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Implications of estimating road traffic serious injuries from hospital data

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ABSTRACT

To determine accurately the number of serious injuries at EU level and to compare serious injury rates between different countries it is essential to use a common definition. In January 2013, the High Level Group on Road Safety established the definition of serious injuries as patients with an injury level of MAIS3 + (Maximum Abbreviated Injury Scale). Whatever the method used for estimating the number or serious injuries, at some point it is always necessary to use hospital records. The aim of this paper is to understand the implications for (1) in/exclusion criteria applied to case selection and (2) a methodological approach for converting ICD (International Classification of Diseases/Injuries) to MAIS codes, when estimating the number of road traffic serious injuries from hospital data. A descriptive analysis with hospital data from Spain and the Netherlands was carried out to examine the effect of certain choices concerning in- and exclusion criteria based on codes of the ICD9-CM and ICD10. The main parameters explored were: deaths before and after 30 days, readmissions, and external injury causes. Additionally, an analysis was done to explore the impact of using different conversion tools to derive MAIS3 + using data from Austria, Belgium, France, Germany, Netherlands, and Spain. Recommendations are given regarding the in/exclusion criteria and when there is incomplete data to ascertain a road injury, weighting factors could be used to correct data deviations and make more real estimations.

1. Introduction

In most countries, road safety performance has traditionally been measured by the reduction of fatalities. 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). However, crashes also cause numerous serious road injuries, resulting in considerable economic and human costs. For the first time, in 2016, the European Commission published a global estimate for the number of people seriously injured on Europe's roads: 135,000 in 2014 (European Commission, 2016). It has been estimated that in some countries the number of serious road injuries has not been decreasing as fast as the number of fatalities, while in other countries the number of serious road injuries has even been increasing (Berecki-Gisolf et al., 2013; OECD/ITF, 2011; Weijermars et al., 2015). In light of this trend, serious road injuries are more commonly being adopted by policy makers as an additional road safety indicator. Moreover, the Valletta Declaration on Road Safety established that the transport ministers will set a target of halving the number of serious injuries in the EU by 2030 from the 2020 baseline using this common definition and in the framework of an overall road safety strategy for this period (Malta, March 2017) ("Valletta Declaration on Road Safety," 2017).

However, one difficulty with tackling the serious road injury problem is how to define serious road injuries. In the past, different countries have applied different definitions which usually related to time of hospitalisation. To determine accurately the number of serious injuries at EU level and to compare serious injury rates and developments between different countries, it is essential to use a common

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definition. In January 2013, the High Level Group on Road Safety representing all EU Member States established the definition of serious injuries as patients with an injury level of MAIS (Maximum Abbreviated Injury Scale) ≥ 3 (Jeanne Breen, 2012, European Commission, 2013).

The Abbreviated Injury Scale (AIS) and its derivative the MAIS (Maximum 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 AIS allows injuries to be ranked by severity. It classifies each injury using 7-digit number that describes the body region (1), type of anatomical structure (2–3), specific anatomical structure (3–4), specific injuries (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 (1 Minor, 2 Moderate, 3 Serious, 4 Severe, 5 Critical, 6 Maximum, 9 Not specified). 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. AIS can be coded directly or can be derived from other injury coding systems, like the International Classification of Diseases in its several versions (ICD, ICD9-CM, ICD10, etc). When using large databases, usually hospital databases, it is likely that AIS is not coded directly but derived using a convertor algorithm.

Various conversion tools are available for recoding ICD codes into AIS codes: ICDmap90,[1] ICDpic,[2] DGT,[3] ECIP,[4] AGU[5] or AAAM.[6] The use 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) (Ringdal et al., 2012). 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 influence the severity that is assigned to a casualty and therefore also on the estimated number of MAIS3 + casualties. However, there is very limited amount of literature comparing directly coded (M)AIS levels to ICD-derived (M)AIS levels, derived using recoding tools (Bartolomeo et al., 2010; Greene et al., 2015).

After establishing the definition of serious injuries, the High Level Group recommended that all EU countries provide data to the European Commission and identified three main ways which Member States can use to estimate the number of serious road traffic injuries: 1) by applying a correction to police data, 2) by using hospital data and 3) by using linked police and hospital data (Omran, 1971). However, there are no clear guidelines on how to apply each method. It is recommended that all EU countries provide data for serious injuries according to this definition from 2014 onwards. Currently, the individual EU Member States use different procedures to determine the number of MAIS3 + casualties. 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 between Member States and therefore the numbers generated may not be fully comparable. The impact of this heterogeneity on final estimations is unknown. One of the work packages of the SafetyCube project[7] (WP7) has the objective to assess and improve the estimation of the number of serious road injuries by providing guidelines for Member States. All three of the recommended methods used for estimating the number of serious traffic injuries (MAIS3 +) are in one way or another based on a selection of hospital records. Therefore, before any guidelines or recommendations can be made addressing how the methods should be applied it is first necessary to have clear criteria for which hospital records should be included or excluded as a first step in the process. This paper considers how hospital data can be used in a harmonised way. The aim of this paper is to understand the implications for (1) in/exclusion criteria applied to case selection and (2) a methodological approach for converting ICD to AIS codes, when estimating the number of road traffic serious injuries from hospital data.

