates of road traffic serious injuries (MAIS ≥ 3) using different methods

This chapter describes estimations of serious injuries in different countries. It compares estimates of road traffic serious injuries defined as MAIS ≥ 3 obtained from the same dataset with different estimation methods using data from the Netherlands and Austria.

9.1 COMPARISONS OF ESTIMATES OF SERIOUS INJURIES USING DIFFERENT METHODS

9.1.1 Background

Despite harmonized definitions and tuned procedures between countries, there remains a large difference between both the rate of serious (MAIS ≥ 3) and fatal road traffic injuries per 100,000 of population. These differences are likely to be due in part to differences in available data and the method applied for estimating the number of serious traffic injuries. The method applied (i.e. correction to police data, use of hospital data, use of linked police and hospital data) will depend on the data available. When comparing number of serious traffic injuries between countries it is important to know to what extent these differences are due to which method is applied and how that method is applied. For example, there are different approaches for applying correction factors countries.

Therefore, this section reports the outcome of a data analysis exercise which examined how the estimated number of serious injuries differs depending on which method is applied. In order to provide a true comparison of the impact of methodological approach to MAIS ≥ 3 estimation it is necessary to apply the three methods within the same country. Therefore, comparison can only be undertaken in countries with access to hospital data, police data and linked data. However, there are few countries which are able to apply all three methods. In the following section, data from the Netherlands is used as a experience. This is supplemented with findings from Austrian data where it is possible to calculate MAIS ≥ 3 using a correction factor applied to police data and hospital data.

9.1.2 Methods for estimating MAIS ≥ 3 casualties

To compare the impact of the different approaches to MAIS ≥ 3 calculation, the three methods proposed by the European Commission were applied to data from the Netherlands (2004-2014):

1. Correction factor applied to police data
2. Use of hospital data
3. Use of linked police and hospital data

To supplement these findings, methods 1 and 2 have been applied to Austrian data (2010 – 2014). In preparing all data for the analysis the steps outlined in the earlier section of these guidelines were followed (e.g. inclusion and exclusion criteria), details can be found in Appendix E.

For the Netherlands, two different correction factors were applied to police data. Firstly, a standard correction factor considering all transport modes together. Secondly, a variable correction factor calculated by considering each transport mode independently and then combining results. One, standard correction factor (all transport modes combined) is applied to Austrian data.

9.1.3 Results

The Netherlands

The total number of MAIS ≥ 3 casualties per year for each method applied to Netherlands data is shown in Figure 9-1

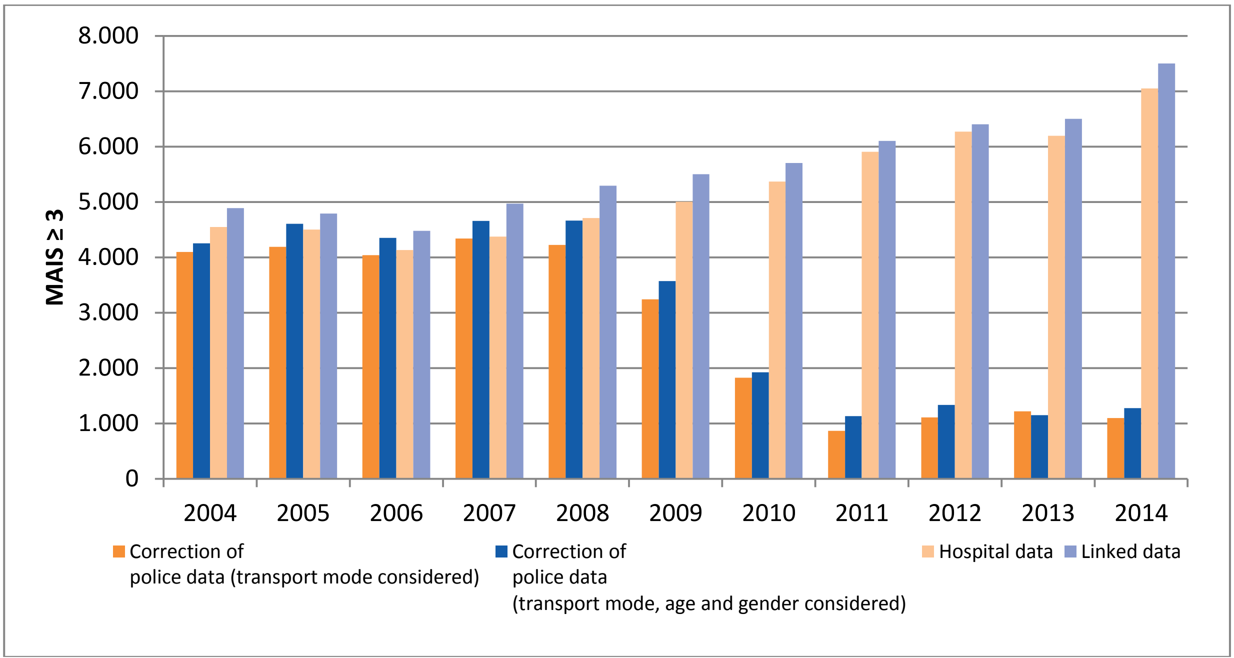

Figure 9-1 Comparision of total number of MAIS ≥ 3 casualties per year for three methods (2 different correction factors, hospital data and linked data) applied to the Netherlands for 2004-2014

Overall, the estimations based on linked data provide the highest numbers of MAIS ≥ 3 casualties, while corrections of police data for different transport modes provides the lowest ones. Applying a more detailed correction factor which takes into account age and gender in addition to transport mode results in a slightly higher estimate of MAIS ≥ 3 casualties. There is a noticeable difference in the estimated MAIS ≥ 3 numbers from 2009 onwards, which coincides with a change in police crash data registration.

Figure 9-2 shows the discrepancy between MAIS ≥ 3 casualty estimates by gender and age using data from the year 2009.

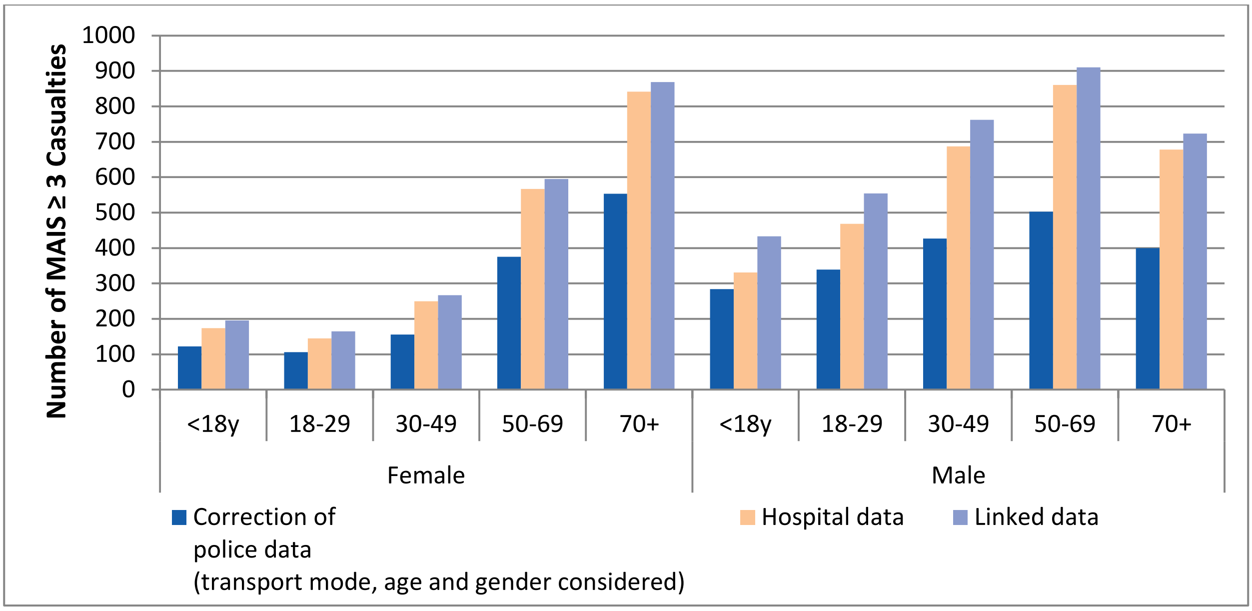

Figure 9-2 Comparison of total number of MAIS ≥ 3 casualties by age and gender for three methods (correction factors to police data, hospital data and Linked data) applied to Netherlands data for 2009

When results are examined separately by age and gender, the use of linked data generally provides the largest estimated number of MAIS ≥ 3 casualties while a correction factor applied to police data provides the lowest estimate of MAIS ≥ 3 casualties. It is known that it is wrong to apply correction factors to police data of which the quality deteriorates over time. It is likely that the low MAIS ≥ 3 estimations based on method 1 are mainly due to the decreased quality of police data in 2009 compared to previous years. The pattern of distribution (differences between age groups and gender) are similar for each method.

Figure 9-3 shows the discrepancy between MAIS ≥ 3 casualty estimates by transport mode using data from the year 2009.

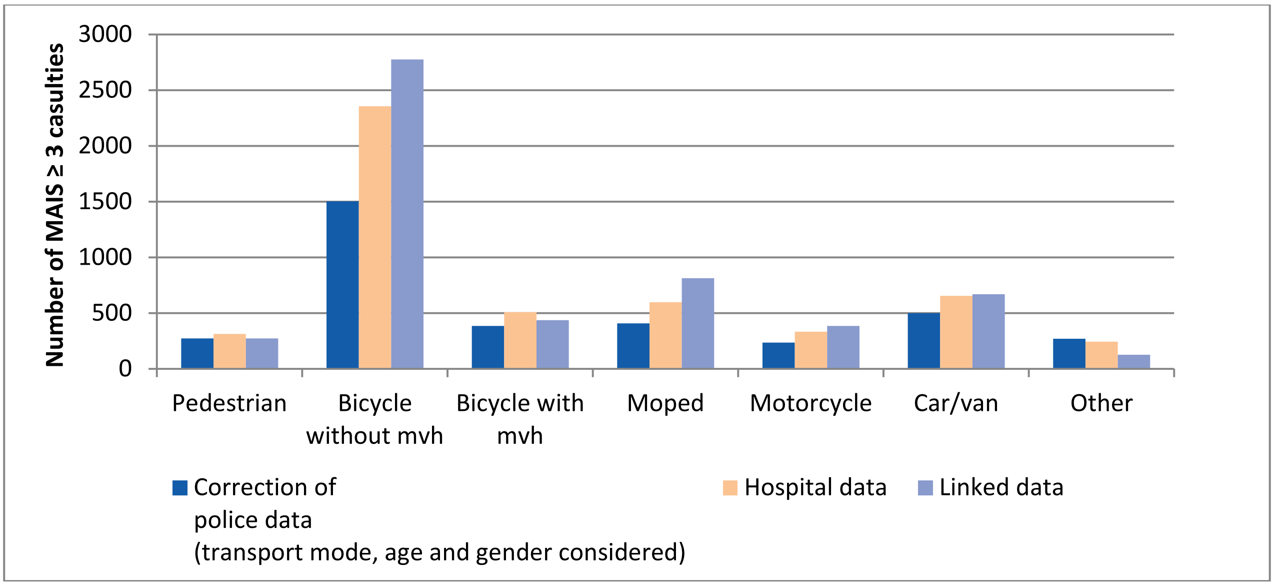

Figure 9-3 Comparison of total number of MAIS ≥ 3 casualties by transport mode for three methods (correction factors to police data, hospital data and Linked data) applied to Netherlands data for 2009

When the results are examined separately for different transport modes, the largest MAIS ≥ 3 numbers are observed for bicycle crashes without a motor vehicle, whatever the method applied. Linked data provides the highest estimated number of MAIS ≥ 3 casualties for bicycle crashes without motor vehicles, mopeds, motorcycles and car/van. Hospital data provides the highest estimate of MAIS ≥ 3 casualties for pedestrian and bicycle crashes with motor vehicles. Correction to police data provides the lowest estimate of MAIS ≥ 3 casualties for all modes of traffic, except for other vehicles.

9.1.3.1 Austria

The total number of MAIS ≥ 3 casualties per year for each method applied to Austrian data is shown in Figure 9-4

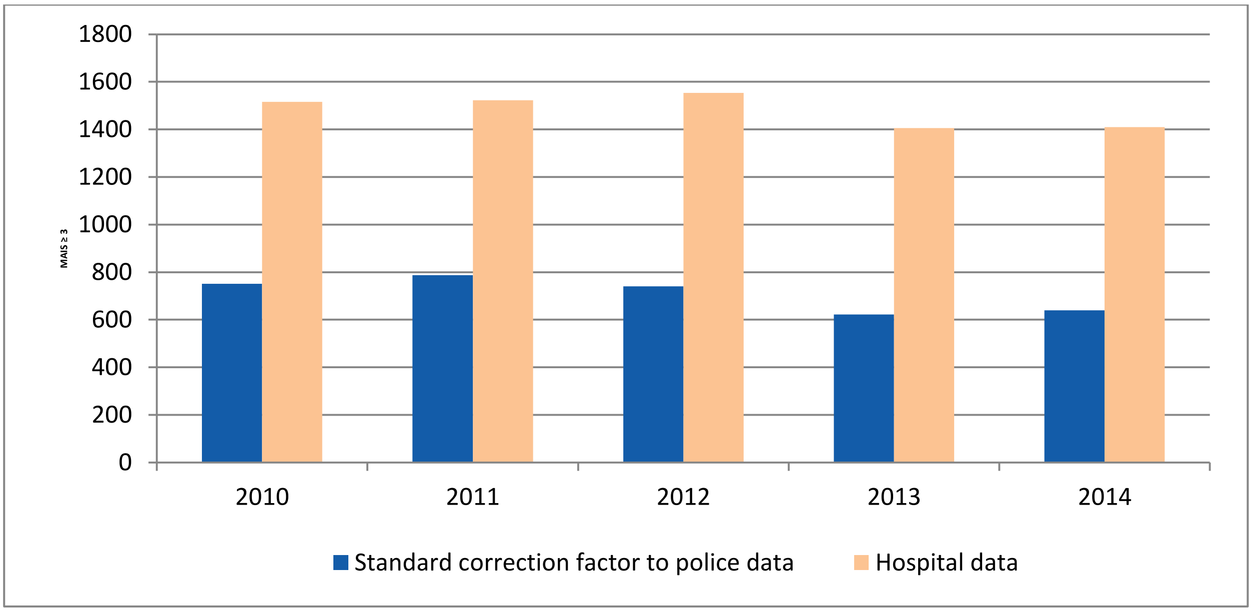

Figure 9-4 Comparison of total number of MAIS ≥ 3 casualties per year for two methods (correction factors to police data and hospital data) applied to Austria data from 2010 to 2014

Consistently, using hospital data provides the highest estimated numbers of MAIS ≥ 3 casualties while a standard correction (all transport modes considered together) factor applied to police data provides the lowest ones.

Figure 9-5 shows the discrepancies between MAIS ≥ 3 casualty estimates by gender and age using combined data from the years 2010-2014.

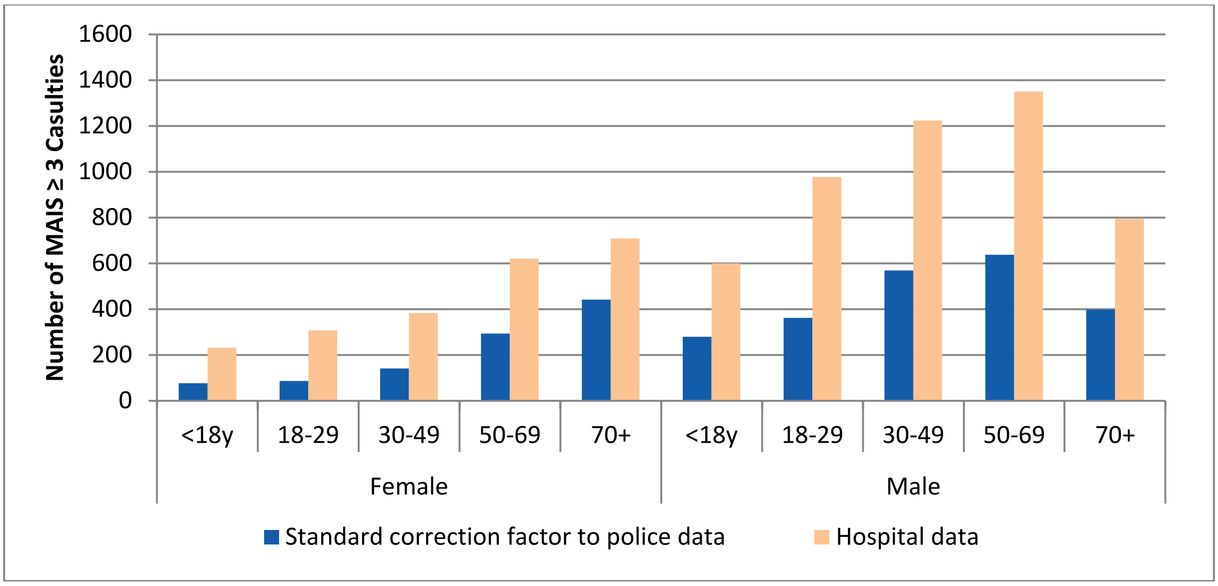

Figure 9-5 Comparison of total number of MAIS ≥ 3 casualties by age and gender for two methods (correction factors to police data and hospital data) applied to Austria data from 2010-2014

When the results are examined separately for different age and gender categories the use of hospital data generally provides the greatest estimated number of MAIS ≥ 3 casualties and a standard correction factor (all transport modes considered together, separately for age and gender) applied to police data provides the lowest estimate of MAIS ≥ 3 casualties. The highest difference in absolute number between the two calculation methods is observed for males aged 18-29,30-49 and 50-69. The distribution of MAIS ≥ 3 observations across age groups and gender are similar whatever the type of correction applied.

9.2 DISCUSSION OF RESULTS FROM COUNTRY PRACTICES

The method used to calculate MAIS ≥ 3 injuries has obvious implications for the overall number of MAIS ≥ 3 casualties identified. Using data from the Netherlands it is clear that the highest numbers of MAIS ≥ 3 casualties are identified using Linked data. This suggests that all other methods are subject to a greater amount of under reporting. While Linked data may be considered the most accurate method to calculate MAIS ≥ 3 there are still limitations (e.g. accuracy of recording and difficulties in linking the cases (see 9.3)). Additionally, it is important to consider the quality of the data to which the method is being applied. In the present example, each method was applied to the same dataset. However, the quality of data collection and processing (e.g. removal of duplicate cases) prior to the calculation of MAIS ≥ 3 will impact the reliability of the calculated total serious injury cases.

On the basis of the Dutch and the Austrian experience, applying the correction factor to police data consistently identify the fewest number of MAIS ≥ 3 injuries. This may be expected as the foundation data in this case is collected by the police, and their reporting effort has sharply decreased after 2009. The development of road safety in the Netherlands (where elderly become more mobile, especially on (electric) bicycles – resulting in more casualties) have further caused the factors that were derived on the data of 2004-2008 to be insufficient to compensate well for the underreporting by the police.

Data from Austria supports the general findings from the Netherlands by demonstrating a greater number of MAIS ≥ 3 casualties using hospital data than a correction factor to police data. These findings suggest that the greatest number of MAIS ≥ 3 casualties can be identified by using linked data, followed by hospital data alone, with correction factors applied to police data identifying the fewest MAIS ≥ 3 casualties. This suggests that of these three methods, applying correction factors to police data is subject to the greatest degree of underreporting.

The approach used to calculate correction factors, in terms of the number of factors considered, has a strong influence on the possibility to stratify the number of MAIS ≥ 3 casualties identified as well as limitations derived from using hospital data (see Chapter 6). However, although the absolute number of MAIS ≥ 3 casualties varies, the general pattern of distribution over years and when results are broken down by gender and age remains consistent. It should be noted that the methods used to calculate MAIS ≥ 3 presented here have a large degree of overlap, for example the correction factors applied to police data originate from the hospital data. Therefore, the similarities in the distribution of MAIS ≥ 3 casualties should be expected. As discussed in Chapter 0, the benefit of a correction factor is limited by the accuracy of the data to which it is applied. In the case of the Netherlands, there is a clear difference in MAIS ≥ 3 calculations using correction factors applied to police data before and after 2009. This coincides with a change to the police crash registration process (Vis, M. A., Reurings, M. C. B., Bos, N. M., Stipdonk, H. L., & Wegman, 2011). Prior to this date the police crash report form included a wider range of variables to be recorded. At the same time the overall national information system (Basic Enforcement Facility or BVH) was implemented. There is some evidence that this system has resulted in reduced quality of road crash records (Vis, M. A., Reurings, M. C. B., Bos, N. M., Stipdonk, H. L., & Wegman, 2011). This change in practice, taken together with the large magnitude of difference in MAIS ≥ 3 casualties between method 1 and 2 suggests that it is not appropriate to use the findings from correction factors applied to police data for the years since 2009.

Although, overall findings suggested linked data to identify the greatest number of MAIS ≥ 3 casualties, this is not true for all transport modes. For example, slightly more MAIS ≥ 3 pedestrian casualties are identified from hospital data alone than linked data. This is however due to a disagreement in the mode of transport between the two data sets. As the police was on scene the police information is taken as truth here, resulting in a lower number of real pedestrians than reported in hospital. But criteria in some cases can be different. In Belgium, for instance it was found out that a proportion of registered "pedestrians" in hospital data were not involved in a road accident but just fell on a public road. This is maybe also the case in HDR data in other countries.

All results should be interpreted as an estimate of the number of MAIS ≥ 3 casualties. They are based on standardised calculation procedures, each of which is subject to limitations. In no case should this be considered the "exact true number" of severe injuries. The lower number of MAIS ≥ 3 casualties calculated from applying correction factors to police data and from hospital data compared with linked data present some evidence that additional correction factors may be beneficial when using these methods. It is likely that countries using either method 1 or 2 to calculate MAIS ≥ 3 are under reporting severe injury casualties compared with countries using method 3 (linked data).

9.3 ADVANTAGES AND LIMITATIONS OF DIFFERENT METHODS FOR ESTIMATES OF SERIOUS INJURIES

All three methods for estimating the number of serious traffic injuries have both advantages and limitations. A summary of these are provided in Table 9.1. It is important to adopt a method which results in as the most accurate report of road related serious injuries as possible. However, the decision needs to be made within the context and constraints of each individual country. In addition to recording the total number of serious injuries it is also useful to monitor changes over time. For this purpose, it may be sufficient to use a method which is less accurate i.e. is known to under report the number of seriously injured. As long as any underreporting remains consistent across years it will still be possible to accurately observe any trend in serious traffic injuries.

Table 9.1 Summary of the advantages and limitations of three methods for calculating the number of serious injuries.

Method for MAIS ≥ 3 calculation	Advantages	Limitations
Correction factor applied to police data	- Police data is commonly available in most countries. - Potentially the easiest and cheapest data to obtain. - Most information available about crash circumstance. - In countries where police data are earlier available than hospital data, correction factors makeit possible to estimate the number of MAIS ≥ 3	- Police data do not contain injury severity. In order to generate the correction factors, access to hospital data is required. - Results are influenced by the number of items considered when deriving correction factors e.g. transport mode, age and gender. A single correction factor should not be used. - Correction factors should be regularly recalculated and updated. - Each country should calculate its own correction factor. - The output is only as good as the data to which the correction factor is applied. - Limited information about injuries.
Hospital data	- Almost all countries have hospital discharge registers at national level - More comprehensive record of injury than police data. - Enables to assess the injury severity MAIS converting from injury diagnoses. - More reliable than applying correction to police data.	- May be difficult or expensive to obtain. - Personal data protection. - Cause of injury as traffic related may not be accurately recorded or missing. - Relies on recording of ICD codes to AIS for MAIS ≥ 3 calculation, which has its own limitations. - Limited information about crash circumstance. - Weighting factors should be applied to correct for missing data. - Not all hospitals are always included. E.g. private hospitals may not be included in the register. - The reliability of injury coding in hospitals must be assumed. - The number of digits used in ICD coding may be limited.
Linked police and hospital data	- Most reliable estimate of the number of MAIS ≥ 3 casualties. - Detailed information available about both injuries and crashes.	- Requires access to both police and hospital data. - Frequently lack of personal identifiers - Affected by the limitations of both police and hospital data. - Not all cases can be matched. - Often has a longer time lag than the other methods. - Cases are matched based on the probability they are the same, the criteria used for this influences the probability that a match is accurate.

Table 9.2 Summary of methods comparison

• **The method applied influences the estimated number of MAIS ≥ 3 casualties.** • **Comparing the three methods recommended by the EC using data from the same country demonstrates that Linked data is the most reliable method to estimate the number of MAIS ≥ 3 casualties, followed by hospital data alone.** • **Each method is subject to limitations. The number of serious injury casualties identified should be considered an estimate.** • **The biggest limitation for all methods is the quality of the data being used. Attempts should always be made to access data of the highest quality possible.**

10 Discussion and conclusions

This Chapter discusses the most relevant issues addressed concerning the estimation of road serious injuries using the MAIS ≥ 3 definition. Although the adoption of a common definition for serious injuries has undoubtedly given an impetus to the collection of data on serious traffic injuries in Europe, a high variability has been shown in the methods used and a lack of harmonisation in criteria and tools used has been identified. The different methodologies applied are likely to influence the estimated number of serious traffic injuries and the comparability across countries.

In January 2013, the High Level Group on Road Safety, representing all EU Member States, established the definition of serious traffic injuries as road casualties with an injury level of MAIS ≥ 3. Moreover, the High Level group identified three main ways Member States can collect the data: 1) by applying a correction on police data, 2) by using hospital data and 3) by using linked police and hospital data. This Deliverable discusses the current state of data collection across Europe, analyses the effect on estimates of using the different methods, and provides guidelines for each of the three ways identified by the High Level Group. Moreover, differences between methods were investigated by applying various methods (or specifications of methods) to the same country (or region). This section discusses the most relevant issues addressed concerning the estimation of road serious injuries using the MAIS ≥ 3 definition (a Maximum Abbreviated Injury Severity level of 3 or more).

This chapter is organized in 2 sections. First there is a brief discussion on the need to have access to hospital data and limitations and secondly the main conclusions of the deliverable are given. Chapter 11 presents the main recommendations derived from this study.

10.1 DISCUSSION

10.1.1 Access to hospital discharge data

Hospital data are essential for determining the number of serious traffic injuries, defined as MAIS ≥ 3 casualties. At the same time, access to hospital data seems to be problematic for at least some countries, due to privacy regulations.

One of the problems identified by the countries was for the transport sector, respectively the accident statistics sector, **to get hold of hospital discharge data** in the first place. Usually ministries of transport or interior do not have access to health care data, which is owned usually by the ministry of health. This data is highly protected by the privacy personal data protection laws because it includes very sensitive information such as individual health information. But on the other hand, if it is properly anonymized in a way in which it is not possible to identify a person, it should be accessible just to apply this data for research or statistical purposes.

When hospital data is used for linkage with police data and/or other data sources, when possible, it is convenient that data are not anonymized because identifying variables are needed for linking records from both data sources. As a result of the linking of multiple data sources, it could be possible to identify persons. In that case, additional measures should be taken to ensure privacy.

Currently, all EU countries submit Hospital Discharge data to Eurostat. In principle, the anonymized HDR data set that is transmitted to Eurostat could be used also for a MAIS-3 calculation. In practice, however, for most countries the aggregation of ICD-10 diagnoses at a 3-digit level and missing external cause information do not allow for this kind of analysis. To get hold of hospital discharge data, at a national level it is necessary to establish inter-sectorial collaboration between the health and the transport or interior ministries. At a European level institutional collaboration with Eurostat, World Health Organisation and DG-MOVE would improve reporting serious road traffic injuries in Europe. A future aspect of accessing HDR data at Eurostat level – with the advantage of having the data already defined and (formally) harmonized to a certain degree – would be for the traffic safety sector to participate in the discussion about specific implementing measures of the data collection in the domain for EU public health statistics. The aim would be to refine the HDR data provision in such a way that AIS-assessment would also be possible with the HDR at Eurostat.

10.1.2 Limitations of MAIS ≥ 3 as a definition of serious traffic injuries

A common definition is a first, very important step for comparing the number of serious injuries in various countries and to monitor trends. Moreover, the definition of road traffic casualties with an injury severity of MAIS ≥ 3 results from an extensive process and input from the research community.

As was also mentioned by IRTAD (OECD/ITF, 2011), to obtain data for international comparisons, a measure of injury severity that is limited to the "threat to life" dimension, seems to be the most appropriate indicator as it can be derived from hospitalisation data for most countries. Moreover, the number of MAIS ≥ 3 casualties seems to be quite independent from extraneous factors such as supply of and access to medical facilities. Therefore, a MAIS ≥ 3 casualty is considered to be an appropriate definition to determine the number of serious traffic injuries in Europe and to compare EU countries.

However, one should be aware of its limitations as well. Hospital discharge establish threat to life injury, but fail to capture an important part of the disabilities, cost and burden generated by the injuries (OECD/ITF, 2011). According to a study by Polinder et al. (Polinder et al., 2015), MAIS ≥ 3 casualties and fatalities together account for only 54% of the total health burden (measured in DALYs) of road traffic injuries in the Netherlands.

10.1.3 Limitations of this study

This study provides an overview of the current practice (2016) in Europe. However, one should be aware that the collection of data on serious injuries is an area in which a lot of developments are going on. Future plans were looked for, but there may be developments that are not foreseen at this moment. Therefore, results from the survey will be out-dated in a few years.

Furthermore, the analyses that were done for the countries also have some limitations. Most importantly, most of the analyses only include a limited number of countries, likely to be non-representative of all countries, particularly those who differ in motorisation and shares of modes of transport. Similarly, some of the weighting factors are based on a limited set of data, which would need be extended. Comparison of the three ways to derive the number of serious injuries is based only on one country, the Netherlands, because no other dataset was available that would allow for these analyses. Therefore, conclusions must be interpreted with caution.

More in general, all determined number of MAIS ≥ 3 casualties should be interpreted as an estimate of the 'true' number of MAIS ≥ 3 casualties. They are based on standardised calculation procedures, each of which is subject to limitations. In no case should this be considered as the "true number" of severe injuries. The biggest limitation for all methods is the quality of the data being used. Attempts should always be made to ensure access to data of the highest possible quality

10.2 CONCLUSIONS

The survey made it obvious that the **methodologies currently used vary between countries**, depending on the available data. Only two countries estimated a correction factor for police data ("EC method 1"), nine countries (plus England) used hospital data alone ("method 2") and four countries had established a link between police and hospital data ("method 3"). Another two countries used other or combined methods: France (generalisation based on the Rhône Trauma Register and Germany (generalisation based on GIDAS in-depth data and data from the German Trauma Register DGU®). Several countries plan to modify their methodology in the future, the majority of them towards deterministic or probabilistic linking between police and hospital data.

Hospital data is imperative for the determination of the number of serious traffic injuries. Even when applying correction factors to police data, it is necessary at some point to have hospital data to derive the correction factors. Given the crucial role of hospital data in the calculation of the correction coefficients, it is also advised to ensure that they are of optimal quality.

The method applied obviously affects the estimated number of serious traffic injuries. The survey results show that **the ratios between serious injuries and fatalities vary substantially between the countries**. These differences probably are partly due to differences in available data and the method applied for estimating the number of serious traffic injuries. Moreover, comparing the three methods recommended by the EC using data from the Netherlands demonstrates that linked data identifies the greatest number of MAIS ≥ 3 casualties, followed by hospital data alone. Correction factors applied to police data identify the fewest MAIS ≥ 3 casualties. Also Austrian data shows that applying correction factors to police data results in lower numbers of serious traffic injuries compared to using hospital data. Thus, applying correction factors to police data appears to be subject to the greatest degree of underreporting and countries using either method 1 (correction factors) or 2 (use of hospital data) are possibly under reporting severe injury casualties compared with countries using method 3 (linked data).

The following subsections will draw more detailed conclusions on each of the three ways to collect data on serious traffic injuries proposed by the EC. Finally, some concluding comments are made.

10.2.1 Hospital data

Hospital data is essential for the determination of the number of serious traffic injuries. All countries that report MAIS ≥ 3 casualties seem to use at least a sample of hospital data. However, the specific characteristics of hospital data differ from one country to the other and it is not always possible to select all serious traffic injuries in hospital data. By means of a number of experiences we analysed 1) the effects of applying different in/exclusion criteria to select road casualties from hospital data, and 2) the difference between direct AIS coding and the use of various recoding tools for the determination of MAIS.

In- and exclusion criteria to select road casualties from hospital data

Serious traffic injuries are defined as road traffic casualties with MAIS ≥ 3. Therefore, ideally also MAIS ≥ 3 casualties that are **not admitted to the hospital** should be taken into account as serious road injuries. However, as in most countries, hospital discharge data is used to estimate the number of serious traffic injuries, this is not possible in most cases. Based on data from the Rhone register, we estimate that exclusion of non-hospitalized MAIS ≥ 3 casualties results in an underestimation of the number of serious traffic injuries of about 5%.

Moreover, persons who **die within 30 days** of the accident should be excluded as they are counted as a fatality and readmissions should be excluded to avoid duplicates. On the basis of data from Spain and the Netherlands, we estimate that the inclusion of fatalities within 30 days results in an overestimation of the number of serious traffic injuries of about 5% and that inclusion of readmissions results in an overestimation of about 3%. To account for these differences, weighting factors could be applied.

Hospital Discharge Register uses the International Statistical Classification of Diseases to codify the main diagnosis, or reason for the hospital admission. Hospital data is coded with ICD-9 or ICD-10, and, based on those codes, road traffic injuries have to be identified. According to the **ICD9-CM the definition** of road traffic injuries includes any traumatic injury including codes from 800 to 959. For those countries using **ICD10 codes** for traumatic injury these include: S00-T88. In addition, ICD distinguishes between "**Traffic accident**" (any vehicle accident on a public road) and "Non-traffic accident" (any vehicle accident occurring entirely somewhere other than on a public road), so it is therefore possible to consider traffic injuries occurring on public roads, as has been proposed by international organizations, and to exclude the non-traffic deaths. General recommendations are to include codes for traffic injuries and/or weighting -correcting for non-public road- for non-traffic injury codes.

The ICD nomenclature also provides codes for **external causes**, which allow the identification of road traffic injuries in all-injury hospital databases. E-codes describe the external causes of injuries. The general recommendation suggests including as E-codes: E810-E19, E826, E827, E829 and E988.5 and excluding E828. Data from Spain and the Netherlands suggests that inclusion of E828 or E820-E825 or excluding of E929 only has a small effect on the estimated number of serious traffic injuries. More important, s**everal countries suffer from incomplete specification of external causes** in their hospital injury records. In Belgium for example, despite of a compulsory registration of E-codes in hospitals, E-codes are missing for around 20% of all casualties. Some countries look for other variables to identify traffic injury cases like the compensation payer company.

Direct coding versus the use of various converting tools to derive severity

The AIS levels of injuries of a casualty can be determined in several ways. **AIS coding can be direct** or can be derived from other injury coding systems, like ICD. Moreover, various conversion tools are available for recoding ICD codes into AIS codes, e.g. **ICDmap90**, **ICDpic**, **European Center for Injury Prevention Algorithm (ECIP)** and **AAAM**. Some of these tools recode the ICD codes into the latest AIS© 2005/update 2008 codes, but other, older tools transform ICD data into AIS codes that are based on previous versions of the AIS coding (AIS2005, AIS1998 or AIS1990). Also ICD has different versions and is subject to regular updates. All these elements (AIS version, ICD version and conversion tool) influence the AIS levels of the injuries and therefore the resulting number of MAIS ≥ 3 casualties.

Application of AIS1990/AIS1998 results in an overestimation of the number of MAIS ≥ 3 casualties by 12%, so in order to make data from different countries more comparable, the number of MAIS ≥ 3 casualties should be multiplied by a factor 0.89 when injuries are coded in AIS1990 or AIS1998 instead of AIS2005 or AIS2008. The ECIP recoding tool seems to result in reliable numbers of serious traffic injuries if codes are complete. We should note however, that this conclusion is based on a small sample. The difference in the estimated number of MAIS ≥ 3 casualties between the ICD9cm recoding tools is at most 7%. It was not possible to investigate the difference between ICD9 tools and direct coding. The AAAM10 conversion table appears to result in serious underreporting in MAIS ≥ 3 casualties and does not seem to fit to European practice.

The **majority of countries now use the AAAM** ("Association for the Advancement of Automotive Medicine,") tool as provided by DG-MOVE. It became obvious, however, that the US-based AAAM10 table does not yet provide satisfying transformation rates for the ICD versions currently being used in Europe; especially in those countries for which only one diagnosis and only four ICD digits are available from the hospital data, the fail rate can be around 20%. Looking into the AAAM10 conversion table in more detail shows that the conversion table actually uses ICD10CM and possibly the most recent version that is used in the USA. As most European countries use an older version of ICD10 without clinical modification, this does not fit with European practice.

Due to hospital practice or privacy regulations, some countries use 4-digits injury codes instead of 5-digits codes. Effect of **truncation of injury codes** depends on the recoding tool that is applied. AAAM10 and ICDpic do not seem able to deal with truncated codes. In case other tools are used, underestimation is between 3% and 10%. Finally, in some cases, only a **limited number of injuries** were coded or available for analysis. Including less than 4 injuries in determining MAIS, results in an underestimation of 5% for 3 injuries, up to 22% in case of only 1 injury.

10.2.2 Applying correction factors to police data

If hospital data is only available for part of the country or for a limited time period (or in case hospital data becomes available at a later stage), one could also estimate the number of serious traffic injuries by applying correction factors to police data.

Basically, a correction factor estimates the actual (or the hospital registered) number of MAIS ≥ 3 casualties on the basis of the number of casualties that is registered by the police. As especially the police registration differs between various groups of road users (age gender, transport mode) and accident types (single vs. multi-vehicle, place of occurrence etc.), correction factors differ between different groups of road users. Therefore, a set of correction factors should be derived and applied. It is useful to model the effects of various variables (such as year, type of road user, age, gender, etc.) on the ratios of police/hospital registrations as a first step. This allows the determination of which variables significantly affect these ratios and, consequently, the correction factors.

The **correction factors vary substantially between countries**. This variability is due to the fact that police and hospital registration as well as the injured population itself vary widely between countries. As a consequence of the substantial variations between countries, correction factors are concluded to be country specific and it is strongly recommended not to apply correction factors from one country to determine the number of serious traffic injuries in another country. Specifically, a sample of hospital data is imperative for deriving correction factors that can be applied to police data. Moreover, as is also shown by the Dutch experiencie, police and hospital registration may **change over time** and therefore correction factors need to be validated and possibly updated on a regular basis. When applying correction factors estimated for one-time period to another one, it is necessary to previously check that police registration methods have not changed from one point in time to the other.

Whenever possible, an attempt should be made to link hospital data with police data, at least at some time. This allows obtaining more accurate estimates of the total number of casualties.

10.2.3 Using linked/matched police and hospital data

A third method for estimating the actual number of serious traffic injuries (MAIS ≥ 3) is by linking police data with hospital data. The main interests in using data linkage are to maximise use of available data sources, to provide insight into the completeness of police and hospital data as well as to identify and possibly reduce selection biases and underreporting. In this way, one could for example correct for missing or misspecified E-codes.

The **linking process** must be based on variables included in both records. An ideal variable is a unique personal identification number (deterministic linkage), but this information is often unavailable for privacy reasons. In the absence of such a unique identifier, probabilistic or distance-based linkage is recommended. Linking variables commonly used are date and time of the crash (and/or date and time of hospital admission), location of the crash, gender and date of birth of the casualty, mode of transport. Once the linkage between hospital and police data has been completed, the number of traffic casualties recorded in hospital data but not identified as such can be estimated using the capture-recapture method. Then, in this specific context, the capture-recapture method can be viewed as a means to better estimate the number of MAIS ≥ 3 casualties from hospital data as a result of the linkage with police data, especially in the case where many external causes are unknown.

