Deliverable: D1.3 Guidelines for the policy making: Future trends in accident scenarios and ISO 13232 review

Grant Agreement Number: 769054

Project acronym: PIONEERS
Project full title: Protective Innovations of New Equipment for Enhanced Rider Safety

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Due delivery date: M12
Actual delivery date: M17

Organisation name of lead participant for this deliverable: IDIADA

Project funded by the European Commission within Horizon 2020		
Dissemination level		
PU	Public	X
CO	Confidential, only for members of the consortium (including the Commission Services)	
Type		
R	Document, report	X
DEM	Demonstrator, pilot, prototype	
ORDP	Open Research Data Pilot	
ETHICS	Ethics Requirement	

Document Control Sheet

Deliverable number:	D.1.3
Deliverable responsible:	IDIADA
Work package:	WP1
Editor:	Genís Mensa

PIONEERS
INNOVATION FOR RIDER SAFETY

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Document Revision History			
Version	**Date**	**Modifications Introduced**	
		Modification Reason	**Modified by**
V0.1	2019.06.25	Template + introduction	Genís Mensa
V0.2	2019.07.18	Sections update	G Mensa, S Piantini
V0.3	2019.08.02	Update on the CARE database	Genís Mensa
V0.4	2019.08.16	Input on the trend calculation	Genís Mensa
V0.7	2019.09.10	Input on sections 3.2 and 3.3	María del Mar Rasines
V0.9	2019.09.25	Input on sections	Simone Piantini
V1	2019.09.30	Final revision of the document	Genís Mensa

Abstract

The Protective Innovations of New Equipment for Enhanced Rider Safety (PIONEERS) project is aiming to reduce the number of Powered Two Wheelers (PTW) fatalities and severe injuries in the upcoming years. The idea behind this project is to increase the safety, performance, comfort and usage rate of Personal Protective Equipment (PPE), as well as to develop new on-board safety devices for PTW protection.

Thus, the main objective of this deliverable is to develop guidelines for the policy making. To this end, the most critical scenarios identified in D1.1 have been compared with the ISO13232:2005 standard. Moreover, Key Accident Scenarios in Europe (KASE) for the development of safety measures in PTW vehicles have been defined, and a forecast of PTW accident scenarios within the next years has been provided.

The comparison between results of D1.1 and ISO13232:2005 has deliver the following outcomes: the application of the ISO13232:2005 methodology in recent crash data triggered some consideration on the crash configurations suggested by the ISO standard. Both literature and PIONEERS data processed using the ISO13232:2005 methodology, showed differences in the selection of the crash configurations to be tested. But, unfortunately, the question if these crash configurations are representative of the current European accident configurations is still open.

Furthermore, a forecast of future PTW accident scenarios, based on the CARE database, has been determined. For this purpose, total PTW fatalities reported in the EU countries, as well as the number of rural and urban fatalities, have been considered. In each case, accidents involving motorcycle and moped vehicles have been differentiated.

After applying a lineal regression model, predicted values for PTW fatalities in the EU within 2030 are 4,604 for the total number of accidents; 2,590 in rural scenarios; and 1,753 in urban scenarios. As compared to their forecasted values for 2018, this means a reduction of 9.5%, 7.1% and 15.4%, respectively, in the accident occurrence.

PIONEERS faces a future scenario in which PTW registrations are rising year on year in all EU countries. Compared with the same period last year, motorcycle registrations have increased by 9.1% during the first half of 2019, moped registrations by 19.5% and electric PTW registrations by 70%.

The output of this deliverable will be especially useful for WP6, which will assess safety and economic benefits of the new PIONEERS systems and the new testing methods, considering the policy guidelines defined in this report.