2. Data and method

In this section, we describe the methods used to identify the inclusion and exclusion criteria and the factors that affect obtaining MAIS3 + through conversion tools. The paper addresses the two objectives in two separate sections. Firstly, we explore the effect of in/exclusion criteria using data from Spain and the Netherlands. Secondly we analyse the impact of using different conversion tools to derive MAIS3 + using data from Austria (AT), Belgium (BE), France (FR), Germany (GE), Netherlands (NL) and Spain (ES).

2.1. Inclusion and exclusion criteria

A descriptive analysis was carried out 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 as to which codes should be used to report road traffic serious injuries.

The main parameters explored were:

- What to do with deaths before and after 30 days
- Whether scheduled admissions should be included
- Whether 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 codes for external causes

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

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

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

[4] 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] 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] 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”.

[7] SafetyCube (Safety CaUsation, Benefits and Efficiency) (H2020 N.633485) is a research project funded by the European Commission under the Horizons 2020, the EU Framework Programme for Research and Innovation, in the domain of Road Safety. The project started on May 1st, 2015 and will run for a period of three years. http://www.safetycube-project.eu.

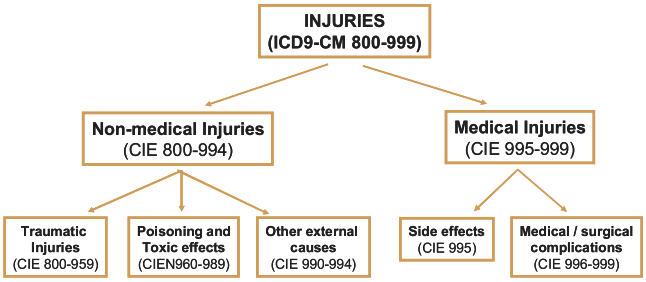

Fig. 1. Injury classification according to ICD9-CM (International Classification of Injuries, ninth revision clinical modification).
Adapted from (Smith et al., 1991).

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). 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, and if they are not traumatic no AIS can be derived. Fig. 1 shows injury classification according to ICD9-CM.

In addition, as in many countries, frequently the availability of data does not allow identification of all specific criteria to select cases from hospital data. A sensitivity analysis has been carried out with the aim of deriving weighting factors to use when no data is available. Weighting factors were calculated based on the effect resulting from including/excluding each option.

A descriptive analysis was carried out for each parameter using hospital data from Spain and The Netherlands separately.

In Spain, two data sources were used. First, the Spanish Database from Hospital Discharge Register (HDR) for 2011 was used 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 whole the Spanish population. The unit of analysis of the database are admissions, not individuals. To identify individuals a personal identification code is used. The criteria for defining a readmission can vary across countries. In Spain, if the same person has different admissions due to the same reason in the same hospital or another within less than 30 days of difference, they are classified as re-admissions (of the same individual). Due to data protection, frequently it is not possible to identify number of visits of the same person, therefore we need to rely on the hospital definition. In the same sense 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, so we also studied them in the analyses.

Spain was coding diseases and injuries using the ICD9-CM up 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). 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 has coded mortality using ICD10 since the year 2000.

In order to identify road traffic injuries in hospital data it is necessary to know the police definition. The Spanish General Directorate of Traffic (DGT) in accordance with Eurostat defines a 'Road traffic collision with victims' as "collision occurring or starting on a road which is the 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".

According to the ICD9-CM the definition of road traffic injuries includes any traumatic injury including codes from 800 to 959. We will analyse the impact of including late effects of injury and complications of physical trauma (905 to 909, 958 and 959). In addition, external codes E810-819 ("Motor vehicle traffic accident") are clearly relevant to identifying road traffic casualties. However, there are codes that in some cases do not fulfil the police definition of "traffic accident" such E826 ("Pedal cycle accident"), E820-E825 "Motor Vehicle Nontraffic Accidents (not on a public road)", 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". We will include them in the sensitivity analysis.