To be valid, the capture-recapture approach must meet six conditions. Among them, three are particularly important: (i) the definition of the road casualty in the two data sources should be the same or included into the another. In this case, the most restricted definition applies to the outcome of the linkage. (ii) The two registrations are supposed to be independent. When this hypothesis is not met, the estimation is biased downwards in case of positive dependence, upwards otherwise. (iii) All subjects of interest should have the same probability of being registered by a given source. This homogeneity assumption is usually only valid within subgroups (e.g. mode of transport). These subgroups should hence be taken into account with stratification or modelling methods.

Then, in this specific context, the capture-recapture method can be viewed as a means to better estimate the number of MAIS ≥ 3 casualties from hospital data thanks to linkage with police data, especially in the case where many external causes are unknown or misspecified. However, it is necessary to investigate the possibility of applying this approach when the proportion of missing or misspecified external causes is very high (e.g. 80%).

The main limitations of the use of linked police and hospital data are that two data sources are needed, the linkage is only possible if some key variables are common between police and hospital records, and capture-recapture is based on important assumptions. On the other hand, this method has the big advantage of providing the most complete estimate of the number of MAIS ≥ 3.

10.2.4 Concluding comments

The adoption of a common definition for serious injuries has undoubtedly given an impetus for the collection of serious injuries data throughout the Member States of Europe. The methodologies currently used to identify and to report serious traffic injuries in Europe vary between countries, depending on the available data. A number of countries are currently able to report serious traffic injuries and several plan to modify their methodology in the future, the majority of them towards deterministic or probabilistic linking between police and hospital data. High variability has been shown in the methods used and a lack of harmonisation in criteria and tools used has been identified. The different methodologies applied influence the estimated number of serious traffic injuries and the comparability across countries.

Hospital data are essential for determining the number of serious traffic injuries, defined as MAIS ≥ 3 casualties. Even when applying correction factors to police data, it is necessary at some point to have hospital data to derive the correction factors. At the same time, access to hospital data seems to be problematic for at least some countries, due to privacy regulations.

The actions undertaken in each country and the methods developed are characterized by important differences. Harmonisation will certainly be necessary. Further actions will be needed to ensure that the estimated numbers of MAIS ≥ 3 road traffic injuries are comparable. This will take time. As for now, provisional solutions may be applied, such as the application of correction factors to police data.

More generally, it is important to discuss, report and interpret the estimation results also taking into account the different specific methodologies they are derived from. The analyses presented in this deliverable have indeed shown that different criteria to ascertain casualties, missing E-codes, AIS version, ICD – AIS recoding tools, and the number of injuries taken into account when determining MAIS can have a large influence on the estimations.

Finally, all three methods for estimating the number of serious traffic injuries have both advantages and limitations. It is important to adopt a method that results in the most accurate report of road related serious injuries possible. However, the decision needs to be made within the context and constraints of each individual country. In addition to recording the total number of serious injuries it is also useful to monitor changes over time. For this purpose, it may be sufficient to use a method, which is less accurate i.e., is known to underreport the number of seriously injured. As long as any underreporting remains consistent across years it will still be possible to accurately observe any trend in serious traffic injuries.

11 Recommendations

This Chapter summarizes the main recommendations for policy makers, practioners and researchers.

General recommendations

- There should be an effort to obtain hospital data that allows best estimates of serious injuries. This implies providing at least 4 diagnosis of injuries, no truncation of ICD codes, registration of E-codes, and using the latest version of AIS (2008).

- Given the crucial role of hospital data in the calculation of the correction coefficients, it is also advised to ensure that they are of optimal quality. It may be necessary, in some cases, to apply correction factors to hospital data as well.

- Whenever possible, an attempt should be made to link hospital data with police data. This allows obtaining (1) a more accurate estimate of the number of casualties (for all levels of injury severity) and (2) application of the estimated proportion of MAIS ≥ 3 casualties to these estimates.

- Whenever possible, and provided that the procedure proves sufficiently accurate, linkage-based methods are to be preferred.

- AAAM10 needs to be improved including the missing ICD10 codes as well as considering different versions of ICD10. Adapt the conversion tables for the AAAM10 tool to better fit European needs. In the current state the AAAM10 tool results in a clear underestimation of the number of MAIS ≥ 3 casualties, and moreover, truncation codes in an increase in the number of MAIS ≥ 3 casualties.

For policy makers

- One of the identified main problems to report serious road traffic injuries is the difficulty in accessing hospital data for many countries. At a national level it is necessary to establish inter-sectorial collaboration between the health and the transport or interior ministries.

- Furthermore, linking hospital data with police data requires these datasets (police and hospital) having common variables (needed for linking). The hospital data does not contain date of accident but only date of hospital admission and the reverse is true for police data. The hospital data does not contain location of the crash, but usually only county of residence, and the police data does not contain the name of the hospital where the casualty was admitted. It is hence necessary that the two databases contain complete dates of birth and names of the serious traffic injuries.

- At a European level institutional collaboration with Eurostat, World Health Organisation and DG-MOVE would improve reporting serious road traffic injuries in Europe. A future aspect of accessing HDR data at Eurostat level – with the advantage of having the data already defined and harmonized to a certain degree – would be for the traffic safety sector to participate in the discussion about implementing specific measures for the data collection in the domain of EU public health statistics. The aim would be to refine the HDR data provision in such a way that AIS-assessment would also be possible with the anonymized HDR at Eurostat.

For practitioners

Recommended issues when estimating serious road traffic injuries through correction factors applied to police data

- There is no single, general correction factor that should be applied. It is more appropriate to apply several correction factors because the ratios of hospital/police registrations vary as a function of the characteristics of the victims (age, gender, transport mode) and of the accident (single- vs. multi-vehicle accident, place of occurrence, etc.). It is recommended to account for specific variables:
    i. that have the most diverse impact on hospital/police ratios (the impact of road-user type, for example, differs widely depending on the particular road-user category considered: the ratio will be moderate for powered-two-wheelers, very high for cyclists, but low for car occupants). Of all variables listed above, "road user type" is probably one of the most significant and most frequently available variables.
    ii. with values combinations that also result in significant variation in correction factors (e.g.: transport mode*age).

- It is useful to analyse with multivariable models the effects of various variables (such as year, type of road user, age, gender…) on the ratios of police/hospital registrations as a first step. This allows the determination of which variables significantly affect these ratios and consequently the correction factors.

- Since as well police as hospital registration and crash characteristics differ between countries and correction factors are largely influenced by all three elements, it is strongly recommended that countries derive their own correction factors and do not directly apply those estimated in other countries. More specifically is strongly recommended that access should be obtained to hospital data, or to a sample of it. Without such access, this makes their calculation very difficult, if not impossible and no benchmark will be available.

- As correction factors are neither temporally, nor geographically constant they should be recalculated if the time or location parameters change. *Correction* factors should therefore be updated on a regular basis. Before applying correction factors estimated for one-time period to another one, one should check that police registration methods have not changed.

Recommended criteria for selecting cases from hospital data

As for any of the three methods hospital data is necessary at some point, some of these recommendations can be applied when using method 1 (correction factors) or method 3 (record linkage) when estimating road serious injuries.

- The study showed a high variability in the methods used to report serious road traffic injuries as well in the criteria to ascertain the cases. It would be good to harmonize the methods and criteria for in/exclusion, but of course, possibilities are limited by available data and current procedures in hospital. It is necessary to harmonize methods and criteria to select cases.

- If a person is admitted to hospital but finally dies within 30 days after the admission he/she should be accounted as a fatality. If the person dies after 30 days and has an injury severity MAIS ≥ 3, it should be counted as a serious injury. If it is not possible to exclude fatalities within 30 days, a weighting factor of 0.95 could be applied.

- Exclude readmissions to avoid duplicates within a full calendar year (or within a month if it is not possible to identify through the full year) and exclude scheduled admissions when they are a second episode of a previous emergency injury but they are not defined as readmissions. If it is not possible to exclude readmissions, a weighting factor of 0.97 could be applied.

- Include all traffic injury hospitalisations even those with short length of stay.

- Include all cases with any injury diagnosis (ICD9CM: 800-999; ICD10: S00-T88).

- Include external causes for road traffic injuries: (ICD9CM: E810-E819, E826, E827, E829, E988.5; ICD10: V01-89 for those codes for traffic injuries and/or weighting -correcting for non-public road- for non-traffic injury codes).

- To compensate for missing E-codes, additional sources for the identification of traffic injuries as accident compensation payer could be used when available.

Recommendations about deriving MAIS ≥ 3

- Multiply the number of MAIS ≥ 3 casualties by a factor 0.89 when injuries are coded in AIS1990 or AIS1998 instead of AIS2005 or AIS2008.

- Apply the following weighted factors in cases where less than 4 injuries are taken into account for the determination of the number of MAIS ≥ 3 casualties

  - 1.28 in cases of 1 injury
  - 1.11 in cases of 2 injuries
  - 1.05 in cases of 3 injuries

- Do not use the ICDpic tool in combination with truncated codes.

- Use the following weight factors to correct for truncated codes:

  - 1.06 in case of ICDmap90 or DGT
  - 1.03 in case of ECIP
  - 1.11 in case of AAAM9

- The current version of the AAAM-10 table does not seem to fit to the European practice. We recommend to wait for a new verion of the AAAM-10 table

Recommended issues when estimating serious road traffic injuries through record linkage

When using linked/matched police and hospital data:

- All available information should be used (Police+Hospital+Other sources). Linking data can only be based on variables that are included in both (all) records.

- The most ideal variable is a unique personal identification number (deterministic linkage), but this information is rarely available for privacy reasons. Privacy issues might be solved by resorting to encryption of personal information and/or based on the intervention of a neutral, trusted organisation ("trusted third party").

- In the absence of such a unique identifier, probabilistic or distance based linkage is recommended. Commonly used linking variables are date and time of the crash (and/or date and time of hospital admittance), location of the crash, gender and date of birth of the casualty, mode of transport, etc.

- For most countries, MAIS ≥ 3 can only be assessed from hospital data. MAIS ≥ 3 casualties are mostly hospitalized and well reported in hospital data, but external causes derived from ICD that allows their identification are often missing or sometimes misspecified.

- The number of such casualties (traffic casualties recorded in hospital data but not identified as such) can be estimated by linking hospital data of all hospitalized with a traumatic injury, with police data, and using capture-recapture method.

Recommended issues when estimating serious road traffic injuries through record linkage using capture-recapture:

The capture-recapture approach is based on six conditions, among them the three following ones:

- The definition of the road casualty in the two data sources should be the same or included into one another. In this case, the most restricted definition applies to the outcome of the linkage.

- Independence between the registrations: when this hypothesis is not met, estimation is biased downwards in case of positive dependence, upwards otherwise.

- Homogeneity of capture by a given registration: homogeneity is usually only valid within subgroups (e.g. mode of transport). These subgroups should hence be taken into account with stratification or modelling methods.

For researchers

- Due to the limited data sets used to derive weighted factors, validation of them would be necessary, as well as to develop unknown weighted factors, as for unknown external causes and different ICD recoding tools.

- Compare ICD9 recoding tools with direct coding to obtain more insight into weighting factors needed for ICD9 tools.

- Validate of using MAIS ≥ 3 reporting with other injury severity scales.

- Estimate the impact of including all injury severities for reporting burden of diseases at European level.

- To investigate the possibility of applying this approach when the proportion of missing or misspecified external causes is very high (e.g. 80%).

Glossary

AIS – Abbreviated Injury Scale
EEA - European Economic Area
EU – Europe
HDR - Hospital Discharge Register or Hospital Discharge Database
ICD – International Classification of Diseases
ICD10 - International Classification of Diseases, 10th revision
ICD10-CM - International Classification of Diseases, 10th revision, Clinical Modification
ICD10-GE - International Classification of Diseases, 10th revision, German Edition
ICD9-CM - International Classification of Diseases, 9th revision, Clinical Modification
ISS -Injury Severity Score
LoS – Length of Stay at hospital
MAIS – Maximum Abbreviated Injury Scale
OECD – Organisation for Economic Co-operation and Development
RTC – Road traffic casualties
WHO –World Health Organisation

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Appendix A: Methods to derive correction factors

This chapter describes the methods applied to derive correction factors to estimate the number of serious injuries (MAIS ≥ 3) using as examples data from Belgium, France and Austria.

EXPERIENCE OF BELGIUM 1

Background description of Belgian hospital data

The Belgian hospital discharge data (abbreviated to HDR) cover all Belgian hospitals except for private hospitals and non-general hospitals such as psychiatric hospitals and specialized revalidation centres. Consequently, the hospital data contain virtually all patients who were hospitalized, including road casualties.

The registration of HDR has been obligatory since 1990. E-codes were not recorded at that time, but diagnoses were recorded in terms of ICD-9-CM. ICD-9-CM was used in Belgium until 2014. 2015 is a year of transition in which both ICD-9-CM and ICD-10-CM were used. The registration of E-codes in hospitals has been obligatory since 2003.Yet, despite this obligation, E-codes are not consistently recorded. However, registration improves year after year: in 2004 35% of hospitalized patients with a principal diagnosis within the range 800-959.9 did not receive an E-code. Since 2008 this percentage has always been lower than 20% and in 2010 this figure was no more than 16%. The reverse situation does also occur: 90% of all patients with E-code 810-819, E826, E827 and E829 did not get a principal diagnosis between 800 and 959.9 (in the period 2004-2011). It is possible though that a diagnosis between 800 and 959.9 is still selected as secondary diagnosis.

Missing E-codes make the identification of road casualties impossible. If not adjusted for, this will result in an underestimation of the number of road casualties admitted at hospital, both slightly injured and MAIS ≥ 3 casualties. Missing diagnoses on the other hand, result in the inability to calculate the MAIS-score of a patient, and consequently in an underestimation of MAIS1, MAIS2 and MAIS ≥ 3 casualties. In Belgium, as hospitals do not directly record AIS severity codes, the MAIS score can only be obtained by converting ICD9 codes to AIS severity scores.

Why are correction factors used?

Belgium applies two of the three options proposed by the European Commission in order to estimate the actual number of MAIS ≥ 3 victims, namely: 1) correction factors and 2) hospital data. We use option 2, hospital data, for those years for which hospital data are available. At this moment (April 2016), the Federal Public Service of Public Health provide hospital discharge data up until 2012. At the time the Belgian Road Safety Institute provided its (first) estimation of the total number of hospitalized MAIS ≥ 3 road victims in 2014, HDR were only available until 2011. Because hospital discharge data were, at the moment of study 1, only available until 2011, correction factors were used to estimate the number of MAIS ≥ 3 road casualties in the period 2012-2014.

How are correction factors defined?

Calculation of MAIS ≥ 3 victims between 2004 and 2011

Belgium has applied two of the three options proposed by the European Commission in order to estimate the actual number of MAIS+3 victims, namely: 1) correction factors and 2) hospital data alone. However, the first method - the calculation of correction factors - is entirely based on the second one: hospital data. The calculation of correction factors was possible only to the extent that the second method was first applied for those years for which both police data and HDR were available. We start our description of the calculation of correction factors with a description of the estimation of MAIS ≥ 3 victims based on hospital data alone.

In a first stage, road victims were selected from the HDR by the Federal Public Service of Public Health (FPS Public Health), on request of the Belgian Road Safety Institute (BRSI).

Both E-codes and principal diagnoses were used as selection criteria. In a first step, all patients with a principal diagnosis between 800 and 959.9 were randomly selected. In a second step, all those with codes E810 – E819 (accidents involving a motor vehicle and occurring on a public road) were selected and 90% of patients with codes E826, E827 and E829 ("non-motor vehicle road accidents"). The choice to select only 90% of patients with codes E826, E827 and E829 was based on previous investigations of E-code E849, which describes the place of occurrence of an accident. These investigations had shown that approximately 10% of patients with codes E826, E827 and E829 have had an accident on private roads (home, garden, place for recreation or sport, residential building, etc.), and not on public roads.

After carrying out this selection, the Federal Public Service of Public Health handed the data over to the BRSI under the form of data aggregated by principal diagnosis, age, road user type and year of admission. The BRSI converted the principal diagnosis, from an ICD9 code to an AIS severity score by means of the free conversion table ICDPIC. This conversion resulted in the number of MAIS ≥ 3 victims in Belgium, amounting to 3288 people in 2011 (Figure A 1).

Calculation of MAIS ≥ 3 victims between 2004 and 2011: discussion and limitations

Note that the number of MAIS ≥ 3 victims Figure A 1 is certainly underestimated because:

- MAIS ≥ 3 victims that were not hospitalized are not included in the figures. We assume though that the number of non-hospitalized MAIS ≥ 3 victims is negligible in Belgium.
- The MAIS score of a patient in this study is based solely on the AIS score of the principal diagnosis. Posterior analyses showed that about 20% of MAIS ≥ 3 victims are missing because not all diagnoses were taken into account.
- No correction factor was applied in this study for missing E-codes and missing principal diagnoses, which is likely to have resulted in an underestimation of MAIS ≥ 3 victims. The implication of these missing values is unclear. We know that 16% of all patients with a principal diagnosis within the range 800-959.9 didn't get an E-code in 2010, but it is unknown to what extent this percentage can directly be extrapolated to (severely injured) road victims. Similarly, although we know that 10% of patients with an E-code 810-819, 826, E827 and E829 did not get a principal diagnosis between 800 and 959.9 it is uncertain whether this percentage is also valid for the special subcase of severely injured (= MAIS ≥ 3 victims).

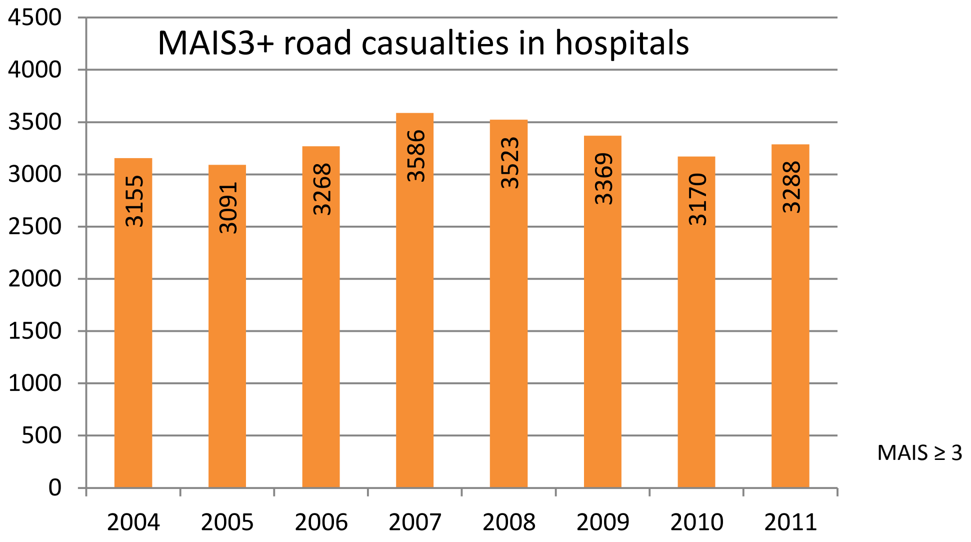


Figure A 1 Evolution of the number of MAIS ≥ 3 victims between 2004 and 2011 on the basis of hospital discharge data

Source: FPS Public Health / Edited by BRSI

Derivation and application of correction factors between 2012 and 2014

The correction factors for the years 2012-2014 were based on the investigation of the ratio of the number of MAIS ≥ 3 road traffic victims in HDR to the number of seriously injured registered by the police. Within police data, a seriously injured victim is defined as a road victim whom the police presume that he/she will be hospitalized for at least 24 hours. The distinction between slightly and seriously injured in police data is only rarely based on feedback from paramedics or hospitals.

Decision steps:

- Because of the very high proportion of missing E-codes before 2008 resulting in an underestimation of MAIS ≥ 3 victims, we decided to study only the ratios as of 2008 (missing e-codes are also encountered from 2008 on, yet to a considerably smaller extent).
- The evolution of the ratios was calculated per road user type. Four categories have been distinguished:
  - Pedestrians
  - Cyclists
  - Powered two-wheelers or PTW's (drivers + passengers)
  - Motorized vehicles other than PTW's (drivers + passengers), other and unknown

  "Other and unknown" include the following road user types according to ICD-9-CM coding: occupants of streetcars, occupants of animal-drawn vehicles, riders of animals, other specified persons, and unspecified persons.HDR data offered the possibility to distinguish "motorized vehicles other than PTW's (drivers + passengers)" from "other and unknown" but the police data did not (note that provisional police data have been used for this study instead of the conventional official police data). Therefore, these two categories have been merged in a single one.
- No systematic increasing or decreasing trend of the ratio has been observed in the short period of 2008-2011 for none of the four road user types. The assumption was therefore made that the ratios are also relatively stable in the following years.

The corrections factors in this case correspond to the average ratio of the number MAIS ≥ 3 road traffic victims (hospital data) to the number of seriously injured (police data) calculated for each road-user type. The corrected number of MAIS ≥ 3 victims per road user type is hence the product of the specific ratio of some transport modus with the number of seriously injured recorded in police data for the same transport modus.

The total estimated number of "MAIS ≥ 3 victims" from 2012 until 2014 is the sum of the estimated numbers of "MAIS ≥ 3 victims" by road user type.

Table A 1 Correction factors to be applied to police reported seriously injured in order to arrive at the best possible estimate of the number of MAIS ≥ 3 casualties

Road User Type	Correction factors
Pedestrians	0,52
Cyclists	1,20
PTW's	0,60
Other than PTW, other, unknown	0,44
Total	0,65

Source: BRSI, Belgian Road Safety Institute

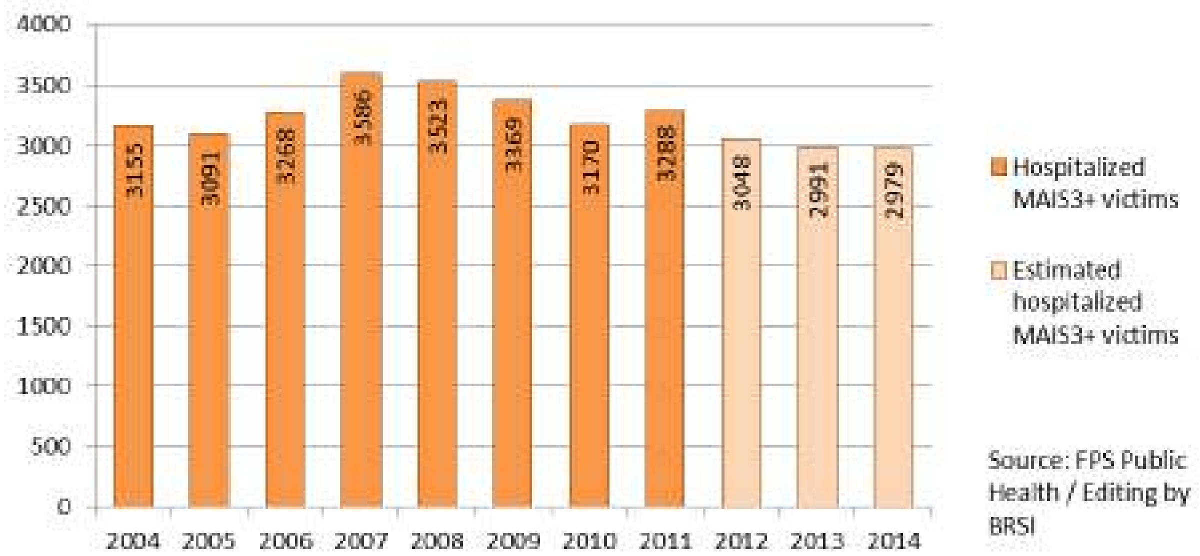


Figure A 2 Evolution of the observed number of MAIS ≥ 3 victims in HDR between 2004 and 2011 and the estimated number of MAIS ≥ 3 victims in HDR as from 2012

Discussion and limitations

The limitations of the observed number of MAIS ≥ 3 victims for 2009-2011 have been listed in the previous section. The estimated number of MAIS ≥ 3 victims for the period 2012-2014 suffers from exactly the same problems given that the whole estimation procedure is based on the numbers observed in 2008-2011. This means that the estimated numbers for both periods are certainly underestimations due to missing E-codes and principal diagnoses, and because of only one diagnosis per patient, the principal diagnosis, has been taken into account.

In addition to these shortcomings, there is the fact that the information about road user types available in the data was limited. The applied road user categorization was therefore not ideal. Besides, the data did not allow the calculation of correction factors based on e.g. age or gender (variables that are known to affect the extent of underreporting).
The second Belgian study will tackle some of the shortcomings of the first study.

EXPERIENCE OF BELGIUM 2

The nature of the Belgian hospital discharge data and the reasons why correction factors are used in Belgium are already described in the framework of the first Belgian study. Because these circumstances are identical for the first and the second study, they will not be repeated here.

How are correction factors defined?

Calculation of hospitalized MAIS ≥ 3 victims between 2009 and 2011

Correction factors in this second study are based on the ratio of MAIS ≥ 3 victims in hospital data to injured in police data for 2009 to 2011[14], the years for which both types of data are available.

In the first study, hospital data were available only under aggregated format, and with information limited to four variables (principal diagnosis, age, road user type and year of admission). In the second study however about 80 variables were available, and this for each hospital stay. These variables can be subdivided into four groups:

- information about the hospital stay (date of admission, date of discharge, type of admission, type of discharge, etc.);
- diagnostics (ICD-9CM codes for the principal diagnosis and all secondary diagnoses);
- accident related variables (road user type; place of occurrence of the accident);
- socio-demographic variables (age, sex, communality of residence).

Given the richness of the information available, the ratios of the hospital severely injured (MAIS ≥ 3) to police injured were in this case modelled on the basis of variables suspected to affect the likelihood of registration in police data, and hence the ratio of hospital (MAIS ≥ 3) to police injured casualties. The variables included as predictors in the model were: the age, gender and transport mode of the victims; and whether or not the accident involved at least one motorized vehicle.

Traffic casualties in hospital data were selected from the hospital discharge data by the Federal Public Service of Health. All patient who had been attributed one of the following E-codes were selected as traffic victims: E810 till E819, E826, E827, E829, E929.0, E9885.

The resulting dataset contains one record for each hospital stay, so it may contain several records per patient. It also contains an encrypted identification number. This allowed relating different stays to one individual patient, identifying readmissions as well as patients who had been involved in more than one traffic accident during the period in question.
Of this original dataset, BRSI excluded the following additional records:

- Readmissions (see chapter 6.3)
- Fatalities within 30 days (but patients with MAIS6 were not excluded)

[14] Hospital data were actually available from 2008 on. However, several registration problems have been encountered in 2008, and examination of the raw data confirms that they cannot be considered reliable. Therefore, the data used for this analysis were limited to 2009 to 2011.

48% of the records selected for the analyses were provided with an E849 code which displays the place of occurrence of the accident. A record was excluded if the place of occurrence was different from E849.5 (="street and highway"). 8,6% of the records that were provided with an E849 code were excluded on this basis (which amounts to 4,1% of the total number of records).

All diagnoses were then converted from ICD9 codes to AIS severity scores by means of the AAAM9 conversion table. The MAIS score of a traffic victim corresponds to the highest AIS score for this person. The total number of MAIS ≥ 3 victims resulting from this selection amounts to 3853 MAIS ≥ 3 victims for the year 2011. Note that in the first study this number amounted to 3288 MAIS ≥ 3 victims for the same year.

As in the first study, the MAIS ≥ 3 numbers obtained here were not 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 MAIS ≥ 3 victims.

Derivation and application of correction factors

Five road-user categories could be identified in this study (contrary to the first one where only 4 could be distinguished): pedestrians; cyclists; PTW users; occupants of motorized vehicles other than PTW; and other/unknown. For modelling purposes, "pedestrian" was defined as the reference category against which the other categories of the "Road-user Type" variable would be compared. For the "Gender", and "Motorized crash types" variables, the reference categories were respectively "male" and "motorized" (meaning that the crash involved at least one motorized vehicle).

The observed ratios were then modelled by means of a generalized linear regression model, with the natural logarithm of the ratio of hospital (MAIS ≥ 3) to police numbers of injured defined as the response variable. Model fit was investigated on the basis of the so-called Akaike Information Criterion (or AIC), which is a tool for selecting the most efficient among a series of (nested) models. The AIC indicates a model's goodness of fit (its correctness in predicting the observed data) while taking into account the number of parameters necessary to achieve a particular degree of fit (for a given goodness of fit value,a model including only two parameters will be preferred over one containing three parameters). The lower the AIC, the better the model can be considered.

The first modelling step involved road-user type; gender; and age (squared[15]); as well as year of admission and a binomial variable indicating whether the accident involved a motorized vehicle or not. As year of admission was not significant, it was removed from the model[16]. Additional analyses revealed a significant interaction of "(Un)motorized Crash" with "road-user type", and this interaction term was consequently included in the final version of the model.

Table A 1 below presents the coefficients associated with each (category) of the different predictors included in the final model. The model intercept is calculated for motorized accidents involving occupants of motorized vehicles other than PTW (and hence occupants of cars and larger vehicles),

[15] The decision to use the square of age values was made on the basis of the inspection of a plot of the residuals against the predicted values of the model. For the homoscedasticity assumption to be met, the residuals should be homogeneously spread around the model's predicted values. In this case however, the plot revealed that the residuals were markedly larger around both extremes of the predicted values. This suggests that the model fared poorer for these, and that the relation between age and the outcome variable might be quadratic rather than linear. Indeed, the introduction of the age squared variable in the model led to a noticeable decrease of the AIC value.

[16] The year variable has been defined as a continuous predictor in the modelling steps described here. But additional analyses have been performed in which it was defined as a categorical predictor, and its effect proved no more significant. The main problem with this variable lies however in the number of years of observation available, as discussed later on in this paragraph.

and males. The intercept value shows that in this case the number of injured reported by the police considerably exceeds the number of MAIS ≥ 3 in hospital data. This was to be expected however, given that police data are not restricted to serious injuries. The coefficient associated with the "(Un)Motorized accident" variable indicates that the difference between MAIS ≥ 3 and injured recorded by the police is lower in the case of unmotorized accidents as compared to motorized ones. This is also the case for all road users other than those defined in the reference category, namely: pedestrians, cyclists and P2W drivers.

Further examination of the "Road user type*(Un)motorized crash" interaction term additionally revealed that the MAIS ≥ 3 and police injuries records become even closer to each other in the case the "unmotorized" category and the "cyclist" (or pedestrian) one are combined.

It may at first sight seem surprising that the number of police injured consistently exceed the numbers of MAIS ≥ 3 victims recorded by the hospitals. However, it is important to bear in mind that all police injuries have been taken into account here, and that the MAIS ≥ 3 criterion is a rather stringent. The aim of these analyses was not to understand and investigate underreporting by the police, but rather to correct police data in order to obtain reliable estimates of the number of MAIS ≥ 3 victims.

All in all, these results confirm the importance of taking road users and crash characteristics into account when estimating the correction coefficients. It is also important to stress that the fact that the variable "year of admission" was not significant in this analysis does not indicate with certainty, that time does not affect the registration methods in police and hospital data. The variable used here was indeed based on only three years of observations (because these were the only for which hospital data were available). This is clearly insufficient to perform a proper analysis of temporal effects. Whenever possible, the time variable should be included on the basis of sufficient observations and using appropriate analyses methods suited for time series data.

Table A 2 Coefficients estimates for the final model selected

		Coefficient estimates	Standard Errors
Model description		**Natural Logarithms**	
Model Intercept		-2.92 ***	0.038
Road-User Type	*Pedestrian*		
	Cyclist	-0.56 ***	0.05
	Powered 2 Wheeler	-0.22***	0.05
	Motorized Vehicle Occupant	-0.96***	0.04
	Other and Unknown	1,44 ***	0.05
Gender	*Male*		
	Female	-0.28***	0.03
"Motorized" crash type	*At least 1 mot. Vehicle involved*		
	No mot. Vehicle involved	1,67***	0.10
Age^2		0.0003***	0.00
Road-user Type*Motorized crash	*Pedestrian – Motorized crash*		
	Cyclist – Unmotorized crash	-0.08***	0.11
	P2W – Unmotorized crash	/	
	Other Motorized R-U – Unmotorized crash	/	
	Other and unknown – Unmotorized crash	-0.08***	0.02

Table A 3 shows the estimated ratios/correction factors for the 20-year-olds. The lower and upper boundaries are quite close to the estimated correction factors. This reflects the good fit of the model.

Table A 3 Estimated ratios (=correction factors) to be applied to police reported casualties (all injured victims) in order to arrive at the best possible estimate of the number of MAIS ≥ 3 casualties. Example for 20-years-olds

Age	Road User Type	Motorized vehicle involved in accident	Gender	Estimated Correction Factor	Lower boundary	Upper boundary
20	Pedestrian	Yes	Man	0,31	0,26	0,38
20	Pedestrian	No	Man	0,03	0,03	0,04
20	Cyclist	Yes	Man	0,4	0,37	0,43
20	Cyclist	No	Man	0,07	0,07	0,08
20	PTW	Yes	Man	0,39	0,32	0,48
20	PTW	No	Man	0,02	0,02	0,02
20	Motorized other than PTW	Yes	Man	0,12	0,1	0,15
20	Motorized other than PTW	No	Man	0,25	0,23	0,27
20	Other and unknown	Yes	Man	0,57	0,38	0,86
20	Other and unknown	No	Man	0,04	0,04	0,05
20	Pedestrian	Yes	Woman	0,24	0,2	0,29
20	Pedestrian	No	Woman	0,02	0,02	0,03
20	Cyclist	Yes	Woman	0,3	0,28	0,32
20	Cyclist	No	Woman	0,06	0,05	0,06
20	PTW	Yes	Woman	0,3	0,24	0,36
20	PTW	No	Woman	0,02	0,02	0,02
20	Motorized other than PTW	Yes	Woman	0,09	0,07	0,11
20	Motorized other than PTW	No	Woman	0,19	0,17	0,2
20	Other and unknown	Yes	Woman	0,43	0,29	0,65
20	Other and unknown	No	Woman	0,31	0,26	0,38

Source: BRSI

Figure A 3 provides plots of the observed ratios and the estimated ratios as a function of age, and separately for motorized and unmotorized crashes and for men and women. Each color represents a road user type.

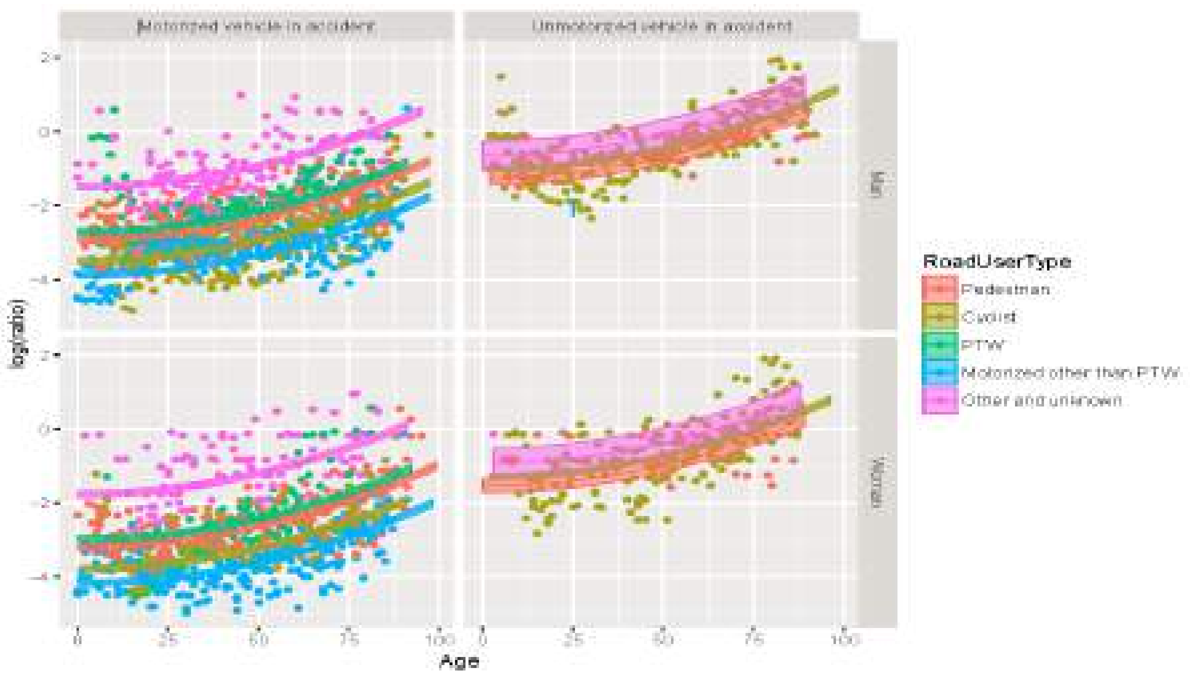


Figure A 3 Plots of predicted against observed ratios of hospital to police injured casualties. Real observed ratios versus estimated ratios (=correction factors)

The estimated correction factors are based on the number of MAIS ≥ 3 victims (HDD) and injured victims (police data) in the period 2009-2011. We can apply these correction factor table to more recent years (2012-2015).

Discussion and limitations

The mode and significance of predictor variables will need to be re-evaluated frequently. Additionally, re-evaluation will also include possible predictor variables that were not in the present model, such as the year of admission.
This second study has some limitations:

- MAIS ≥ 3 victims that did not visit the hospital are not included
- Missing E-codes and missing diagnoses were not corrected for and are likely to cause an underestimation of MAIS ≥ 3 victims

The second Belgian study offers the following improvements over the first one:

- All diagnoses have been taken into account and not only the principal one
- Many of the inclusion/exclusion criteria recommended in Chapter 3 of these Guidelines for the selection of road traffic casualties in hospital data are taken into account
- The correction factor is estimated on the basis of four variables: road user type, age, gender, involved in a motorized accident (yes/no). Only one variable, namely road user had been used in the first study.
- The correction factors are derived form a statistical model accounting for a large part of the variation in the observed hospital/police ratios No statistical modelling was involved in the first study.

EXPERIENCE OF FRANCE

Background description of the Rhône road trauma registry

The Rhône road trauma registry covers all casualties from road crashes occurring in the Rhône county who seek medical care in health facilities. All health care facilities (from public and private hospitals) in the county and its surrounding area which may receive crash victims participate: about 220 health units ranging from pre-hospital emergency care, emergency departments, intensive care units, surgery units... to rehabilitation departments. It covers hospitalised people, as well as those treated at the Accident and Emergency departments only. The Forensic institute also participates, so that all deceased people are included: those who died on the scene and those who died in the hospital. Injury assessment is based on all diagnoses established in the different health services a casualty may have visited. Diagnoses are directly coded with the Abbreviated Injury Scale (AIS), 1990 version. The registry data are available since 1996. 2012 is the most recent year for which these data are available. The Rhône county has 1.6 million inhabitants. It includes the large city of Lyon, its suburbs and also some rural areas.

Why are correction factors used?

We use correction factors for different purposes. The first one is to estimate the real number of road casualties at the national level, for all severities and for serious injuries only (Amoros et al., 2008). The second purpose is to obtain a national dataset that is unbiased and hence suitable for use for different analyses: on different road users for instance.

We use two types of factors: we distinguish them into prediction factors and correction factors:

- Our **prediction factors** are used to predict the proportion of MAIS ≥ 3 casualties among police-recorded casualties all severities (MAIS1+), on aggregated data and hence their frequency.

- Our **correction factors** are needed to correct for police under-reporting of road casualties and for its associated biases. The most important bias sources are severity of the casualty, severity of the crash (fatal/non-fatal), mode of transport (cyclists, pedestrians, MTW users, car occupants), single-vehicle versus multiple-vehicle accident, type of police (3 types in France).

Step 1: Prediction factors

How are prediction factors defined?

Police data and the Rhône road trauma registry have been linked on the Rhône county (see French Experience in Appendix D: Study 4.Record-linkage methods). We can use the linked subset, that is, the casualties identified as common to the police data and the road trauma registry, as it contains the MAIS from the registry and a number of crash characteristics from the police data. On this subset, we can construct a model to predict the proportion of MAIS ≥ 3 casualties, among casualties all severities (MAIS1+) according to crash and casualty characteristics. Under the assumption that this model contains enough information to be generalizable to France, and that the subset is not biased compared to the national police data, we can apply it to the national police data, at an aggregated level (not at individual), and hence obtain the number of MAIS ≥ 3 casualties, and decline it according to some characteristics: age, gender, road user type.