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Abbreviations and Acronyms

Acronym	Definition
AIS	Abbreviated Injury Scale
CRI	Configuration Risk Index
EDA	French in-depth accident study by IFSTTAR (Etudes Détallées d'Accidents)
GIDAS	German In-Depth Accident Study
InSAFE	In-depth Study of accidents in Florence (University of Florence)
ISO	International Standard Organization
H2020	Horizon 2020
KASE	Key Accident Scenarios in Europe
MC	Motorcycle
On-board safety systems	Protective systems/ devices that are installed directly on the PTW
OV	Opponent Vehicle
PCB	Pre-Crash Braking
PIONEERS	Protective Innovations of New Equipment for Enhanced Rider Safety
PPE	Personal Protective Equipment
PTW	Powered Two Wheelers
RHA	Relative Heading Angle
WP	Work Package

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1 Introduction

PIONEERS is a Horizon 2020 project that aims to reduce the number of Powered-Two-Wheeler (PTW) fatalities and severely injured by increasing the safety, performance, comfort and usage rate of Personal Protective Equipment (PPE), as well as the development of new on-board safety devices.

One of the objectives of this project is to gather knowledge and achieve a better understanding of the safety issues that PTWs encounter on real roads. Thus, once the Key Accident Scenarios in Europe (KASE) have been identified, current and future relevant scenarios for the development of safety measures will be defined. Therefore, this task will balance the current scenarios with existing trends and market evolution to recognize future safety issues related to PTWs.

2 ISO13232:2005 review

2.1 Rationale

The ISO13232:2005 standard, *'Test and analysis procedures for research evaluation of rider crash protective devices fitted to motorcycles'*, defines a set of configurations of PTW-to-car impact scenarios to be tested in full-scale crash tests. It was first developed in 1996 and revised in 2005.

The crash configuration code is composed by three digits describing the other vehicle (OV) contact point, the motorcycle (MC) contact point and their relative impact angle, followed by the OV impact speed and the MC impact speed, e.g. the code 143-9,8/0 means that the OV crashes frontally (1) the left side (4) of the MC with an angle of 90 degrees at 9.8 m/s and 0 m/s, respectively.

The seven most relevant crash configurations defined by the ISO13232:2005 are the **143**-9.8/0, **114**-6.7/13.4, **413**-6.7/13.4, **412**-6.7/13.4, **414**-6,7/13.4, **225**-0/13.4 and the **413**-0/13.4.

The impact configurations had been previously drawn by a set of 621 random real-world accident cases coming from the in-depth databases of Los Angeles (US) and Hannover (EU). Out of 621 crash cases, 211 occurred in Hannover and 410 in Los Angeles. It should be noted that both datasets were compiled before 1996.

The ISO13232:2005 standard remarks that the selection of the impact configurations should be based on accident analysis and the know-how related to testing facilities and protocols. However, this means the absence of a structured ranking method, together with the lack of a complete description of the procedure used.

From the explanation of why the seven impact configurations were chosen, it can be determined that the configuration was, in some cases, selected according to a high frequency of occurrence, and a high frequency of head and leg injuries occurrence. In other cases, the ISO13232:2005 seems to choose the impact configuration based only on the frequency of occurrence (so no injury frequency was considered), the apparent leg exposure, historical reasons, or because it is a “relatively easy test to perform”.

Recently, Grassi et al. (2018) applied the ISO13232:2005 methodology using a more recent and representative European accident dataset (MAIDS database) to determine whether the 7 most relevant impact configurations identified by the standard still represent the EU context.

The main results achieved can be summarized in the following points:

1) definition of a new set of 7 impact configurations;
2) definition of a more robust method to rank the impact configurations according to the frequency of occurrence, and the injury frequency and severity (Configuration Risk Index, CRI);
3) an unbalanced distribution of the impact configurations between the Los Angeles and the Hannover dataset has been pointed out.

Using the digitalized ISO database included in ISO13232:2005-Part 2, the authors compared the distribution of the impact configurations between the two datasets, finding an unbalanced allocation.

The Hannover database was mainly built defining 7 out of 25 different impact configurations (Figure 1), and clearly having an influence on the final most relevant impact configurations suggested by the ISO13232:2005 (143-9,8/0; 114-6,7/13,4; 413-6,7/13,4; 412-6,7/13,4; 414-6,7/13,4; 225-0/13,4 and the 413-0/13,4).