For the purposes of this study, we used as a core definition of traffic injury one that has been considered based by previous studies (Pérez et al., 2014). Due to the frequency of missing information on the code of external cause (E code) we also considered using the compensation payer company to identify traffic injury cases. Traffic injuries were defined as those injuries meeting either criteria 1 or criteria 2:

1 E-code for external cause (ICD9-CM): E810-819, E826-829, E929, E988.5.
2 Road Accident compensation payer.

Police registers include road traffic fatalities as those up to 30 days after the collision. Therefore, in hospital databases it is important to ensure that fatalities are not double counted (as injured and as fatality), and would produce an overestimation. This means that if a person is admitted to hospital but finally dies within 30 days after the admission they should be counted as a fatality (as in the police registers). However, if the person dies after 30 days, they should be recorded as injured according to their severity, since they are not included in the fatalities statistics.

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

For ICD10 it has not been possible to derive MAIS (apart from all fatal cases) 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.

In the Netherlands, a selection of the Dutch Database from the Hospital Discharge Register (HDR) for 1993–2013 was used. Dutch hospitals code injuries with the ICD9-CM. The database includes up to 10 diagnoses (1993-2009 including diagnosis of injuries, diseases and codes of external causes). After 2012, hospitals gradually introduced ICD10 for coding. In this study only the ICD9-CM cases of 2012 and 2013 have been considered. For this analysis, all ICD10 codes have been converted to ICD9-CM and treated likewise. The Dutch Hospital Data includes all hospitalisations for patients with a transport accident as the external cause (E-codes 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. For some of the years of interest some hospitals did not provide data, but because the number of patients treated is known an accurate estimate of the missing data can be given. The population of study is complete the Dutch population, including all persons –irrespective of their nationality- having an accident in the Netherlands who are admitted to a Dutch hospital. At a first stage, the unit of analysis of the database is admissions, not casualties of (traffic) incidents. Therefore, as with the Spanish data, it is necessary to identify the individuals before any analysis can be completed using the patient number. AIS and MAIS were derived from the icdmap90 module of Johns Hopkins University (1998).

In the Netherlands, for this study, to examine the sensitivity for the

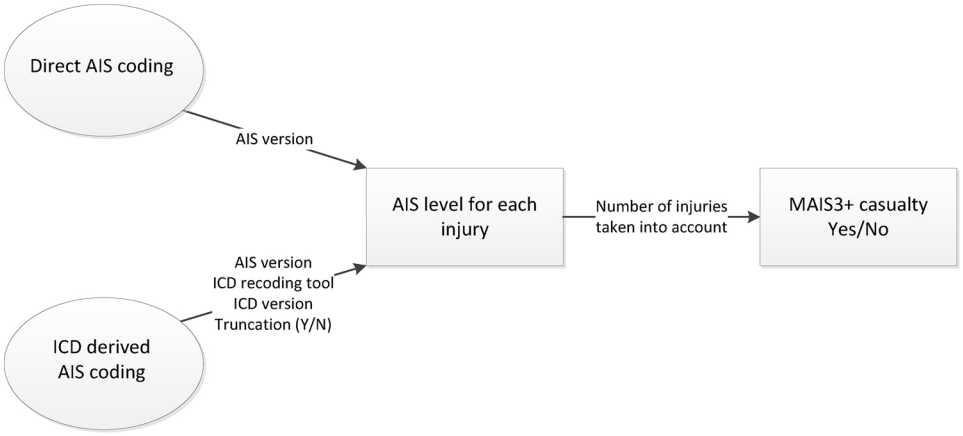

Fig. 2. Issues related to deriving MAIS3 + that may influence the number of MAIS3 + casualties.

inclusion criteria the following definition was used: all severities on the MAIS scale, including deaths, and all patients with an E-code in the range E810-E829 + linked cases for E929.0 and E988.5 were included. 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 accidents.

2.2. Conversion tools to derive MAIS3+

When deriving MAIS3 + from ICD codes using conversion tools there are a number of factors that might affect the final estimates such as:

1 AIS versions and ICD-derived AIS compared to direct AIS coding;
2 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 of directAIS coding;
3 Using a limited number of injuries per casualty for the MAIS score;
4 Using 4 digits instead of the full ICD injury code when deriving AIS.

Fig. 2 summarises the issues related to deriving MAIS3+. In an ideal situation MAIS3 + casualties would be 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. Using ICD conversion tools is often necessary to derive AIS, but, the combination of differing ICD conversion tools and various versions of the coding instructions may result in variations in the estimated number of MAIS3 + casualties. In a similar way, including a limited number of injuries and the use of truncated injury codes has the potential to affect the estimated casualties.

We studied these effects using hospital data from Austria (AT), Belgium (BE), France (FR), Germany (DE), Netherlands (NL), and Spain (ES).