On the linked subset, we construct a multivariate logistic model to predict MAIS ≥ 3 (yes/no) among MAIS1+ casualties (we also construct a multivariate logistic model to predict MAIS2+ (yes/no) among MAIS1+ casualties in order to be able to distinct MAIS 1, 2 and 3+). Casualty and crash variables (as reported by the police) included in the regression are:

- Type of area (urban / rural)
- Police type (CRS / gendarmerie / police)
- Severity of the crash (fatal / non-fatal)
- Severity of the casualty reported by police (hospitalized: yes / no)
- Road user type (pedestrian / cyclist / MTW user / car occupant / other)
- Crash opponent (yes / no)
- Type of crash opponent (pedestrian or cyclist / MTW user / car occupant or other / van / heavy vehicle / none)
- Age and gender of the casualty

And possible interactions; at least:

- Police type x hospitalised (yes/no)
- Road user type x crash opponent (yes/no) x hospitalised (yes/no)

NB: the interaction police type x hospitalised is useful as it appears that information of hospital admission is not accurate; it seems that it is sometimes an evaluation made by the police, and not the information from the hospital.

Results-examples

Below (Table A 4) and are examples of estimated probability of MAIS ≥ 3 for some groups of casualties from the modelling.

Table A 4 estimated probability of MAIS ≥ 3 for some groups of casualties from the modelling

Road user	Crash opponent	P(MAIS ≥ 3)
M2W	M2W	0.42
M2W	pedest-cyclist	0.45
M2W	van	0.54
M2W	none	0.53
M2W	heavy vehicle	0.59
M2W	car-other	0.46
bicycle	M2W	0.36
bicycle	pedest-cyclist	0.38
bicycle	van	0.48
bicycle	none	0.45
bicycle	heavy vehicle	0.53
bicycle	car-other	0.40
car	M2W	0.20
car	pedest-cyclist	0.21
car	van	0.28
car	none	0.33
car	heavy vehicle	0.33
car	car-other	0.22
pedestrian	M2W	0.42
pedestrian	pedest-cyclist	0.44
pedestrian	van	0.53
pedestrian	heavy vehicle	0.58
pedestrian	car-other	0.45

Table A 5 Estimated probability of MAIS ≥ 3 for Hospitalised casualties (according to police) who crashed in urban areas, in "police" areas, men, aged 30-54, in a non-fatal crash

oad user	Crash opponent	P(MAIS ≥ 3)
M2W	M2W	0.42
M2W	pedest-cyclist	0.45
M2W	van	0.54
M2W	none	0.53
M2W	heavy vehicle	0.59
M2W	car-other	0.46
bicycle	M2W	0.36
bicycle	pedest-cyclist	0.38
bicycle	van	0.48
bicycle	none	0.45
bicycle	heavy vehicle	0.53
bicycle	car-other	0.40
car	M2W	0.20
car	pedest-cyclist	0.21
car	van	0.28
car	none	0.33
car	heavy vehicle	0.33
car	car-other	0.22
pedestrian	M2W	0.42
pedestrian	pedest-cyclist	0.44
pedestrian	van	0.53
pedestrian	heavy vehicle	0.58
pedestrian	car-other	0.45

Table A 6 Estimated probability of MAIS ≥ 3 for Non-hospitalised casualties (according to police) who crashed in urban areas, in "police" areas, men, aged 30-54, in a non-fatal crash

Road user	Crash opponent	P(MAIS ≥ 3)
M2W	M2W	0.04
M2W	pedest-cyclist	0.05
M2W	van	0.07
M2W	none	0.12
M2W	heavy vehicle	0.08
M2W	car-other	0.05
bicycle	M2W	0.02
bicycle	pedest-cyclist	0.02
bicycle	van	0.04
bicycle	none	0.03
bicycle	heavy vehicle	0.04
bicycle	car-other	0.03
car	M2W	0.01
car	pedest-cyclist	0.01
car	van	0.02
car	none	0.04
car	heavy vehicle	0.02
car	car-other	0.01
pedestrian	M2W	0.06
pedestrian	pedest-cyclist	0.07
pedestrian	van	0.10
pedestrian	heavy vehicle	0.12
pedestrian	car-other	0.07

These estimated probabilities are then applied to the national police data, according to the casualty and crash characteristics, with the assumption that these characteristics are enough to predict the severity of the casualties, on average (not at an individual level), and that the sample on which this model is constructed is not biased compared to the national police data.

These estimated probabilities are also applied to the Rhône police data to obtain the estimated number of MAIS 1 / 2 / 3+ casualties in the Rhône police data, which will be used to estimate the correction factors (see step 2 below).

Discussion and limitations

The estimation of the proportion of MAIS ≥ 3 among casualties all severities is based on two assumptions. First, the subset on which the model is constructed should be representative of the national police data (as it is applied on these). Secondly, it assumes that the model is "good": that it includes enough casualty and crash variables to correctly predict the proportion of MAIS ≥ 3 (on average, for given groups of casualties) according to these characteristics.

Step 2: Correction factors.

How are correction factors defined?

They are estimated as the ratio between the total number of road casualties estimated by capture-recapture on the road trauma registry and the police data, at the Rhône level (see French experience in Appendix D: Study 4. Record-linkage methods). This is done through a multivariate multinomial logit model.

The response variable is the source of the data: either common linked records between the police and registry data, or unlinked of police data, or unlinked registry data.

The variables included in the multivariate model are those that influence the probability of reporting in the police data. These are:

- type of police force (CRS / gendarmerie / police),
- type of road network,
- year in a quantitative mode,
- injury severity (hospitalised (yes/no),
- injury severity (MAIS 1 / 2 / 3+),
- whether the crash was fatal or not,
- mode of transport (pedestrian / cyclists / MTW user / car occupant / other vehicle),
- whether there was a crash opponent (yes/no)

and possible interactions: at least:

- type of police force * injury severity
- mode of transport * crash opponent (yes / no)

At this stage, we work on MAIS1+ casualties. In the unlinked registry data, the number of MAIS 1 / 2 / 3+ casualties correspond to the observed number of MAIS 1 / 2 / 3+ casualties; whereas in the unlinked police data plus the common linked data (= police data), it corresponds to the estimated number of MAIS 1 / 2 / 3+ casualties, after application at the Rhône level, of the prediction model of MAIS constructed in the first step.

Below are some of the correction factors estimated by the capture-recapture multivariate modelling. These have to be applied on frequencies, for specific characteristics (those included in the model; they are listed in the table below (+ type of road + type of police+ year)).

Table A 7 Examples of correction factors for under-reporting in police data (on national and county roads, 2011, police type= "police"), based on capture-recapture modelling, Rhône data, 2006-2012, n=56911 MAIS1+ casualties

Mode of transport	Crash opponent?	Accident severity	Severity (hospitalised or not)	Severity (MAIS)	Correction factor
MTW users	yes	injury crash	hospitalised	MAIS1	1.1
MTW users	yes	injury crash	hospitalised	MAIS2	1.1
MTW users	yes	injury crash	hospitalised	MAIS ≥ 3	1.0
MTW users	yes	injury crash	non-hospitalised	MAIS1	1.7
MTW users	yes	injury crash	non-hospitalised	MAIS2	1.4
MTW users	yes	injury crash	non-hospitalised	MAIS ≥ 3	1.2
MTW users	yes	fatal crash	hospitalised	MAIS1	1.0
MTW users	yes	fatal crash	hospitalised	MAIS2	1.0
MTW users	yes	fatal crash	hospitalised	MAIS ≥ 3	1.0
MTW users	yes	fatal crash	non-hospitalised	MAIS1	1.0
MTW users	yes	fatal crash	non-hospitalised	MAIS2	1.0
MTW users	yes	fatal crash	non-hospitalised	MAIS ≥ 3	1.0
MTW users	no	injury crash	hospitalised	MAIS1	2.6
MTW users	no	injury crash	hospitalised	MAIS2	1.9
MTW users	no	injury crash	hospitalised	MAIS ≥ 3	1.6
MTW users	no	injury crash	non-hospitalised	MAIS1	10.1
MTW users	no	injury crash	non-hospitalised	MAIS2	6.3
MTW users	no	injury crash	non-hospitalised	MAIS ≥ 3	4.3
MTW users	no	fatal crash	hospitalised	MAIS1	1.1
MTW users	no	fatal crash	hospitalised	MAIS2	1.0
MTW users	no	fatal crash	hospitalised	MAIS ≥ 3	1.0
MTW users	no	fatal crash	non-hospitalised	MAIS1	1.5
MTW users	no	fatal crash	non-hospitalised	MAIS2	1.3
MTW users	no	fatal crash	non-hospitalised	MAIS ≥ 3	1.2
cyclists	yes	injury crash	hospitalised	MAIS1	1.3
cyclists	yes	injury crash	hospitalised	MAIS2	1.2

Mode of transport	Crash opponent?	Accident severity	Severity (hospitalised or not)	Severity (MAIS)	Correction factor
cyclists	yes	injury crash	hospitalised	MAIS ≥ 3	1.1
cyclists	yes	injury crash	non-hospitalised	MAIS1	2.0
cyclists	yes	injury crash	non-hospitalised	MAIS2	1.6
cyclists	yes	injury crash	non-hospitalised	MAIS ≥ 3	1.4
cyclists	yes	fatal crash	hospitalised	MAIS1	1.0
cyclists	yes	fatal crash	hospitalised	MAIS2	1.0
cyclists	yes	fatal crash	hospitalised	MAIS ≥ 3	1.0
cyclists	yes	fatal crash	non-hospitalised	MAIS1	1.1
cyclists	yes	fatal crash	non-hospitalised	MAIS2	1.0
cyclists	yes	fatal crash	non-hospitalised	MAIS ≥ 3	1.0
cyclists	no	injury crash	hospitalised	MAIS1	25.3
cyclists	no	injury crash	hospitalised	MAIS2	15.2
cyclists	no	injury crash	hospitalised	MAIS ≥ 3	9.8
cyclists	no	injury crash	non-hospitalised	MAIS1	97.3
cyclists	no	injury crash	non-hospitalised	MAIS2	57.4
cyclists	no	injury crash	non-hospitalised	MAIS ≥ 3	35.8
cyclists	no	fatal crash	hospitalised	MAIS1	2.2
cyclists	no	fatal crash	hospitalised	MAIS2	1.7
cyclists	no	fatal crash	hospitalised	MAIS ≥ 3	1.4
cyclists	no	fatal crash	non-hospitalised	MAIS1	5.9
cyclists	no	fatal crash	non-hospitalised	MAIS2	3.8
cyclists	no	fatal crash	non-hospitalised	MAIS ≥ 3	2.8
car occupants	yes	injury crash	hospitalised	MAIS1	1.2
car occupants	yes	injury crash	hospitalised	MAIS2	1.1
car occupants	yes	injury crash	hospitalised	MAIS ≥ 3	1.1
car occupants	yes	injury crash	non-hospitalised	MAIS1	2.0
car occupants	yes	injury crash	non-hospitalised	MAIS2	1.6
car occupants	yes	injury crash	non-hospitalised	MAIS ≥ 3	1.4

Mode of transport	Crash opponent?	Accident severity	Severity (hospitalised or not)	Severity (MAIS)	Correction factor
car occupants	yes	fatal crash	hospitalised	MAIS1	1.0
car occupants	yes	fatal crash	hospitalised	MAIS2	1.0
car occupants	yes	fatal crash	hospitalised	MAIS ≥ 3	1.0
car occupants	yes	fatal crash	non-hospitalised	MAIS1	1.1
car occupants	yes	fatal crash	non-hospitalised	MAIS2	1.0
car occupants	yes	fatal crash	non-hospitalised	MAIS ≥ 3	1.0
car occupants	no	injury crash	hospitalised	MAIS1	1.4
car occupants	no	injury crash	hospitalised	MAIS2	1.2
car occupants	no	injury crash	hospitalised	MAIS ≥ 3	1.2
car occupants	no	injury crash	non-hospitalised	MAIS1	3.4
car occupants	no	injury crash	non-hospitalised	MAIS2	2.4
car occupants	no	injury crash	non-hospitalised	MAIS ≥ 3	1.9
car occupants	no	fatal crash	hospitalised	MAIS1	1.0
car occupants	no	fatal crash	hospitalised	MAIS2	1.0
car occupants	no	fatal crash	hospitalised	MAIS ≥ 3	1.0
car occupants	no	fatal crash	non-hospitalised	MAIS1	1.1
car occupants	no	fatal crash	non-hospitalised	MAIS2	1.1
car occupants	no	fatal crash	non-hospitalised	MAIS ≥ 3	1.0
pedestrians	yes	injury crash	hospitalised	MAIS1	1.2
pedestrians	yes	injury crash	hospitalised	MAIS2	1.1
pedestrians	yes	injury crash	hospitalised	MAIS ≥ 3	1.1
pedestrians	yes	injury crash	non-hospitalised	MAIS1	1.7
pedestrians	yes	injury crash	non-hospitalised	MAIS2	1.4
pedestrians	yes	injury crash	non-hospitalised	MAIS ≥ 3	1.3
pedestrians	yes	fatal crash	hospitalised	MAIS1	1.0
pedestrians	yes	fatal crash	hospitalised	MAIS2	1.0
pedestrians	yes	fatal crash	hospitalised	MAIS ≥ 3	1.0
pedestrians	yes	fatal crash	non-hospitalised	MAIS1	1.0

Mode of transport	Crash opponent?	Accident severity	Severity (hospitalised or not)	Severity (MAIS)	Correction factor
pedestrians	yes	fatal crash	non-hospitalised	MAIS2	1.0
pedestrians	yes	fatal crash	non-hospitalised	MAIS ≥ 3	1.0
others	yes	injury crash	hospitalised	MAIS1	1.1
others	yes	injury crash	hospitalised	MAIS2	1.1
others	yes	injury crash	hospitalised	MAIS ≥ 3	1.0
others	yes	injury crash	non-hospitalised	MAIS1	1.3
others	yes	injury crash	non-hospitalised	MAIS2	1.2
others	yes	injury crash	non-hospitalised	MAIS ≥ 3	1.1
others	yes	fatal crash	hospitalised	MAIS1	1.0
others	yes	fatal crash	hospitalised	MAIS2	1.0
others	yes	fatal crash	hospitalised	MAIS ≥ 3	1.0
others	yes	fatal crash	non-hospitalised	MAIS1	1.0
others	yes	fatal crash	non-hospitalised	MAIS2	1.0
others	yes	fatal crash	non-hospitalised	MAIS ≥ 3	1.0
others	no	injury crash	hospitalised	MAIS1	1.5
others	no	injury crash	hospitalised	MAIS2	1.3
others	no	injury crash	hospitalised	MAIS ≥ 3	1.2
others	no	injury crash	non-hospitalised	MAIS1	2.8
others	no	injury crash	non-hospitalised	MAIS2	2.1
others	no	injury crash	non-hospitalised	MAIS ≥ 3	1.7
others	no	fatal crash	hospitalised	MAIS1	1.0
others	no	fatal crash	hospitalised	MAIS2	1.0
others	no	fatal crash	hospitalised	MAIS ≥ 3	1.0
others	no	fatal crash	non-hospitalised	MAIS1	1.1
others	no	fatal crash	non-hospitalised	MAIS2	1.1
others	no	fatal crash	non-hospitalised	MAIS ≥ 3	1.0

For example, for people injured as MTW users, in an injury crash (=non-fatal), without opponent, classified as non-hospitalized by the police, the police-recorded number of MAIS1, MAIS2 and MAIS ≥ 3 casualties respectively, must be multiplied by 10.1, 6.3 and 4.3 respectively, to obtain the estimated real number of MAIS1, MAIS2 and MAIS ≥ 3 injured people, respectively.

These correction factors are hence applied to the national police data (on which the prediction model of MAIS has been applied in the first step), with the assumption that police reporting practices are rather homogenous across the French territory, for a given police type, and for given crash and casualty characteristics. In particular, it is assumed that the amount of under-reporting, and of its biases, observed in the Rhône is roughly the same elsewhere in France.

Some examples of results

The estimations presented below are based on prediction of MAIS first (based on the subset of "common linked data between police data and the road trauma registry", on the Rhône county), followed by capture-recapture.

For 2012, in France, the number of MAIS1+ road casualties according to the police data is 75 900, while it is estimated at 292 600. Table A 8 gives the figures by road user type.

Table A 8 Number or MAIS1+ by road user type, France, 2012

MAIS1+	MTW users	Cyclists	Car occupants	Pedestrians	Others	Total
Police data	23403	3913	33734	11248	3634	75932
Estimated	93502	51921	114093	23941	9148	292605

Below (
Table A 9) is the estimation of the number of MAIS ≥ 3 casualties.

Table A 9 Estimated number of MAIS ≥ 3 and observed number of deaths within 30 days, France, 2006-2012

year	MAIS ≥ 3	killed	Ratio MAIS ≥ 3 / killed
2006	33144	4708	7.0
2007	33131	4620	7.2
2008	31397	4275	7.3
2009	30726	4271	7.2
2010	28462	3992	7.1
2011	28035	3963	7.1
2012	25540	3652	7.0

This estimation gives a ratio of 7 MAIS ≥ 3 casualties for 1 killed.

Discussion and limitations

The use of capture-recapture is based on a number of assumptions (see Chapter 5 on the use of record-linkage data). The main implication on the results is that, because of positive dependency between police and paramedics on the crash scene, the estimated total number of casualties is a lower bound.

The application of the correction factors estimated on Rhône data to the national police data is based on another assumption: that police reporting practices are homogenous across the French territory, for a given police type, and for given crash and casualty characteristics. Note that we do NOT extrapolate the Rhône accidentality characteristics (estimated from the Registry linked with the policedata) but the police reporting characteristics, from Rhône to France.

The estimated real number of MAIS1+ casualties generates a ratio of about 79 injured people for one death (versus 21 according to police data) which is close to the ratios observed in countries like Germany and UK (2009 data).

EXPERIENCE OF AUSTRIA

Introduction

In 2014, KFV carried out a feasibility study for the calculation of an indicator for the number of seriously injured road accident victims in Austria. The study was commissioned by the Austrian Road Safety Fund in view of the European Commission's goal to introduce a common definition for serious traffic injuries based on medical evidence.

Of the three main options offered by the Commission to the Member States, this feasibility study focused on options one and two:

1. continue to use the police data but apply a correction coefficient;
2. report the number of injured based on data from hospitals;
3. create a link between police and hospital data.

The study described in this chapter contains a description of the application of option 1.

Background description of Austrian road accident data (police data)

In Austria, nationwide traffic accident statistics is maintained by Statistics Austria since 1961. It is based on a standard accident registration form collected by the Federal Police. It covers all road traffic accidents that occur on a public road in Austria and that involve both people being injured or killed and at least one moving vehicle.

Three degrees of injury severity of an accident victim are distinguished: fatal (death at the scene or within 30 days after the accident), severe and slight. Whether an injury is severe or slight is determined by §84 of the Austrian criminal code (StGB). A severe injury is one that causes a health problem or occupational disability longer than 24 days, or one that "causes personal difficulty". An injury or health problem that "causes personal difficulty" is one that affects an "important organ", if it results in a "health handicap", if the "healing process is uncertain", or if it leads to the fear of "additional effects". Injury severity is assessed either directly by the police on the scene (in most cases) or by a subsequent indication from a hospital.

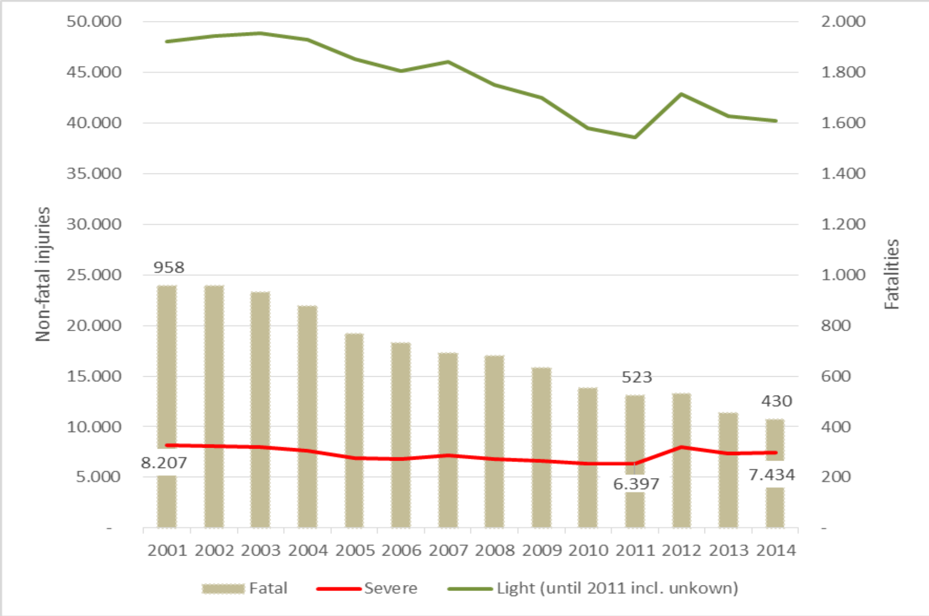


Figure A 4 Police road accident data by injury severity

Source: STATISTICS AUSTRIA, 2013. In 2012, a revised survey method has been implemented; a direct comparison with previous results is not permitted.

Compared to the trend in road accident fatalities (-45%), between 2001 and 2011, the number of severely injured persons has decreased far less (-16%). The ratio of fatal to severe injuries has increased from 1 to 8.6 in 2001 to 1 to 12.2 in 2011.

Background description of Austrian hospital data

The Austrian hospital discharge dataset (HDR) covers all persons who were admitted to a hospital (inpatients, as opposed to outpatients who only visited the Emergency Department). In 2011, the HDR covered 273 hospitals (173 for acute cases) with 2.8 million discharges (2.2 million acute cases), 282.000 of which had an injury diagnosis (214.000 acute cases).

All types of hospitals in Austria are legally obliged to document all inpatient episodes according to the WHO ICD-10 guidelines (Version ICD-10 BMSG 2001). Unfortunately, this ICD-10 version has only very limited options for coding the accident cause (referred to as U-codes), two of which can be used to identify road traffic accidents (U11 and U12):

U01 occupational accident - excl.: traffic accident
U02 school accident - excl.: traffic accident
U11 traffic accident - excl.: as an occupational accident
U12 traffic accident as an occupational accident - incl.: traffic accident on the way to/from work/school
U21 sports accident
U22 accident during housekeeping
U23 accident during home improvement and gardening
U29 other accidents during home and leisure activities in the private sector
U31 suicide attempt or deliberate self-harm
U41 deliberate violation by other persons
U99 other causes of exogenous injuries

According to Figure A 4 HDR cases explicitly coded as road accidents has decreased from about 18.000 in 2001 to about 12.000 in 2012. Furthermore, a high number of patients involved in an accident has been attributed an "unspecified accident" U-code. This number seems to be subject to considerable systematic changes over the years.

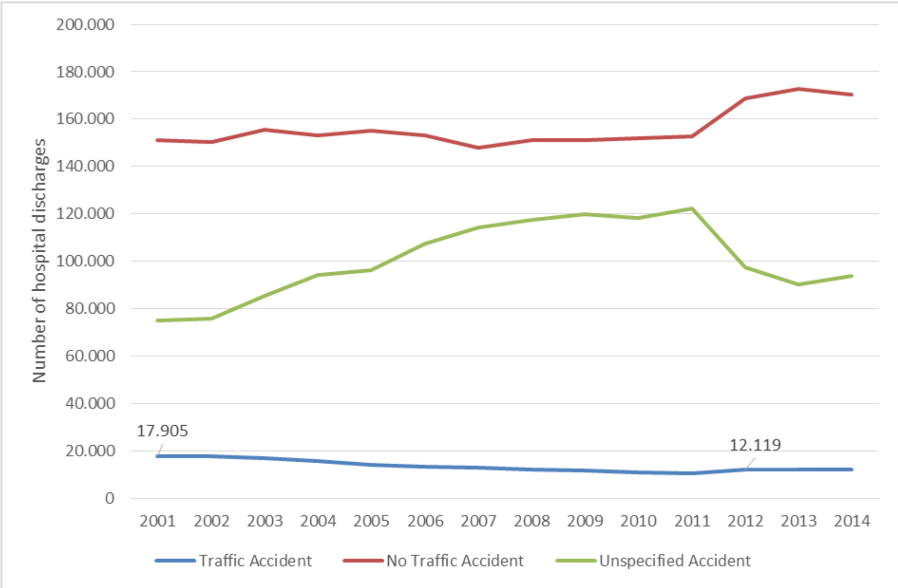


Figure A 5 Injury Hospital Discharges by "Cause"

Source: STATISTICS AUSTRIA, hospital discharge register.

Why are correction factors used?

Correction factors are both used in the context of method 1 ("continue to use the police data but apply a correction coefficient") and method 2 ("hospital data") proposed by the European Commission to estimate the number of MAIS ≥ 3 victims. With respect to method 2, correction factors are used in order to adjust HDR for re-admissions, potential traffic accidents in the group of unspecified accidents and potential MAIS ≥ 3 victims in the group of cases that could not be mapped to AIS (we referred in this deliverable as weighting factors see Chapter 4).

How are correction factors defined?

The general procedure for the calculation of the MAIS ≥ 3 indicator for both options - as indicated above - is illustrated in Figure A 6.

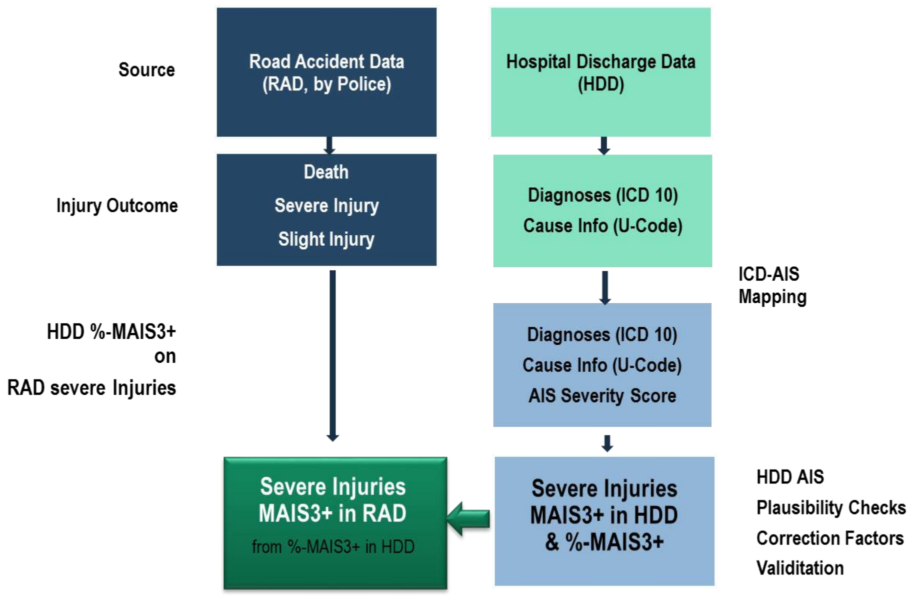


Figure A 6 Data and procedural options in Austria for the calculation of the of the MAIS ≥ 3 indicator

Calculation of the MAIS ≥ 3 correction factor for the police data

The procedure of the first option ("continue to use the police data but apply a correction coefficient") in the Austrian experience comprised the following steps (the figures provided are calculated for 2012):

1. An accident case definition was applied to the full set of HDR data:
- 282,187 HDR patients with both an injury diagnosis from ICD-chapter XIX (S and T codes) and a valid external cause code refereeing a traffic accident (U-code) were selected from the full HDR set for the subsequent analysis

2. Traffic accident casualties were identified by the respective U-codes (U11 and U12 for traffic accidents):
- 12,119 traffic accident casualties were selected (from 282,187 HDR accident or injury cases)

3. An "ICD-10 to AIS" mapping was performed for casualties selected in step 2 according to the mapping table provided by the University of Navarra. Only one diagnosis, the so-called main diagnosis was available for the mapping.
- 10,488 traffic accident casualties (86,5% out 12,119) received an AIS score between 1 and 6, 87 (1,2%) a score of 9 and 1,544 (12,7%) could not be mapped

4. Traffic accident casualties with a positive AIS assignment (excluding score 9) were grouped into MAIS1+2 and MAIS ≥ 3 categories
- 9,265 traffic accident casualties (88,3% out of 10,488) fell into category MAIS1+2
- 1,223 traffic accident casualties (11,7%) fell into category MAIS ≥ 3

5. The MAIS ≥ 3 proportion was calculated using the MAIS ≥ 3 category without AIS score 9
- 11,7% or 1,223 of 10,488 traffic accident casualties fell into category MAIS ≥ 3

6. Application of the MAIS ≥ 3 proportion to the number of severely injured from the police data
- In 2012, the police data indicated a number of 8,017 severely injured

- 11,7% or 935 of these accident casualties are considered MAIS ≥ 3 road accident victims. This number of 935 MAIS ≥ 3 road victims is considered as an indicator only and does not necessarily reflect the "true number" of MAIS ≥ 3.

Table A 10 ICD10 to AIS Mapping: Distribution of AIS Severity Scores for road accidents in HDR - absolute numbers

	Traffic accidents (U11, U12)							
	AIS							
Year	1 and 2	3+	9	no AIS	Total (U11, U12)	Other accidents	Unspecified accidents (U99)	All HDR accidents
2001	13903	1646	274	2082	17905	155512	75038	248455
2002	13481	1691	216	2332	17720	154828	76008	248556
2003	12822	1548	207	2446	17023	159600	85310	261933
2004	11820	1489	209	2409	15927	157132	94305	267364
2005	10593	1341	207	2005	14146	159212	96488	269846
2006	10124	1266	204	2025	13619	156931	107342	277892
2007	9659	1265	231	1939	13094	151495	114232	278821
2008	9306	1147	232	1639	12324	154418	117420	284162
2009	9049	1135	138	1629	11951	154404	119877	286232
2010	8520	1101	108	1414	11143	155387	118256	284786
2011	8143	1109	102	1277	10631	156132	122464	289227
2012	9265	1223	87	1544	12119	172482	97586	282187

Table A 11 ICD10 to AIS Mapping: Distribution of AIS Severity Scores for road accidents in HDR - percentages

	Traffic accidents (U11, U12)							
	AIS							
Year	1 and 2	3+	9	no AIS	Total (U11, U12)	Other accidents	Unspecified accidents (U99)	All HDR accidents
2001	78%	9%	2%	12%	100%	63%	30%	100%
2002	76%	10%	1%	13%	100%	62%	31%	100%
2003	75%	9%	1%	14%	100%	61%	33%	100%
2004	74%	9%	1%	15%	100%	59%	35%	100%
2005	75%	9%	1%	14%	100%	59%	36%	100%
2006	74%	9%	1%	15%	100%	56%	39%	100%
2007	74%	10%	2%	15%	100%	54%	41%	100%
2008	76%	9%	2%	13%	100%	54%	41%	100%
2009	76%	9%	1%	14%	100%	54%	42%	100%
2010	76%	10%	1%	13%	100%	55%	42%	100%
2011	77%	10%	1%	12%	100%	54%	42%	100%
2012	76%	10%	1%	13%	100%	61%	35%	100%

Source: STATISTICS AUSTRIA, hospital discharge register.

Discussion and limitations

It is estimated that 11,7% or 935 of seriously injured in police data are considered to be MAIS ≥ 3 road accident victims.

This estimate has some limitations:
- the estimate is based on the main diagnosis only
- the estimate of the number of MAIS ≥ 3 victims among the seriously injured registered by police is lower than the number of MAIS ≥ 3 victims found in hospital data

Austria developed another estimation method based on method 2 of the EC. This method is described in Chapter 3.

Appendix B: Criteria for inclusion / exclusion road traffic injuries from health data sources

This chapter describes the sensitivity analysis done in order to explore how the number of serious injuries varies depending on the criteria used for selecting cases, using hospital data from Spain and from Netherlands.

Hospital databases are one of the main ways that Member States collect data on serious traffic injuries. The quality of the data differs by Member States and the numbers may not be fully comparable between Member States.

Since January 2013, the definition of serious injuries as in-patients with an injury level of MAIS ≥ 3 was established by the High Level Group on Road Safety representing all EU Member States. However, up to now, there are no clear recommendations about how to select traffic cases from health data sources. There is no consensus on what codes of diagnosis need to be included, on what Codes of External Cases (E-code) should be selected or on which patients should be included.

An agreement on the optimal definition should be reached. The effect of including or not some parameters has to be studied in order to define the optimal definition of serious traffic injuries.

The aim of this chapter is to run some sensitivity analyses in order to examine the effect of certain choices concerning in- and exclusion criteria based on codes of the International Classification of Diseases/injuries (ICD9-CM, ICD10) with the aim to arrive at a common consensus on codes to report road traffic serious injuries.

The main parameters to explore will be:

- How to treat deaths before and after 30 days
- Whether or not scheduled admissions should be included
- Whether or not readmissions should be included
- How to treat hospitalisations of 1 day treatment or less
- ICD9-CM
    - Inclusion of E-codes E827-E829, E929.0 and E988.5
    - Usefulness of the E-code E849. (Place of the occurrence of the accident)
    - Inclusion of people without any traumatic injury (800-959)
    - Inclusion of codes 905-909 and 959
- Traumatic injury only in the main diagnosis or in any diagnosis
- ICD10

We analysed data from two countries, Spain and the Netherlands. The results are presented separately by countries and finally common conclusions are discussed.

EXPERIENCE OF SPAIN

Methods

In Spain, two data sources were used: On one hand, we used the Spanish Database from Hospital Discharge Register (HDR) for 2011 to analyse criteria based on ICD9-CM. This database includes all hospitalisations for any injury (traffic and non-traffic) in Spain from all public hospitals and around 99% of private hospitals. The population of study is all the Spanish population. At a first stage; the unit of analysis of the database are admissions, not individuals. We need therefore to identify individuals because the same individual may have multiple admissions. Spain has been coding diseases and injuries using the International Classification of Diseases 9th revision, Clinical Modification (ICD9-CM) until December 2015 when the process of coding changed to ICD10. The database includes up to 14 diagnoses (including diagnosis of injuries, diseases and codes of external causes).

On the other hand, to analyse criteria based on ICD10, we used data from the National Register of Mortality for the years 2009-2013. We included cases with ICD10 codes V01 to V99. Spain codifies mortality with ICD10 since year 2000.

The Spanish General Directorate of Traffic (DGT) in accordance with Eurostat defines: Road traffic collision with victims: collision occurring or starting on a road which is object of motor vehicle traffic and road safety legislation (public road), involving at least one vehicle in motion, and which results in the death and/or injury of one or more people.

ICD9-CM

For the purposes of this study, first of all, it is necessary to define the core definition of traffic injury that has been considered based on previous studies ((Pérez et al., 2014). Due to the frequently missing information of the code of external cause (E code) we consider also the compensation payer company to identify traffic injury cases.

Traffic injuries must meet criteria 1 or criteria 2:

1. **E-codeforexternal (ICD9-CM): E810-819, E826-829, E929, E988.5.**
2. **Accident compensation payer: "Traffic accident insurance Company".**

The Hospital Discharge Register (HDR) included 258,432 episodes of hospitalisationsduring 2011 due to all causes of injuries. Out of them, there were 31,338 traffic admissions in Spain according to the criteria 1 or 2 (E-code or Accident compensation payer). The distribution of cases with E-code and with or without accident compensation payer (traffic insurance) is shown in Table B 1.

Table B 1 Distribution of traffic injury hospitalisations according E-code information and accident compensation payer. Hospital Discharge Register, Spain 2011

		Accident compensation payer		
Traffic E-code for external cause		Yes	No	Total
	Yes	12,075	11,315	23,390
	No	7,948	/	7,948
	Total	20,023	11,315	**31,338**

AIS and MAIS

Severity has been defined by the Maximum Abbreviated Injury Score (MAIS).The MAIS is the maximum of the AIS (Abbreviated Injury Score) scores, and is frequently used for assessing overall severity. It does not necessary havea linear relationship with the probability of death. Severity has been categorised as MAIS0-2 or MAIS ≥ 3, considering severe injuries those of MAIS ≥ 3.

For ICD9-CM, AIS and MAIS have been derived from the icdpic module of Stata ("STATA Data Analysis and Statistical Software," n.d.) from the 14 diagnosis reported in the Spanish Hospital Discharge Database for 2011.

For ICD10 it has not been possible to derive MAIS (a part from that all cases are fatalities) because there is no information in the data set about injuries. There is only information about the external cause of injury. Therefore we used this information to show the distribution of ICD10 codes stratified by traffic and non-traffic, in order to establish criteria for inclusion.

Results

Several issues have been explored in order to determine its influence and its suitability in the final definition of road traffic injuries. The different impact of all these factors have been studied both for minor and severe traffic injuries.

How to treat fatalities?

According to the Spanish Hospital Discharge Register (HDR), 31,338 persons were hospitalised due to traffic injury in 2011: 583 people died (526 people died within 30 days after admission in hospital and 57 died 30 days or more after admission), 21,835 were slightly injured (MAIS0-2) and 8,888 were severely injured (MAIS ≥ 3). (Table B 2)

Eighteen fatalities that died 30 days or more after admission had slight or moderate injuries (MAIS = 0-2). 66% were male, and forboth sexes, 50% were younger than 60.

Table B 2 Hospital admissions in Spain according to severity of injury and final outcome. Hospital Discharge Register, Spain 2011

			Traffic Injuries	Other Injuries	Total
		Severity			
Deaths	Death within 30 days	MAIS0-2	73	1,086	1,159
		MAIS ≥ 3	453	4,694	5,147
		Unknown	0	84	84
	Total Deaths		526	5,864	6,390
Injured	Death after 30 days	MAIS0-2	18	84	102
		MAIS ≥ 3	39	317	356
		Unknown	0	25	25
	Alive	MAIS0-2	21,835	143,120	164,955
		MAIS ≥ 3	8,888	74,548	83,436
		Unknown	33	3,135	3,168
	Total Injured		30,813	221,229	251,559
Total			31,339 (12.1%)	227,093 (87.9%)	258,432

A person who is admitted to hospital, but finally dies within 30 days after the admission, should be accounted as a fatality and, therefore not computed as severe injured. Otherwise there will be double counted with the police registers, which include road traffic fatalities up to 30 days after the collision. If the person dies after 30 days, it should be counted injured according to his/her MAIS.

From this point and for the purposes of this study, deaths before 30 days (n= 526, 0) are excluded for the sensitivity analyses. Deaths after 30 days are distributed according their MAIS. Therefore, the database includes 30,813 admissions.

In the case that the total number of traffic injuries was available but not the distribution of injuries and deaths within 30 days, the total number of traffic injured people (alive within 30 days) could be calculated by multiplying the total number of total injuries by **a weighting factor** in each case.Based on the Spanish data this factor would be 8,927 / 9,380=0.952 in order to calculate the total number of MAIS ≥ 3 alive after 30 days and 30,813 / 31,339=0.983 to calculate the total number of alive injured for traffic.

Readmissions

There could be admissions that are a second episode of an injury, even though they are not scheduled. These are known as readmissions and it is suggested to exclude them to avoid double counting. Among severe traffic injuries (MAIS ≥ 3) 2.3% were readmissions. In Spain readmissionhas been defined as one or more episodes due to the same reason for attendance within 30 days in the same hospital. This is a standard definition used by the HDR. Admissions in different hospitals or within a calendar year are impossible to identify with the current database in Spain. (Table B 3)

Table B 3 Traffic readmissions by severity. Hospital Discharge Register, Spain 2011

	MAIS0-2	MAIS ≥ 3	Unknown	Total
No readmission	20,875 (95.5%)	8,723 (97.7%)	32 (97%)	29,630
Readmission	978 (4.5%)	204 (2.3%)	1 (3%)	1,183
Total traffic injuries	21,853	8,927	33	30,813

It is suggested to exclude readmissions to avoid duplicates within a full calendar year. In some cases it is only possible to identify readmissions by month.

In the case that the number of readmissions is not known, the**weighted factor** that must be used based on the Spanish data would be 8,723 / 8,927=0.977 in order to calculate the total number of MAIS ≥ 3 excluding readmissions and 29,639 / 30,813=0.962to calculate the total number of traffic injuriesexcluding readmissions.