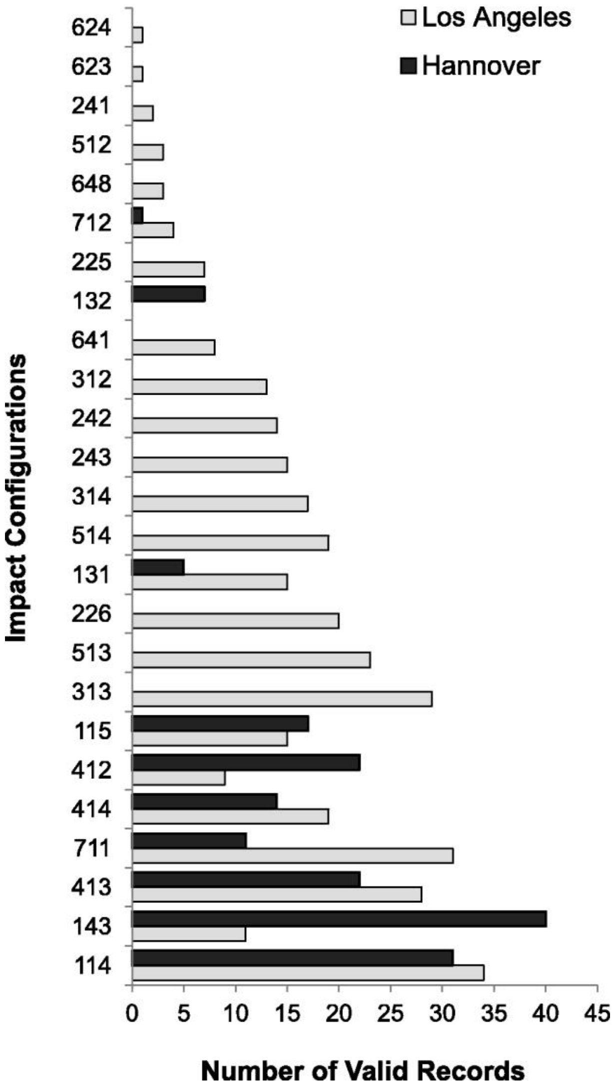

Figure 1. Comparison of valid impact configurations in Los Angeles and Hannover datasets (ISO13232:2005)

Although the MAIDS dataset is from 2009, it is still relevant because of its sample size (including 921 cases), the random collection of data, and the wide sampling area (involving 5 EU countries: Italy, Spain, Germany, France and The Netherlands).
To determine if the 7 most relevant impact configurations identified by the ISO13232:2005 still represented the European context, Grassi et al. (2018) processed the MAIDS database using ISO methodology. This involved applying the ISO sampling policy (i.e. L3 vehicle category, passenger car as opponent vehicle, PTW without pillion rider, rider in seated position at impact, and testable configuration), returning a comparable dataset composed of 142 accident cases.

After comparing the configuration rankings of the ISO13232:2005 and the MAIDS database, the authors highlighted that only 3 out of 7 impact configurations were in both datasets. Moreover, configurations 412, 413, and 414 in MAIDS database represented a smaller proportion of the total dataset in contrast to ISO13232:2005, where configurations 312, 313, and 314 made up a larger proportion (Figure 2).

Nevertheless, the authors also underlined some limitations. Discrepancies might be biased by differences in the codification of the car contact point. In the MAIDS database, car passenger models are not provided and OVs' lengths are unknown. Therefore, the authors codified contact points only according to their description and assuming corresponding locations on a sedan car.