The implications for each of the factors (1–4) listed above were considered in relation to the following:

a The effect of different AIS versions was studied using the GIDAS (DE) in-depth accident survey data set of accidents recorded since 2008 that have been coded in both AIS1998 and AIS2008.
b To study the effect of direct coded AIS compared to ICD-derived AIS, a dataset from Germany (GIDAS) 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 the direct AIS. Unfortunately, no other datasets were available to study other combinations of AIS versions.
c 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.
d The effect of using a limited number of injuries for the MAIS calculation was investigated by studying the effect on the estimated number of MAIS3 + casualties in case of leaving out injuries (NL, BE, ES).
e The effect of truncation of injury codes was assessed by truncating the ICD injury codes in countries where full codes were available (NL, BE, ES).
f To study the effect of the different tools to derive the AIS from ICD, two or more tools were used on the same data set. The results are analysed to show the differences in the total number of MAIS3 + casualties, for combinations of ICD-version, tool and AIS-version where the difference was substantial (DE, NL, BE, ES).

3. Results

3.1. Inclusion and exclusion criteria for road traffic case selection from hospital data

The Hospital Discharge Register (HDR) of Spain included 258,432 episodes of hospitalisations during 2011 due to all causes of injuries. Out of them, there were 31,339 traffic admissions in Spain according to the definition of criteria 1 or 2 (E-code or Accident compensation payer). In 25% of cases there was no E-code but the compensation payer was a road traffic insurance company.

Therefore, according to the Spanish Hospital Discharge Register (HDR), 31,339 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 (MAIS 0–2) and 8888 were seriously injured (MAIS3+). Eighteen fatalities that died after 30 days of admission had slight or moderate injuries (MAIS = 0–2) (Table 1). (Obviously, there were fatalities who died at the scene and were not admitted to hospital).

From this point and for the purposes of this study, deaths within 30 days (n = 526) are excluded for the sensitivity analyses. Deaths after 30 days are distributed according to their MAIS. Therefore, the database includes 30,813 admissions (Table 1).

According to data showed in Table 2, if re-admissions are excluded, the percentage of severe road traffic injuries is similar (29.0% versus 29.4%). 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 dropped from 30,813 to 24,761. If we exclude people injured who stay 0 days hospitalised (defined as no overnight stay), the percentage remains similar from 29.0% to 28.8%.

On the other hand, if only people with traumatic injuries are selected as traffic injuries, the number of people injured will drop from

Table 1
Hospital admissions in Spain according to severity of injury and outcome. Hospital Discharge Register, Spain 2011.

		Severity	Traffic Injuries	Other Injuries	Total
Deaths	Death within 30 days	MAIS 0-2	73	1086	1159
		MAIS3+	453	4694	5147
		Unknown	0	84	84
	Total Deaths		**526**	**5864**	**6390**
Injured	Death after 30 days	MAIS 0-2	18	84	102
		MAIS3+	39	317	356
		Unknown	0	25	25
	Alive	MAIS 0-2	21,835	143,120	164,955
		MAIS3+	8888	74,548	83,436
		Unknown	33	3135	3,168
	Total Injured		**30,813**	**221,229**	**251,559**
Total			**31,339 (12.1%)**	**227,093 (87.9%)**	**258,432**

30,813 to 27,140 and consequently the percentage of severely injured people change from 29.0% to 32.9%, although total number of severely injured will not change (8927). Moreover, if traumatic injuries are selected only from the main diagnosis, the number of people severely injured falls to 11,885 and the percentage of seriously injured changes to 25.7%.

Finally, the sensitivity analysis has been done by varying the inclusion of the E-codes (E826-E829, E929.0, E988.5). The numbers are so small that the percentage of severely injured people will not change in most of the cases (Table 2).

According to the Dutch Hospital Discharge Register (HDR), 433,077 hospital admissions took place because of a traffic accident, of which 6308 people died (1.5%). Most of them (92%) died within 30 days after admission in hospital and 8% died after 30 days of admission. Table 3 shows what would be the effect of using different criteria.

Regarding the external 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 A1 (see Appendix A) shows the distribution of cases of fatalities according to ICD10 classification of road user by traffic and non-traffic for the mortality database in Spain. For all road users, there are a notable number of cases with unspecified information. Tables A2 and A3 in the appendix present the list of codes of external causes for ICD9-CM and for ICD10.

Table 3
Traffic hospital admissions in the Netherlands according to all the different definitions. (HDR, The Netherlands 1993–2014).

	MAIS1/ unknown	MAIS2	MAIS3+	index	Overestimation Factor
MAIS3 + definition	88,555	196,112	97,138	100%	
Including E828	4018	12,680	3394	3.5%	0.966
Including E929	47	1	0	0.0%	1.000
Including E820-825	2248	5946	2176	2.2%	0.978
Including re-admissions	1991	8194	3656	3.8%	0.964
Including deaths within 30d	540	403	4623	4.8%	0.955
Including combinations	172	809	373	0.4%	
Total	**97,571**	**224,145**	**111,361**		

3.1.1. *Use of weighting factors to make data more comparable with other countries*

Sometimes it is not possible to have complete hospital data for a country. In that case weighting factors could be used to correct for data deviations to generate estimations which are more comparable to

Table 2
Traffic hospital admissions according factors and injury severity. Hospital discharge Register of Spain, 2011.