Emergency versus Scheduled

Hospital admissions could be through emergency attendance or scheduled. Among severe traffic injuries (MAIS ≥ 3) 6.2% were scheduled (Table B 4**Fout! Verwijzingsbron niet gevonden.**). These could be a second episode of a previous emergency injury. In order to avoid duplicates it would be convenient to exclude all these scheduled admissions but in some cases excluding readmissions is sufficient to avoid duplicates. In the case of Spain, among readmissions MAIS ≥ 3, 58.5% (n=121) were scheduled attendances, but among non-readmissions MAIS ≥ 3 4.8% (n=436) were scheduled admissions (Table B 4). Therefore, in this case it is it is suggested toexclude both scheduled and readmissions.

Table B 4 Traffic hospital admissions according to injury severity. Hospital Discharge Register, Spain 2011

	MAIS0-2	MAIS ≥ 3	Unknown	Total
Emergency	16,352 (74.8%)	8,376 (93.8%)	23 (69.7%)	24,751 (80.3%)
Scheduled	5,491 (25.1%)	551 (6.2%)	10 (30.3%)	6,052 (19.6%)
Unknown	10 (0%)	0 (0%)	0	10 (0%)
Total traffic injuries	21,853	8,927	33	30,813

In the case that the number of scheduled admissions is not known, the **weighting factor** that must be used based on the Spanish data would be 8,376 / 8,927=0.938 in order to calculate the total number of MAIS ≥ 3 excluding scheduled admissions and 24,751 / 30,813=0.803 to calculate the total number of traffic injuries excluding scheduled admissions.

Table B 5 Traffic hospital admissions and readmissions according scheduled or emergency attendance. Hospital Discharge Register, Spain 2011

	No Readmissions		Readmissions	
	MAIS ≥ 3	**Total**	**MAIS ≥ 3**	**Total**
Emergency	8,737 (95.2%)	24,834 (82.4%)	86 (41.5%)	432 (36.3)
Scheduled	436 (4.8%)	5,306 (17.6%)	121 (58.5%)	757 (63.6)
Unknown	0	9	0	1
Total	9,173	30,149	207	1,190

If the number of readmissions is known but it is not possible to know the number of scheduled admissions, two correction factors are provided based of Spanish data: 86/207=0.415 to calculate the total number of MAIS ≥ 3 excluding both readmissions and scheduled admissions and 432/1,190=0.363 to calculate the total number of traffic injuries.

Managing scheduled admissions can depend on the country. The aim is to avoid double counting. If it is possible to avoid duplicates just excluding readmissions, it is not necessary to exclude scheduled admissions. If not they should be excluded.

Overnight and non-hospitalisation

There are some doubts about how to treat hospitalisations which last less than one day. In the available HDR database of Spain there is only information on the date of admission, not the hour. Therefore it is not possible to know exactly how many people were admitted for less a day. Among severe traffic injuries (MAIS ≥ 3), 1.3% reported discharges the same date as admission, and 4.0% reported 1 day admission (Table B 6).

Table B 6 Days of hospitalisation of traffic hospital admissions by severity. Hospital Discharge Register, Spain 2011

	MAIS0-2	MAIS ≥ 3	Unknown	Total
0 days	140 (0.6%)	119 (1.3%)	0	259 (0.8%)
1 day	5,608 (25.7%)	356 (4.0%)	2 (6.1%)	5,966 (19.4%)
More	16,105 (73.7%)	8,452 (94.7%)	31 (93.9%)	24,588 (79.8%)
Total traffic Injuries	21,853	8,927	33	30,813

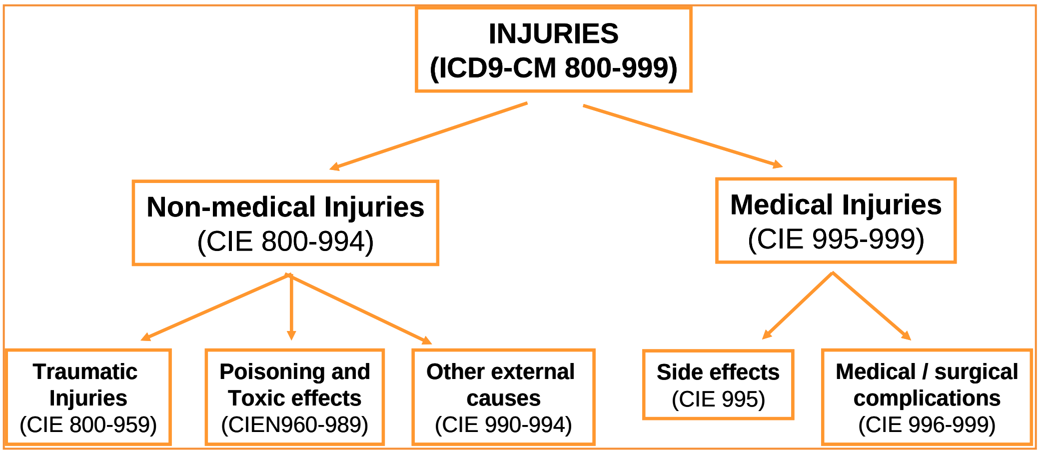
On the other hand, it can happen that patients with MAIS ≥ 3 are not hospitalized. The Hospital Emergency Register of Road Traffic Injuries of Barcelona (2003-2014) shows that only 0.4% (576 out of 131,788) of cases non-hospitalized attended at the Emergency Department are MAIS ≥ 3. In France, from the Register du Rhône (2006-2012), 5% of non-hospitalized patients were MAIS ≥

3(n=174 victims MAIS ≥ 3 out of 3,720 non hospitalized). According to the road trauma registry in the Rhône county (France), over the 2006-2012 period (N=55833 road traffic casualties not killed in the accident), the average hospitalization rate was 94.2% for MAIS=3, 99.7% for MAIS=4, and 100% for MAIS5+. 174 non-hospitalized casualties had AIS ≥ 3 lesions, mostly fractures. These injuries are not life-threatening but generally lead to hospitalization: 95% of casualties with one of these injuries are hospitalized. But sometimes, as is the case here, the casualty is not hospitalized. This can be due to various reasons: slightly displaced fracture and reduced on site, no more serious injury, mild amnesia, family context favourable for home-based care, problem of bed availability in hospitals, absence of serious pathology, non-hospitalization upon the request of the patient or discharge against medical advice, etc.

It is suggested to include all traffic injury hospitalisations in the definition because, although they have such a short hospitalisation, they might be transferred to other hospitals. They will be registered then as readmission or as a scheduled admission and not as an emergency. That means that it's unlikely to be duplicated.

Traumatic Injuries definition

Defining traumatic injuries derived from a traffic accident is a key issue because injury severity is calculated by the Maximum Abbreviated Injury Score (MAIS) which uses the traumatic injuries for its calculation. Not all injuries are traumatic. If they are not traumatic no AIS can be derived. Figure B 1 shows injury classification according to ICD9-CM.



Adapted from
Smith et al. Methodological issues in using hospital discharge data to determine the incidence of hospitalized injuries.Am J Epidemiol1991.

Figure B 1 Injury classification according to ICD9-CM.

According to the International Classification of Injuries (ICD9-CM) traumatic injury definition includes codes from 800 to 959. These include fracture, dislocation, sprain, internal injury, open wound, injury to blood vessel, superficial injury, contusion, crushing, foreign body entering through body orifice, burns, and injury to nerves and spinal cord. It also includes late effects of injury and complications of physical trauma (905 to 909, 958 and 959) (Table B 7).

Table B 7 Traumatic and non-traumatic injuries distribution by severity. Hospital Discharge Register, Spain 2011

	MAIS 0-2	MAIS ≥ 3	Unknown	Total
Traumatic Injuries (800-959)	18,180	8,927	33	**27,140**
No traumatic Injuries	329	0	0	**329***
Poisoning (960-989)	12	0	0	12
Other (990-994)	6	0	0	6
Medical side Effects (995)	12	0	0	12
Medical/Surgical complications (996-999)	302	0	0	302
No Injury	3,344			**3,344**
Total	**21,853**	**8,927**	**33**	**30,813**

** It does not sum up the total because a person can have more than one type of injuries*

Among severe injured (MAIS ≥ 3) 0.6% were late effects, 7.6% early complications of trauma, and 5.5% other injury unspecified (Table B 8).

Theoretically it would be more correct to include only cases with traumatic injuries, but by definition MAIS can only be derived if there is a traumatic injury. Therefore, in order to make easier the selection we recommend to include cases with any injury (ICD9CM 800-999).

Table B 8 Traffic hospital admissions including codes 905-909, 958 and 959, by severity. Hospital Discharge Register, Spain 2011

	Traffic Injuries			Total
	MAIS 0-2	MAIS 3+	Un-known	Total
905 Late effects of musculoskeletal and connective tissue injuries	356	25	0	381
906 Late effects of injuries to skin and subcutaneous tissues	37	4	0	41
907 Late effects of injuries to the nervous system	204	17	0	221
908 Late effects of other and unspecified injuries	44	8	0	52
909 Late effects of other and unspecified external causes	8	4	0	12
958 Certain early complications of trauma	172	681	1	854
959 Injury other and unspecified	1,103	493	0	1,596

Table B 9 Traffic hospital admissions according codes 905-909, 958 and 959, by severity. Hospital Discharge Register, Spain 2011

Traffic Injuries definition	MAIS0-2	MAIS ≥ 3	Total Traffic Injuries
Including codes 905-909, 958 and 959	21,853 (70.9%)	8,927 (29.1%)	30,813
Excluding codes 905-909, 958 and 959	18,180 (67.0%)	8,927 (32.9%)	27,140

*** Traffic injuries with unknown severity are not shown

A traumatic injury (defined by codes 800 to 959) could be the main/first diagnosis reported or could be one of many diagnoses. Consequently, case selection may differ whether it is based only on the main diagnosis or will consider all diagnosis.

Among severe traffic injured (MAIS ≥ 3) 25.7% have traumatic injuries diagnosis only in the main diagnostic, 1.7% in any secondary diagnoses (but not in the main), and 72.6% in both main and secondary diagnoses (
Table B 10).

Table B 10 Traumatic injuries in main or secondary diagnoses by severity. Hospital Discharge Register, Spain 2011

	MAIS0-2	MAIS ≥ 3	Unknown	Total
Traumatic injury only in the main diagnosis	9,584 (43.9%)	2,295 (25.7%)	6 (18.2%)	11,885
Traumatic injury only in secondary diagnoses	976 (4.5%)	150 (1.7%)	3 (9.1%)	1,129
Traumatic injuries in both main and secondary diagnoses	7,620 (34.9%)	6,482 (72.6%)	24 (72.7%)	14,126
No Traumatic injuries in any diagnostic	3,673 (16.8%)	0	0	3,673
Total	21,853	8,927	33	30,813

*** Traffic injuries with unknown severity are not shown

The traumatic injury diagnosis could be the main diagnosis or could be one of many diagnoses. The definition will change if one or the other criteria is used. For example, it can happen that in some cases such as pregnant women or a new-born the first diagnosis in case of traffic collision is always pregnancy. That means that, if we just select traumatic injuries of the first diagnosis, these cases would be excluded. Main diagnosis of those cases that present a traumatic injury but not in the main diagnostic is showed inTable B 11. Most of them are care diagnoses.

Table B 11 ICD9-CM codes for traffic injuries with traumatic injuries but not the first diagnostic. Hospital Discharge Register, Spain 2011

ICD9-CM Code	n
648.93 Other current conditions classifiable elsewhere of mother, antepartum condition or complication	18
717.83 Old disruption of anterior cruciate ligament	13
723.1 Cervicalgia	14
724.3 Sciatica	16
733.81 Malunion of fracture	24
733.82 Non-union of fracture	118
780.2 Syncope and collapse	22
996.49 Other mechanical complication of other internal orthopaedic device, implant, and graft	10
996.66 Infection and inflammatory reaction due to internal joint prosthesis	10
V54.01 Encounter for removal of internal fixation device	60
V57.1 Care involving other physical therapy	38
V57.89 Care involving other specified rehabilitation procedure	136
V58.43 Aftercare following surgery for injury and trauma	14
Others	636
Total	1,129

Code 849 (Place of occurrence)

The E-code 849 allows identifying the place of occurrence and can be useful to identify whether the collision occurred in a public or out of public way. As it can be seen in Table 11.1, the majority of cases do not have the E-code filled in and in many cases that code is filled in as "undefined". The usefulness of the E-code 849 is low at least for this moment in Spain.

Table 11.1 Place of occurrence of traffic hospital admissions, by severity. Hospital Discharge Register, Spain 2011

	MAIS0-2	MAIS ≥ 3	Total Traffic Injuries
Street or public via	2,774 (12.7%)	1,554 (17.4%)	4,331 (14.1%)
Undefined	1,016 (4.6%)	469 (5.3%)	1,487 (4.8%)
Others	213 (1.0%)	82 (0.9%)	296 (1.0%)
No code	17,850 (81.7%)	6,822 (76.4%)	24,699 (80.2%)

*** Traffic injuries with unknown severity are not shown

Selection of codes of external causesfor ICD9-CM (E-codes)

Codes for external causes (E-codes) defined as traffic injury includes: **E810-819, E826-829, E929, E988.5** codes. Codes **E820-825** are no traffic injuries.

In general there is agreement about includingcodes E810-819 ("Motor vehicle traffic accident") but it is not so clear about E826 ("Pedal cycle accident"). An unknown number of patients with E826 are not road victims, but are cyclists that had an accident on a private location (garden, sports fields etc.) or in rural paths or mountain tracks. This can be the case for children or adults biking for leisure.

As can be seen in Table B 12**Fout! Verwijzingsbron niet gevonden.**, among severe traffic injuries (MAIS ≥ 3) 11.4% are Pedal cycle accident (E826).

There is less consensus about including E827"Animal-drawn vehicle accident", E828 "Accident involving an animal being ridden", E829 "Other road vehicle accident" and E988.5 "Injury by crashing of motor vehicle, undetermined whether accidentally or purposely inflicted". The distribution of these cases can be seen in 0.These cases represent a very low proportion of cases (less than 0.3%) except for E828 ("Accident involving an animal being ridden") which represents 2.2% (n=193) of cases among severe traffic injuries (MAIS ≥ 3). Although in the case of Spain this distribution is very low, it is suggested to include all these E-codes: E827, E829 and E988.5 because maybe in other contexts they represent a higher percentage but to exclude E828. In Belgium, it is estimated that based on the "place of occurrence" code E849 less than 5% of E828victims were injured on public roads. Most of them were probably horse riders injured at a horse riding school or other private location.

Table B 12 Distribution of E-codes among traffic injuries, by severity. Hospital Discharge Register, Spain 2011

Traffic Injuries	MAIS0-2	MAIS ≥ 3	Total
No E-code	5,241 (24.0%)	811 (9.1%)	6,054 (19.6%)
E810-819 Motor vehicle traffic accident	11,620 (53.2%)	6,438 (72.1%)	18,075 (58.7%)
E826 Pedal cycle accident	2,716 (12.4%)	1,018 (11.4%)	3,734 (12.1%)
E827 Animal-drawn vehicle accident	18 (0.1%)	7 (0.1%)	25 (0.1%)
E828 Accident involving an animal being ridden	450 (2.1%)	193 (2.2%)	644 (2.1%)
E829 Other road vehicle accident	80 (0.4%)	28 (0.3%)	108 (0.4%)
E929.0 Late effects	228 (1%)	8 (0.1%)	238 (0.8%)
E988.5 Injury by crashing of motor vehicle, undetermined whether accidentally or purposely inflicted	1 (0%)	3 (0%)	4 (0%)
Other E-code	1,499 (6.9%)	421 (4.7%)	1,931 (6.3%)
Total	21,853	8,927	30,813

** Only taking into account the first E-code reported in each case.
*** Traffic injuries with unknown severity are not shown

In the case that it was not possible to identify E828 cases a **weighting factor** can be used to correct the numbers based on the Spanish data.This would be 1-(193/8,927)=0.978 in order to calculate the total number of MAIS ≥ 3 excluding E828 cases and 1-(644/30,813)= 0.979 to calculate the total number of traffic injuries excluding E828 cases.To identify E929 cases the **weighting factor** that can be used to correct the numbers is 1-(8/8,927)=0.999 in order to calculate the total number of MAIS ≥ 3 excluding E929 cases and 1-(238/30,813)= 0.992 to calculate the total number of traffic injuries excluding E929 cases.

Codes E820-E825 are listed in Table B 13 which includes a 3-column for traffic injuries with the definition we used until now in this chapter (n=30,813) and 3-column of non-traffic injuries from the overall database of hospitalisations due to injuries (n= 221,229). Among severe traffic injuries (MAIS ≥ 3), there are 42 cases that might be included as traffic injuries because they fulfil other criteria such road traffic compensation payer. We suggest excluding these E-codes as they would not fulfil police definition of "traffic accident".

Table B 13 Distribution of other E-codes among traffic injuries and non-traffic injuries by injury severity. Hospital Discharge Register, Spain 2011

	Traffic Injuries			Non-traffic Injuries			Total
	MAIS 0-2	MAIS 3+	Un-known	MAIS 0-2	MAIS 3+	Un-known	Total
E820 No traffic accident involving motor-driven snow vehicle	0	0	0	13	2	0	15
821 No traffic accident involving other off-road motor vehicle	9	8	0	46	34	0	97
E822 Other motor vehicle no traffic accident involving collision with moving object	2	3	0	12	8	0	25
E823 Other motor vehicle no traffic accident involving collision with stationary object	30	23	1	158	55	3	270
E824 Other motor vehicle no traffic accident while boarding and alighting	13	8	0	51	22	1	95
E825 Other motor vehicle no traffic accident of other and unspecified nature	0	0	0	0	0	0	0

In the case that it was not possible to identify codes E820-E825 a **weighting factor** can be used to correct the numbers based on the Spanish data.This would be 1-(42/8,927)= 0.995 in order to calculate the total number of MAIS ≥ 3 excluding E820-E825 cases and 1-(99/30,813)= 0.997 to calculate the total number of traffic injuries excluding E820-E825 cases.

It is suggested to include as E-codes: E810-E19, E826, E827, E829 and E988.5. Ifthe proportion of cases which occur on public roadsisknown, a random sample of these casescan be selected to avoid overestimation.
It is suggested to exclude E820-E825 and E828 as they would not fulfil police definition of "traffic accident".

If we would have included other E-codes, fatalities or readmissions, the following cases would have been selected additionally:

Table B 14 Traffic hospital admissions in the Spain according to all the different definitions. Hospital Discharge Register, Spain 2011

	MAIS ≥ 3	Weighting Factor	Total	Weighting Factor
Initial definition	9,380		31,338	
Including deaths within 30 days	39	0.95	57	0.98
Definition excluding deaths	8,927		30,813	
Including Readmissions	204	0.98	1183	0.96
Including E929	8	0.99	238	0.99
Including E828	193	0.98	644	0.98
Including E820-825	42	0.99	99	0.99

Externals causes for ICD10 (V codes)

According to ICD10, "A transport accident (V01-V99) is any accident involving a device designed primarily for or being used at the time primarily for, conveying persons or goods from one place to another". ICD10 distinguishes between "Traffic accident" (any vehicle accident on a public road) and "Non-traffic accident" (any vehicle accident occurring entirely somewhere other than on a public road).

Table B 15 shows the distribution of cases of fatalities according ICD10 classification of road user by traffic and non-traffic. As we can see, for all road users there are a notable number of cases with unspecified information.

Table B 15 Distribution of external causes for ICD10 (V codes) among traffic injuries (Mortality Register, Spain 2009 -2013)

CODE	Traffic Injuries	Non-traffic Injuries	Total
V01 Pedestrian injured in collisions w pedal cycle	7	0	7
V02 Pedestrian injured in collisionsw 2-3PW	61	3	64
V03 Pedestrian injured in col w car,pick-up truck or van	923	14	937
V04 Pedestrian injured in collisionsw heavy transport vehicle or bus	186	13	199
V05 Pedestrian injured in collisionsw railway train or railway vehicle	41	217	258
V06 Pedestrian injured in coll w other nonmotor	1	1	2
V09 Pedestrian injured in other and unspecified transport accidents	1,010	118	1,128
V10 Cyclist injured in coll w pedest or animal	0	0	0

CODE	Traffic Injuries	Non-traffic Injuries	Total
V11 Cyclist injured in coll w other cycle	0	0	0
V12 Cyclist injured in coll w 2-3PW	8	0	8
V13 Cyclist injured in coll w car, pick-up truck or van	146	3	149
V14 Cyclist injured in coll w heavy transport veh or bus	31	0	31
V15 Cyclist injured in coll w railway train or railway veh	1	1	2
V16 Cyclist injured in coll w other nonmotorveh	0	0	0
V17 Cyclist injured in coll w fixed or stationary object	13	0	13
V18 Cyclist injured in noncoll transport acid	52	15	67
V19 Driver cyclist injured in coll w other and unspecif motor veh	82	5	87
V20 Motorcycle rider inj in coll w pedest or animal	13	1	14
V21 Motorcycle rider inj in coll w cycle	2	0	2
V22 Motorcycle rider inj in coll w 2-3PW	30	1	31
V23 Motorcycle rider inj in coll w car, pick-up truck or van	509	4	513
V24 Motorcycle rider inj in coll w heavy transport veh or bus	91	1	92
V25 Motorcycle rider inj in coll w railway train or railway veh	3	0	3
V26 Motorcycle rider inj in coll w other nonmotorveh	1	0	1
V27 Motorcycle rider inj in coll w fixed or stationary object	224	8	232
V28 Motorcycle rider inj in noncoll transport accid	328	7	335
V29 Motorcycle rider inj in coll w other and unspecif motor veh	427	20	447
V30 Occupant of 3PW inj in coll w pedest or animal	0	0	0
V31 Occupant of 3PW inj in coll w cycle	0	0	0
V32 Occupant of 3PW inj in coll w 2-3PW	2	0	2
V33 Occupant of 3PW inj in coll w car, pick-up truck or van	0	0	0
V34 Occupant of 3PW inj in coll w heavy transport veh or bus	3	0	3
V35 Occupant of 3PW inj in coll w railway train or railway veh	0	0	0
V36 Occupant of 3PW inj in noncoll transport accid	0	0	0
V37 Occupant of 3PW inj in coll w fixed or stationary object	1	0	1
V38 Occupant of 3PW inj in noncoll transport accid	1	0	1
V39 Occupant of 3PW inj in coll w other and unspecif motor veh	0	0	0
V40 Car occupant inj in coll w pedest or animal	13	0	13

CODE	Traffic Injuries	Non-traffic Injuries	Total
V41 Car occupant inj in coll w cycle	1	0	1
V42 Car occupant inj in coll w 2-3PW	8	2	10
V43 Car occupant inj in coll w car, pick-up truck or van	1,239	7	1,246
V44 Car occupant inj in coll w heavy transport veh or bus	567	5	572
V45 Car occupant inj in coll w railway train or railway veh	17	0	17
V46 Car occupant inj in coll w other nonmotorveh	7	0	7
V47 Car occupant inj in coll w fixed or stationary object	554	13	567
V48 Car occupant inj in noncoll transport accid	1,103	20	1,123
V49 Car occupant inj in coll w other and unspecif motor veh	702	25	727
V50 Occupant of pick-up truck or van inj in coll w pedest or animal	6	0	6
V51 Occupant of pick-up truck or van inj in coll w cycle	0	0	0
V52 Occupant of pick-up truck or van inj in coll w 2-3PW	1	0	1
V53 Occupant of pick-up truck or van inj in coll w car, pick-up truck or van	42	1	43
V54 Occupant of pick-up truck or van inj in coll w heavy transport veh or bus	73	0	73
V55 Occupant of pick-up truck or van inj in coll w railway train or railway veh	0	1	1
V56 Occupant of pick-up truck or van inj in coll w other nonmotorveh			
V57 Occupant of pick-up truck or van inj in coll w fixed or stationary object	13	0	13
V58 Occupant of pick-up truck or van inj in noncoll transport accid	60	1	61
V59 Occupant of pick-up truck or van inj in coll w other and unspecif motor veh	7	7	14
V60 Occupant of heavy transpvehinj in coll w pedest or animal	0	0	0
V61 Occupant of heavy transpvehinj in coll w cycle	0	0	0
V62 Occupant of heavy transpvehinj in coll w 2-3PW	0	0	0
V63 Occupant of heavy transpvehinj in coll w car, pick-up truck or van	19	0	19
V64 Occupant of heavy transpvehinj in coll w heavy transport veh or bus	78	0	78
V65 Occupant of heavy transpvehinj in coll w railway train or railway veh	1	0	1
V66 Occupant of heavy transpvehinj in coll w other nonmotorveh	0	0	0
V67 Occupant of heavy transpvehinj in coll w fixed or stationary object	14	0	14
V68 Occupant of heavy transpvehinj in noncoll transport accid	125	6	131
V69 Occupant of heavy transpvehinj in coll w other and unspecif motor veh	36	11	47
V70 Bus occupant inj in coll w pedest or animal	0	0	0

CODE	Traffic Injuries	Non-traffic Injuries	Total
V71 Bus occupant inj in coll w cycle	0	0	0
V72 Bus occupant inj in coll w 2-3PW	0	0	0
V73 Bus occupant inj in coll w car, pick-up truck or van	6	0	6
V74 Bus occupant inj in coll w heavy transport veh or bus	8	0	8
V75 Bus occupant inj in coll w railway train or railway veh	1	0	1
V76 Bus occupant inj in coll w other nonmotorveh	0	1	1
V77 Bus occupant inj in coll w fixed or stationary object	0	0	0
V78 Bus occupant inj in noncoll transport accid	25	1	26
V79 Bus occupant inj in coll w other and unspecif motor veh	11	3	14
V80 Animal-rider or occupant of animal-drawn vehicle injured in transport accident	0	41	41
V81 Occupant of railway train or railway vehicle injured in transport accident	1	95	96
V82 Occupant of streetcar injured in transport accident	1	0	1
V83 Occupant of special vehicle mainly used on industrial premises injured in transport accident	1	6	7
V84 Occupant of special vehicle mainly used in agriculture injured in transport accident	131	297	428
V85 Occupant of special construction vehicle injured in transport accident	2	11	13
V86 Occup of special all-terrain or other motor veh designed primarily for off-road use,inj in transpaccid	9	10	19
V87 Traffic accid of specified type but victim's mode of transp unknown	14	0	14
V88 Non-traffic accid of specified type but victim's mode of transport unknown	0	2	2
V89 Motor- or nonmotor-vehicle accident, type of vehicle unspecified	1,671	89	1,760
V90-v99	0	214	214
Total	**10,770**	**1,295**	**12,065**

We propose to consider traffic injuries as those occurring on public roads, as international organizations propose, thus excluding the non-traffic ones.

Sensitivity analysis

A sensitivity analysis has been done in order to clarify the effect of different alternative choices in the criteria for inclusion / exclusion of diseases/injuriesin the final definition of severe traffic injury. Several issues have been explored in order to determine its influence and its suitability in the final definition.

Table B 16 Hospital admissions in Spain according to severity of injury and final outcome. Hospital Discharge Register, Spain 2011

	Traffic Injuries	Other Injuries	Total
Deaths within 30 days	526	5,864	6,390
Deaths after 30 days	57 (9.8%)	426 (6.8%)	483 (7.0%)
Total deaths	583 (100%)	6,290 (100%)	6,873 (100%)
(1) Deaths after 30 days classified as injured			
Deaths 1	526 (1.7%)	5,864 (2.6%)	6,390 (2.5%)
Total Injured 1	30,813 (98.3%)	221,229 (97.4%)	252,042 (97.5%)
(2) Deaths after 30 days classified as deaths			
Deaths 2	583 (1.9%)	6,290 (2.8%)	6,873 (2.7%)
Total Injured 2	30,756 (98.1%)	220,803 (97.2%)	251,559 (97.3%)
Total			
Total	**31,339 (100%)**	**227,093 (100%)**	**258,432 (100%)**
•			
(1) Deaths after 30 days classified as injured			
Total Injured 1 *	30,813 (100%)	221,229 (100%)	252,042 (100%)
MAIS 0-2	21,853 (70.8%)	143,204	165,657
MAIS ≥ 3	8,927 (30.0%)	74,865	83,792
(2) Deaths after 30 days classified as deaths			
Total Injured 2 *	30,756 (100%)	220,803 (100%)	251,559 (100%)
MAIS 0-2	21,835 (71.0%)	143,120	164,955
MAIS ≥ 3	8,888 (28.9%)	74,548	83,436

** Traffic injuries with unknown severity are not shown*

Deaths after 30 days represents the 9.8% of the total deaths occurred by road traffic injuries. It is suggested to code these deaths as injuries according to his/her MAIS (Table B 16). The sensitivity analysis shows that total injured percentage will drop from 98.3% to 98.1% if those deaths after 30 days were not excluded. Moreover, the percentage of severe injured (MAIS ≥ 3) will drop from 30% to 28.9%.

Table B 17 shows how the percentage of severe traffic injury varies according to all the studied parameters:

Table B 17 Traffic hospital admissions according to injury severity. Hospital discharge Register of Spain, 2011.

	MAIS0-2	MAIS ≥ 3	Total *
Readmissions (n)	978	204	1,183
Readmissions included	21,853	8,927 (29.0%)	30,813 (100%)
Readmissions excluded	20,875	8,723 (29.4%)	29,630 (100%)
Scheduled admissions (n)	5,491	551	6,052
Scheduled admissions included	21,853	8,927 (29.0%)	30,813 (100%)
Scheduled admissions excluded	16,362	8,376 (33.8%)	24,761 (100%)
People with 0 days of hospitalisation (n)	140	119	259
Included	21,853	8,927 (29.0%)	30,813 (100%)
Excluded	21,713	8,808 (28.8%)	30,554 (100%)
Traumatic Injuries (ICD9:800-959) (n)	18,180	8,927	27,140
Including all	21,853	8,927 (29.0%)	30,813 (100%)
Selecting only traumatic Injuries	18,180	8,927 (32.9%)	27,140 (100%)
Traumatic injuries (Number of diagnosis)			
Traumatic injury in any diagnosis	21,853	8,927 (29.0%)	30,813(100%)
Traumatic injury only in the main diagnosis	9,584	2,295 (25.7%)	11,885(100%)
External causes (ICD9)**			
Total traffic injuries	21,853	8,927 (29.0%)	30,813(100%)
E826 Pedal cycle accident (n)	2,716	1,018	3,734
Traffic injuries excluding E826	19,137	7,909 (29.2%)	27,079 (100%)
E827 Animal-drawn vehicle accident (n)	18	7	25
Traffic injuries excluding E827	21,835	8,920 (29.0%)	30,788 (100%)
E828 Accident involving an animal being ridden (n)	450	193	644
Traffic injuries excluding E828	21,403	8,734 (29.0%)	30,169 (100%)

E829 Other road vehicle accident (n)	80	28	108
Traffic injuries excluding E829	21,773	8,899 (29.0%)	30,705(100%)
E929.0 Late effects (n)	228	8	238
Traffic injuries excluding E929.0	21,625	8,919 (29.2%)	30,575 (100%)
E988.5 Injury by crashing of motor vehicle, undetermined whether accidentally or purposely inflicted (n)	1	3	4
Traffic injuries excluding E988.5	21,852	8,924 (29.0%)	30,809 (100%)

* Traffic injuries with unknown severity are not shown

** All the sensitivity analysis have been done assuming that excluded cases are not selected as road traffic injury by any other criteria

According to data showed in **Fout! Verwijzingsbron niet gevonden.**, the percentage of severe road traffic injuries increase from 29.0% to 29.4% if readmissions are excluded. In the same sense, the percentage increases when scheduled admissions are excluded (from 29.0% to 33.8%). This is mainly due to the fact that the total number of road traffic injuries drop from 30,813 to 24,761. Regarding to injured people who is 0 days hospitalised, the percentage will drop from 29.0% to 28.8% if those people were excluded.

On the other hand, if only people with traumatic injuries are selected as injured by traffic injuries, the number of people injured will drop from 30,813 to 27,140 and consequently the percentage of severe injured people change from 29.0% to 32.9%. Moreover, if only people with traumatic injuries in the main diagnosis are considered as traffic injured people, the number of people injured hugely falls to 11,885 and the percentage of severe injured changes to 25.7%.

Finally, the sensitivity analysis has been done with the E-codes where there was not definitive consensus (E826-E829, E929.0, E988.5). The numbers are so small that the percentage of severe injured people will not change in the majority of the cases, with the exception of Pedal cycle accidents (E826) and late effects (929.0), where the percentage will increase from 29.0% to 29.2%.

Traffic hospital admissions in Spain according to the different definitions for ICD9-CM

Table B 18 shows how the estimated number or MAIS ≥ 3 RTC from HSR of serious injuries varies according the different selection criteria for ICD9-CM that has been discussed.

Table B 18 Distribution of traffic hospital admissions in Spain according to the criteria definitions for ICD9-CM. Hospital Discharge Register, Spain 2011

Traffic Injuries						
31,338						
Excluding deaths within 30 days	30,813					
Severity	**MAIS 0-2**	**MAIS ≥ 3**	**Unknown**	**Total**		
Excluding deaths within 30 days	21,853	8,927	33	30,813		
Excluding deaths within 30 days **and scheduled admissions**	16,352	8,376	23	24,751		
Excluding deaths within 30 days and scheduled admissions **and readmissions**	16,010	8,293	23	24,326		
	Including All E-codes			Excluding Late Effects E929.0		
	MAIS 0-2	**MAIS ≥ 3**	**Total**	**MAIS 0-2**	**MAIS ≥ 3**	**Total**
Excluding deaths within 30 days and scheduled admissions and readmissions	16,010	8,293	24,326	15,927	8,257	24,204
Excluding deaths within 30 days, scheduled admissions, readmissions and **codes N905-N909, N958, N959 (Late effects and complications)**	15,080	8,293	23,396	15,006	8,257	23,283
Excluding deaths within 30 days, scheduled admissions, readmissions and codes N905-N909, N958, N959 (Late effects and complications) **and taking into account traumatic injuries in any diagnosis**	15,080	8,293	23,396	15,006	8,257	23,283
Excluding deaths within 30 days, scheduled admissions, readmissions and codes N905-N909, N958, N959 (Late effects and complications) **and taking into account only traffic injuries with traumatic injuries in the main diagnosis**	14,945	8,293	23,261	14,911	8,257	23,188

**** Traffic injuries with unknown severity are not shown in the second part of the table.*

EXPERIENCE OF THE NETHERLANDS

Methods

We used as a source of information a selection of the Dutch Database from Hospital Discharge Register (HDR) for 1993-2013. Dutch hospitals code injuries with the International Classification of Diseases 9th revision, Clinical Modification (ICD9-CM). The database includes up to 10 diagnoses (1993-2009 and even more after that (including diagnosis of injuries, diseases and codes of external causes).

After 2012, hospitals gradually introduced ICD10 for coding. In this study only the ICD9cm cases of 2012 and 2013 have been taken into account. For section 6.4 these all have been converted to ICD9-CM and treated likewise.

This database was filtered by Dutch Hospital Data (DHD) and includes all hospitalisations for patients with a transport accident as external cause (Ecodes in: E800-E848) , extended with a wide range of external causes where –in case of miscoding- other traffic casualties can be found (E-codes in:E880-E889 (falls), E890-E899 (burns), E928 (unknown accidental), E929 (late effects), E958 (suicide), E988 (unspecified).

All hospitals are included in the database. In some years some hospitals did not provide data, but the number of patients treated is known, so an accurate estimate can be given of the missing data.

The population of study is all the Dutch population, including persons –irrespective of their nationality- having an accident in the Netherlands and that are admitted to a Dutch hospital. At a first stage, the unit of analysis of the database are admissions, not casualties of (traffic) incidents. We need therefore to identify individuals.

Note: the numbers shown in this chapter a little lower than the best estimate of MAIS ≥ 3 road traffic casualties for the Netherlands. This is caused by the fact that other in/exclusion criteria are used, that this is based of Hospital data only and no correction for underreporting/miscoding was applied.

ICD9-CM

Regularly in the Netherlands a person seriously injured in a traffic accident must meet the following criteria:

1. the severity on the Maximum Abbreviated Injury Scale (MAIS) is 2 or more
2. the patient did not die within 30 days after admission
3. E-code for external cause (ICD9-CM): E810-819, E826-829, excluding E817 (getting in/out a vehicle, not a collision) and E828 (animal being ridden) or the casualty is linked to the police register of road traffic accidents "BRON"

For this case-study we deviated from this practice in order to study the sensitivity for the inclusion criteria: We studied all severities on the MAIS scale, including deaths and we selected all patients with an E-code in the range E810-E829 + linked cases for E929.0 and E988.5.

According to this selection in the Hospital Discharge Register (HDR) there were 433,077 admissions in the Netherlands in the period 1993-2013 due to traffic.

Severity has been defined by the Maximum Abbreviated Injury Score (MAIS). The MAIS is the maximum of the AIS (Abbreviated Injury Score) scores, and is frequently used for assessing overall severity. It does not necessary have a linear relationship with the probability of death. Severity has been categorised as MAIS0-2 or MAIS ≥ 3, considering severe injuries those of MAIS ≥ 3. AIS and MAIS have been derived from the icdmap90 module of Johns Hopkins University (1998).

Results

How to treat deaths?

According to the Dutch Hospital Discharge Register (HDR), 433,077 hospital admissions took place because of a traffic accident: 6,308 people died (1.5%). Most of them (92%) died within 30 days after admission in hospital and 8% died 31 days or more after admission.

In total 106,542 admittances are related to Severe Injuries MAIS ≥ 3 (Table B 19).

Table B 19 Hospital admissions in the Netherlands according to severity of injury and final outcome, 1993-2013.

Discharge	SEVERITY				
	MAIS1-	MAIS2	MAIS ≥ 3	Unknown	Sum
Alive	87,479	223,648	106,155	9,488	426,770
Dead within 30d	406	427	4.819	164	5.817
Dead after 30d	25	70	387	9	491
	87.910	**224.145**	**111.361**	**9.661**	**433.077**

A person who is admitted to hospital but finally died should be excluded from the database as severe injured if he/she dies within 30 days after the admission. Otherwise it will be double counted by the official registers which include road traffic fatalities up to 30 days after the collision. On the other side in hospital fatalities that occur later than 30 days should be included as severe injuries. This is the case for 387+34 cases as can be seen inTable B 19.

From the 111.361 casualties with MAIS ≥ 3, 4,819 died within 30 days of the crash and according to international standards (Vienna, 1968) these are counted as road traffic fatalities and should not be double counted in a Serious Traffic injuries figure. The 387 persons that died after 30 days have not been counted as fatalities and should be included in the number of Serious Traffic injuries.

The other 1,101 persons that died (MAIS is 1,2,9) are not counted as Serious Traffic injuries as they do not have an injury rated as MAIS ≥ 3. Although they have an external cause which indicates a relation with a road accident, it is possible that the traffic accident is not the cause of death. It is therefore risky to include these casualties in the count of Serious Traffic injuries.

If we would not have access over the variable indicating death, the number of SRI would have been overestimated. A factor can be used to compensate for this. Based on the Dutch data this factor would be 106,542 / 111,361 = 0.957.

If we would not have access over the variable indicating the length of stay from which we can see that death occurred after 30 days, the number of SRI would have been slightly underestimated. A factor can be used to compensate for this. Based on the Dutch data on ICD9-cm this factor would be 106,542 / 106,155= 1.004.

Emergency vs Scheduled and Readmissions

When counting the number of road traffic casualties, it is necessary to compensate for persons that were hospitalized more than once. If casualties are transported to another hospital, or readmitted after discharge, it is likely that in the Hospital file there exist more than one record of this one casualty.

Hospital admissions could be clinical treatments, day-treatment or observations. For day-treatment; the patient usually schedules an appointment with the doctor to treat the injury. One could argue that this injury is not urgent and therefore not serious, however this injury can also be severe as can be seen in 0. Another argument is that when scheduling the appointment, the doctor is seeing the patient and already creates a record in the hospital administration. In the Dutch situation, it is very unlikely that it is a Hospitalisation and discharge + a readmittance in the form of a day-treatment. The day-treatment is more likely to be the first hospitalisation (unless readmittance is specified).

In Table B 20 can be seen that 1,240 from 23,539 cases of day-treatment are rated as MAIS ≥ 3 and therefore should be counted to the MAIS ≥ 3 traffic casualties (5.3%).