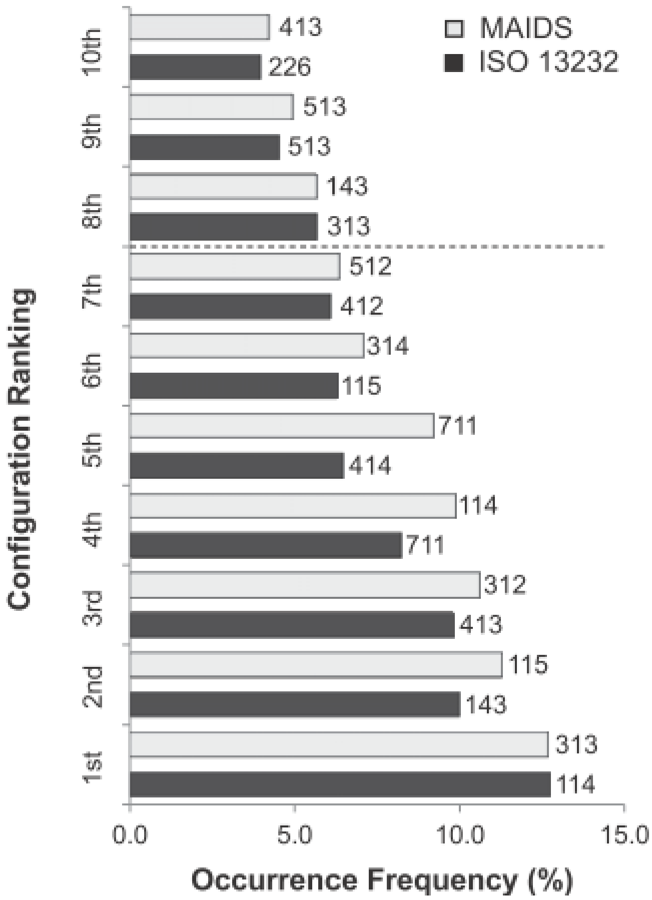

Figure 2. Comparison of configuration rankings by occurrence frequency

In addition, ISO13232:2005 uses the AIS90 (Gennarelli & Wodzin, 1990) to code and define body regions and injury types, as shown in Figure 3 and Figure 4, respectively.

Although body regions and injury types have been specified, it is not so clear which contents have to be included in each body region. For example, while it is easy to identify the code for the pelvic bone or the bones of the abdominal region, finding the right code for the internal organs is much harder, as no clear distinction between them exists.

On the other hand, and not according with the AIS© code, the ISO13232:2005 standard gives the possibility to assign minor injuries (such as abrasion and/or contusion) to their exact body region. And this was found to be useful and important as mentioned in Chapter 2.2 of Deliverable 1.1 (D1.1).

Body region	Code
Head	1
Face	2
Neck	3
Upper extremity	4
Chest	5
Abdomen	6
Thoracic spine and/or lumbar spine	7
Pelvis and/or hips	8
Thigh	9
Knee	10
Lower leg	11
Ankle and/or foot	12
Other injury location	13

Figure 3. ISO13232:2005 injury body region codes

Injury type	Code
Abrasion and/or contusion	1
Laceration	2
Rupture	3
Dislocation	4
Fracture	5
Amputation	6
Concussion	7
Crush	8
Hematoma	9
Other type of injury	10

Figure 4. ISO13232:2005 injury type codes

Grassi et al. (2018) also compared the injury frequency between MAIDS and ISO13232:2005 datasets (Figure 5). Even though the most injured body regions coincided in both cases, they had a different frequency. In ISO13232:2005, head injuries represented a 6.6%, lower leg injuries a 5.1%, and upper extremities and shoulders injuries a 3.9%. For MAIDS, upper extremities and shoulders injuries represented a 9.4%, lower leg injuries a 8.0%, and head injuries a 5.0%.