	MAIS0-2	MAIS3+	Total[a]
Re-admissions (n)	**978**	**204**	**1183**
Re-admissions included	21,853	8927 (29.0%)	30,813 (100%)
Re-admissions excluded	20,875	8723 (29.4%)	29,630 (100%)
Scheduled admissions (n)	5491	**551**	6052
Scheduled admissions included	21,853	8927 (29.0%)	30,813 (100%)
Scheduled admissions excluded	16,362	8376 (33.8%)	24,761 (100%)
People with 0 days of hospitalisation (n)	**140**	**119**	**259**
0 days hospitalisation included	21,853	8927 (29.0%)	30,813 (100%)
0 days hospitalisation excluded	21,713	8808 (28.8%)	30,554 (100%)
Traumatic Injuries (ICD9:800-959) (n)	**18,180**	**0**	**27,140**
All injuries included	21,853	8927 (29.0%)	30,813 (100%)
Selecting only traumatic Injuries	18,180	8927 (32.9%)	27,140 (100%)
Traumatic injuries (Number of diagnosis)			
Traumatic injury in any diagnosis	21,853	8927 (29.0%)	30,813(100%)
Traumatic injury only in the main diagnosis	9584	2295 (25.7%)	11,885(100%)
External causes (ICD9)[b]			
Total traffic injuries	21,853	8927 (29.0%)	30,813(100%)
E826 Pedal cycle accident (n)	2716	1018	3734
Traffic injuries excluding E826	19,137	7909 (29.2%)	27,079 (100%)
E827 Animal-drawn vehicle accident (n)	18	7	25
Traffic injuries excluding E827	21,835	8920 (29.0%)	30,788 (100%)
E828 Accident involving an animal being ridden (n)	450	193	644
Traffic injuries excluding E828	21,403	8734 (29.0%)	30,169 (100%)
E829 Other road vehicle accident (n)	80	28	108
Traffic injuries excluding E829	21,773	8899 (29.0%)	30,705(100%)
E929.0 Late effects (n)	228	8	238
Traffic injuries excluding E929.0	21,625	8919 (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	8924 (29.0%)	30,809 (100%)

[a] Traffic injuries with unknown severity are not shown.
[b] All the sensitivity analysis has been done assuming that excluded cases are not selected as road traffic injury by any other criteria.

Table 4
Weighting factors among selection criteria for serious injuries (MAIS3+) traffic hospital admissions in Spain and in The Netherlands. Spanish Hospital Discharge Register 2011 and Dutch Database from Hospital Discharge Register, 1993-2013.

	Spain	Netherlands	Average	Effect of not meeting criteria
Including deaths within 30 days	0.95	0.96	0.95	If fatalities within 30 days cannot be excluded, the results is an overestimation of 5%
Including Re-admissions	0.98	0.96	0.97	If re-admissions cannot be excluded the result is an overestimation of 3%
Including E929	0.99	1.00	1.00	Inclusion of E929 does not have an effect
Including E828	0.98	0.97	0.97	Inclusion of E828 results in an overestimation of 3%
Including E820-825	0.99	0.98	0.99	Inclusion of E820-E825 results in an overestimation of 1 to 2%.

estimates from other countries. Table 4 shows weighting factors calculated for road traffic serious injuries (MAIS3+) 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 road injuries. Based on these effects, weighting factors were derived. When these weighting factors are very close to 1, will not have a large impact on the estimated number of MAIS3 + casualties, therefore it would be better not to apply any weighting factor in this instance. This is for example the case regarding the inclusion of E-codes E820-E825 and E929 in Spain and the Netherlands. Inclusion of fatalities within 30 days has the largest effect on the estimated number of MAIS3 + casualties of the analysed factors and results in an overestimation of 5%.

3.2. How to derive MAIS3+

3.2.1. Direct coding versus various conversion tools

Directly coded AIS levels were compared with ICD derived AIS levels, different ICD recoding tools and different AIS versions were considered. The results of those analyses are summarised in Table 5. In the German GIDAS database, 16,695 casualties were coded in both AIS1998 and AIS2008. Line 1 in Table 5 shows that the AIS1998 version results in roughly 12% more MAIS3 + casualties compared to the AIS2008 version. Some of the data from the German GIDAS database could be matched to patient information from the Medical School in Hannover. For 209 trauma casualties, ICD10GM (ICD10 German modification) injury codes were available and recoded to AIS using various ICD10 recoding tools. Line 2 of Table 5 shows that using ECIP results in a 13% higher number of MAIS3 + casualties compared to direct coding, whereas both AAAM10 and AGU result in an underestimation. Note that the difference between direct coding and ECIP can be fully explained by a difference in AIS version.