Table B 20 Traffic hospital admissions according to type of treatment, readmission and injury severity. (HDR, the Netherlands 1993-2014)

Type of treatment		**SEVERITY**				
		MAIS1-	**MAIS2**	**MAIS ≥ 3**	**Unknown**	**Sum**
Clinical	Admission	75.885	203.801	106.201	8.598	394.485
	Readmission	1.467	7.472	3.381	172	12.492
Day treatment	Admission	10.097	11.349	1.240	843	23.529
	Readmission	462	1.523	539	47	2.571
		87.910	**224.145**	**111.361**	**9.661**	**433.077**

A scheduled admission because of a traffic injury could be a second episode of a previous emergency injury. When readmissions are removed, there is no reason to exclude day-treatments with a severity of MAIS ≥ 3.

In NL readmissions are counted in the same hospital over a period of a full calendar year.Furthermore, admissions are deduplicated (over all hospitals) that have the same Date of Birth+Gender+Municipality of Living+Principal Diagnosis over two years.

It is known that the fraction of patients that are treated in day-treatments varies much across Europe (EUROSTAT, n.d.). A comparison of the numbers of Clinical treatments or Day treatments is very country specific. We do observe that readmittances are more often organised as day-treatment.

If we would not have access over a variable that indicates readmittance, we would overestimate the number of Serious Traffic injuries. A factor can be used to compensate for this. Based on the Dutch data on ICD9-cm this factor would be (106,201 + 1,240) / 111,361 = 0.965.

Overnight

Hospitalisation for less than one day represents the 5.6% of severe traffic injuries hospitalisations in the Netherlands. It is suggested to include them in the traffic injury definition because, although they have such a short hospitalisation, they might be transferred to other hospitals. They will be registered then as readmitted or as a scheduled admission and not as an emergency. That means that the information might not be duplicated (Table B 21).

Table B 21 Days of hospitalisation of traffic hospital admissions by severity. (HDR, the Netherlands 1993-2014)

Type of treatment	LoS*	SEVERITY				
		MAIS1	**MAIS2**	**MAIS ≥ 3**	**Unknown**	**Sum**
Clinical	1 day	23.852	31.873	6.171	2.654	64.550
	2 days	30.306	62.039	9.158	3.233	104.736
	3-30 days	22.619	112.215	83.666	2.713	221.213
	31+ days	575	5.145	10.587	170	16.478
Day treatment	1 day	9.878	11.634	1.639	824	23.975
	2 days	341	642	96	35	1.114
	3-30 days	340	597	44	31	1.012
		87.910	**224.145**	**111.361**	**9.661**	**433.077**

**LoS: Lenght of stay in hospital*

It is well known (Van Kampen, 2007; Cryer, Gulliver, Langley, & Davie, 2010) that the average length of stay is decreasing over the years. Not only for road traffic casualties, but for all sorts of hospital treatment. The percentage of 5.6% mentioned above is therefore time dependant. In more recent years the percentage is much higher than in early years (not shown).

Traumatic Injuries

The issue of traumatic injury (an injury in the range ICD9-CM 800-959) or Non-traumatic Injury (injury in the range 960-999) is not used in the Netherlands. The mapping to AIS determines if a severe injury is present and to which MAIS-class the casualties should be counted. As the mapping tool that is used (ICDmap90) does not rate any injury in the non-traumatic range to MAIS2+, the impact on the analysis above can be neglected. On rating the severity of a patient, all injury codes are taken into account (up to 10).

Intensive Care

Some countries can only access data from Intensive Care units (IC).Not all RTC are treated at an intensive care, so when the estimate of Serious Traffic injuries is based on this source only, the picture obtained is not complete.

In the Netherlands we have for some years (2011, 2012) information on whether the patient is treated at an Intensive Care department (Table B 22).

Table B 22 Intensive Care treatment of traffic hospital admissions by severity. (HDR, the Netherlands 2011, 2012).

	Slight/unknown	MAIS2	MAIS ≥ 3	SUM
ICD9 total admissions	13.259	23.066	10.716	47.041
of which IC	111	460	1.269	1.840
% of admissions with IC	1%	2%	12%	4%
of which deaths within 30d	15	9	142	166
% of deaths30d with IC from all deaths at 30 days	31%	21%	44%	

We see that an estimate based on the number of IC treated patients is far from complete. A factor of 6 is needed to correct for MAIS ≥ 3 cases that were not treated at an IC.

More severe injuries are associated with higher proportions of IC treatment; however 30% of IC treated patients have an injury severity of 2 or less.

Selection of Ecodes

The codes for external causes (E-codes) defined as traffic accidents for this analysis include: **E810-829, E826-829, E929.0, E988.5**.

In this section we will assess what difference is introduced to a national definition which deviates from the SafetyCube definition. There is no doubt about codes E810-819 which includes "Motor vehicle traffic accident" with an exception for E817 (getting on/off the vehicle, no collision).

Also E826-E829 are generally seen as "Traffic accidents without involvement of a motor vehicle".Butthe criteria is not so clear in the case of "Animal-drawn vehicle accident" (E827), "Accident involving an animal being ridden" (E828) and "Other road vehicle accident" (E829).

Also unclear are "Late effects of motor vehicle accident or other transport accident" (E929.0,1) and "Injury by crashing of motor vehicle, undetermined whether accidentally or purposely inflicted" (E988.5)". The distribution of these cases can be seen ino. Shaded cells are considered road traffic crashes in the Netherlands with respect to their External Cause.

In the Netherlands some correction factors are applied to adjust for the lack of information when it is unknown whether the accident occurred in a public road or not:

- For ICD9 (data up to 2013) E820-E825 are excluded and cases E826 are weighted the with a factor 0,971.

- For ICD10 (data after 2012) all 4th digits (determining "in traffic" and "not in traffic") are included because it has been noticed that in both corresponding groups the proportion "not in traffic" is much higher than expected/than before. This is the case with both groups (with and without involvement of a motor vehicle).
-

This is probably caused by the situation that e.g. V18.0 is coded (instead of V18.4) as there seems not to be a conflict with any other traffic participant; the casualty blames himself for inattention etc.

In the mean time, comparable to ICD9, cases are weighted with a factor 0,618 (motor vehicle crashes) and 0,971 (without motor vehicle) respectively. i.e.: all cases (100%) corresponding to E810-E819 are taken into account and 61,8% of the cases corresponding to E820-E825.

Table B 23 Distribution of E codes among traffic injuries, by severity. (HDR, Netherlands 1993-2014) – ICD9 coded admissions and ICD10 coded (and converted to ICD9) admissions.

		Severity ICD9					Severity ICD10 converted			
Ecode		MAIS1-	MAIS2	MAIS ≥ 3	Unknown		MAIS1-	MAIS2	MAIS ≥ 3	Unknown
810	Motor vehicle - train	54	85	115	0		7	12	10	0
811	Motor vehicle - motor vehiclereentering road	629	992	577	83		605	1.486	906	78
812	Motor vehicle - motor vehicle	21.246	30.987	17.436	1.983		2.196	1.536	956	150
813	Motor vehicle - non motor vehicle	6.083	20.497	11.901	684		1.148	2.781	2.266	228
814	Motor vehicle - pedestrian	3.474	12.629	6.248	322		394	958	675	59
815	Motor vehicle - object	6.561	10.505	6.866	780		976	1.261	964	95
816	Motor vehicle - out of control	9.546	18.366	7.257	874		985	2.267	923	129
817	during getting on/off vehicle, no collision	453	1.412	950	36		32	108	96	12
818	Motor vehicle - on fire	2.599	7.725	2.521	271		118	221	125	17
819	Motor vehicle - not specified	9.620	20.963	10.647	1.472		147	441	213	30
820	Nontraffic accident involving motor-driven snow vehicle	22	85	28	4		0	0	0	0
821	Nontraffic accident involving other off-road motor vehicle	652	2.105	670	89		429	1.482	540	73
822	Other motor vehicle	197	522	250	20		414	790	427	67

	nontraffic accident involving collision with moving object									
823	Other motor vehicle nontraffic accident involving collision with stationary object	186	365	173	26		246	354	238	38
824	Other motor vehicle nontraffic accident while boarding and alighting	244	547	292	17		114	146	84	17
825	Other motor vehicle nontraffic accident of other and unspecified nature	794	2.598	920	80		499	1.095	542	79
826	Bicycle accident	21.249	79.127	40.112	2.498		4.587	15.373	8.953	1.127
827	Wagon (animal traction)	118	348	185	6		563	1.703	549	73
828	Accident with ridden animal	3.717	13.197	3.523	375		0	0	0	0
829	Tram - derailment, getting on/off	419	1.089	688	41		90	181	80	17
929.0	Late effects of motor vehicle accident	47	1	0	0		1	0	0	0
988.5	Injury by crashing of motor vehicle, undetermined whether accidentally or purposely inflicted	1	1	1	0		0	0	0	0
Sum		**87.910**	**224.145**	**111.361**	**9.661**		**13.550**	**32.197**	**18.548**	**2.288**

Criteria definition for ICD9-CM

In the preceding sections we have elaborated on the different inclusion and exclusion criteria, such as how to deal with Fatalities before and after 30 days, Readmissions, Day-treatment/observation, Short stay, Intensive Care, Traumatic injuries and External causes (E-codes).

When we count the number of Serious Traffic injuries MAIS ≥ 3 according to the (proposed) definition:

- E-codes in E810-E819 + E826+E828+E829+E988.5
- without fatalities<30 days
- without readmissions
- Day-treatment and length of stay and IC treatment and type of injury are not relevant – as far as the MAIS is 3 or more.

This results in 97,138 for Serious Traffic injuries in the Netherlands (1993-2012, ICD9cm).

If we would have included other Ecodes, fatalities or readmissions, the following cases would have been selected additionally:

Table B 24 Traffic hospital admissions in the Netherlands according to all the different definitions. (HDR, the Netherlands 1993-2014)

	Slight/unk	MAIS2	MAIS ≥ 3	index	Overestimation Factor
MAIS ≥ 3 definition	88,555	196,112	**97,138**	100%	
InclE828	4,018	12,680	3,394	3.5%	0.966
InclE929	47	1	0	0.0%	1.000
InclE820-825	2,248	5,946	2,176	2.2%	0.978
Inclreadmissions	1,991	8,194	3,656	3.8%	0.964
Incldeaths within 30d	540	403	4,623	4.8%	0.955
Inclcombinations	172	809	373	0.4%	
Sum	**97,571**	**224,145**	**111,361**		

In order to compare with the definition, we would need to multiply our results with the factors in the last column of Table B 24.

So when we would have included all fatalities and E828 (i.e. when we were not able to filter these cases from our dataset), our result should be multiplied with 0.966 * 0.955 in order to best approach the number according to the definition. In this example, this would result in (97,138+3,394+4,623 + some cases from the combinations) = 97,009 + 41

The number or proportion of casualties "not on public roads" (E820-E825) may vary across countries, so the factor that is calculated here on Dutch data, should be handled with care. If for example the proportion of "off-road roads" and" off road vehicles" is different, e.g. by the number of snow vehicles in winter-sports areas (E820) this influences the factor that is needed to correct for that.

Table B 25 Externals causes for ICD9-CM (E-codes) and their inclusion in the Netherlands

ICD9 Codes	Traffic Injuries
E810 Motor vehicle traffic accident involving collision with train	All
E811 Motor vehicle traffic accident involving re-entrant collision with another motor vehicle	All
E812 Other motor vehicle traffic accident involving collision with motor vehicle	All
E813 Motor vehicle traffic accident involving collision with other vehicle	All
E814 Motor vehicle traffic accident involving collision with pedestrian	All
E815 Other motor vehicle traffic accident involving collision on the highway	All
E816 Motor vehicle traffic accident due to loss of control, without accident while boarding or alighting	All
E817	No
E818 Other no collision motor vehicle traffic accident	All
E819 Motor vehicle traffic accident of unspecified nature	All
E826 Pedal cycle accident	Weighted
E827 Animal-drawn vehicle accident	Weighted
E828	No
E829 Other road vehicle accident	Weighted
E988.5 Injury by crashing of motor vehicle, undetermined whether accidentally or purposely inflicted	All

Table B 26 Externals causes for ICD10 (V codes) and their inclusion in the Netherlands

ICD10 - codes	Traffic injuries		Non-traffic transport injuries (Did not occur on public road)	
Pedestrian:				
V01 - V06	**.1, .9**	All	0	Weighted
V09	**.2, .3**	All	.0, .1, .9	Weighted
Pedal cyclist:				
V10 - V18	**.4, .5, .9**	All	.0, .1, .2, .3	Weighted
V19	**.4, .5, .6, .9**	All	.0, .1, .2, .3, .8	Weighted
Motorcycle rider:				
V20 - V28	**.4, .5, .9**	All	.0, .1, .2, .3	Weighted
V29	**.4, .5, .6, .9**	All	.0, .1, .2, .3, .8	Weighted
Occupant of three-wheeled motor vehicle:				
V30 - V38	**.5, .6, .7, .9**	All	.0, .1, .2, .3, .4	Weighted
V39	**.4, .5, .6, , .9**	All	.0, .1, .2, .3, .8	Weighted
Car occupant:				
V40 - V48	**.5, .6, .7, .9**	All	.0, .1, .2, .3, .4	Weighted
V49	**.4, .5, .6, .9**	All	.0, .1, .2, .3, .8	Weighted
Occupant of pick-up truck or van:				
V50 - V58	**.5, .6, .7, .9**	All	.0, .1, .2, .3, .4	Weighted
V59	**.4 .5, .6, .9**	All	.0, .1, .2, .3, .8	Weighted
Occupant of heavy transport vehicle:				
V60 - V68	**.5, .6, .7, .9**	All	.0, .1, .2, .3, .4	Weighted
V69	**.4, .5, .6, .9**	All	.0, .1, .2, .3, .8	Weighted
Bus occupant:				
V70 - V78	**.5, .6, .7, .9**	All	.0, .1, .2, .3, .4	Weighted
V79	**.4, .5, .6, .9**	All	.0, .1, .2, .3,.8	Weighted

ICD10 - codes	Traffic injuries		Non-traffic transport injuries (Did not occur on public road)	
Animal-rider or occupant of animal-drawn vehicle				
V80	**-**		.0.1, .2, .3, .4, .5, .7, .9	Weighted
Occupant of railway train or railway vehicle:				
V81	**0,1**	All	.0, .2, .3, .4, .5, .6, .7, .8, .9	Weighted
Occupant of streetcar:				
V82	**.1, .9**	All	.0, .2, .3, .4, .5, .6, .7, .8	Weighted
Occupant of special industrial vehicle:				
V83	**.0, .1, .2, .3**	All	.4, .5, .6, .7, .9	Weighted
Occupant of special agricultural vehicle:				
V84	**.0, .1, .2, .3**	All	.4, .5, .6, .7, .9	Weighted
Other:				
V85 - V86	**.0, .1, .2, .3**	All	.4, .5, .6, .7, .9	Weighted
V87	**.0, .1, .2, .3, .4, .5, .6, .7, .8, .9**	All	-	Weighted
V88	-		.0, .1, .2, .3, .4, .5, .6, .7, .8, .9	Weighted
Type of vehicle not specified:				
V89	**.2,.3**	All	.0, .1, .9	Weighted

Inclusion criteria for ICD10 in the Netherlands, 'non traffic' is not accurately coded, so therefore these cases are included with a weighting factor (Bos, N.M., Houwing & Stipdonk, 2014)

Conclusions

These two cases studies show how the number of cases may differ depending on the criteria used to select cases from the hospital databases.

From these analyses we recommend the following criteria:

- **Exclude fatalities within 30 days after admission**
- **Fatalities after 30 days should be counted as injured according to his/her MAIS**
- **Exclude readmissions to avoid duplicates within a full calendar year (or within a month if it is not possible to identify through the full year)**
- **If it is possible to avoid duplicates by just excluding readmissions, it is not necessary to exclude scheduled admissions. If not, readmissions should be excluded.**
- **Include all traffic injury hospitalisations even those with short length of stay**
- **Include all cases with any injury diagnosis (ICD9CM: 800-999; ICD10: S00-T88)**
- **Include external causes for road traffic injuries: (ICD9CM: E810-E819, E826, E827, E829, E988.5; ICD10: V01-89 for those codes for traffic injuries and/or weighting - correcting for non-public road- for non-traffic injury codes)**
- **If it is not possible having complete data of these hospital data, weighting factors could be used to correct data deviations and make more real estimations.**

Appendix C: Methods to derive MAIS

This chapter analyses the effect of issues related to determining whether a casualty has an injury severity of MAIS ≥ 3 or not, based on data from the Netherlands, France, Slovenia, Spain, Austria, and Belgium

INTRODUCTION

To determine whether or not a casualty of a road traffic incident is severely injured (MAIS ≥ 3), the severity of each of the injuries sustained in the crash is to be assessed. There are different approaches, but the best method uses the following standards:

- The AIS coding is direct and based on the latest AIS coding instructions: AIS© 2005/update2008.
- The MAIS is based on the maximum AIS of all injuries.

Only few countries code the injuries directly in AIS. Many countries use ICD coding instead of AIS coding to record the individual injuries. Therefore, data specialists in these countries must recode their ICD codes into AIS codes prior to being able to calculate MAIS ≥ 3. This recoding process is performed by means of conversion tools such as ICDmap90, ICDpic, DGT, ECIP, AGU or AAAM and leads to so-called ICD-derived AIS values. Some of these tools recode the ICD codes into the latest AIS© 2005/update 2008 codes, but other older tools recode ICD data into AIS codes that are based on previous versions of the AIS coding (AIS2005, AIS1998 or AIS1990). Recoding always has the disadvantage that some information gets lost or is not available so that a best match must be selected (in the recoding tool). This may have an effect on the severity that is assigned to a casualty and therefore also on the estimated number of MAIS ≥ 3 casualties.

A further complication is that different versions of the ICD have been developed and is subject to regular updates. It is hard to find out which exact versions were used in hospitals of a country in which year. Unless we find peculiar things we omit these ICD-updates, other than ICD9 – ICD10 and clinical modifications (cm). In some countries (NL, ES), tools exist to convert between ICD-versions.

In order to become a little more familiar with the different coding systems the basic structure of the injury codes is described below:

Table C 1 Format and range of Injury codes in different coding systems, the number of injury-codes in use:

system	Range/structure	number of codes for injury
ICD9cm	800.00 – 999.99	2,880
ICD10	S00.00 – T99.99	3,900 Germany uses the ICD10GM, a version that is optimised for German billing requirements
ICD10cm	S00.000A – T99.999Z	17,500
AIS	BTSSLL.s (predot.AIS)	**B**odyRegion, **T**ype, **S**pecific structure or nature, **L**evel, **s**everity
AIS1990		1,200
AIS1998		1,200
AIS2005		1,980
AIS2008		1,980 (AIS is the same, only the Functional Capacity Index FCI is added)

As an example, the table below shows how a typical injury is denoted in the different coding systems and where differences occur.

Table C 2 Example of a typical head injury that is denoted in the different coding systems.

system	code	description
ICD9cm	851.32	Cortex (cerebral) laceration with open intracranial wound, with moderate [1-24 hours] loss of consciousness
ICD10	S06.31	Contusion and laceration of cerebrum, open, any duration In ICD10GM it should be coded together with S06.71 for the duration of loss of consciousness between 30 minutes to 24 hours
ICD10cm	S06.333A	Contusion and laceration of cerebrum, unspecified, with loss of consciousness of 1 hour to 5 hours 59 minutes, initial encounter
or	S06.334A	Contusion and laceration of cerebrum, unspecified, with loss of consciousness of 6 hours to 24 hours, initial encounter
AIS 1990	160206.3	Unconsciousness known to be 1-6 hours without neurological deficit
	160210.4	Unconsciousness known to be 6-24 hours without neurological deficit
AIS2005	161006.3	Cerebral contusion, loss of consciousness 1-6 hours (severe concussion)
	161007.4	Diffuse Axonal injury prolonged traumatic coma < 6 hours

For recording causes of death, the use of ICD9 or ICD10 is sufficient, whereas for use in hospital, the clinical modification is preferred as this extension is capable of coding intermediate consequences such as the duration of unconsciousness. For fatalities this is not important; the final outcome is death. But for injuries and the rating of the severity in AIS it is relevant information.

The different versions of ICD and AIS have been developed over time in order to more specifically record diagnoses. Specifiers present in one coding system may be unavailable in another because of its different purpose (billing, epidemiology, estimating severity or impairment). For AIS it is possible that an injury originally rated as severe, could be rated less severe in newer version because of better treatment possibilities, or because original codes are further specified into more detailed codes with different severity levels are available in the new version. This is for example the case for open fractures of the radius. AIS1990 and AIS1998 contain one injury code (AIS=3), whereas in AIS2005 and AIS2008 thirteen types/locations of the fracture can be distinguished of which seven are rated now as AIS=2.

It is not clear to what extent the number of MAIS ≥ 3 casualties varies depending on whether direct coding by the 'gold standard' of AIS© 2005/update 2008 or various ICD-derived severities are used. In this study, the estimated number of MAIS ≥ 3 casualties is compared for different versions of AIS and for different recoding tools.

In addition, for some countries the Maximum AIS is based on a limited number of injuries, where in other countries the MAIS is based on many more or even all injuries of an injured person. It is not known to what extent the number of injuries included when determining the MAIS influences the number of MAIS ≥ 3 casualties.

A fourth issue relates to the use of full codes. In some countries (e.g. Austria, Slovenia) the AIS is based on ICD10-drived AIS, where before applying the conversion to AIS, the injury code is truncated to four digits. It is possible that, this may lead to deviation from the AIS of the injury and therefore, Maximum AIS of the casualty, which will finally also lead to deviation in the number of MAIS ≥ 3 casualties.

The main objective of this analysis is to study these effects in the participating countries and to provide recommendations for corrections for:

1. the effect of different AIS verions and ICD-derived AIS compared to direct AIS coding;
2. the effect of using of different conversion tools for converting ICD codes into AIS codes (this is a mixed effect of the ICD-version, the tool and the AIS version that it converts to) – in relation to the gold standard;
3. the effect of using a limited number of injuries per casualty for the MAIS score;
4. the effect of using 4 digits instead of full when driving AIS.

Method

For each of the factors listed above an approach was selected to study the effect.

1. The effect of different AIS versions was studied using the GIDAS data set of accidents recorded since 2008 that have been coded in both AIS1998 and AIS2008.

   In order to study the effect of direct AIS compared to ICD-derived AIS, a dataset from Germany was available where AIS-codes and independent ICD10 codes were available for the same RTC (Road Traffic Casualty). ICD10 codes were recoded with AAAM10, ECIP and AGU to rate the severity and compared to dAIS. Unfortunately no other datasets were available to study other combinations of AIS versions.
2. The effect of different mapping tools was studied with data from NL, ES, BE where the ICD-codes were recoded to AIS with different tools: ICDmap90, DGT, ICDpic, AAAM9, ECIP and AAAM10.

3. The effect of using a limited number of injuries for the MAIS calculation was investigated by studying the effect on the estimated number of MAIS ≥ 3 casualties in case of leaving out injuries (NL, BE, ES).

4. The effect of truncation of injury codes was assessed by trunking the ICD injury codes in countries where full codes were available (NL, BE, ES).

To study the effect of the different tools to derive the AIS from ICD, partners used two or more tools on the same data set. The results are analysed to show the differences in the total number of MAIS ≥ 3 casualties. For combinations of ICD-version, Tool and AIS-version where the difference was substantial, additional analyses were completed by mode of transport and age.

The table below provides an overview of the available tools:

Table C 3 Available tools to derive the AIS

	Access	System	Predot.AIS	MAIS	ISS 0..75,99	ISS_ BodyRegion	AIS per BodyRegion
AIS direct	paid	AAAM handbooks	yes	1,2,3,4,5,6,9	yes	yes	yes
ICD9cm							
ICDmap90	paid	DOS application	1990	0,1,2,3,4,5,6,9	yes	yes	Yes
DGT	open	SAS	1998	0,1,2,3,4,5,6,9	no *	no *	no *
ICDpic	open	Stata	2005	0,1,2,3,4,5,6,9	yes	yes	Yes
AAAM9	open	Excel	No	2-, 3+, 9	no	no **	no **
ICD10							
ECIP	open	SPSS, Stata	1998	0,1,2,3,4,5,6,9	yes	yes	Yes
AGU	restricted	SQL/php	No	0,1,2,3,4,5,6,9,3+	No	No	Yes
AAAM10	open	Excel	No	2-, 3+, 9	No	no **	no **
ICD10cm							
AAAM10	open	Excel	no	2-, 3+, 9	No	no **	no **

Overview of available tools

* the body region can also be determined in ICD, e.g. Barrel matrix, it requires some additional work to calculate the ISS.
** the body regions with an AIS ≥ 3 can be identified; requires some additional work.

Direct coding of AIS is generally seen as the best way to assess the severity of the injury. This can be done at the scene of the crash by the ambualce or at the emergency department of a hospital.

From ICD9cm, there are several tools to recode the AIS. The MS-DOS application ICDmap90 (Johns Hopkins, 1998) still runs on Windows XP machines but has stopped functioning on more recent operating system. It works with an input file and outputs the predot codes, severities and body regions. The DGT algorithm is a SAS® recode of ICD9-injuries into predot codes and severities. Both

ICDmap90 and DGT can assign two predots to one ICD9 injury. The ICDpic stata tool was developed in 2009 by Clark, Osler and Hahn and the data set recoding the injuries into predots and severities was used in this study. The AAAM9 and AAAM10 excel tables (AAAM, 2015) were provided by the European Commision. This tool only separates Serious injuries (3+) from Slight injuries (1,2) and Undetermined (9).

From ICD10 the number of tols is more limited. In the EC-Apollo project, the European Center for Injury Prevention of the University of Navarra (ECIP 2006) developed an Algorithm to transform ICD-10 codes into AIS1990 (1998 update).

Very recent, iIn Switzerland AGU (Working Group on Accident Mechanics), Zürich developed a method to derive MAIS ≥ 3 information based on matching police data with hospital data (Schmitt KU, Baumgartner L, Furter K, Gubler A, Scholz S, Lüber B, 2014). A core of this research was the development of a mapping algorithm for deriving AIS based on ICD10GM information. Taking into account the spirit of AIS (which is normally to code the lowest severity level that matches with the available information) Schmitt et al used a conservative approach for the mapping algorithm. In order to increase the level of detail in the analysis compared to the use of ICD only, they are including additional information such as the duration of stay in hospital, the duration of intensive care and the age of the patient.

The AAAM10 tables do not explicitly distinct ICD10 and ICD10cm codes. The codes are simply listed and some appear to be ICD10cm (7 characters) where others have just 4 or 5 characters.

Some of the tools have the possibility to determine other severity indicators as well, such as the Injury Severity Score (ISS). This is calculated as the sum of the squares of highest AIS code in each of the three most severely injured ISS body regions. It ranges from 1 to 75. Table C 4 shows which tools are applied in which countries for this study.

Table C 4 Overview of countries and their current and possible use of ICD-AIS tools

Country	Basic coding	Current AIS	Possible to apply in
France (Rhone 2006-2012)	dAIS (1990)	Direct	-
Sweden	dAIS (2005)	Direct	-
Germany (Gidas)	dAIS (1998 + 2008)	Direct	
Germany (Gidas/MHH)	dAIS2008 + ICD10GM	Direct	ECIP, AAAM10, agu
Netherlands (1993-2013)	ICD9-cm	ICDmap90	DGT, ICDpic, AAAM9
	Convert to ICD10		ECIP, AAAM10
Netherlands (2012-2014)	ICD10		ECIP, AAAM10
	Convert to ICD9cm	ICDmap90	DGT, ECIP, AAAM9
Spain (2011)	ICD9cm	ICDpic	AAAM9
	Convert to ICD10		ECIP, AAAM10
Belgium (2009-2011)	ICD9cm	ICDpic	AAAM9
Austria (2014)	ICD10-4 main	-	AAAM10
Slovenia (2013)	ICD10-4 main	-	AAAM10
United Kingdom (Scotland)	ICD9cm	ICDpic	-
(England)	ICD10	-	ECIP, AAAM10

Inclusion/exclusion

For practical reasons and for an optimal distinctive power we decided to consider a broad range of traffic casualties, i.e. E800-E829 in ICD9, or V00-V89 in ICD10, extended with cases that could be selected on the basis of "Car-insurance payment" (Spain) or "Linked to police casualty" (Netherlands) or other criteria. Double counting was avoided whenever possible by excluding readmissions. The presence or lack of injuries is not an exclusion criterion here as that is the subject of this study; fatalities and patients staying for observation or receiving day treatment were included. More specific in/ exclusion criteria may have a large effect on the total number of MAIS ≥ 3 road traffic casualties, however the percentages of MAIS ≥ 3 among all casualties and the severities that the recoding tools assign are hardy influenced.

General description of datasets used in case countries

AUSTRIA: In 2014 there were 12,274 road traffic casualties in the Hospital Discharge Register that coded the injuries in ICD10. Only the principal diagnosis was available in truncated (4-digit) form. With the AAAM10 tool it was possible to rate 856 (7%) of them as MAIS ≥ 3.

The Austrian institute was not able to apply the tools themselves, but Statistics Austria was able to help.
See Analysis 3.

BELGIUM: Over the years 2009-2011, 79,028 road traffic casualties were selected in the Hospital Discharge Register (Classic stays only), of which 19,143 (24%) were classified as MAIS ≥ 3 according to the ICD9cm ICDpic tool.

Patients were selected by
1) E-code E810-E819, E826, E827, E829, E988.5
2) At the emergency department the patient was registered as "involved in a traffic accident" (but pedestrians were nevertheless excluded here because with most of them no vehicle was involved in the accident and therefore should not be counted to road traffic accidents).
Fatalities are included; re-admissions are excluded. Patients not staying overnight are excluded (as no external cause or coded injury is available for them).
See Analysis 2,3,4.

FRANCE: Over the years 2006-2012 there were 51,940 reported road traffic casualties in hospitals in the Rhône region. The injuries have been coded directly in AIS (version 1990). 3,488 (6.7%) of them were rated as MAIS ≥ 3.
See Analysis 3.

GERMANY: Two datasets were studied:
1 Over the years 2008-2015, 16,695 casualties were selected from the GIDAS database. For these casualties the AIS is coded directly (version 1998 and 2008) based on the medical reports. The difference in severity of this group is studied.
2 Over the years 2007-2015, 209 road traffic casualties that were treated in the Medical School Hannover and gave their written consent to study their medical data were selected from the GIDAS in-depth database. For these casualties the ICD10 derived severities were compared to the direct AIS2008 severities. Both codifications are based on the same medical reports. It is important to note that the selected causalities do not represent a representative subset of the GIDAS data sample nor of the German road traffic accidents because as a specialised Trauma Center severly injured patients are more likely to be treated in this hospital than in other zones of the investigation region.
See analysis 1.

NETHERLANDS: Two datasets were studied:
1) Over the years 1993-2013 many patients were admitted in hospital. Among them there were 418,777 casualties of road crashes (E810-E829, excluding readmissions, including fatalities, including other External causes if they were matched to police reported road traffic casualties).

The injuries (ICD9cm) of these patients are recoded to AIS with the ICDmap90 tool. Also the injuries were converted to ICD10 and other tools were applied to recode the AIS and MAIS of these casualties. The result is that 107,738 casualties (26%) were classified as Serious (MAIS ≥ 3) by ICDmap90.

2) A similar exercise was completed on hospital records over the years 2012-2014 that were initially coded in ICD10. Among them there were 59,151 casualties of road crashes (V00-V89, excluding readmissions, including fatalities, including other External causes if

they were matched to police reported road traffic casualties). The injuries of these casualties are converted to ICD9cm and ICDmap90 rates 15.156 (26%) of them as MAIS ≥ 3.
See Analysis 2,3,4.

SLOVENIA: In 2013, 3,121 road traffic casualties have been selected from the Hospital Discharge Register that codes the injuries in ICD10. Only the principal diagnosis was available in truncated (4-digit) form. With the AAAM10 tool it was possible to rate 383 of them (12%) as MAIS ≥ 3.

The Slovenian institute was not able to apply the tools themselves, but the health sector NIJZ (National Institute of Public Health) has been very helpful and is now working on a dataset that contains not just the main diagnosis, but also other.
See Analysis 3.

SPAIN: In the year 2011, 30,813 road traffic casualties have been admitted to hospital of which 8,274 (27%) were classified as MAIS ≥ 3 according to the ICD9cm ICDpic tool. The traffic injury definition used for all the Spanish analysis was:

Traffic injuries must meet criteria 1 or criteria 2:
1. E-code for external (ICD9-CM): E810-819, E826-829, E988.5.
2. Accident compensation payer: "Traffic accident insurance Company".
The selection excludes deaths within 30 days, scheduled admissions, and readmissions and takes into account traumatic injuries in any diagnostic.
See Analysis 2,3,4.

SWEDEN: Swedish data were available to BIVV, however executing one of the studies appeared not feasible.

UNITED KINGDOM: data were not accessible during the time frame of the project, due to recent policy changes for institution requirements for being granted data access.

RESULTS

Determine AIS: different AIS versions; direct or ICD-derived

The main objective of this analysis is to determine the effect of different AIS versions and of direct coding versus different recoding tools for ICD dervides AIS codes.

For this analysis it was required that the injuries (next to direct AIS) were also coded independently in ICD. For the first part of those analysis we were happy to have injuries even coded in two AIS-versions in the GIDAS data set.

Different AIS Versions

The AIS definitions developed during time in order to take into account new medical treatment methods that influence the mortality risk and new diagnosis methods that allow for further specification of several injuries. Currently the most common AIS version used is AIS 2005 (with update 2008). There is only limited information on how a RTC rated in previous versions of AIS would be rated with the most recent version.In the GIDAS database however, RTC have been coded in both AIS2005/update2008 and in AIS1990/update1998 during the years 2008-2015, so for 16,695 RTC both indicators are present and can be compared.

For all RTC in the considered data set the distribution of MAIS 1-2 compared to MAIS ≥ 3 for AIS 1998 and 2008 is shown in Table C 5. In the majority of cases the MAIS ≥ 3 metrics is not influenced by the AIS version. However, of 1,019 cases that were rated as MAIS ≥ 3 according to AIS 1998 there are 111 that are MAIS 1-2 according to AIS 2008 and 11 for which the injury severity level is unknown. In contrast for 10 out of 14,794 RTC the injury severity assessment according to AIS 1998 is lower than for the AIS 2008 assessment.

Table C 5. Cross table for MAIS 1-2 and MAIS ≥ 3 for AIS 1998 and AIS 2008

		AIS 2008			total
		MAIS 1-2	MAIS ≥ 3	unknown	
AIS 1998	MAIS 1-2	14,752	10	32	14,794
	MAIS ≥ 3	111	897	11	1,019
	unknown	7	2	873	882
total		14,870	909	916	16,695

When comparing individual MAIS levels according to AIS 1998 and AIS 2008 the assessment is identical for both systems, see Table C 6**Fout! Verwijzingsbron niet gevonden.**. for 14,453 cases (87%, cases on the diagional). However, there is a relative large group of MAIS 2 assessments according to AIS 1998 that are rated MAIS 1 according to AIS 2008. The 2008 metric is normally identical to the 1998 assessment or results in a lower injury severity level.

Table C 6 Comparison of individual MAIS levels according to AIS 1998 and AIS 2008

		AIS 2008							total
		MAIS 1	MAIS 2	MAIS 3	MAIS 4	MAIS 5	MAIS 6	unknown	
AIS 1998	MAIS 1	11,747	12	3				18	11,780
	MAIS 2	1,055	1,938	7				14	3,014
	MAIS 3		100	**555**	**22**	**1**		1	679
	MAIS 4		11	**91**	**84**			4	190
	MAIS 5			**1**	**14**	**89**		5	109
	MAIS 6						**40**	1	41
	unknown	6	1				2	873	882
Total		12,808	2,062	657	120	90	42	916	16,695

From this table we can derive a factor that we can use to estimate the true number of MAIS ≥ 3 (according to AIS2008) on the basis of the AIS1998 number. By multiplying the number in AIS1998 (1,019) with a factor 0.892, we obtain the correct number (909).

Figure C 1 shows the percentage of MAIS ≥ 3 casualties for different transport modes and different AIS versions. From this figure can be seen that for all transport modes, AIS2005 results in lower number of MAIS ≥ 3 casualties than AIS1998. Figure C 1 shows the cross tables and correction factors for different road user types. The correction factors vary between 0.871 for pedestrians and 0.927 for "all other road user types".

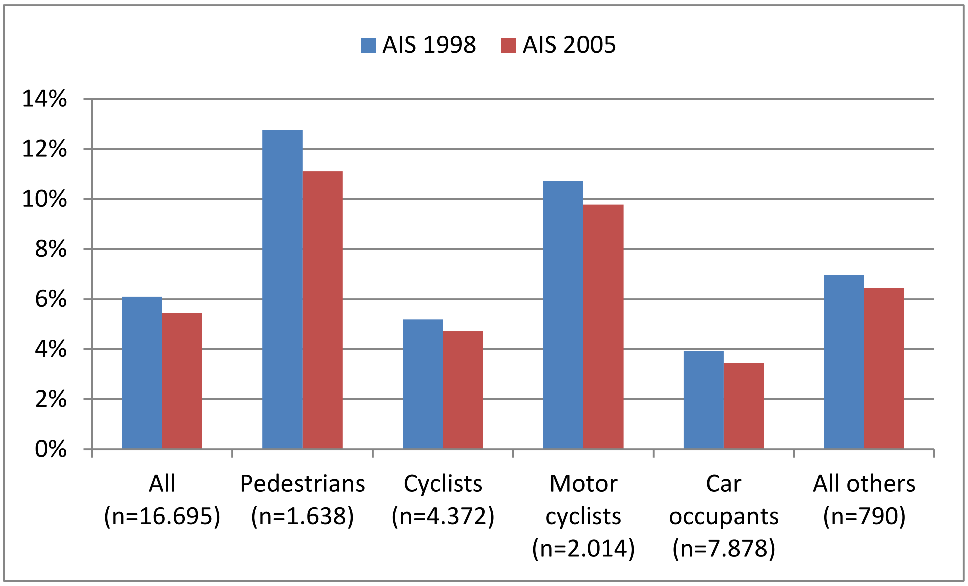


Figure C 1 Comparison of percentage of RTC that is rated MAIS ≥ 3 according to AIS 1998 and AIS 2008 by road user type.

Table C 7 Correction factors for different road user types.

	Off diagonal		Total no. of RTC	MAIS ≥ 3		Difference AIS versions		Factor AIS 1998 -> 2008	% MAIS ≥ 3 amongst injured	
	N	%		1998	2008	N	%		1998	2008
All traffic participants	173	1.0	16,695	1,019	909	110	10.8	0.892	6.1	5.4
Pedestrians	38	2.3	1,638	209	182	17	8.1	0.871	12.8	11.1
Cyclists	39	0.9	4,372	227	206	21	9.3	0.907	5.2	4.7
Motor cyclists	31	1.5	2,014	216	197	19	8.8	0.912	10.7	9.8
Car occupants	60	0.8	7,878	310	272	38	12.3	0.877	3.9	3.5
All other RTC	4	0.5	790	55	51	4	7.3	0.927	7.0	6.5

The deviation between the correction factors to derive MAIS ≥ 3 2008 estimation based on MAIS ≥ 3 1998 figures for different road user types is small. When applying the average correction factor of 0.892 the mistake ranges between -3.8% and 2.4%. The largest deviation occurs for all other RTC. For these crashes a small total number of MAIS ≥ 3 is recorded. Following that the difference may not be statistically relevant. The second largest deviation with 2.4% can be observed for pedestrians. For the cyclists group an additional analysis for different accident scenarios (single bicycle accident, accident against motorised vehicle and all other bicycle accidents is further analysed and shows no difference.

Note that we could also take another design to make results of AIS 1998 and AIS2008 comparable. It is possible that specific injuries were rated MAIS ≥ 3 in AIS1998 but are no longer 3+ in the 2008 version. Excluding these injuries from the severity assessment was another option. However, to setup such an exclusion list of injuries would require more medical background than we had available in the team.