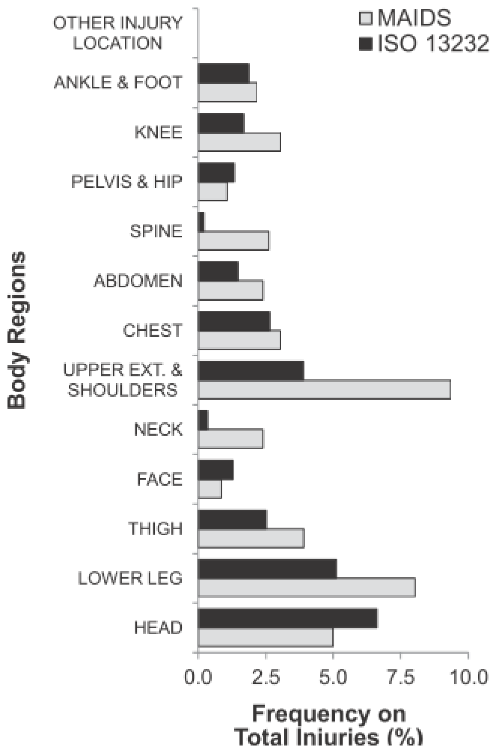

Figure 5. Injury frequency distribution: comparison between MAIDS and ISO13232:2005

In conclusion, the authors suggested to use the following set of impact configurations for the initial development and testing of protective devices: PTW impacting the side of the car (313, 312, 314), head-on impacts (114 and 115), car impacting the side of the PTW (243) and rear-end impacts (711).

2.2 In-depth accident data

Task 1.1 *'Road Traffic Accident Scenarios involving Powered Two-Wheelers'* provided cases from the following major accident databases: GIDAS, IGLAD, InSAFE and EDA (see D1.1, chapter 2.5, for a detailed description). It is important to indicate that all crash cases collected in these databases were more recent than those included in the ISO13232:2005 dataset.

At a more detailed level, the GIDAS dataset contains 1,000 accidents from 2005 to 2018 involving PTWs; the IGLAD dataset contains 120 accidents from 2012 to 2015; the InSAFE dataset contains 57 accidents from 2010 to 2018; and the EDA dataset contains 45 accidents from 2005 to 2018.

All databases were queried according to the following inclusion criteria.

2.2.1 Inclusion criteria

The case selection has been performed according to the ISO13232:2005 inclusion criteria as follows:

- Passenger car as opponent vehicle
- L3 vehicle category
- Rider in seated position at impact
- Injury severity AIS2+
- Without pillion rider

From each database, the following variables have been requested:

- Relative Heading Angle (RHA)
- Motorcycle (MC) impact speed
- Opponent Vehicle (OV) impact speed
- OV contact point
- MC contact point
- Presence of the helmet
- List of injuries according to the AIS code

According to the previous inclusion criteria, the case selection revealed 238 accidents from GIDAS, 27 accidents from IGLAD, 18 accidents from InSAFE and 11 accidents from EDA database (Table 1).

Table 1. In-depth road accident databases and relative sample size

Database	Sample size
EDA	11
GIDAS	239
IGLAD	27
InSAFE	18
Total	**295**

2.3 Methodology

To be consistent with ISO13232:2005 and obtain comparable results, the methodology described in this standard was followed.

The PIONEERS dataset was processed to create the configuration code on the basis of the Figure 6 and the

Table 2, Table 3 and Table 4. For each dataset, the OV and MC contact points have been extracted according to own codification system. Only for the EDA and InSAFE datasets have been possible to have the right ISO13232:2005 contact point codification. On the other hand, GIDAS and IGLAD contact points have been inferred according to the information available.