Lines 2–6 in Table 5 show comparisons between different recoding tools, in combination with different AIS and ICD versions. As it was not possible to compare ICD9 derived AIS with direct coding, it was not possible to determine which tool provides the best result. Considering a 12% difference between AIS1990/1998 and AIS2005/2008, ICDpic appears to result in the highest number of MAIS3 + casualties in all three countries. Besides, the difference between the ICD9-CM recoding tools is at most 7%. Also, these analyses show that the AAAM10 tool results in a much lower number of MAIS3 + 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 ICD9CM to ICD10 and vice versa and the effect of these conversions is unknown, it was not possible to make a good comparison between tools that use ICD9 and tools that use ICD10 to recode to AIS.

3.2.2. 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 considering the primary diagnosis, 1, 2, 3 and all injuries and comparing the results. This analysis is done using Belgium, Spanish and Dutch data. On average, taking into account only 1 injury results in an estimated number of MAIS3 + casualties which is only 78% of the number that is estimated based on all injuries. When 2 injuries are taken into account, 90% of the serious road injuries are identified and when 3 injuries are taken into account, on average 95% of the number of MAIS3 + casualties are identified (Table 6).

3.2.3. Consequence of truncated injury codes

Due to hospital practice or privacy regulations, some countries use 4-digit injury codes instead of 5-digit 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 considering the severities of the injuries underneath.

Table 7 shows the effect on the number of MAIS3 + casualties caused by truncation when using 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 MAIS3 + casualties when injuries are truncated. The AAAM10 tool shows a considerable increase in the number of MAIS3 + casualties in cases of truncated injury codes compared to using full codes.

4. Discussion

Hospital data is an important data source for all three EC recommended methods for estimating MAIS3 + serious injuries. These

Table 5
Estimated number of MAIS3 + casualties when applying different AIS versions and different ICD to AIS recoding tools. In italic bold: 'true number'.

N	Country	AIS 1998	AIS 2008	ICD9-CM				ICD10		
				ICDmap90 1990	DGT 1998	ICDpic 1985	AAAM9 2008	ECIP 1998	AAAM10 2008	agu 2008
1	Germany	1 019 (112%)	***909 100%***							
2	Germany		***103 (100%)***					116 (113%)	82 (80%)	89 (86%)
3	Netherlands (1993–2013)			107,738	109,605	103,747	102,900			
4	Netherlands (2012–2014)							14,384	8391	
5	Belgium					19,143	18,381			
6	Spain					8274	7656			

Table 6
Estimated numbers of serious road injuries when taking 1, 2, 3, or all injuries into account and applying different conversion tools (upper half), and proportion of MAIS3 + casualties that is included when taking account 1, 2 or 3 injuries (all injuries is 100%).

	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	8274	135,151	
3	17,900	105,728	14,766	7753	131,381	
2	16,654	102,392	14,258	7315	126,361	
1	13,678	91,159	12,489	6357	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%

Table 7
Estimated number of MAIS3 + casualties when using truncated codes compared to using full codes, % of underreporting when using truncated codes and weighted factors to correct for truncated codes.

		Using full codes	Using truncated codes	%	Factor
ES	ICDpic	8274	2108	25%	3.9
BE	ICDpic	19,143	3949	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	8480	12,123	143%	0.70

are the types of injuries that cause significant or long-term damage and consequences and this is where efforts should be focused (European Commission, 2013). This paper emphasises the impact that different inclusion and exclusion criteria for selecting casualties from hospital data has on overall estimated number of serious injuries. Additionally, the methods for deriving MAIS using conversion tools from ICD diagnoses also influence end estimates of MAIS3 + casualties. It is hoped that by harmonising the way hospital data is selected for inclusion there will be increased comparability of MAIS3 + injuries across countries. Finally, a definition of road traffic injuries for use with hospital data is recommended.

When using hospital data, missing E-codes, the AIS version applied and considering only a limited number of injuries particularly influences the estimated number of MAIS3 + casualties. A number of weighting factors are proposed to deal with some of these differences. However, it was not possible to derive weighting factors for all methodological issues. The accuracy of estimates will vary if the criteria for processing hospital data differ between countries. Failure to obtain reliable and valid figures will result in under or over reporting and will compromise the comparisons across countries.