1.2 Direct AIS compared to ICD-derived AIS

For a small subset of the German GIDAS data sample it is possible to compare the direct coded AIS that is the GIDAS standard to the ICD that is coded in the hospital. In Germany ICD10 is used for billing purposes and the ICD is coded by experts on medical billing requirements. Also Sweden and France (Rhône) use direct AIS coding, but for these countries ICD derived codes are not available. Other countries only have ICD and no direct coding of AIS.

209 casualties from the GIDAS database were matched to patient information of the Medical School Hannover. In total 1,520 injuries were coded for these patients (average 10.3 for the 103 serious cases MAIS ≥ 3 and 4.3 for the 106 minor cases MAIS2-). The severity of these ICD10 injuries were rated with three tools: ECIP, AAAM10 and AGU and their resulting (M)AIS scores were compared to the direct (M)AIS scores (version 2008) assigned in GIDAS. As direct coded AIS is considered as the best method, differences that appear when applying different recoding tools are considered to be errors; incorrect ratings of the casualties' severity.

The comparison of the correct and incorrect ratings, including the distribution of cases the tools were unable to assign an MAIS level is shown in 0. ECIP best succeeds to rate the correct MAIS ≥ 3 category followed by the AGU algorithm. However, the ECIP algorithm also assigns more often incorrectly MAIS ≥ 3 than the other two tools and for the AGU algorithm the number of cases without definite assignment of either MAIS 1-2 or MAIS ≥ 3 is considerably high with 58 cases in the MAIS 1-2 category and 16 cases in the MAIS ≥ 3 category (assigned by GIDAS).

Before discussing the probable reasons for incorrect coding it is important to remind on the different ICD10 versions the tools might be optimised for. While the AGU tool is developed for ICD10GM it is unclear which versions are the base for the other two tools, being the standard WHO version the most likely. Following that it might be, that the deviation is only a result of different ICD versions which would need to be further elaborated. For cases which initially deviated from the direct AIS, a check took place which ICD code caused the deviation to the MAIS ≥ 3 rating, and if needed corrections were done to both direct AIS and ICD10GM codes on the basis of the injury descriptions.

ECIP

Five of the false positives (cases that were rated MAIS ≥ 3, but not according to dAIS) are caused by incorrectly coded ICDs. That means that there was no mistake from the tool itself. One case is the result of the AIS coding itself. The AIS code book distinguishes between lung contusion not further specified (nfs), unilateral lung contusion and bilateral lung contusion. While the unilateral lung contusion is rated with AIS2 the bilateral lung contusion and lung contusion nfs are rated with AIS3. In the case the lung contusion was unilateral but ICD does not distinguish between the three different types and the ECIP algorithm uses the code as the code for lung contusion nfs, which seems to be logical. However, it does not take into account the general coding rule to assign the code with the lowest possible AIS level. In four cases the issue results of the unprecise coding options concerning the loss of consciousness in the ICD10GM system or the differences between ICD10 and ICD10GM, respectively. In seven cases a fracture was mapped as an open fracture although information on the soft tissue injuries are coded separately in the ICD10GM if relevant. Further analysis of the different ICD versions showed that the approaches ICD are different. While in the ICD10 approach the soft tissue injury involved in a bone fracture is coded together, in the ICD10GM version two different codes are used; one for the fracture and one for the soft tissue injury connected with the fracture. For the remaining 6 cases important deviations between ICD10 and ICD10GM caused likely the differences. That means that in total only for one deviation the method itself is responsible for deviations of MAIS ≥ 3 mapping. In all other cases the ICD was coded incorrectly or different versions of ICD codes at least contributed to the deviation.

Regarding the false negatives (dAIS rates MAIS ≥ 3 where ECIP rates a lower MAIS) one case is based on wrong ICD coding (two broken ribs were coded by ICD although actually a series fracture involving three ribs was reported). For the other cases differences in the ICD versions can be made responsible for the wrong assessment. All of them were either open fractures that were correctly coded by ICD10GM or rib fractures with at least three ribs. For both items the ICD coding rules are completely different in the two relevant systems.

AAAM

There are five false positives within the AAAM algorithm (AAAM rates MAIS ≥ 3, dAIS not). Two cases result from wrong ICD codes. For two cases the injury severity for a specific injury without further information is higher than for the actual injury in the accident with the additional information concerning the small extend of the injury. For one of these two cases the ICD code could be translated to the AIS injury "intra cerebral bleeding nfs" which corresponds to AIS 3. When it is known that the intra cerebral bleeding is not associated with loss of consciousness the injury is rated as AIS 2, which is the case for this victim. The other case is equal to the already described issue with unilateral, bilateral and lung contusion nfs. In addition, there is one case that seems to be caused by differences in the ICD versions.

For the false negatives (dAIS reates MAIS ≥ 3, AAAM not) there are four cases for which the level of detail within ICD is insufficient to decide between AIS 2 and AIS 3. For one case a wrong ICD coding is responsible for the deviation. For the other 13 cases differences in the ICD versions at least contributed to the underestimated injury severity. All of them were either open fractures that were correctly coded by ICD10GM or rib fractures with at least three ribs.

AGU

There are five false positive cases (AGU rates MAIS ≥ 3, dAIS not). Two of them are caused by wrong ICD coding and for three it remains unclear why it is wrong. It is important to note, that the agu method is developed for ICD10GM. That means that differences in the ICD versions are unlikely the cause of the wrong estimation.
Regarding the false negatives (dAIS rates MAIS ≥ 3, AGU not) there are three cases. For all of them a correct estimation should be possible when taking into account the combination of bone fracture with the additional code on tissue injury.
The AGU algorithm shows a considerable high number of unknowns.

Intersections between the methods
The table below shows which tool rates the casualty as MAIS3 The number of cases for which all tools rate MAIS 1-2 and MAIS ≥ 3 are 33 and 78 respectively, For these cases there is no doubt about their severity. For the remaining 98 cases the tools do not give uniform ratings or the severity could not be decided.

Table C 8 Influence of cases without assigned MAIS on the MAIS ≥ 3 rate

Method	Number MAIS ≥ 3	Number MAIS 1-2	Number not assigned	MAIS ≥ 3 rate complete sample	MAIS ≥ 3 rate only assigned cases
MHH	103	106	0	49%	49%
ECIP	116	83	10	56%	58%
AAAM10	82	100	27	39%	45%
AGU	89	46	74	43%	66%

The VENN diagram below (Figure C 2) shows the overlap and differences between the MAIS ≥ 3 rated cases by dAIS (GIDAS) and ICD-derived severities with ECIP, AAAM and AGU.

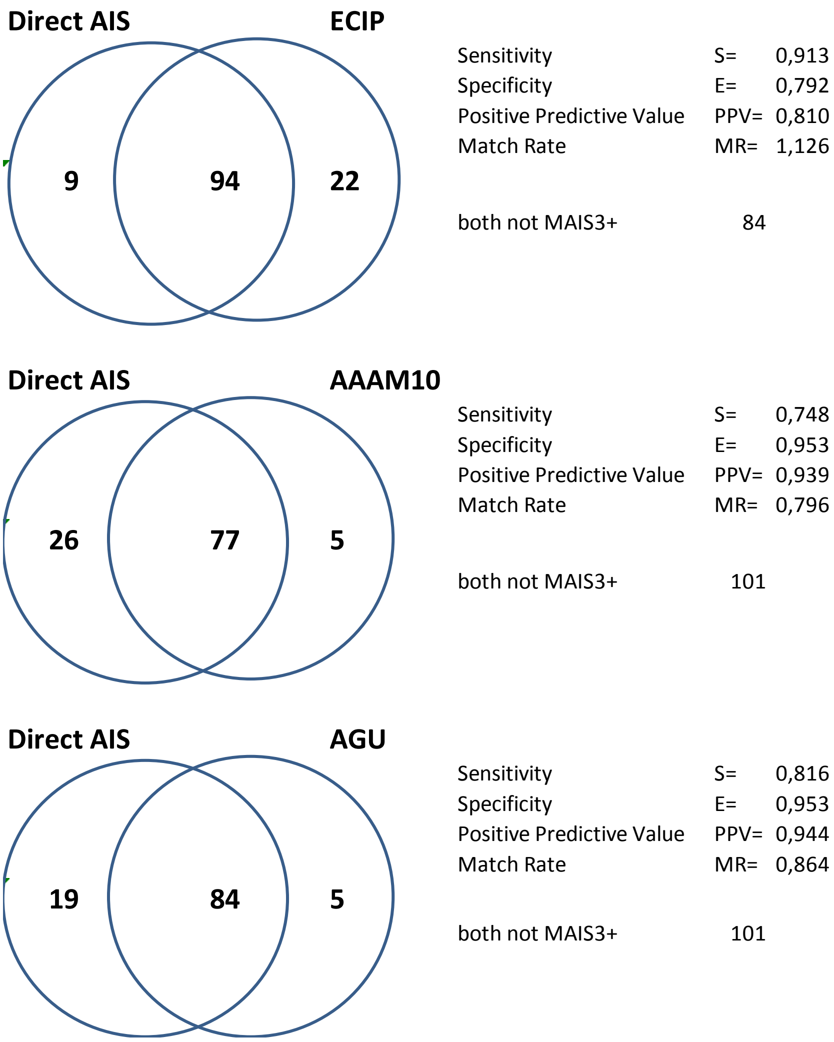


Figure C 2 Overlap and differences between the MAIS ≥ 3 rated cases by dAIS (GIDAS) and ICD-derived severities with ECIP, AAAM and AGU

Since we consider direct coding as the gold standard, we can conclude from the VENN diagram that ECIP misses 9 cases and shows 22 false positives. AAAM10 misses 26 cases and shows 5 false positives. AGU misses 38 cases and shows 2 false positives.

The indicators were calculated using the following formulas, with TP=True Positive, FP=False Negative, FN=False Negative and TN=True Negative:

Sensitivity	S = TP/(TP+FN)
Specificity	E = TN/(FP+TN)
Positive Predictive Value	PPV = TP/(TP+FP)
Match Rate	MR = (TP+FP)/(TP+FN)

The Sensitivity gives the probability that the tool correctly assigns MAIS ≥ 3 (1 being 100% correspondence). The Specificity reflects the probability that a slight injury is indeed assigned a MAIS2-. The PPV indicates the probability that an assignment of MAIS ≥ 3 is correct and the Match Rate is a factor that gives the difference in the number of assigned MAIS ≥ 3 cases.

We see that ECIP scores best at Sensitivity and Match Rate. Its relatively low values for Specificity and PPV are probably caused by the fact that it recodes to another AIS version. AAAM10 and AGU are not perfoming well on Sensitivity, but have much better scores for Specificity and PPV. For selecting MAIS ≥ 3 casualties, the Sensitivity s more important, for our objective ECIP appears to be most suitable of the three tools.

Table C 9 Comparing numbers of MAIS ≥ 3 casualties for direct coding and ICD10-derived coding.

Method	Number MAIS ≥ 3	Index (GIDAS = 100%)
GIDAS	103	100%
ECIP	116	113%
AAAM10	82	80%
AGU	89	86%

Table C 9 shows the summary results. ECIP appears to result in a 13% higher number of MAIS ≥ 3 casualties compared to direct coding. This can be fully explained by the difference in AISversion. Recoding by AAAM10 and AGU rates 20% and 14% less RTC as MAIS ≥ 3 respectively. Please note that these results are based on a very small sample (209 casualties) of trauma casualties, coded in ICD10GM. Thus, although ECIP, after correction for AIS version, results in exactly the same number of MAIS ≥ 3 casualties, we cannot be sure that ECIP results in a perfect estimate. We recommend to repeat the exercise with a larger sample and an ICD version that is used within the algorithms. The latter could for example be achieved by recoding of the analysed cases by ICD10 specialists. The individual injury descriptions could be made available for this exercise.

Using different tools to recode ICD into AIS

Based on the available tools and data the following matrix was constructed to present which tools can be used and compared by partners from which countries. The resulting numbers of MAIS ≥ 3 casualties are also presented. As each dataset has a different number of casualties, the comparison is limited to the different numbers in a line.

Table C 10 Overview of MAIS ≥ 3 casualties per country and tool

			dAIS		icd9cm				icd10		
	Country	Code system	AIS 1998	AIS 2008	ICDmap90	DGT	ICDpic	AAAM9	ECIP	AAAM10	AGU
					1990	1998	2005	2008	1998	2008	2008
1	Germany Gidas/MHH	dAIS1998 + dAIS2008	1,019 (112%)	909 (100%)							
2	Germany Gidas	dAIS2008 + ICD10		103 (100%)					116 (113%)	82 (80%)	89 (86%)
3	Netherlands	ICD9cm			107,738	109,605	103,747	102,900			
	(1993-2013)	Convert to ICD10							93,418	59,094	
4	Netherlands	ICD10							14,384	8,391	
	(2012-2014)	convert to ICD9cm			15,156	15,272	14,722	12,699			
5	Belgium	ICD9cm					19,143	18,381			
6	Spain	ICD9cm					8,274	7,656			
		Convert to ICD10							7,532	4,963	

The first and second line repeat results that are discussed before. The green cells show the gold standard; direct coding using AIS2008. Lines 3, 4, 5 and 6 compare the numbers of MAIS ≥ 3 casualties that result from different recoding tools. On the basis of the available data, it was not possible to determine which recoding tool provides the best result. When taking into account a 12% difference between AIS1990/1998 and 2005/2008, the resulting numbers of MAIS ≥ 3 differ at most 7% between the different ICD9cm recoding tools. Moreover, ICDpic appears to result in the highest number of MAIS ≥ 3 casualties in all three countries (Nl, Be, ES). Looking at the ICD10 tools, both in the Netherlands and Spain, ECIP results in a much higher number of MAIS ≥ 3 casualties then the AAAM10 tool. This is partly due to the fact that ECIP recodes to AIS1998. Moreover, as we saw in line 2, AAAM10 appears to result in an underestimation of the number of MAIS ≥ 3 casualties. Looking into the AAAM10 conversion table in more detail shows that the conversion table actually uses ICD10cm and possibly the most recent version that is used in the USA. As most European countries use an older version without clinical modification, this does not fit with European practice. We recommend adapting the conversion tables for this tool to better fit to our needs, instead of applying a large correction factor.

Comparison of ICD9cm and ICD10 tools appears to be difficult as the conversion between ICD9cm and ICD10 (and ICD10 to ICD9cm) also plays a role. Lines 3b, 4a and 6b concern converted injuies and it is unknown what is does to the ICD-derived severities. Taking into account the 12% difference between AIS1998 and AIS2008, the combination of ICD-conversion and the recoding tool results in a difference in the number of MAIS ≥ 3 casualties of maximum 25%. It seems that the conversion from ICD10 to ICD9cm performs better than the conversion between ICD9cm to ICD10, although this can also be a result of ICD10 not being able to code clinical details, such as the duration of unconsciousness. As we don't know to what extent the ICD conversion causes the difference between the ICD9 and the ICD10 recoding tools, we cannot really compare the results of the ICD9 and the ICD10 tools.

Detailed results per country

BELGIUM: The two tools applied to the Belgium road traffic casualties rated a slightly different number of cases as MAIS ≥ 3. A factor of 1.042 would be needed to correct the AAAM9 number into the ICDpic number under the assumption that ICDpic is correct.

Table C 11 Number of casualties according number of diagnoses and conversion tool.

		ICDPIC	AAAM9	ICDPIC	AAAM9
MAIS	.	10,018	60,647	12.7%	76.7%
	1	11,373		14.4%	
	2	38,494		48.7%	
	3	15,864	18,381	20.1%	23.3%
	4	2,576		3.3%	
	5	636		0.8%	
	6	67		0.1%	
	Total	79,028	79,028	100%	100%
	MAIS ≥ 3	19,143	18,381	24.2%	23.3%

NETHERLANDS: The injuries (ICD9cm) of the 417,777 road traffic casualties were mapped to AIS with different tools. Also the injuries were converted to ICD10 and other tools were applied to derive the AIS and MAIS of these casualties.

The result is that 120.798 casualties were classified as MAIS ≥ 3 by any of these tools (28.8%). AAAM10 clearly fails as many injuries were not present in the conversion table. The number for each tool is shown in the table above. 83.495 were classified as MAIS ≥ 3 by all tools (excluding AAAM10), so 69% of the MAIS ≥ 3 cases by any tool, were selected by all tools.

A similar exercise was done on hospital records of the years 2012-2014 that were initially coded in ICD10. The injuries (ICD10) of the 59,151 road traffic casualties were mapped to AIS with different tools. Also the injuries were converted to ICD9cm and other tools were applied to derive the AIS and MAIS of these casualties.

The result was that 16,616 casualties were classified as MAIS ≥ 3 by any of these tools (28,1%). AAAM10 clearly fails as many injuries were not present in the conversion table. The number for each tool is shown in the table above. 11,873 were classified as MAIS ≥ 3 by all tools (excluding AAAM10), so 71% of the MAIS ≥ 3 cases by any tool were selected by all tools.
From the number assigned by each tool, a factor was calculated to recalculate the number resulting from any other tool. Further analysis by year gave quite stable factors. Also analysis by age group and transport mode gave no reason to believe there is a systematic difference by any of these variables.

The one exception is that ICDmap90 resulted in a lower number of MAIS ≥ 3 casualties for children under 10 years of age. This is known and described in the ICDmap90 documentation. E.g. 820.22

(Closed fracture of subtrochanteric section of neck of femur) and 821.00 (Closed fracture of unspecified part of femur) score AIS=3 for adults and AIS=2 for children.

SPAIN: Patients were classified from ICD9cm as MAIS ≥ 3 with two tools: ICDpic and AAAM9. Data were also converted to ICD10 and rated with ECIP and AAAM10.

Table C 12 Use AAAM9 and compare with the current ICDpic:

Traffic Injuries	MAIS0-2	MAIS ≥ 3	Missing	Total
Severity - ICDpic	15,984	8,274	20	24,278
Severity– AAAM9	15,192	7,656	1,430*	24,278

AAAM9 shows a lower number of MAIS ≥ 3 RTC. A factor of 1.081 would be needed to correct the AAAM9 number into the ICDpic number under the assumption that ICDpic is correct.

Table C 13 Convert ICD9 to ICD10 and use ECIP and AAAM10 and compare:

Traffic Injuries	MAIS0-2	MAIS ≥ 3	Missing	Total
Severity - ECIP	11,036	7,532	5,770	24,278
Severity – AAAM10	13,926	4,963	5,389	24,278

Both ECIP and AAAM10 show lower numbers that the ICDpic tool. The mixed effect of conversion from ICDE9cm to ICD10 and the tool cannot be separated, however ECIP would need a factor 1,099 and AAAM10 would need a factor 1,67 to compensate for the loss of MAIS ≥ 3 cases.

The effect of using a limited number of injuries per casualty

A patient might have multiple diagnoses, among which one or more injuries. Besides injuries diagnoses can also specify External cause and Diseases. The most important injury, as a reason for hospitalisation, is usually coded as first/principal/main diagnosis. This is not necessarily the most severe one. In some countries onlyu a limited number of injuries is taken into account.

The third analysis focuses on the effect of this complication when determining the Maximum AIS of a road traffic casualty.

In many countries, diagnoses are recorded for every (responsibility) episode of hospital departments. Therefore, it may occur that the same injuries are reported for more episodes. These duplicates have been removed.

A reduction on the number of injuries taken into account when determining the severity of a RTC, only has an effect on rating patients who have more than one injury. Approximately 40% of the seriously injured casualties have only 1 injury.

Table C 14 Distribution of RTC by the number of injuries that have been record on them. In case there is no injury, observation codes (V-code in ICD9, Z code in ICD10) can be counted – if available. Duplicate injury codes were removed (when possible) before the analysis.

Nr of diagnoses ALL casualties included	**SI (2013) ICD10**	**AT (2014) ICD10**	**BE ('09-'11) ICD9cm**	**FR-Rhone ('06-'12) AIS90**	**ES () ICD9cm**	**DE ('14-'15) ICD10**	**NL ('93-'13) ICD9cm**	
N=	3,121	12,274	79,028	51,940	24,278	209	472,087	
No injury diagnosis (%)		0	11.8	1.2	4.3	0	1.2	
Observation								
1 =main = principal	41.3	100	44.9	43.7	41.2	9	68	
2= 1 sub dia	31.6	-	19.7	32.2	21.5	12	18	
3	10.2	-	10.1	16.8	13.2	9	6.9	
4	7.0	-	5.5	4.7	7.9	9	2.9	
5	3.9	-	3.0	1.3	4.6	11	1.4	
6	2.1	-	1.8	0.5	2.7	7	0.7	
7	1.2	-	1.1	0.3	1.7	7	0.4	
More	2.7	-	2.0	0.5	2.8	35	0.4	

Table C 15 As Table C 15, but now for the selection on MAIS ≥ 3 (see the basic tool that is used for each country in table 38).

Nr of diagnoses MAIS ≥ 3casualties only	**SI**	**AT**	**BE**	**FR-Rhone ('06-'12)**	**ES**	**DE ('14-'15)**	**NL ('93-'13) ICD9cm**	
N=	353	856	19,143	3,488	8,274	103	117.850	
1 =main = principal (%)	74.2	100	37.3	15.9	25.8	2	53	
2= 1 sub dia	15.3	-	19.4	23.9	19.6	8	20	
3	6.5	-	12.7	22.2	16.6	4	11	
4	3.1	-	8.9	13.4	12.2	6	6.3	
5	0.8	-	6.2	9.1	8.9	8	3.9	
6	0.0	-	4.7	5.5	5.6	8	2.3	
7	0.0	-	3.2	3.5	3.9	10	1.4	
More	0.0	-	7.5	6.5	7.2	55	1.4	
% MAIS ≥ 3 of all	11%	7.0%	24%	6.7%	34%	49%	25%	

The cumulative frequency of Serious injuries (MAIS ≥ 3) by their number of reported injuries is displayed in Figure C 3. On average three out of four casualties have 3 or less injuries. This average excludes Germany because of the small sample not being representative for all serious traffic injuries in Germany.

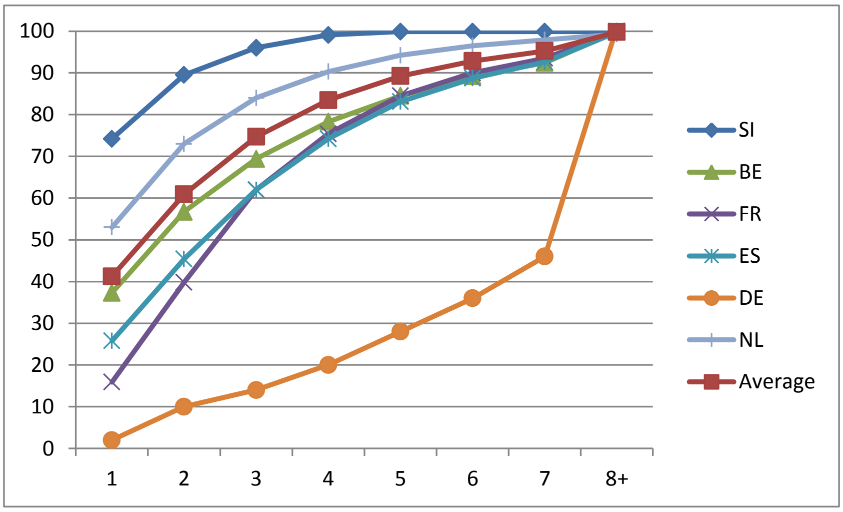


Figure C 3 Cumulative distribution of MAIS ≥ 3 casualties by their number of injuries

In some cases, only a limited number of injuries is coded or available for analysis. The consequence of this limitation was investigated by running the conversion tools taking into account 1, 2, 3 and all injuries and comparing the results. This analysis is done using Belgium, Spanish and Dutch data and Table 11.2 shows the results.

Table 11.2 Consequences of limiting the number of injuries in Belgium, the Netherlands and Spain. Top rows show the numbers of MAIS ≥ 3 cases; bottom rows show the percentage of cases that is still rated as MAIS ≥ 3 when not all injuries are taken into account.

	BE (ICD9cm ICDpic)	NL (ICD9cm ICDmap90)	NL (ICD10 converted to icd9cm ICDmap90)	ES (ICD9cm ICDpic)	SUM ICD9cm	Average ICD9cm (BE+NL+ES)/3
All	19,142	107,735	15,078	8,274	135,151	
3	17,900	105,728	14,766	7,753	131,381	
2	16,654	102,392	14,258	7,315	126,361	
1	13,678	91,159	12,489	6,357	111,194	
All	100%	100%	100%	100%		
3	94%	98%	98%	94%	97%	95%
2	87%	95%	95%	88%	93%	90%
1	71%	85%	83%	77%	82%	78%

On average, taking into account only 1 injury, results in an estimated number of MAIS ≥ 3 casualties that is 78% of the number that is estimated on the basis of all injuries. In case 2 injuries are taken into account, 90% of the serious traffic injuries is selected and when 3 injuries are taken into account, on average 95% of the number of MAIS ≥ 3 casualties are selected. This results in the following correction factors:

- In case only 1 injury is available per casualty, the estimated number of MAIS ≥ 3 casualties should be multiplied by 1.28
- In case only 2 injuries are available per casualty, the estimated number of MAIS ≥ 3 casualties should be multiplied by 1.11
- In case only 3 injuries are available per casualty, the estimated number of MAIS ≥ 3 casualties should be multiplied by 1.05
- In case 4 or more injuries are available, no correction is required.

Detailed results per country

BELGIUM:

Table C 16 Belgium limiting the number of injuries.

		Number of injuries taken into account									
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
MAIS	**1,2,9**	5,464	2,488	1,242	636	302	131	59	20	6	0
	3	12,083	14,312	15,182	15,611	15,803	15,893	15,899	15,905	15,894	15,883
	4	1,356	1,976	2,279	2,390	2,480	2,521	2,557	2,562	2,568	2,573
	5	212	327	386	450	500	537	564	592	609	621
	6	27	39	53	55	57	60	63	63	65	65
	Total	19,142	19,142	19,142	19,142	19,142	19,142	19,142	19,142	19,142	19,142
	MAIS ≥ 3	13,678	16,654	17,900	18,506	18,840	19,011	19,083	19,122	19,136	19,142
% of 19,142		71,5%	87,0%	93,5%	96,7%	98,4%	99,3%	99,7%	99,9%	100%	100%

SPAIN:

For 8,274 serious road traffic casualties in the Spanish hospital data, it was simulated what would be the effect of not using all injuries available for the determination of MAIS. Ending with just the first (principal) diagnosis it appeared that 77% of the casualties were still rated as MAIS ≥ 3. 23% of the cases had a lower severity on their first diagnosis and would have been rated as slight if not other diagnoses were available.

Table C 17 Spain limiting the number of injuries

	1	2	3	All (up to 14
MAIS2-	1,917	959	521	0
MAIS ≥ 3	6,357	7,315	7,753	8,274
%	77%	88%	94%	100%

NETHERLANDS:

The 107,735 cases scoring MAIS ≥ 3 (ICD9cm → ICDmap90) were selected to estimate what would be the resulting MAIS if the number of injuries was lowered to eventually include the principal diagnosis only. This analysis was carried out not on the ICD9cm injuries but on the predots that were associated with them. Some ICD9-codes map to more than one AIS-predot (average 1.09 per ICD9 code).

Ending with just the first (principal) diagnosis it appeared that 85% of the casualties were still rated as MAIS ≥ 3. 15% of the cases had a lower severity on their first diagnosis and would have been rated as slight if not other diagnoses were available.

Table C 18 Netherlands limiting the number of (predot) injuries

	ICD9cm-5 Number of diagnosis taken into account									
MAIS	1	2	3	4	5	6	7	8	9	10
0129	16,576	5343	2007	799	284	114	36	7	1	0
3	66,476	68,803	70,514	71,019	71,139	71,069	71,008	70,979	70,955	70,949
4	21,628	28,854	29,435	29,779	29,995	30,116	30,179	30,189	30,199	30,203
5	2,856	4,521	5,548	5,899	6,073	6,191	6,267	6,315	6,334	6,337
6	199	214	231	239	244	245	245	245	246	246
Total	107,735	107,735	107,735	107,735	107,735	107,735	107,735	107,735	107,735	107,735
MAIS ≥ 3	91,159	102,392	105,728	106,936	107,451	107,621	107,699	107,728	107,734	107,735
%	85%	95%	98%	99%	100%	100%	100%	100%	100%	100%

The 15.078 cases in the years 2012-2014 that were coded in ICD10 were converted to ICD9 cm and the tool ICDmap90 was used to rate the AIS-severity. Similarly, to the cases above it was simulated what the MAIS would be wen injuries were left out. Ending with just the first (principal) diagnosis it appeared that 83% of the casualties were still rated as MAIS ≥ 3. 17% of the cases had a lower severity on their first diagnosis and would have been rated as slight if not other diagnoses were available.

The difference with the converted cases is amall, which indicates that the priority mechanism to select the main diagnosis was not altered with the implementation of ICD10 in dutch hospitals.

Table C 19 Netherlands limiting the number of (predot) injuries

	ICD10-5 Number of diagnosis taken into account									
MAIS	1	2	3	4	5	6	7	8	9	10
0129	2,580	820	312	135	53	27	9	2	0	0
3	9,656	10,372	10,626	10,704	10,745	10,749	10,753	10,754	10,754	10,753
4	2,841	3,836	4,079	4,165	4,205	4,223	4,235	4,241	4,242	4,243
5	0	48	59	69	70	74	76	76	77	77
6	1	2	2	5	5	5	5	5	5	5
Total	15,078	15,078	15,078	15,078	15,078	15,078	15,078	15,078	15,078	15,078
MAIS ≥ 3	12,498	14,258	14,766	14,943	15,025	15,051	15,069	15,076	15,078	15,078
%	83%	95%	98%	99%	100%	100%	100%	100%	100%	100%

It is clear that taking into account a lower number of diagnoses, reduces the number of MAIS ≥ 3 casualties. As compared to other countries it appears that in the Netherands more often the most severe injury is coded as the main reason for admittance, as the loss in MAIS ≥ 3 cases is small. This may be related to the mechanism of deciding which is the main diagnosis:

The primary diagnosis is defined retrospectively (ie at discharge), as the diagnosis that is considered the main ***reason for hospitalization***. This definition deviates from the WHO guidelines in ICD-10 where the ***need for treatment or research*** is considered as the principal diagnosis. In both definitions, the primary diagnosis does not have to be the most severe diagnosis.

The effect of truncating injury codes before deriving AIS

The fourth and final analysis is conducted to get more insight on the effect of using 4-digit injury codes instead of full codes. There are several reasons for the unavailability of full codes (ICD9 or ICD10), such as: hospital practices (the description of the injuries is not detailed enough and administrative effort is reduced by coding the aggregated code) and privacy regulations (the detailed codes are not allowed to leave the hospital or medical sector).

The tools used differ on how they deal with truncated codes. Some tools simply say that the injury is not detailed enough to assess the severity and return MAIS=0 or MAIS=9 (unknown). Other tools, like AAAM, also provide a severity for the aggregated level, by taking into account the severities of the injuries underneath. If all injuries underneath score MAIS2– then it is assumed that the severity of the truncated injury is MAIS2– as well. On studying the AAAM10 list it appears that the severity of the truncated code can be either higher (e.g. S35.2) or lower (e.g. S02.4) than some of the detailed injuries. Apparently AAAM does make an assessment of the likeliness of MAIS ≥ 3 within the group. As documentation is lacking on the particular method used to assign 0,1,9 we need to see how it works in practice. Possibly cases where everyone gets 0 compensate groups where everyone gets MAIS ≥ 3 and by this balancing the total number to be comparable.

Method**:** Countries that use the full codes, truncate all the injuries to 4 digits and run their tool(s) again. The result is compared. It is expected that the number of MAIS ≥ 3 casualties will be lower on the truncated run. This difference can be expressed in a factor that can be applied on the truncated results in order to arrive at the number that resulted from the analysis on the full codes. This analysis can be performed with every AIS-derive tool. Truncation of injuries was studied in ICD9cm in Spain, Belgium and the Netherlands. A smaller dataset in ICD10 was available in the Netherlands.

The table below shows the effect on the number of MAIS ≥ 3 casualties in case of truncation for various conversion tools. Most conversion tools, except from ICDpic and AAAM10 appear to be quite capable to deal with truncated codes. ICDpic shows a large decrease in the number of MAIS ≥ 3 casualties in case injuries are truncated. A factor 4 to 5 decrease was observed in Spain and Belgium.Therefore, we recommend not to use ICDpic in case of truncated codes. The AAAM10 tool shows a considerable increase in the number of MAIS ≥ 3 casualties in case of truncated injury codes. We recommend to repeat this analysis when the conversion tables are adapted for the European needs and to have a closer look at how the tool deals with truncated codes.The other recoding tools loose less then 10% in case of truncated injury codes.

Table C 20 The number of severe (MAIS ≥ 3) injured according using full codes or truncated codes, and % of reporting

Country	Injury coding	Tool	Using full codes	Using truncated codes	%	Factor
ES	ICD9cm	ICDpic	8,274	2,108	25%	3.9
BE	ICD9cm	ICDpic	19,143	3,949	21%	4.8
NL	ICD9cm	ICDmap90	107,735	101,549	94%	1.06
		DGT	115,380	109,039	95%	1.06
		ICDpic	109,373	17,454	16%	6.3
		AAAM9	108,509	97,660	90%	1.11
NL	ICD10	ECIP	14,519	14,071	97%	1.03
		AAAM10	8,480	12,123	143%	0.70

Conclusions from the table:

1 When you have access to truncated injuries in ICD9cm only, then it is recommended to use ICDmap90 or DGT as recoding tool and correct with a factor 1.06, or use AAAM9 with a factor 1.11. Do not use the ICDpic tool in combination with truncated codes.

2 When you have access to truncated injuries in ICD10 only, then it is recommended to use ECIP as recoding tool. No correction is required. Combined with the factor to be in line with AIS2008, the net factor is 0.9.

Detailed results per country

BELGIUM:

All injuries of all road traffic casualties in Belgium have been selected and the severity was rated with ICDpic. This was done twice: on full icd9 codes and on truncated codes. Then the Maxiumum AIS was determined using all (up to 10) severities. This resulted in a number of seriously injuried RTC watch was much lower that using the full injury codes. Only 20% of the cases could be selected again as MAIS ≥ 3.

Table C 21 Truncation of injury codes leads to a drastic reduction in the number of Serious Injuries MAIS ≥ 3.

		Full code XXX.XX	Truncated injury XXX.X	Row%
MAIS	,	10,018	37,562	375%
	1	11,373	11,000	97%
	2	38,494	26,617	69%
	3	15,864	3,449	22%
	4	2,576	280	11%
	5	636	84	13%
	6	67	36	54%
	Total	79,028	79,028	100%
	MAIS ≥ 3	19,143	3,849	20%
	% MAIS ≥ 3	24,22%	4,87%	

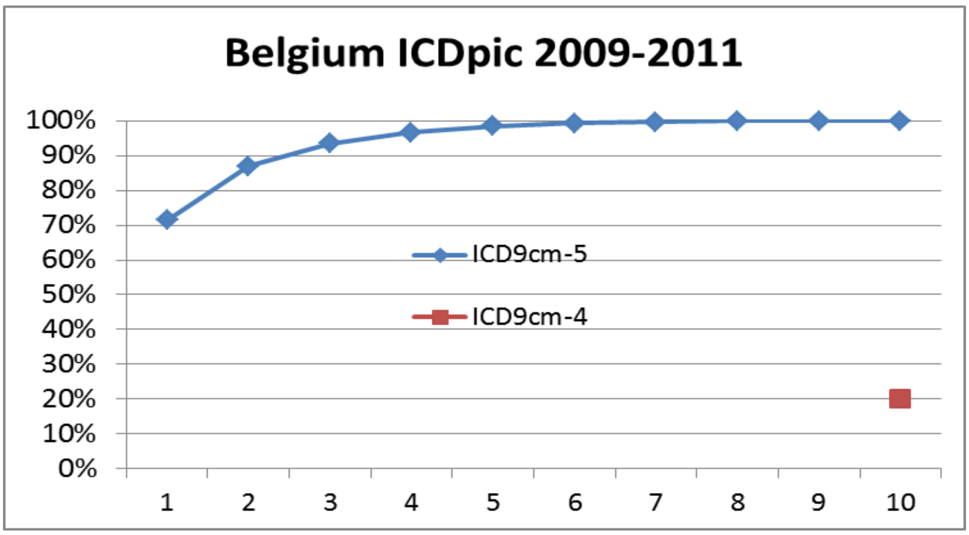


Figure C 4 Belgium trends in severity assessed with ICDpic, 2009-2011

NETHERLANDS:

The 107,735 cases scoring MAIS ≥ 3 (ICD9cm → ICDmap90) were selected and it was simulated what would be the MAIS if the last digit of the injury was removed. Cases that initially were not rated as MAIS ≥ 3 were not analysed. This analysis was combined with the previous analysis by subsequently leaving out (predot) injuries as well. The ICD9cm injuries were the ones that were truncated.

With Dutch data in ICD9cm and using ICDmap90, the loss in MAIS ≥ 3 cases is small (6%). Far more than 70% is remaining, even when limiting the number of diagnoses to the main diagnosis only.

Table C 22 Netherlands ICD9cm, limiting the number of injuries combined with truncation to 4 and 3 digits.

	ICD9cm-4 Number of diagnosis taken into account									
MAIS	1	2	3	4	5	6	7	8	9	10
MAIS2-/unknown	22,181	11,228	8,141	6,937	6,451	6,279	6,213	6,188	6,186	6,186
3	65,938	68,752	70,547	71,224	71,418	71,413	71,382	71,371	71,358	71,358
4	19,137	27,122	28,381	28,885	29,167	29,336	29,428	29,462	29,476	29,476
5	427	567	591	609	618	625	630	632	633	633
6	52	66	75	80	81	82	82	82	82	82
Total	107,735	107,735	107,735	107,735	107,735	107,735	107,735	107,735	107,735	107,735
Trunc 4 MAIS ≥ 3	85,554	96,507	99,594	100,798	101,284	101,456	101,522	101,547	101,549	101,549
%of 107,735	79%	90%	92%	94%	94%	94%	94%	94%	94%	94%
%of 101,549	84%	95%	98%	99%	100%	100%	100%	100%	100%	100%
	ICD9cm-3 Number of diagnosis taken into account									
Trunc 3 MAIS ≥ 3	75,952	83,405	86,070	87,222	87,738	87,966	88,064	88,093	88,103	88,103
% of 107,735	70%	77%	80%	81%	81%	82%	82%	82%	82%	82%
% of 88,103	86%	95%	98%	99%	100%	100%	100%	100%	100%	100%

A similar exercise was performed on the patients originally coded in ICD10 and that were converted to ICD9cm (note that ICD10->9 converted cases are not included in the summary tables, as the converted data obscure the pure effect). The ICD9cm codes have been truncated and the result is compared to full ICD9cm code results:

Table C 23 Netherlands ICD10, limiting the number of injuries combined with truncation to 4 and 3 digits.