In summary, following exploratory analysis with data sets from several European countries, the following criteria for identifying road traffic cases from hospital data are recommended in order to obtain the most accurate estimation of MAIS3 + casualties possible:

- Exclude fatalities within 30 days after admission
- Fatalities after 30 days should be counted as injured according to his/her MAIS
- Exclude re-admissions related to the same crash to avoid duplicates
- If it is possible to avoid duplicates by just excluding re-admissions, it is not necessary to exclude scheduled admissions. If not, scheduled admissions 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 to have complete data of these hospital data, weighting factors could be used to correct data deviations and make more real estimations.

Recommendations for using different conversion tools to derive MAIS3 + are:

- In order 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 ECIP recoding tool for ICD10 seems to result in the most reliable numbers of serious road injuries.
- The difference in the estimated number of MAIS3 + casualties between the ICD9CM recoding tools is at most 7%. It was not possible to investigate the difference between ICD9 tools and direct coding.
- Current version of the AAAM10 tool (2016) is not recommended until it is updated to better-fit European needs.
- The following weighting factors could be applied in cases where less than 4 diagnoses of injuries are taken into account for the determination of the number of MAIS3 + 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 when codes are truncated.
- 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

4.1. General criteria for case selection/inclusion

As it is shown in the results, it is necessary to exclude re-admissions as it would lead to overestimates. The time established to consider a re-admission might be different across countries preferably during a 12-month period from the date of the hospitalisation. However, it is not always possible to identify them due to data protection. As it is explained, in Spain a re-admission is defined as “within 30 days in the same hospital” due to hospital procedures (Pérez et al., 2014). Re-admissions are identified by the hospitals using information not available in the data file made available for road accident research. In other countries, as in the Netherlands, re-admissions can be identified in the other hospitals as well over a period of a full calendar year, as the HDR of the previous year is available and readmissions of road traffic casualties can be excluded in a de-duplication process where a patient with the same date of birth, gender, township of residency and main diagnosis can be found.

The way scheduled admissions (contrary to acute admissions) are treated can also vary from one country to the other. If a scheduled admission is interpreted as the second medical examination after a first visit to the hospital (probably in the accident & emergency department) and the diagnosis information is specific enough to identify a MAIS3 + injury and this case is present in the hospital data file, then the scheduled admission can be left out as information of the first encounter is present. If re-admissions can be excluded from the database (as these are explicitly recorded or can be identified in a de-duplication process), it is not necessary to exclude scheduled admissions as the

process of de-duplication takes care of that. If re-admissions are not specifically recorded, as in the case of Spain, then scheduled admissions they should be also excluded as they are likely to include many re-admissions.

Ideally MAIS3 + casualties that are not admitted to the hospital should also be taken into account as a serious road injury. However, as in most countries, hospital discharge data is the only database available to estimate the number of serious road injuries, it is not possible to include non-hospitalised casualties. The Rhone register in France estimates that exclusion of non-hospitalised MAIS3 + casualties results in an underestimation of the number of serious road injuries of roughly 5%. The actual inclusion or not of outpatients within the definition of serious road traffic injuries varies depending on the country; however, it is convenient to include them in the definition all traffic injury hospitalisations, even if they only generate short stays in the hospital.

In the case of the inclusion of late effects of injury and complications of physical trauma (905–909, 958 and 959) it should be noted that they automatically are excluded when obtaining severity. As it is previously explained some E-Codes do not fulfil the police definition of “traffic accident” such as E826, E820-E825, E827, E828, E829 and E988.5. It is suggested to include the E-codes: E810-E19, E826, E827, E829 and E988.5 and exclude E828 because this is not supposed to fulfilled Eurostat definition of motor vehicle traffic in the sense that maybe there is not at least one vehicle in motion involved in a public road.

Frequently external causes of injury are underreported. For example, in Belgium, the registration of E-codes in hospitals has been compulsory since 2003. Yet, despite this obligation, they are still not consistently recorded. However, registration improves year after year: in 2004 35% of hospitalised patients with a principal diagnosis within the range 800–959.9 did not receive 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. In Spain, 17% of records are missing the E-code. Due to the lack of a complete database with E-codes it is not possible to derive a weighting factor adjusting for missing E-codes. Some countries look for other variables to identify traffic injury cases. In Spain for example, “compensation Payer Company” is used as an additional variable to select road traffic casualties. The use of this variable enabled identifying 25% of all road traffic casualties that were not identified by the selection of E-codes.

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). To address difficulties in knowing whether a crash is or is not a traffic accident, 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 to avoid overestimation. Inclusion criteria for ICD10 in the Netherlands, ‘non traffic’ is not accurately coded, so therefore these cases are included using a weighting factor (Bos et al., 2014).