	ICD10-4 Number of diagnosis taken into account									
MAIS	1	2	3	4	5	6	7	8	9	10
MAIS2-/unknown	2,579	872	403	244	166	143	126	122	121	121
3	9,573	10,265	10,486	10,548	10,586	10,589	10,595	10,595	10,595	10,594
4	2,843	3,856	4,104	4,197	4,237	4,257	4,268	4,272	4,273	4,274
5	0	1	1	2	2	2	2	2	2	2
6	1	2	2	5	5	5	5	5	5	5
Total	15,078	15,078	15,078	15,078	15,078	15,078	15,078	15,078	15,078	15,078
Trunc 4 MAIS ≥ 3	12,417	14,124	14,593	14,752	14,830	14,853	14,870	14,874	14,875	14,875
%of 15,078	82%	94%	97%	98%	98%	99%	99%	99%	99%	99%
%of	9,573	10,265	10,486	10,548	10,586	10,589	10,595	10,595	10,595	10,594
	ICD10-3 Number of diagnosis taken into account									
Trunc 3 MAIS ≥ 3	11,339	12,795	13,221	13,373	13,438	13,466	13,482	13,487	13,489	13,489
% of 15,078	75%	85%	88%	89%	89%	89%	89%	89%	89%	89%
% of 13,489	84%	95%	98%	99%	100%	100%	100%	100%	100%	100%

The results are shown in the figure below:

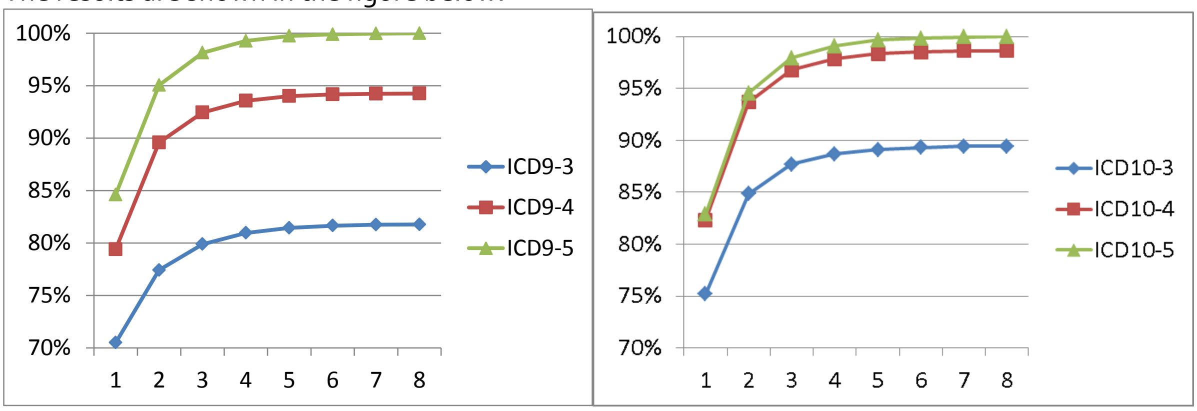


Figure C 5 Netherlands, limiting the number of injuries combined with truncation to 4 and 3 digits.

As an additional exercise *different tools* to map AIS have been studied on both full codes and truncated codes. For all road traffic casualties, originally recorded in ICD9cm during the years 1993-2013, the ICD9cm codes were truncated and the tools were run to rate the severity. Especially ICDpic gives pour results and becomes actually useless.

In order to apply ICD10 tools, the full ICD9 cm codes were converted and the resulting ICD10 code was truncated before running the tool again. (note that ICD9->10 converted cases are not included in the summary tables, as the converted data obscure the pure effect). DGT and ICDmap90 manage to keep 95% of the cases within the group of MAIS ≥ 3. The AAAM9 rating keeps 90% of the cases. Where ECIP now underestimates the number of MAIS ≥ 3 RTC by 13%, AAAM10 overestimates the number by 25%.

The same exercise was done on the cases that were originally coded in ICD10 during the years 2012-2014. In order to apply ICD9cm tools, the full ICD10 codes were converted and the resultingICD9cm codes were truncated before running the tool. Now ICDmap90, DGT and AAAM9 are able to keep all cases on board. ICDpic still performs bad. Among the tools working on ICD10, ECIP uses only 3%. It is remarkable that AAAM10 selects more casualties as MAIS ≥ 3 on truncated data then on using full codes, allthoug the number is still substantially lower than the ECIP selection.

Aside from the effect of using another tool, the effect of truncation is summarized in the table below.

Table C 24 the Netherlands MAIS ≥ 3 after applying different tools on truncated injuries. Yellow shaded cells indicate that injury codes were converted prior to running the tool to derive AIS. ICD converted cases are not included in the summary tables, as the converted data obscure the pure effect.

	Original, full codes		**Trunced codes**		**trunc within tool**	
	ICD9cm (1993-2013)	ICD10 (2012-2014)	ICD9cm	ICD10	ICD9cm	ICD10
Icdmap90	113,390	15,304			94%	99%
DGT	115,380	15,420	109,039	15,216	95%	99%
ICDpic	109,373	14,868	17,454	5,555	16%	37%
AAAM9	108,509	12,819	97,660	12,866	90%	100%
ECIP	98,616	14,519	86,210	14,071	87%	97%
AAAM10	62,231	8,480	77,612	12,123	125%	143%

Results summary

1. AIS1998 rated significantly more RTC as MAIS ≥ 3 than AIS2008. A factor 0,9 is needed to correct for the difference.The difference between AIS1990 and AIS1998 and between AIS 2005 and AIS 2008 can be neglected
   No significant effect of ICD-derived AIS compared to direct AIS coding could be derived;
2. ICD9cm,4 tools were included in the analysis, the difference in the estimated number of MAIS ≥ 3 casualties was at most 7% between the tools. For ICD10 there seems to be only one tool available, as the AAAM10 mapping does not actually fit to the European coding practice (no clinical modification);
3. The availability of just the main diagnosis leads to an underestimation of the number of MAIS ≥ 3 casualties. On the basis of data from 3 countries (NL, ES, BE), we propose a weight factor of 1.3 to compensate for this. In case two or three injuries are available the weight factors proposed are 1,1 and 1,05 respectively. The availability of more than 5 injuries hardly makes any difference as compared to 4. (less than 10% of the patients have more than 5 injuries and the situation that the 5^{th} or later injury is more severe than any of the first four can be neglected);
4. Truncation of Injury codes leads to an underestimation of the number of MAIS ≥ 3 casualties. Depending on the tool used to derive the AIS, a factor 1.3 (ICDmap90) to 4 (ICDpic) is proposed to compensate for this. The use of ICDpic is therefore discouraged when the full injury code is not available.

Recommendations

- Amend the AAAM10 tables for European use, without clinical modification.
- Further research on the systematic difference between dAIS and ICD-derived AIS.
- Promote availability of Hospital Discharge Data with full injury codes and at least four injuries.

References and Methods

Tools to RecodE ICD to AIS

ICDmap90	Johns Hopkins University (1998). ICDmap90 and ICDMAP-90 user's guide. Baltimore.
DGT	Directorate General de Trafico Madrid, Spain. SAS-algorithm. Available for this study. ICD9cm (version 1996) to AIS1998.
ECIP-SPSS	European Center for Injury Prevention, University of Navarra, Algorithm to transform ICD-10 codes AIS 90 (1998 update) and ISS, [version 1 for SPSS]. Pamplona, Spain 2006. with partial funding from the EU, DG SANCO Grant Agreement Nº 2004119 Project Apollo WP2.
ECIP-Stata	European Center for Injury Prevention, University of Navarra, Algorithm to transform ICD-10 codes into AIS 90 (98 update), version 1.0 for STATA Pamplona, Spain 2006. with partial funding from the EU, DG SANCO Grant Agreement Nº 2004119 Project Apollo WP2.
ICDpic	Clark, Osler, Hahn (2010). Stata module to provide methods for translating International Classification of Diseases (Ninth Revision) diagnosis codes into standard injury categories and/or scores. https://ideas.repec.org/c/boc/bocode/s457028.html.
AAAM9	AAAM (2015). "Copy of aaam_icd9map_v1 0_Feb2015 read only.xls".
AAAM10	AAAM (2015). "Copy of aaam_icd10map_v1 0_Feb2015 read only.xls".
AAAM10-cm	AAAM (2015). "Copy of aaam_icd10map_v1 0_Feb2015 read only.xls".
Agu	Schmitt KU, Baumgartner L, Muser M, Furter K, Scholz S, Lüber B, Thomas P, Simma A (2014) *Developing a scheme to report AIS-coded injury severity for Swiss traffic accident data*. IRCOBI Conference 2015. Berlin. 2014 Paper no. IRC-14-50. Schmitt KU, Baumgartner L, Muser M, Baudenbacher M, Simma A, (2015) *Improving the Swiss National Accident Statistics by Providing AIS Data to Classify Injury Severity*. 24th ESV Conference. Gothenburg. 2015. Paper No. 15-0323.

Conversions between AIS-versins and between ICD-versions

AIS9805	AAAM(2015). Crosswalk AIS1990/Update1998 conversion to AIS2005/Update2008 and vice versa. Accessed 5-1-2016 from http://www.aaam.org/ais-crosswalk.php
ICD9cm10cm	General Equivalence Mappings 2015. US convertor for ICD9cm to ICD10cm and vice versa. Download from http://www.cms.gov/Medicare/Coding/ICD10/2015-ICD-10-CM-and-GEMs.html https://www.cms.gov/Medicare/Coding/ICD10/Downloads/DiagnosisGEMs_2015.zip
ICD9cm10	Dutch converter for ICD9cm to ICD10 and vice versa. Download from http://www.rivm.nl/who-fic/ICD.htm http://www.rivm.nl/who-fic/in/Conversie80-10.zip http://www.rivm.nl/who-fic/in/ConversieICD10-CVZ80.zip For the purpose of the ICD-10 implementation in Dutch hospitals there are various forms of support and products available, such as the conversion ICD-9cm (CvZ80) to

ICD-10 and ICD-10 to ICD-9cm (CvZ80). By downloading these files, you represent and warrant:

- The WHO-FIC Collaborating Centre free of liability for the consequences of use and / or processing of the files,
- not to edit or use the files for commercial purposes.

Appendix D: Record linkage methods

This chapter analyses exemples from France, the Netherlands and Slovenia of deriving the number of serious injured (MAIS ≥ 3) using hospital and police record linkage.

Where police data are not suitable to assess the severity of the injuries sustained in an accident, a hospital discharge file can be used to assess the severity. Linking both datasets enables the selection of serious cases from the police file.
By doing so, it appears that police datasets are not complete as not all patients can be found. A second aim of linking therefore is to assess the completeness of the police dataset. The reporting rate can be defined as the number of cases present in the dataset compared to the true number of cases (MAIS ≥ 3).

EXPERIENCE OF FRANCE

Aim

Police data and the Rhône road trauma registry have been linked in routine on the Rhône county (1.6 million inhabitants), with several aims, including to estimate the real number of casualties. This aim is achieved with the construction on linked police and registry records of a model to predict the proportion of MAIS ≥ 3 among casualties of all severities, followed by capture-recapture.

Data

The police French data are supposed to include all accidents that cause injury or death, that occur on the road network open to public, and implying at least a moving vehicle. The injury severity of a casualty is only approached by fatal/hospitalized/non-hospitalized (however the last criteria is not reliable).

The Rhône road trauma registry has been set up to cover all people injured in road crashes occurring in the Rhône county, that seek health care in public or private hospitals, whether they are only treated at emergency departments or hospitalized. Deceased are also included. Injuries are all coded directly with the AIS (Abbreviated Injury Scale). People kept under observation or for medical check-up that appear not to be injured are excluded from the registry. At this stage, we work on casualties of all severities (MAIS1+). The prediction of the proportion of MAIS ≥ 3 casualties among casualties of all severities is done at another stage before (for details about prediction factors see French study in Appendix A – Methods to derive correction factors).

Methods

Linkage

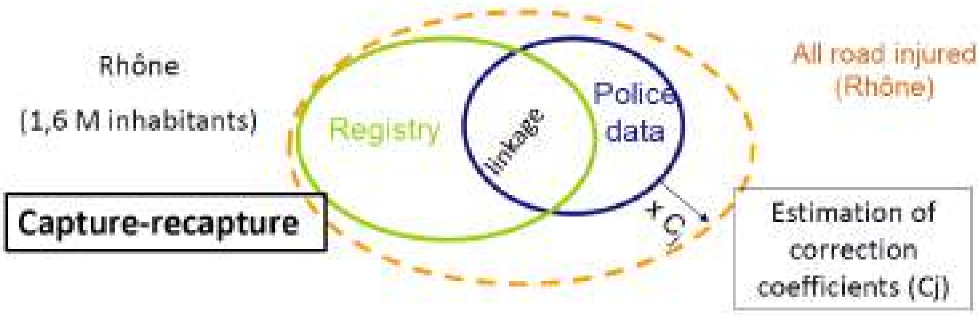
Data have been linked in routine using date and time of crash, place of crash (town/ village, and road or street name), month and year of birth of the casualty, gender, mode of transport (date and time of crash is indeed coded in the road trauma registry).

The procedure of linking is clerical and semi-automated: when a road trauma casualty is typed into the registry, all the police records of crashes that occurred the same day (± 1 day) are displayed in the data entry application, and the road trauma record is manually matched to a police record when linkage variables are concordant and with a conservative attitude (if the data entry clerk is not sure that the two records belong to the same casualty the decision of linking is not taken). The linkage is probabilistic since we allow for small discordances between linkage variables (e.g. ± 1 day for date of crash when the crash occurs around midnight).

To assess the quality of the linkage and improve it, we estimated with probability calculations the number of false positive (wrongly linked) and the number of false negative (wrongly unlinked) and we use these frequencies to correct the number of linked casualties and unlinked casualties.

Use of record-linkage to estimate correction factors (for under-reporting and bias) with capture-recapture approach

After the linkage has been carried on, the fact that a number of casualties are registered by one source but not by the other indicates that some casualties may escape both registrations. To estimate how many do, and hence the total real number of road casualties, and further correction factors, we use a capture-recapture approach (see Figure D 1).



Capture-recapture is based on the following conditions:

Figure D 1 Capture-recapture approach on the Rhône county

1. No entry or loss between the two registrations

This means that there should not be any systematic group of casualties that escape one source of registration. There might in fact be some loss for the road trauma registry: slight casualties who have an accident in the Rhône county but who do not live in this area may prefer to go to the hospital close to where they live rather than in the Rhône. Health services on the surroundings of the Rhône county are routinely checked and when such casualties are found, they are included in the Rhône registry. Secondly, in the majority of crashes (in the Rhône at least), people involved in the crash live nearby.

2. Perfect linkage between the two sources

This is not the case. To be as close as possible to this condition, we used estimation of the number of false positive and false negative to improve the linking.

3. Independence of recording between the two sources

The condition of independence between police and hospital registrations is not fulfilled for road casualties. We rather face positive dependence (typically, if the police are first on the crash scene, they will call paramedics, so being recorded in hospital data depends on being recorded in police data). In this case (of positive dependence), the estimation of the total number of casualties will be an under-estimation.

4. Homogeneity of capture by a given source

About homogeneity of capture, or in other words probability of being recorded: for road casualties, this usually depends on the severity of the injuries, and on other factors. In France it also depends on: whether there was a crash opponent or not, the mode of transport (pedestrian / cyclists / MTW users / car occupants / others), the type of police (three types in France: Compagnie Républicaine de Sécurité (CRS) / gendarmerie / police), the severity of the crash (fatal / non-fatal), on top of the severity of the casualty. It means the probability of being recorded is only constant within the group defined by these characteristics. This must be taken into account, either by stratifying on these variables, or by conducting a multivariate modeling, adjusting for these variables.

There are two implicit conditions:

5. Same time period and same geographical area

This has been checked. The definition of the geographical area in both registrations is the Rhône county as place of crash.

6. No error in the identification of cases ("injured in road crashes, any severity")

We checked the records and excluded the few ones that appeared not be a road accident (but a horse accident for instance), and those that were uninjured (kept at hospital only for observation for instance).

Multinomial logit regression model

The capture-recapture approach has been implemented with a multinomial logit regression. The outcome variable corresponds to which source the casualty belongs to: i) common linked data between police data and the road trauma registry, ii) unlinked road trauma registry data, or iii) unlinked police data. The explicative variables are those that influence the probability of registration. These are:

- type of police force (CRS / gendarmerie / police),
- type of road network,
- year in a quantitative mode,
- injury severity (hospitalised (yes/no),
- injury severity (MAIS 1 / 2 / 3+),
- whether the crash was fatal or not,
- mode of transport (pedestrian / cyclists / MTW user / car occupant / other vehicle),
- whether there was a crash opponent (yes/no)

and possible interactions: at least:

- type of police force * injury severity
- mode of transport * crash opponent (yes / no)

At this stage, we work on MAIS1+ casualties. In the unlinked registry data, the number of MAIS 1 / 2 / 3+ casualties corresponds to the observed number of MAIS 1 / 2 / 3+ casualties; whereas in the unlinked police data plus the common linked data (= police data), it corresponds to the estimated number of MAIS 1 / 2 / 3+ casualties, after application at the Rhône level, of the prediction model of MAIS constructed in a step before before (for details about prediction factors see Fench study in Appendix A – Methods to derive correction factors).

Fitting the model to the observations provides us total number of casualties estimate, all severities, in the Rhône county and correction factors between the police data (or the registry) and this estimated total number of casualties. The correction factors vary according to the variables included in the model (for example of correction factors see French study in Appendix A – Methods to derive correction factors).

Results-examples

Applying this multivariate model provides the following frequencies, for the Rhône county (population 1.6 million inhabitants): instead of 2800 casualties recorded by the police, or 7400 recorded by the registry, and 8100 altogether, we estimate that there is about 9400 road casualties all severities (average annual frequencies on the 2006-22012 period) (see Table D 1).

Table D 1 Number of road casualties, all severities, from result of capture-recapture in the French Rhône county, based on police data and the road trauma registry, 2006-2012, average annual frequencies

		In the road trauma registry?		
		yes	**no**	**Total**
In Police data?	**Yes**	2100	700	2800
	No	5300		
	Total	7400		9400

- If we only use the union of the registry and the police data (n=8100) (=2100+700+5300), we would under-estimate by 14% (=1 - 8100/9400) the real number of road casualties.
- If we only use the registry data (n=7400), we would under-estimate by 21% (=1 - 7400/9400) the real number of road casualties.
- If we only use the police data (n=2800), we would under-estimate by 70% (=1 - 2800/9400) the real number of road casualties.
- If we only use the intersection of registry and police data (n=2100), we would under-estimate by 78% (=1 - 2100/9400) the real number of road casualties.

Police correction factors correspond to the ratio between the estimated total number and the police frequency, and this is declined according to the characteristics that influence the probability of police reporting (and included in the recapture model). These are then applied to the national police data, so that an estimate of about 292 600 MAIS1+ road casualties is found in 2012 in France (versus 75 900 police-based). Among those, it is estimated that about 25000 are MAIS ≥ 3 (France, 2012). For more details about the estimated correction factors and their application to the national police data, see Appendix A – Methods to derive correction factors.

Limitations-discussion

The estimation is based, as usual, on a number of assumptions.

The main consequence of these conditions, is, because of positive dependency between police and paramedics on the crash scene, that the estimated total number of casualties is a lower bound. Another condition of capture-recapture that has direct effects on the results is the condition of homogenous probability of a casualty of being recorded by a given source. As this is not the case here, we need to account for this heterogeneity by including in the modelling the variables that influence this heterogeneity, or in other words: within groups defined by categories of these variables, there is homogeneous probability of the casualties being reported by one source (ex: the police). The choice of these variables and of some interactions is important.

The assumption for using correction factors estimated at the Rhône level to the French metropolitan territory is that, there is homogeneity of police recording practices across the French territory, for a given police type (3 in France) and for given crash and casualty characteristics. For validation purpose, we searched for other estimations of the total number of road casualties in France. One of them comes from a large national transport survey, in 2007-2008, based on 23 000 persons. Respondents were asked about any road crash in which they were injured and treated for this injury (this means a broader definition than going to a hospital, at the ED or being hospitalized). It gave an estimate of 470 000 injured people in 2006, while our estimate was 350 000 for this year (and 102 000 in police data). They are in the same order of magnitude, ours being lower, and this is coherent with the limit that states the positive dependence (between police and hospital recording) leads to an under-estimation.

EXPERIENCIE OF THE NETHERLANDS

Aim

According to police definition, a serious road injury is a road crash casualty who has been admitted to a hospital and has not died within 30 days after the crash. In the Netherlands, the injury severity of the casualty must be 2 or higher, expressed in the Maximum Abbreviated Injury Score (MAIS), to be considered serious. For international comparisons an injury severity of MAIS 3 or higher is used.

The registration rate of the police in the Netherlands is low for seriously injured road users (especially in non-motor vehicle crashes). We assume that the Dutch Hospital Discharge Register (HDR) contains all seriously injured road users, though for some of these injured road users the external cause is not recorded as a road crash (but e.g. as a result of fall, exposure to smoke/fire, drowning (vehicle into water), suicide attempt or unknown E928). Another issue with hospital data is the lower quality of information on the location of the crash and the vehicles involved.

Consequently, linking police data with hospital data has two major advantages: 1. part of the hospital information can be extended with police information and 2. A better estimate can be made for the number of seriously injured road users.

Data

The Dutch police registry (BRON) contains variables indicating whether or not a victim died and was transported and admitted to a hospital. Both motorised and non-motorised road users are recorded. The police databases contain both victims in injury crashes and in non-injury crashes although in the latter case the recording rate of the crashes is much lower. The MAIS score is not recorded by the police. Therefore, it is not possible to identify serious traffic injuries in the police registry.

The Dutch Hospital Discharge register (HDR) uses ICD10 to record injuries and external causes (ICD9CM until 2012) of casualties admitted to a hospital. The ICD10 injuries are –for the time being- converted to ICD9CM. The tool ICDmap90 then recodes them into AIS codes (ICD9CM to AIS1990) to determine the number of seriously injured. MAIS2+ records are included for analyses on a national level and for international purposes only MAIS ≥ 3 records are used.

Method

Data are linked, using date and time of crash and date and time of hospital admission, gender, date of birth, province of crash and province of hospital (the Netherlands are divided into 12 provinces). Additional key variables are hospital admittance (yes, no, unknown) according to the police registration and the External cause (E or V-code) in the hospital registry.

A distance-based linking procedure is used which means that the variables do not have to be identical in order to match records. In other words, small differences are allowed (Reuirings & Bos 2009).

Regarding the six conditions for Capture-recapture:

1. *No entry or loss between the two registrations*

A small number of patients is present in the Dutch HDR after a crash in Belgium or Germany. The number is assumed to balance the cases where the patient of a crash in the Netherlands is cured in a foreign hospital.

2. *Perfect linkage between the two sources*

The linking software is assumed to identify the true matches. It is possible that a few False Positives are present, as well as False Negatives. A validation (Reurings and Bos, 2009) showed that the number of matche is really small when linking data files of different years. Merging of 3 years of patients and casualties also resulted in a confirmation of the linking method. In another study (Bruin, 2015) a different methodology was tested, again confirming the good identification of matched pairs.

3. *Independence of recording between the two sources*

The presence of an ambulance at the scene of the crash that will taka a casualty to hospital influences the probability of the police to report on that crash and to report persons injured. As we do not use a police remainder file – we assume a slight injury if it cannot be linked to a patient in hospital – this has no further implications.

4. *Homogeneity of capture by a given source*

The probability of being recorded by the police depends on several things, among others: the severity of the crash, the number of vehicles involved and whether these vehicles have insurance. This latter characteristic is not a reason for the police reporting in itself, but is more a matter of persons involved calling for the police or for an ambulance. When only bicycles are involved the medical assistance is often felt more urgent than for presence of the police.
The probability of being reported in hospital is believed to be 100%. When a (seriously injured) person is admitted there will always be a registration. It is however possible that the external cause in not correctly reported. Especially a bicyclist falling is likely to be reported as a pedestrian falling on the streets (E885). This will be taken into account, by stratifying on the external cause.

5. *Same time period and same geographical area*

The linking procedure is performed taking into account crashes of the previous year, that allows a hospitalisation in the previous year to match to a discharge in the current year. There is a correction for the number of cases that have their crash in the current year and will be discharged in the next year.

6. *No error in the identification of cases ("injured in road crashes, any severity")*

The severity that is assigned by the police is usually Hospitalized of Slight. Hospitalized is not a sufficient specification of the severity being MAIS ≥ 3 or not. Morover it appears that some Slight cased can be matched to a hospital discharge record, even with MAIS ≥ 3.
In hospital it is possible that not all injuries are reported (correctly) so that some of them are not identified as serious according to the MAIS scale.

Give the problems with some of the conditions, we developed an alternative method that includes probabilities for a road casualty being recorded in the hospital and the policefiles. These probabilities are different depending on the involvement of a motor vehicle in the crash. The set of equations can be solved under the assumption that the HDR is complete or that its completeness is known.

The method used to determine the number of serious traffic injuries consists of three steps:

1. Linking BRON and HDR;
2. Applying correction factors for crashes that did not occur on public roads (2.6 % of the bicycle crashes E826) and for known incompleteness of the HDR (for years 2005-2014);
3. Crosstabulating the Serious road traffic casualties and calculate the probabilities and true number number of MAIS ≥ 3.

In this crosstabulation, the theoretical contents of each cell is now a concrete number of RTC. This results in a set of linear equations (visualized in a matrix) which can be solved for injuries in motor vehicle crashes (M) and injuries in non-motor vehicle crashes (N). (Table D 2.)

Table D 2 The theoretical contents of cells resulting from record linkage of hospital and police data

		In HDR (Hospital Discharge Register)			
		Traffic with mvh	**Traffic without mvh**	**No Traffic (in HDR)**	**SUM**
in BRON (police data)	**With mvh**	$M P_M (1-a_1-a_2)$ (1)	$M P_M a_1$ (2)	$M P_M a_2$ (3)	$P_M M$
	Without mvh	$N P_N b_1$ (4)	$N P_N (1-b_1-b_2)$ (5)	$N P_N b_2$ (6)	$P_N N$
Not in BRON	**With mvh**	$M (1-P_M)$ **$(1-a_1$**$-a_2$**$)$**	$M (1-P_M) a_1$	$M (1-P_M) a_2$	$(1-P_M) M$
	Without mvh	$N (1-P_N) b_1$ (7)	$N (1-P_N)$ **$(1-b_1$**$-b_2$**$)$** (8)	$N (1-P_N) b_2$	$(1-P_N) N$
SUM		$M (1-a_1-a_2) + N b_1$	$M a_1 + N (1-b_1-b_2)$	$M a_2 + N b_2$	$M + N$

- Mvh = motor vehicle
- N = Number of injuries in a non motor vehicle crash
- M = Number of injuries in a motor vehicle crash
- Pm = probability of recording in BRON for M-Victims

- Pn = probability of recording in BRON for N-Victims
- a_1 = probability that a M-victim is recorded in the HDR as a N-victim;
- a_2 = probability that a M-victim is recorded in the HDR as a N-victim;
- 1- a_1- a_2 = probability that a M-victim is recorded as in the HDR as a M-victim (in the HDR is a victim either a M-victim, a N-victim, or a no-traffic victim;
- b_1 = probability that a N-victim is recorded in the HDR as a N-victim;
- probability that a N-victim is recorded in the HDR as a M-victim;
- 1- b_1- b_2 = probability that a N-victim is recorded as in the HDR as a N-victim;

The recording rates (that follow from the Pm and Pn parameters) for casualties in non-motorised vehicle crashes appear to be lower than for casualties in motorised vehicle crashes, as was expected.

We observe that the sources do not always agree on the involvement of a motor vehicle. And the official number (7500) deviates from this because a correction is applied to be in line with the series of earlier calculations (after a slight change in method which leads to slightly higher results) and due to rounding at 100's. (Table D 3)

Table D 3 Casualites distribution resulting from linking hospital and police data. The Netherlands 2005-2014.

MAIS ≥ 3 (2014)		**In HDR**			
		Traffic with mvh	**Traffic without mvh**	**No Traffic**	**SUM**
in BRON	**With mvh**	1579	104	84	1767
	Without mvh	12	57	6	75
Not in BRON	**With mvh**	1754 (="976'+"778")	3663 (="65"+"3598")	"52" + "355"	"1092"
	Without mvh				"4731"
SUM		3345	3824	"497"	"7665"

Beyond the cases that can be identified in the HDR as a Serious Road Traffic Casualty MAIS ≥ 3, the linking enables to quantify a number of cases that cannot be recognised as RTC because of a miscoded External cause. Moreover, the Capture-Recapture like estimate of unobserved cases is added to the results. Therefore, the estimated number from linking is more complete than the selection of RTC in HDR only.

Results-examples

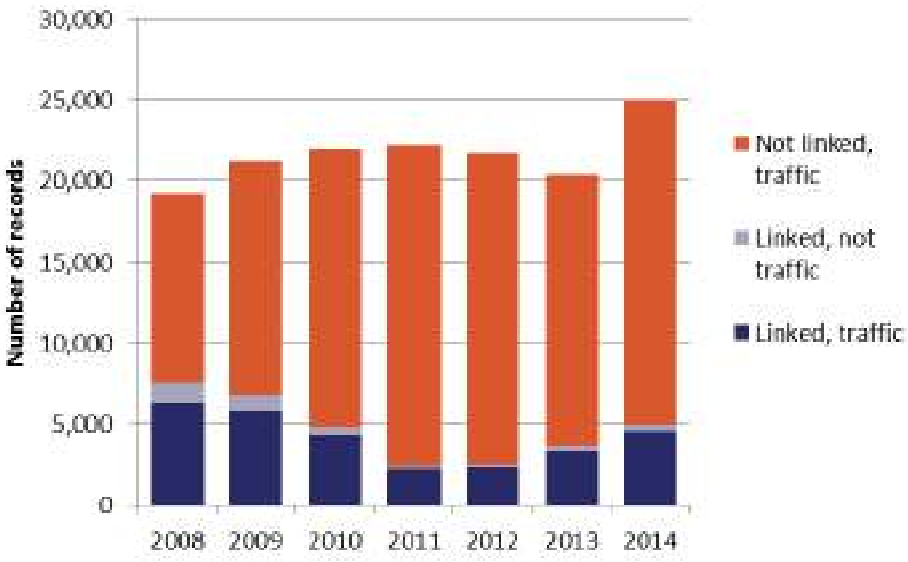


Figure D 2 Number of road traffic casualties in the HDR (all severities, excluding readmissions, including deaths, not corrected for incompleteness of some hospitals).

The resulting estimates for the number of Seriously Injured are presented in Table D 4.

Table D 4 Total estimates of Road traffic casualties MAIS ≥ 3 (rounded to 100), Number of (non fatal) hospital reported road traffic casualties MAIS ≥ 3 (by year of discharge) and Number of road traffic fatalities in the Netherlands for comparison.

Year	Best estimate MAIS ≥ 3	HDR MAIS ≥ 3 traffic	Road traffic Fatalities
2000	**5.220**	4.643	1.166
2001	**5.220**	4.642	1.083
2002	**5.200**	4.739	1.069
2003	**5.270**	4.730	1.088
2004	**4.890**	4.498	881
2005	**4.790**	4.450	817
2006	**4.480**	4.080	811
2007	**4.970**	4.292	791
2008	**5.290**	4.642	750
2009	**5.500**	5.017	720

Year	Best estimate MAIS ≥ 3	HDR MAIS ≥ 3 traffic	Road traffic Fatalities
2010	**5.700**	5.372	640
2011	**6.100**	5.916	661
2012	**6.400**	6.180	650
2013	**6.500**	6.165	570
2014	**7.500**	7.155	570

Limitations and-discussion

Before 2010, the estimate of the number of serious traffic injuries included disaggregated data by degree of severity, region, and mode of transport. However, for three reasons the estimate has become less detailed from 2010 onward:

- the transition of the hospitals to a different encoding system (from ICD9CM to ICD10);
- fewer casualties being registered in BRON due to changes in the policy recording methods;
- the HDR file being less complete due to temporarily administrative problems with the registration of patients in some hospitals. This started in 2005. As from 2014 the HDR file is almost complete again

Retrospectively, the reduced accuracy only allows limited stratification by injury severity (MAIS 2 and MAIS ≥ 3) and by broad mode of transport (motor vehicle crashes versus non-motor vehicle crashes).

The estimate of the total number of seriously injured road users is the best that we can provide on the data that is available at this moment. We consider each year whether deviations are 'real', or the result of a change in registration, in coding or in the method of our estimation. To make this judgement we need to analyse data for a longer period and compare it with developments in the years before the observed deviation. As a result, we sometimes have to change results from previous years retrospectively.

The results of the set of linear equations are sensitive for small numbers and small changes in these numbers. A sensitivity analysis show that the calculated numbers could easily be 100 higher or lower, when the results in the cells that are not in the diagonal contain a few victims more or less. Therefore, we rounded the number of serious traffic injuries up to hundreds. Consequently, differences of a few hundred should be handled with care and not to be seen as shifts in road safety. In 2016, we will be working on a method to provide confidence intervals around our numbers in order to get more insight in the exact uncertainty of our estimates.

However, these limitations do obscure the advantages of the method of an estimate based of linking Police and Hospital data.

EXPERIENCE OF SLOVENIA

Aim

In Slovenia in-patient data were linked to the police data solely for the needs of the project SafetyCube. Police data were the main database, as it contains all traffic accidents. In-patient data include only more severe injuries and not those treated in emergency departments only. Police data were used for identification of all cases of traffic accidents. Cases treated in emergency departments only and casualties who died later than 30 days after the accident has occurred were not linked to the police data.

Data

Slovenian hospital data cover all Slovenian hospitals; except for private hospitals and non-general hospitals, such as psychiatric hospitals. Hospital data are centralized by the National Institute of Public Health. The registration of hospital data (E-codes included) is obligatory since 1988.

Comprehensive electronic data are available from 1997 to 2012 (with only three diagnoses for each hospital treatment and external cause for all injuries and poisonings). From 2013 onwards, data are available with the principal diagnose and up to 19 additional ones for each hospital treatment, and external cause for all injuries and poisonings.

From 2006 onwards, data about the circumstances of injuries (place of occurrence, activity when injured, object/substance producing injury) are also available.

From 1997 to 2012 ICD-10 (2nd edition) was used for encoding diagnoses during hospital stays. From 2013 onwards, Slovenia is using the Australian modification of ICD-10 (version 6) with 5 digits. For the need of international reporting and the preparation of time series analysis, codes are translated from ICD-10-AM (Australian Modification) to ICD-10 (2nd edition) with 4 digits.

National Institute of Public Health collects data on individual level with personal identifier only for inpatients (hospitalised patients and day care patients - day care patients are patients who did not stay overnight; they are included in National Hospital Health Care Statistics Database).

From 2011 to 2014 the National Institute of Public Health collects information about injuries and poisonings reported at emergency departments (ED) on a sample of hospitals (4 hospitals are included in a nationally representative sample which represents about 50 % of all ED stays due to injuries and poisonings. National Institute of Public Health plans to capture all treatments of injuries and poisonings in ED in all Slovenian hospitals from 2017 onwards.

Slovenian hospitals do not record AIS severity codes.

Method

Explicitly for the project SafetyCube, the National Institute of Public Health linked inpatient data to the police data for the years 2012 and 2013, where police data were the main database (it includes all traffic accidents). Data were linked based on date of accident/ date of injury, date of birth and gender.

In-patient data include only more severe injuries and not those treated in EDs only. Police data were used for the identification of all cases of traffic accidents. Cases treated in ED and casualties who died later than 30 days after the accident has occurred were not linked to the police data.

Before linking both databases, conversion of ICD-10 codes of injuries and poisonings to AIS code was done (based on AAAM10 mapping table received from the European Commission). First the Australian modification of ICD-10-AM (version 6) -a 5 digit code of diagnosis - was converted to 4 digit codes (ICD-10, 2nd edition), then 4 digit codes (ICD-10, 2nd edition) were converted to MAIS ≥ 3(AAAM) using mapping table given by EU Commission. Because ICD-10 codes in in-patient database are only 4 digits long and not as detailed as ICD codes in the mapping table, less codes could be transformed to AIS ≥ 3 than was expected.

For the year 2014, the NIPH translated all 20 diagnoses (main + 19 additional diagnoses) and calculated the total severity (where at least one major injury occurred, the record is marked with 1, where at least one minor injury and no heavier occurred, the record lable got 0, where at least one unidentifiable injury and no serious injuries and no light injury occurred, the record got lable 9; for those that are not in the translation table, the system is having a missing value). (Table D 5**Fout! Verwijzingsbron niet gevonden.** to Table D 9).

Results-examples

Data-tables

Table D 5 Data from hospital. Slovenia 2012-2014

AIS_3kat AIS - 3 kategorije							
		Frequency 2012	**Percent**	**Frequency 2013**	**Percent**	**Frequency 2014**	**Percent**
Valid	0 AIS 1, 2	2945	83.5	2664	85.4	1558	83.4
	1 AIS 3, 4, 5, 6	294	8.3	274	8.8	245	13.1
	9 undetermined	61	1.7	42	1.3	17	0.9
	Total	3300	93.6	2980	95.5	1820	97.4
Missing	diagnosis is not in the AAAM10 table	227	6.4	141	4.5	49	2.6
Total		3527	100	3121	100	1869	100

Table D 6 Police database. Slovenia 2012-2014

POLICE DATABASE							
		Frequency 2012	**Percent**	**Frequency 2013**	**Percent**	**Frequency 2014**	**Percent**
Valid		173	0.3	168	0.4	139	0.4
	B no injury	30,207	60.6	25,166	61.4	24,478	62.3
	H seriously injured	848	1.7	708	1.7	826	2.1
	L slightly injured	8,300	16.7	8,034	19.6	7,394	18.8
	S killed	130	0.3	125	0.3	108	0.3
	U no injury-administrative remark	10,184	20.4	6,804	16.6	6,344	16.1
Total		49,842	100	41,005	100	39,289	100

Table D 7 AIS ≥ 3 Distribution. Slovenia 2012

		AIS_3kat AIS			**Total**
		0 AIS 1, 2	1 AIS 3, 4, 5, 6	9	
		2	0	1	3
	B no injury	124	5	9	138
	H seriously injured	471	137	7	615
	L slightly injured	1276	20	7	1303
	S killed	3	24	0	27
	U no injury-administrative remark	19	0	4	23
Total		1895	186	28	2109

Table D 8 AIS ≥ 3 Distribution. Slovenia 2013

		AIS_3kat AIS			Total
		0 AIS 1, 2	1 AIS 3, 4, 5, 6	9	
		1	0	0	1
	B = no injury	100	8	8	116
	H = seriously injured	430	126	8	564
	L = slightly injured	1233	18	7	1258
	S = killed	11	19	3	33
	U = no injury-administrative remark	15	2	0	17
Total		1790	173	26	1989

Table D 9 AIS ≥ 3 Distribution. Slovenia 2014

		AIS_3kat AIS			Total
		0 AIS 1, 2	1 AIS 3, 4, 5, 6	9	
	B = no injury	80	5	6	91
	H = seriously injured	416	213	2	631
	L = slightly injured	1117	28	7	1152
	S = killed	3	21	0	24
	U = no injury-administrative remark	14	1	2	17
Total		1630	268	17	1915

In the Hospital file, the number of road traffic casualties in the years 2012-2014 were 3527, 3121 and 1869, of which 294, 274 and 245 were rated as MAIS ≥ 3 (8.3, 8.8 and 13.1 %).
The linking in the years 2012-2014 showed 2109, 1989 and 1915 matches respectively of which 186, 173 and 268 were MAIS ≥ 3 (8.8, 8.7 and 14.0% of the matches).

Limitations-discussion

In the Police database, there is only information about the severity of the injury (slight, serious, fatal, no injury). From 2013 onwards, for each hospitalization record in-patient database contains one main and 19 additional diagnoses. The above-described testing of conversion to AIS was made based on the main diagnosis, which should be the most important for a single hospital treatment of the patient. For 2014 all 20 diagnoses were used. By doing so the percentage of casualties rated as MAIS ≥ 3 has increased.

The National Institute of Public Health linked those data specifically for the need of this project. Results are available for the National Institute of Public Health use only. As is the case for other data managed at National Institute of Public Health, in-patient data also are available for researchers in an anonymised form after application for data processing has been approved and an agreement has been signed

Appendix E: Comparison of MAIS ≥ 3 estimates using different methods

This chapter analyses examples from the Netherlands and Austria deriving the number of people seriously injured (MAIS ≥ 3) using different approaches

Background

This data analysis exercise has been completed to ascertain whether additional corrections for certain methods should be considered, and to increase general understanding about the comparability of data from different countries.

Exercise aim

To examine how the estimated number of serious injuries differs depending on the method that is applied.

Method

To be able to determine to what extent the applied method affects the resulting number of MAIS ≥ 3 casualties, different methods have to be applied for the same country. Therefore, we will apply the three methods that are proposed by the European Commission (Method 1 = Correction on police data, Method 2 = use of hospital data and Method 3 = use of linked police and hospital data) to an example country: The Netherlands. As it is uncommon to be able to apply all three methods within the same country, these findings will be supplemented with data from Austria where two methods (correction on police data and hospital data) can be applied.

In applying these different methods, the corrections and operationalisations detailed in the earlier parts of this guideline document will be followed. Any situation where this is not possible has been noted.

Analysis are undertaken for the total number of MAIS ≥ 3 casualties as well as casualties per transport mode, gender and age group.