To improve the accuracy of serious injury estimates it is recommended to obtain weighting factors from at least a sample of that country’s hospital data. If this is not possible it may then be appropriate to apply weighting factors from another country. It is recommended to only include weighting factors that are 0.97 or smaller, as higher weighting factors only have a very limited effect. Moreover, we should note that the weighting factors generated from this work are based on two countries only and therefore should be applied with caution. Nonetheless applying weighting factors makes countries slightly more comparable. One of the biggest obstacles weakening the comparability between countries is missing external codes and it is not possible to calculate weighting factors for that because it is very country specific.

4.2. Methods to derive MAIS3+

There is very limited amount of literature comparing directly coded (M)AIS levels to ICD-derived (M)AIS levels, derived using recoding tools. 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, Injury scale based on AIS (Baker et al., 1974)) scores and conclude on the basis of 289 cases that agreement between scores based on ICDpic and scores based on direct coded AIS is poor. The main cause for this poor agreement was 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 AIS3 + 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.

AAAM convertors were developed by the Association for the Advancement of Automotive Medicine for the European Commission, and are the official tool recommended and freely distributed by DG MOVE (Directorate-General for Mobility and Transport). The tool provides for any specific diagnosis whether its MAIS is $<$ or $\geq$ 3. The European Commission acknowledges that the AIS (in all its versions) is the property of the Association for the Advancement of Automotive Medicine (AAAM), owner of the Copyright (European Commission, 2013). Results from our study show that AAAM for ICD9-CM provides acceptable figures, while for ICD10 results in an underestimation of number of serious injuries.

The consequences of truncated injury codes and of including a limited number of injuries when determining MAIS were investigated using data from Spain, Belgium and the Netherlands. The effect of truncation appears to depend on the recoding tool that is applied; AAAM10 and ICDpic do not seem able to deal with truncated codes. ICDpic shows a large decrease in the number of MAIS3 + casualties when injuries are truncated while the AAAM10 tool shows a considerable increase in the number of MAIS3 + casualties. 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.

Moreover, it is recommended that the AAAM10 tool is adapted to better-fit European needs. Other tools – ICDmap90, DGT, and AAAM9- result in an underestimation of MAIS3 + casualties between 3% and 10%. Including less than 4 injuries when determining MAIS results leads to an underestimation in serious injuries. On average, taking into account only 1 injury results in an estimated number of MAIS3 + 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 road injuries are identified and when 3 injuries are taken into account, on average 95% of the number of MAIS3 + casualties are identified.

This study has a number of limitations. In general, most results are based on data from only a few countries so are likely not to be representative of all countries, particularly those that differ in motorisation and share of modes of transport. Also, the weighting factors that are proposed are based on in a limited set of data. More specifically, the comparison of MAIS3 + casualties based on direct coding with ICD derived codes, are based on a very small sample and concern trauma cases with many and relatively serious injuries that are coded in the German version of ICD10 (ICD10GM). We recommend repeating the

exercise with a larger sample and an ICD version that is used within the recoding tools.

In conclusion, the current paper has considered the implications for deciding which hospital cases should be included as part of MAIS3 + calculations and how to derive AIS from ICD conversions. The most suitable hospital data should provide at least 4 diagnosis of injuries, no truncation of ICD codes, registration of E-codes, and use the latest version of AIS (2008). The definition of road traffic casualty should: exclude fatalities within 30 days after admission, readmissions, and scheduled admissions; and include all cases with any injury diagnosis (ICD9CM: 800–999; ICD10: S00-T88), and 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). When there is incomplete data to ascertain a road injury, weighting factors could be used to correct data deviations and make more real estimations. It is essential that maximum effort be applied to obtaining hospital data of high quality which best allows estimates of serious injuries, to monitor trends and allow comparisons between countries.

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Appendix A

Table A1
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 collision w 2-3PW	61	3	64
V03 Pedestrian injured in collision w car, pick-up truck or van	923	14	937
V04 Pedestrian injured in collision w heavy transport vehicle or bus	186	13	199
V05 Pedestrian injured in collision w railway train or railway vehicle	41	217	258
V06 Pedestrian injured in collision w other nonmotor	1	1	2
V09 Pedestrian injured in other and unspecified transport accidents	1010	118	1128
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
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	1239	7	1246
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	1103	20	1123

(*continued on next page*)

Table A1 (*continued*)

CODE	Traffic Injuries	Non-traffic Injuries	Total
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
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 transpaccident	9	10	19
V87 Traffic accident of specified type but victim's mode of transport unknown	14	0	14
V88 Non-traffic accident 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**	**1295**	**12,065**

Table A2
External causes for ICD9-CM (E-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

For patients in collisions without involvement of motorvehicles (external cause E826-E829) it is not known if the crash occurred on a public road. Therefore it is recommended that only a fraction is counted as traffic casualties. This can be achieved by a weighting factor or a random selection. For motor vehicle crashes the range E820-E825 indicates that the crash did not occur on a public road.

Table A3
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	–	
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

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