Data processing

The Netherlands

The following steps were applied to the Netherlands data from 2004 – 2014:

1. Select RTC by severity from police data by Mode, Age group, Gender, Year (2004-2014)
2. Select MAIS ≥ 3 road traffic casualties (RTC) from hospital data (HDR) (in/excl ExtCauses, method to determine MAIS) → HDR number by Mode, Agegroup, Gender, Year (see experiences 2+3, however just a stable/consistent selection is required)
3. Linked HDR+Police, select MAIS ≥ 3 RTC (in/excl ExtCauses, method to determine MAIS), estimate true number (capture/recapture corrections applied, see study 4), and stratify by Mode, Agegroup, Gender, Year

Then:

a) Calculate factors between the police idenfied cases (1; killed and hospitalized according to the police) and the Hospital data-MAIS ≥ 3 (2) by Mode, Age group and Gender for the data of 2004-2008. This results in 70 factors (7 modes: Pedestrian, Bicycle without a motor vehicle involved, Bicycle with motor vehicle involved, Moped, Motorcycle, Car/van, Other), 2 genders, 5 age groups).

b) Apply these correction factors to the police data for the years 2004-2014 and estimate the number of MAIS ≥ 3 then compare these results with the Hospital data-MAIS ≥ 3 selections.

c) Compare both Hospital data-MAIS ≥ 3 and Corrected police data to the results from the Linked data.

To compare the stability of the results over subsequent years, the average factors for a 5-year period (2004-2008) was applied to the years after (2009+) and estimates compared. This approach is similar to study 1 where Belgium applies factors from <2008-2011> to 2012-2014 data. A correction factor based on past data can only be applied when the data to which it is applied (i.e. police records) is stable. For the Netherlands, we know that the completeness of police data shows a dramatic decrease after 2009, therefore correction factors should not be applied to this data, i.e. the results should not be interpreted as a good estimator.The correction factors applied to police data are calculated twice, once using the factors identified by the SafetyNet project considering six separate transport modes (Pedestrian, Bicycle, Moped, Motorcycle, Car/van, Other), and once using the 70 SafetyCube factors by Mode x Age x Gender as described above (see b). This approach has been taken because it has previously been established that using just one correction factor for all modes of transport results in poor estimates.

Austria

The following steps were applied to the Austrian data from 2010 - 2014:

Correction of hospital data:

1. An accident case definition (all accidents, not only road traffic crashes) was applied to the full set of the Austrian HDR data: cases with both an injury diagnosis from ICD-chapter XIX (S and T codes) and a valid external cause code (U-codes).
2. HDR cases were separated into RTC, other specified accidents and unspecified accidents.
3. An "ICD-10 to AIS" mapping was performed for all injury cases selected in step 1 according to the mapping table AAAM10 provided by DGMove (only one diagnosis was available for the mapping).
4. The number of RTC was corrected (increased) according to their suspected share in the category of unspecified accidents (for each AIS score).
5. The number of MAIS ≥ 3 RTC was corrected (increased) according to their suspected share in the category of RTC without an AIS score.

Correction of police data:

6. The HDR share of MAIS ≥ 3 RTC from all RTC with a positive AIS assignment (excluding score 9) was calulated
7. The HDR MAIS ≥ 3 share for RTC was applied to RTC of the police that were classfied as serious RTC.

Results

Total MAIS ≥ 3 casualties

Table E 1 Total number of MAIS ≥ 3 calsualties for the Netherlands and Austria for the available years, calculated using each of the avalable methods.

		Correction of police data (transport mode considered)	Correction of police data (transport mode, age and gender considered)	Hospital data	Linked police and hospital data
Netherlands	2004	4,098	4,251	4,545	4,890
	2005	4,188	4,604	4,499	4,790
	2006	4,038	4,348	4,130	4,480
	2007	4,339	4,656	4,371	4,970
	2008	4,220	4,663	4,707	5,290
	2009	3,240	3,571	5,001	5,500
	2010	1,823	1,925	5,370	5,700
	2011	866	1,130	5,905	6,100
	2012	1,107	1,332	6,272	6,400
	2013	1,216	1,146	6,195	6,500
	2014	1,098	1,274	7,051	7,500
			Standard correction of police data (all transport modes combined)	**Hospital data**	**Linked police and hospital data**
Austria	2010	-	751	1,516	-
	2011	-	788	1,522	-
	2012	-	740	1,554	-
	2013	-	622	1,405	-
	2014	-	640	1,410	-

MAIS ≥ 3 casualties by gender and age

Table E 2 shows the total number of MAIS ≥ 3 casualties for each gender and age group. For the Netherlands, this data is from 2009 as the 2004-2008 were used as the basis to calculate the 70 mode x age x gender factors. The Austrian data is aggregated for the years 2010-2014. Totals are presented separately for each data method approach for the two countries.

Table E 2 Total number of MAIS ≥ 3 casualties for each gender and age group for the Netherlands and Austria for the avalable years, calculated using each of the avalable methods.

			Correction of police data (transport mode, age and gender considered)	Hospital data	Linked police and hospital data
Netherlands 2009	Female	<18y	122	174	195
		18-29	106	145	165
		30-49	156	250	267
		50-69	375	567	595
		70+	553	841	869
Netherlands 2009	Male	<18y	284	331	433
		18-29	339	468	554
		30-49	427	687	762
		50-69	503	860	910
		70+	400	678	723
Netherlands SUM			3,265	5,001	5,474
			Correction of police data (age and gender considered)	**Hospital data**	**Linked police and hospital data**
Austria 2010-2014	Female	<18y	77	232	-
		18-29	86	307	-
		30-49	141	383	-
		50-69	293	621	-
		70+	441	708	-
Austria 2010-2014	Male	<18y	279	600	-
		18-29	362	977	-
		30-49	569	1,223	-
		50-69	637	1,351	-
		70+	398	794	-
Austria SUM			3,283	7,196	

MAIS ≥ 3 casualties per transport mode

Table E 3 shows the total number of MAIS ≥ 3 casualties for each transport mode in the Netherlands, for the year 2009. Unfortunately, the distribution by mode of transport was not available for Austria.

Table E 3 Total number of MAIS ≥ 3 casualties for each transport mode for the Netherlands and Austria for the available years, calculated using each of the avalable methods.

		Correction of police data (transport mode, age and gender considered)	Hospital data	Linked police and hospital data
Netherlands 2009	Pedestrian	273	311	273
	Bicycle without mvh	1,503	2,356	2,775
	Bicycle with mvh	384	508	437
	Moped	407	598	811
	Motorcycle	236	332	385
	Car/van	499	654	669
	Other	269	242	124

As can be seen from this table the Corrected police data are almost always smaller than the HDR selection where it was supposed to correct to. Especially for bicyclists in crashes where no motor vehicle was involved the corrected police number is too low. This is probably caused by a decreasing reporting rate of this type of crashes (which is already the lowest of all modes).

When comparing to the best estimate (Linked), we see that Bicyclists (wihout involvement of a motor vehicle) and Mopeds are underestimated by the HDR in 2009.

Appendix F: List of correspondents of Hospital Discharge Data for Eurostats

DATE REVISED: 31/05/2016

Table F 1 LIST OF FOCAL POINTS FOR THE JOINT DATA COLLECTION ON NON-MONETARY HEALTH CARE STATISTICS

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Appendix G: SafetyCube Survey on road traffic serious injuries

SafetyCube Questionnaire on MAIS ≥ 3 assessment In January 2013, the definition of serious injuries as injury level of MAIS ≥ 3 was established by the High Level Group on Road Safety. It is recommended that all EU countries provide information on the number of MAIS ≥ 3 injuries from 2015 on. Currently, however, Member States use different procedures to determine the number of serious traffic injuries. The High Level Group identified three main ways Member States can collect the data: 1) by applying a correction on police data, 2) by using hospital data alone and 3) by using linked/matched police and hospital data. **Glossary:** AIS: Abbreviated Injury Scale. MAIS: Maximum AIS; The European Union adopted as official definition of serious injury to report cases with MAIS >= 3 HDR: Hospital discharge register ICD: International Statistical Classification of Diseases and Related Health Problems IN-PATIENT: A patient who is formally admitted (or 'hospitalised') to an institution for diagnosis, treatment and / or care and stays for a minimum of one night or more than 24 hours in the hospital or other institution providing in-patient care. DAY CARE PATIENT: A patient who is discharged on the same day as admitted. OUTPATIENT: A patient who has not been formally admitted for diagnosis, treatment or other types of health care. Note: HDR meta-data and main exceptions noted by EU Member States and non-member countries (for 2011 data) are listed in: http://ec.europa.eu/eurostat/statistics-explained/index.php/Hospital_discharges_and_length_of_stay_statistics Note: All questions refer to road traffic casualties (RTC)
0. Contact information
Name
Organisation
E-mail
Phone
1. General information
Institution responsible for data **collection** of RTC (e.g. Police)?
Institution responsible for data **analysis** of RTC (e.g. ministries, statistical bureau, others)?
Institution responsible for **publication / dissemination** of official statistics (e.g. ministries, statistical bureau, others)?
Institution responsible for **analysis of health/hospital data** to report MAIS ≥ 3 injuries (e.g. ministries, statistical bureau, others)?
Additional **comments** or links that help understand the national context & framework
What is the definition of a serious injury in official RTC statistics?
2. MAIS ≥ 3 methodology
Did or will your country report the number of serious injuries (MAIS ≥ 3) to the European Commission? When?
For which year(s) do you have estimation of number of serious injuries MAIS ≥ 3?
Which method do you use to estimate the number of serious injuries? (please specify & roughly describe the method)
- 1 by applying a correction coefficient on police data
- 2 by using hospital data alone
- 3 by using linked/matched police and hospital data
- 4 other
Do you plan to change the methodology to estimate the number of serious injuries MAIS ≥ 3?
If yes, when do you expect to be able to report with the new methodology?
Which new method will you use to estimate the number of serious injuries? (please specify & roughly describe the method)
- 1 by applying a correction coefficient on police data
- 2 by using hospital data alone
- 3 by using linked police and hospital data
3. Information on health/hospital data
What is the **data source** that integrates data from different hospitals and that you (your country) use for the analysis of RTC victims (e.g. Hospital Discharge Register)?
Do you include **outpatients** (non-hospitalised patients)?
Do you include **day care patients** (patients who did not stay overnight)?

Do you include **readmissions?**
Do you include **scheduled** (non-urgent) **admissions?**
Do you include **fatalities** in the hospital within 30 days?
Which **version of ICD** is predominantly used (e.g. ICD9, ICD10)?
How many **digits** of ICD codes are used to derive AIS? (e.g. S00.1 = 4 digits)
How many **diagnoses** are used to calculate MAIS (e.g. only main diagnosis)?
What is the **percentage** of patients for which the ICD -> MAIS **transformation fails?** *(please specify problems, such as multiple injuries T00-T14 or truncated codes not included in AAAM table, AAAM code = 9 [unspecified], …)*
How do you deal with **cases** where the **transformation failed?**
Which **conversion algorithm** is in use (e.g. Navarra/Apollo, AAAM)?
Does MAIS ≥ 3 include **MAIS6?**
What is the percentage of hospitals that **code AIS directly**?
Which ICD **diagnoses** (**ICD Chapter XIX**) are used to identify injuries (e.g. S00-T98; describe exclusions like "late consequences" T90-T98)?
Which ICD **external causes** (e.g. ICD 10-Chapter XX) are used to identify road traffic injuries (e.g. full set V01-Y98 or country-specific subset),
What are the **limitations** in determining external causes, especially as concerns RTC??
Do you make use of **alternatives** (to ICD external causes) to identify road traffic injuries from hospital data?
What is the **percentage of 'unknowns'** with respect to external causes of **all injuries** in your hospital data source?
How do you deal with **injuries with unknown causes**?
4.1 Use of CORRECTION COEFFICIENT to obtain the number of serious injuries MAIS ≥ 3 *from police data (pls complete only when adequate for your country)*
How are the coefficients estimated? (please describe method and data used, limitations …)
How are the coefficients applied? (please describe data source, groups, level of severity…)
Are there different coefficients available by age (pls add available age groups/bands), sex, road user, type of opponent, urban/rural area?
What is the frequency of obtaining the coefficients (only once, yearly, every 5 years, …)
Is under-reporting in police data corrected for, and how?
4.2. Use of HOSPITAL DATA ALONE to report serious injuries MAIS ≥ 3 *(pls complete only when adequate for your country)*
How is the MAIS ≥ 3 assessment being carried out? (please roughly describe the process, data sources, limitations …)
Is your country's MAIS ≥ 3 assessment representative for the whole country?
What further information do you receive from the transformation? (MAIS 1-6, AIS, body region, ISS, other (please specify)
4.3 Use of LINKED/MATCHED POLICE-HOSPITAL DATA to report serious injuries MAIS ≥ 3 *(pls complete only when adequate for your country)*
Which databases are linked/matched?
Are they representative at national level?
Which method is used to link/match records?
What data is used to estimate MAIS ≥ 3?
Which variables are used for linking/matching?
What further information do you receive from the transformation? (MAIS 1-6, AIS, body region, ISS, other (please specify)
Is police under-reporting corrected in linking cases? If yes, how?
Is hospital under-reporting corrected in linking cases? If yes, how?
Which proportion of your estimated MAIS ≥ 3 RTC is reported by the police?
Which proportion of your estimated MAIS ≥ 3 RTC are reported in HDR as a RTC?
Which proportion of your estimated MAIS ≥ 3 RTC is unobserved (not a record in at least one of the sources)?
5. Reporting number of serious injuries MAIS ≥ 3
Number of road traffic **fatalities** in your country for 2014
Number of road traffic **injuries** reported by police in your country for 2014
Number of **serious injuries** reported by police in your country for 2014
Number of **serious injuries MAIS ≥ 3** in your country for 2014
Is the number of MAIS ≥ 3 injuries generically available by **gender**?
Is the number of MAIS ≥ 3 injuries generically available by **age groups**? Which age groups/bands?
Is the number of MAIS ≥ 3 injuries generically available by **road user types**?
Is your country able to report **different MAIS-levels,** i.e. MAIS2, 3, 4, 5, 6?
Is the method used to derive MAIS ≥ 3 in your country published? (if so, please give a reference)
Comments? (additional remarks, problems & limitations, suggestions, …)

Appendix H: Distribution of external causes (ICD10 & ICD9)

Table H 1 Distribution of external causes for ICD10 (V codes) among traffic injuries (Mortality Register, Spain 2009 -2013)

CODE	Traffic Injuries	Non-traffic Injuries	Total
V01 Pedestrian injured in collisions w pedal cycle	7	0	7
V02 Pedestrian injured in collisionsw 2-3PW	61	3	64
V03 Pedestrian injured in col w car,pick-up truck or van	923	14	937
V04 Pedestrian injured in collisionsw heavy transport vehicle or bus	186	13	199
V05 Pedestrian injured in collisionsw railway train or railway vehicle	41	217	258
V06 Pedestrian injured in coll w other nonmotor	1	1	2
V09 Pedestrian injured in other and unspecified transport accidents	1,010	118	1,128
V10 Cyclist injured in coll w pedest or animal	0	0	0
V11 Cyclist injured in coll w other cycle	0	0	0
V12 Cyclist injured in coll w 2-3PW	8	0	8
V13 Cyclist injured in coll w car, pick-up truck or van	146	3	149
V14 Cyclist injured in coll w heavy transport veh or bus	31	0	31
V15 Cyclist injured in coll w railway train or railway veh	1	1	2
V16 Cyclist injured in coll w other nonmotorveh	0	0	0
V17 Cyclist injured in coll w fixed or stationary object	13	0	13
V18 Cyclist injured in noncoll transport acid	52	15	67
V19 Driver cyclist injured in coll w other and unspecif motor veh	82	5	87
V20 Motorcycle rider inj in coll w pedest or animal	13	1	14
V21 Motorcycle rider inj in coll w cycle	2	0	2
V22 Motorcycle rider inj in coll w 2-3PW	30	1	31
V23 Motorcycle rider inj in coll w car, pick-up truck or van	509	4	513
V24 Motorcycle rider inj in coll w heavy transport veh or bus	91	1	92

CODE	Traffic Injuries	Non-traffic Injuries	Total
V25 Motorcycle rider inj in coll w railway train or railway veh	3	0	3
V26 Motorcycle rider inj in coll w other nonmotorveh	1	0	1
V27 Motorcycle rider inj in coll w fixed or stationary object	224	8	232
V28 Motorcycle rider inj in noncoll transport accid	328	7	335
V29 Motorcycle rider inj in coll w other and unspecif motor veh	427	20	447
V30 Occupant of 3PW inj in coll w pedest or animal	0	0	0
V31 Occupant of 3PW inj in coll w cycle	0	0	0
V32 Occupant of 3PW inj in coll w 2-3PW	2	0	2
V33 Occupant of 3PW inj in coll w car, pick-up truck or van	0	0	0
V34 Occupant of 3PW inj in coll w heavy transport veh or bus	3	0	3
V35 Occupant of 3PW inj in coll w railway train or railway veh	0	0	0
V36 Occupant of 3PW inj in noncoll transport accid	0	0	0
V37 Occupant of 3PW inj in coll w fixed or stationary object	1	0	1
V38 Occupant of 3PW inj in noncoll transport accid	1	0	1
V39 Occupant of 3PW inj in coll w other and unspecif motor veh	0	0	0
V40 Car occupant inj in coll w pedest or animal	13	0	13
V41 Car occupant inj in coll w cycle	1	0	1
V42 Car occupant inj in coll w 2-3PW	8	2	10
V43 Car occupant inj in coll w car, pick-up truck or van	1,239	7	1,246
V44 Car occupant inj in coll w heavy transport veh or bus	567	5	572
V45 Car occupant inj in coll w railway train or railway veh	17	0	17
V46 Car occupant inj in coll w other nonmotorveh	7	0	7
V47 Car occupant inj in coll w fixed or stationary object	554	13	567
V48 Car occupant inj in noncoll transport accid	1,103	20	1,123
V49 Car occupant inj in coll w other and unspecif motor veh	702	25	727
V50 Occupant of pick-up truck or van inj in coll w pedest or animal	6	0	6
V51 Occupant of pick-up truck or van inj in coll w cycle	0	0	0
V52 Occupant of pick-up truck or van inj in coll w 2-3PW	1	0	1
V53 Occupant of pick-up truck or van inj in coll w car, pick-up truck or van	42	1	43

CODE	Traffic Injuries	Non-traffic Injuries	Total
V54 Occupant of pick-up truck or van inj in coll w heavy transport veh or bus	73	0	73
V55 Occupant of pick-up truck or van inj in coll w railway train or railway veh	0	1	1
V56 Occupant of pick-up truck or van inj in coll w other nonmotorveh			
V57 Occupant of pick-up truck or van inj in coll w fixed or stationary object	13	0	13
V58 Occupant of pick-up truck or van inj in noncoll transport accid	60	1	61
V59 Occupant of pick-up truck or van inj in coll w other and unspecif motor veh	7	7	14
V60 Occupant of heavy transpvehinj in coll w pedest or animal	0	0	0
V61 Occupant of heavy transpvehinj in coll w cycle	0	0	0
V62 Occupant of heavy transpvehinj in coll w 2-3PW	0	0	0
V63 Occupant of heavy transpvehinj in coll w car, pick-up truck or van	19	0	19
V64 Occupant of heavy transpvehinj in coll w heavy transport veh or bus	78	0	78
V65 Occupant of heavy transpvehinj in coll w railway train or railway veh	1	0	1
V66 Occupant of heavy transpvehinj in coll w other nonmotorveh	0	0	0
V67 Occupant of heavy transpvehinj in coll w fixed or stationary object	14	0	14
V68 Occupant of heavy transpvehinj in noncoll transport accid	125	6	131
V69 Occupant of heavy transpvehinj in coll w other and unspecif motor veh	36	11	47
V70 Bus occupant inj in coll w pedest or animal	0	0	0
V71 Bus occupant inj in coll w cycle	0	0	0
V72 Bus occupant inj in coll w 2-3PW	0	0	0
V73 Bus occupant inj in coll w car, pick-up truck or van	6	0	6
V74 Bus occupant inj in coll w heavy transport veh or bus	8	0	8
V75 Bus occupant inj in coll w railway train or railway veh	1	0	1
V76 Bus occupant inj in coll w other nonmotorveh	0	1	1
V77 Bus occupant inj in coll w fixed or stationary object	0	0	0
V78 Bus occupant inj in noncoll transport accid	25	1	26
V79 Bus occupant inj in coll w other and unspecif motor veh	11	3	14
V80 Animal-rider or occupant of animal-drawn vehicle injured in transport accident	0	41	41
V81 Occupant of railway train or railway vehicle injured in transport accident	1	95	96
V82 Occupant of streetcar injured in transport accident	1	0	1

CODE	Traffic Injuries	Non-traffic Injuries	Total
V83 Occupant of special vehicle mainly used on industrial premises injured in transport accident	1	6	7
V84 Occupant of special vehicle mainly used in agriculture injured in transport accident	131	297	428
V85 Occupant of special construction vehicle injured in transport accident	2	11	13
V86 Occup of special all-terrain or other motor veh designed primarily for off-road use,inj in transpaccid	9	10	19
V87 Traffic accid of specified type but victim's mode of transp unknown	14	0	14
V88 Non-traffic accid of specified type but victim's mode of transport unknown	0	2	2
V89 Motor- or nonmotor-vehicle accident, type of vehicle unspecified	1,671	89	1,760
V90-v99	0	214	214
Total	**10,770**	**1,295**	**12,065**

Table H 2 Distribution of external causes for ICD10 (V codes) among traffic injuries (Mortality Register, Spain 2009 -2013)

CODE	Traffic Injuries	Non-traffic Injuries	Total
V01 Pedestrian injured in collisions w pedal cycle	7	0	7
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V03 Pedestrian injured in col w car,pick-up truck or van	923	14	937
V04 Pedestrian injured in collisionsw heavy transport vehicle or bus	186	13	199
V05 Pedestrian injured in collisionsw railway train or railway vehicle	41	217	258
V06 Pedestrian injured in coll w other nonmotor	1	1	2
V09 Pedestrian injured in other and unspecified transport accidents	1,010	118	1,128
V10 Cyclist injured in coll w pedest or animal	0	0	0
V11 Cyclist injured in coll w other cycle	0	0	0
V12 Cyclist injured in coll w 2-3PW	8	0	8
V13 Cyclist injured in coll w car, pick-up truck or van	146	3	149
V14 Cyclist injured in coll w heavy transport veh or bus	31	0	31
V15 Cyclist injured in coll w railway train or railway veh	1	1	2
V16 Cyclist injured in coll w other nonmotorveh	0	0	0
V17 Cyclist injured in coll w fixed or stationary object	13	0	13

CODE	Traffic Injuries	Non-traffic Injuries	Total
V18 Cyclist injured in noncoll transport acid	52	15	67
V19 Driver cyclist injured in coll w other and unspecif motor veh	82	5	87
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V21 Motorcycle rider inj in coll w cycle	2	0	2
V22 Motorcycle rider inj in coll w 2-3PW	30	1	31
V23 Motorcycle rider inj in coll w car, pick-up truck or van	509	4	513
V24 Motorcycle rider inj in coll w heavy transport veh or bus	91	1	92
V25 Motorcycle rider inj in coll w railway train or railway veh	3	0	3
V26 Motorcycle rider inj in coll w other nonmotorveh	1	0	1
V27 Motorcycle rider inj in coll w fixed or stationary object	224	8	232
V28 Motorcycle rider inj in noncoll transport accid	328	7	335
V29 Motorcycle rider inj in coll w other and unspecif motor veh	427	20	447
V30 Occupant of 3PW inj in coll w pedest or animal	0	0	0
V31 Occupant of 3PW inj in coll w cycle	0	0	0
V32 Occupant of 3PW inj in coll w 2-3PW	2	0	2
V33 Occupant of 3PW inj in coll w car, pick-up truck or van	0	0	0
V34 Occupant of 3PW inj in coll w heavy transport veh or bus	3	0	3
V35 Occupant of 3PW inj in coll w railway train or railway veh	0	0	0
V36 Occupant of 3PW inj in noncoll transport accid	0	0	0
V37 Occupant of 3PW inj in coll w fixed or stationary object	1	0	1
V38 Occupant of 3PW inj in noncoll transport accid	1	0	1
V39 Occupant of 3PW inj in coll w other and unspecif motor veh	0	0	0
V40 Car occupant inj in coll w pedest or animal	13	0	13
V41 Car occupant inj in coll w cycle	1	0	1
V42 Car occupant inj in coll w 2-3PW	8	2	10
V43 Car occupant inj in coll w car, pick-up truck or van	1,239	7	1,246
V44 Car occupant inj in coll w heavy transport veh or bus	567	5	572
V45 Car occupant inj in coll w railway train or railway veh	17	0	17
V46 Car occupant inj in coll w other nonmotorveh	7	0	7

CODE	Traffic Injuries	Non-traffic Injuries	Total
V47 Car occupant inj in coll w fixed or stationary object	554	13	567
V48 Car occupant inj in noncoll transport accid	1,103	20	1,123
V49 Car occupant inj in coll w other and unspecif motor veh	702	25	727
V50 Occupant of pick-up truck or van inj in coll w pedest or animal	6	0	6
V51 Occupant of pick-up truck or van inj in coll w cycle	0	0	0
V52 Occupant of pick-up truck or van inj in coll w 2-3PW	1	0	1
V53 Occupant of pick-up truck or van inj in coll w car, pick-up truck or van	42	1	43
V54 Occupant of pick-up truck or van inj in coll w heavy transport veh or bus	73	0	73
V55 Occupant of pick-up truck or van inj in coll w railway train or railway veh	0	1	1
V56 Occupant of pick-up truck or van inj in coll w other nonmotorveh			
V57 Occupant of pick-up truck or van inj in coll w fixed or stationary object	13	0	13
V58 Occupant of pick-up truck or van inj in noncoll transport accid	60	1	61
V59 Occupant of pick-up truck or van inj in coll w other and unspecif motor veh	7	7	14
V60 Occupant of heavy transpvehinj in coll w pedest or animal	0	0	0
V61 Occupant of heavy transpvehinj in coll w cycle	0	0	0
V62 Occupant of heavy transpvehinj in coll w 2-3PW	0	0	0
V63 Occupant of heavy transpvehinj in coll w car, pick-up truck or van	19	0	19
V64 Occupant of heavy transpvehinj in coll w heavy transport veh or bus	78	0	78
V65 Occupant of heavy transpvehinj in coll w railway train or railway veh	1	0	1
V66 Occupant of heavy transpvehinj in coll w other nonmotorveh	0	0	0
V67 Occupant of heavy transpvehinj in coll w fixed or stationary object	14	0	14
V68 Occupant of heavy transpvehinj in noncoll transport accid	125	6	131
V69 Occupant of heavy transpvehinj in coll w other and unspecif motor veh	36	11	47
V70 Bus occupant inj in coll w pedest or animal	0	0	0
V71 Bus occupant inj in coll w cycle	0	0	0
V72 Bus occupant inj in coll w 2-3PW	0	0	0
V73 Bus occupant inj in coll w car, pick-up truck or van	6	0	6
V74 Bus occupant inj in coll w heavy transport veh or bus	8	0	8
V75 Bus occupant inj in coll w railway train or railway veh	1	0	1

CODE	Traffic Injuries	Non-traffic Injuries	Total
V76 Bus occupant inj in coll w other nonmotorveh	0	1	1
V77 Bus occupant inj in coll w fixed or stationary object	0	0	0
V78 Bus occupant inj in noncoll transport accid	25	1	26
V79 Bus occupant inj in coll w other and unspecif motor veh	11	3	14
V80 Animal-rider or occupant of animal-drawn vehicle injured in transport accident	0	41	41
V81 Occupant of railway train or railway vehicle injured in transport accident	1	95	96
V82 Occupant of streetcar injured in transport accident	1	0	1
V83 Occupant of special vehicle mainly used on industrial premises injured in transport accident	1	6	7
V84 Occupant of special vehicle mainly used in agriculture injured in transport accident	131	297	428
V85 Occupant of special construction vehicle injured in transport accident	2	11	13
V86 Occup of special all-terrain or other motor veh designed primarily for off-road use,inj in transpaccid	9	10	19
V87 Traffic accid of specified type but victim's mode of transp unknown	14	0	14
V88 Non-traffic accid of specified type but victim's mode of transport unknown	0	2	2
V89 Motor- or nonmotor-vehicle accident, type of vehicle unspecified	1,671	89	1,760
V90-v99	0	214	214
Total	**10,770**	**1,295**	**12,065**

Table H 3 Externals causes for ICD10 (V codes) and inclusion recommendations.

ICD9 Codes	Traffic Injuries
E810 Motor vehicle traffic accident involving collision with train	All
E811 Motor vehicle traffic accident involving re-entrant collision with another motor vehicle	All
E812 Other motor vehicle traffic accident involving collision with motor vehicle	All
E813 Motor vehicle traffic accident involving collision with other vehicle	All
E814 Motor vehicle traffic accident involving collision with pedestrian	All
E815 Other motor vehicle traffic accident involving collision on the highway	All
E816 Motor vehicle traffic accident due to loss of control, without accident while boarding or alighting	All
E817 Non collision motor vehicle traffic accident while boarding or alighting injuring passenger in motor vehicle other than motorcycle	No

E818 Other no collision motor vehicle traffic accident	All
E819 Motor vehicle traffic accident of unspecified nature	All
E826 Pedal cycle accident	Weighted
E827 Animal-drawn vehicle accident	Weighted
E828 Accident involving an animal being ridden	No
E829 Other road vehicle accident	Weighted
E988.5 Injury by crashing of motor vehicle, undetermined whether accidentally or purposely inflicted	All

Table H 4 Externals causes for ICD10 (V codes) and inclusion recommendations.

ICD10 - codes	Traffic injuries		Non-traffic transport injuries (Did not occur on public road)	
Pedestrian:				
V01 - V06	.1, .9	All	0	Weighted
V09	.2, .3	All	.0, .1, .9	Weighted
Pedal cyclist:				
V10 - V18	.4, .5, .9	All	.0, .1, .2, .3	Weighted
V19	.4, .5, .6, .9	All	.0, .1, .2, .3, .8	Weighted
Motorcycle rider:				
V20 - V28	.4, .5, .9	All	.0, .1, .2, .3	Weighted
V29	.4, .5, .6, .9	All	.0, .1, .2, .3, .8	Weighted
Occupant of three-wheeled motor vehicle:				
V30 - V38	.5, .6, .7, .9	All	.0, .1, .2, .3, .4	Weighted
V39	.4, .5, .6, , .9	All	.0, .1, .2, .3, .8	Weighted
Car occupant:				
V40 - V48	.5, .6, .7, .9	All	.0, .1, .2, .3, .4	Weighted
V49	.4, .5, .6, .9	All	.0, .1, .2, .3, .8	Weighted
Occupant of pick-up truck or van:				
V50 - V58	.5, .6, .7, .9	All	.0, .1, .2, .3, .4	Weighted
V59	.4 .5, .6, .9	All	.0, .1, .2, .3, .8	Weighted

Occupant of heavy transport vehicle:				
V60 - V68	.5, .6, .7, .9	All	.0, .1, .2, .3, .4	Weighted
V69	.4, .5, .6, .9	All	.0, .1, .2, .3, .8	Weighted
Bus occupant:				
V70 - V78	.5, .6, .7, .9	All	.0, .1, .2, .3, .4	Weighted
V79	.4, .5, .6, .9	All	.0, .1, .2, .3,.8	Weighted
Animal-rider or occupant of animal-drawn vehicle				
V80	-		.0.1, .2, .3, .4, .5, .7, .9	Weighted
Occupant of railway train or railway vehicle:				
V81	0,1	All	.0, .2, .3, .4, .5, .6, .7, .8, .9	Weighted
Occupant of streetcar:				
V82	.1, .9	All	.0, .2, .3, .4, .5, .6, .7, .8	Weighted
Occupant of special industrial vehicle:				
V83	.0, .1, .2, .3	All	.4, .5, .6, .7, .9	Weighted
Occupant of special agricultural vehicle:				
V84	.0, .1, .2, .3	All	.4, .5, .6, .7, .9	Weighted
Other:				
V85 - V86	.0, .1, .2, .3	All	.4, .5, .6, .7, .9	Weighted
V87	.0, .1, .2, .3, .4, .5, .6, .7, .8, .9	All	-	Weighted
V88	-		.0, .1, .2, .3, .4, .5, .6, .7, .8, .9	Weighted
Type of vehicle not specified:				
V89	.2,.3	All	.0, .1, .9	Weighted

Appendix I Leaflet

PRACTICAL GUIDELINES FOR DETERMINING THE NUMBER OF SERIOUS ROAD INJURIES (MAIS3+)

September 2016

Within the EU project SafetyCube[17], guidelines have been developed for determining the number of serious road injuries. This leaflet summarizes these guidelines. For the full guidelines, please see Perez et al. (2016) Deliverable 7.1: Practical guidelines for the registration and monitoring of serious road injuries (http://www.safetycube-project.eu/publications/).

Serious traffic injuries have recently been adopted as an additional indicator of road safety. Reducing the number of serious traffic injuries is one of the key priorities in the Policy Orientations for Road Safety 2011-2020 of the European Commission (EC, 2010). In January 2013, the High Level Group on Road Safety, in which all EU Member States are represented, established the definition of serious traffic injuries as road casualties with an injury level of MAIS3+. The Maximum AIS represents the most severe injury obtained by a casualty according to the Abbreviated Injury Scale (AIS®).

The High Level Group identified three main ways Member States can arrive at data on serious traffic injuries (MAIS ≥ 3):

4) by applying a correction on police data,
5) by using hospital data, and
6) by using linked police and hospital data.

Within SafetyCube, for each of these three ways, practical guidelines have been developed to help countries determining the number of MAIS3+ road casualties. Moreover, it was examined how comparable data from different methods are and how differences in data availability influence on the results.

The estimated number of MAIS3+ casualties is highly influenced by the method applied. Linking of police and hospital data leads to the most reliable estimate, followed by the use of hospital data. However, also between countries that apply the same method, differences might occur because of differences in the data and/or differences in the operationalization of the method applied. For the time being, one should be careful drawing conclusions when comparing MAIS3+ counts between countries. Further harmonisation is certainly desirable over the next years.

Getting access to hospital data

Hospital data is essential for determining the number of MAIS3+ casualties with any of the three ways to identify serious injuries; even when applying correction to police data, it is necessary at some point to have hospital data to derive the correction factors. Anonymised hospital data should therefore be available for research or statistical purposes in all Member States. To this end, there should be more inter-sectorial collaboration between the health and the transport actors at national and international level.

[17] SafetyCube (Safety CaUsation, Benefits and Efficiency) is a European Commission supported Horizon 2020 project. The project's main objective is the development of an innovative road safety Decision Support System (DSS) that will enable policy-makers and stakeholders to select and implement the most appropriate and cost-effective strategies, measures and approaches to reduce casualties of all road user types and of all severities. One of the Work Packages is dedicated to serious road injuries, their health impacts and their costs.

Recommendations

Method 1: Applying correction on police data

WHEN:

- **In case you don't have hospital data for the entire country and/or every year**
- **In case hospital data become available at a too late stage**

HOW:

- **Use a sample of hospital data (previous years and/or part of the country) to derive correction factors that can subsequently be applied to recent police data from the entire country (see *Use of Hospital data* for how to make the right selection within the sample)**
- **As police and hospital registration differs between different groups of casualties, multiple correction factors should be derived. As a first step, one could *model* the effects of various variables (such as year, type of road user, age, gender…) on the ratios of police/hospital registrations. This allows the determination of the variables that significantly affect these ratios and consequently the correction factors.**
- **Update correction factors on a regular basis. Correction factors are likely to vary over time and place. When applying correction factors estimated for one-time period to another one, it is necessary to check first that police registration methods have not changed from one time point to the other.**

Method 2: Use of hospital data

WHEN:

- In case hospital data of good enough quality are available and record linkage with police data is not available

HOW:

Select all **road traffic casualties** with **MAIS3+ injuries** in the hospital discharge data:

- Select patients with **external causes for road traffic injuries** (public road): ICD9CM: E810-E819, E826, E827, E829, E988.5; ICD10: V01-89 for those codes for traffic injuries and/or weighting -correcting for non-public road- for non-traffic injury codes
- Exclude fatalities within 30 days
- **Exclude readmissions** (as well as scheduled admissions when they are a second episode of a previous emergency injury)
- Select all cases with any **injury diagnosis** (ICD9CM: 800-999; ICD10: S00-T88; AIS injury)
- In case of ICD coded injuries, **assess the severity (AIS)** of each injury using a ICD to AIS recoding tool (e.g. ICDpic, ICDmap90, AAAM, ECIP/Navarra)
- **Determine the Maximum AIS** of each casualty and select all MAIS3+ (including MAIS6) casualties

ISSUES TO CONSIDER:

- **External causes** (E/V-codes) may be **missing or misspecified** for many casualties. This makes it difficult to select road traffic injuries. Try to compensate for these missing E-codes by using information from additional sources.
- Only traffic crashes on public roads should be selected, i.e. non-traffic crashes or crashes on non-public roads or terrain should be excluded.

In ICD9 this is arranged by excluding E820-E825 from the selection (crashes where a motor vehicle is involved), but for the range E826-E829 (crashes without involvement of a motor vehicle) there is no way to exclude specific cases. Therefore, a fraction of the cases should be excluded, by sampling or by use of a weighting factor.
In ICD10 the indication of traffic on public road is principally arranged by the 4th digit of the V-code, however this is not always reliable. A country specific weighting factor or sampling should be applied.

- Countries use **different versions of AIS**. To make data from different countries more comparable to each other, the number of MAIS3+ casualties should be multiplied by a factor 0.89 when injuries are coded in AIS1990 or AIS1998 instead of AIS2005 or AIS2008.
- The estimated number of MAIS3+ casualties is also influenced by **the ICD to AIS recoding tool** applied. We were not able to produce weighting factors for all tools. We did find that the current version of the AAAM10 (2016) tool results in a clear underestimation of the number of MAIS3+ casualties and the tool is not able to deal with truncated codes. Therefore, we recommend adapting the conversion tables for the AAAM10 tool to better fit European needs.
- In some countries, only a **limited number of diagnoses** is recorded per casualty. This results in an underestimation of the number of MAIS3+ casualties, as the second or third recorded injury can be more severe than the first diagnosis. The following weighting factors should be applied:
    - 1.28 in case of 1 diagnoses recorded
    - 1.11 in case of 2 diagnoses
    - 1.05 in case of 3 diagnoses
- **ICD codes** are **truncated** in some countries. Use of truncated codes leads to a less reliable selection of MAIS3+ casualties. In cases of truncated ICD codes, we currently advise not to use the ICDpic and AAAM10 tools. The following weighting factors should be used to correct for truncated ICD codes in combination with other ICD to AIS recoding tools:
    - 1.06 in case of ICDmap90
    - 1.03 in case of ECIP/Navarra
    - 1.11 in case of AAAM9

Method 3: Using linked police and hospital data

WHEN:

- In case the selection of MAIS3+ road traffic casualties is problematic in the hospital data (e.g. in case of many missing External causes (E/V-codes))
- In case one aims for the best possible estimate of the number of serious road injuries

HOW:

- **Link hospital and police data** (and possibly data from other sources) on the basis of variables that are common to in both data sources.
    - Ideally, linkage is based on a unique personal identification number (**deterministic** linkage), but this is rarely available for privacy reasons
    - When deterministic linkage is not possible, **probabilistic** or distance based linkage is recommend. Commonly used linking variables are date and time of the crash/hospital admittance, location of the crash and hospital, gender and date of birth of the casualty, mode of transport, etc.
- Once the linkage is completed, the number of serious traffic casualties recorded in

hospital data but not identified as such can be estimated using the ***capture-recapture*** method.

- The capture-recapture approach is based on six conditions, among them the three most important to keep in mind are:
    - o The definition of the road casualty in the two data sources should be the same or included into one another.
    - o Independence between the registrations: estimation is biased downwards in case of positive dependence, upwards otherwise.
    - o Homogeneity of capture by a given registration: homogeneity is usually only valid within subgroups (e.g. mode of transport). These subgroups should hence be taken into account by stratification or modelling methods.

Further information

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The leaflet summarizes the main recommendations from Deliverable 7.1: Practical guidelines for the registration and monitoring of serious road injuries. The full guidelines can be found on (http://www.safetycubeproject.eu/publications/).The following authors contributed to the guidelines:

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