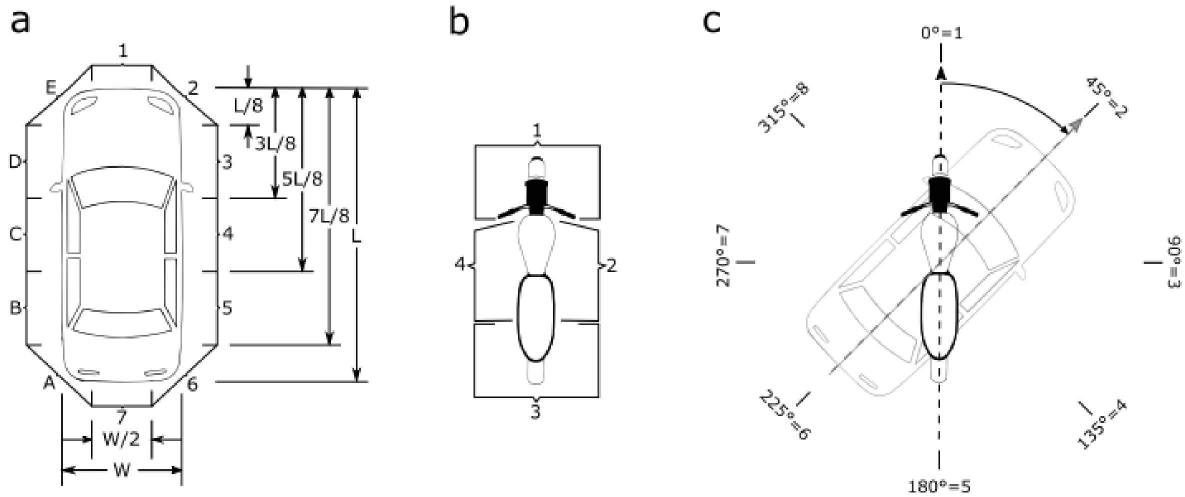

Figure 6. a) OV contact point codes; b) MC contact point codes; c) RHA

Table 2. Heading angle of OV relative to MC

Cell range (deg)	Nominal value (deg)	Code number
337.5 < RHA ≤ 22.5	0	1
22.5< RHA ≤ 67.5	45	2
67.5< RHA ≤ 112.5	90	3
112.5< RHA ≤ 157.5	135	4
157.5< RHA ≤ 202.5	180	5
202.5< RHA ≤ 247.5	225	6
247.5 < RHA ≤ 292.5	270	7
292.5 < RHA ≤ 337.5	315	8

Table 3. OV and MC speed

Cell range (m/s)	Nominal value (m/s)
0 ≤ speed ≤ 4.0	0
4.0 ≤ speed ≤ 8.5	6.7
8.5 ≤ speed ≤ 13.3	9.8
13.3 ≤ speed ≤ 17.5	13.4
17.5 ≤ speed	20.1

Table 4. Reclassification for left side OV contact point codes

Sorted	Reclassified
OV contact point code	
A	6
B	5
C	4
D	3
E	2
MC contact point code	
2	4
4	2
Relative heading angle code	
2	8
3	7
4	6
6	4
7	3
8	2

According to the previous inclusion criteria and the methodology used to compare data, some inconsistent data had been found. As an example, all crash cases where there were not clear information on the upright rider position, the relative heading angle (RHA) and/or the impact location were removed.

Doing so the final sample was made by 276 crash cases as shown in Table 5.

Table 5. PIONEERS dataset size

Database	Sample size
EDA	11
GIDAS	239
IGLAD	9
InSAFE	18
TOTAL	**276**

2.3.1 Configuration Risk Index (CRI)

In the ISO13232:2005, the selection of the crash configuration set has been mainly based on the occurrence frequency. Nonetheless, occurrence frequency alone cannot be the unique or the main key factor to select the most dangerous accident scenarios to test.

Therefore, the Configuration Risk Index (CRI) as defined by Grassi et al. (2018) have been used to assess the riskiness of each crash configuration.

The CRI takes into account both the frequency and the severity of a specific crash configuration (see equation below). In particular, the severity is assessed both using the injury frequency and the AIS score. For each impact configuration, accident and injury frequencies were combined and weighted according to the total number of accidents and injuries in the dataset.

$$CRI_{(x)} = \left(\frac{A_{(x)}}{A_{(t)}} \cdot \frac{\sum_{i=2}^{n} \left(I_{(x,AISi)}\right) \cdot i}{I_{(t)} \cdot \left(\sum_{i=2}^{n} i/n - 1\right)} \right) \cdot \mathrm{SF} \quad n = 6,$$

where x is the configuration code, $A_{(x)}$ is the number of accidents by configuration, $A_{(t)}$ is the total number of accidents across all configurations, i is the AIS level (from 2 to 6), $I_{(x, AISi)}$ is the number of injuries for configuration x at each AIS level, $I_{(t)}$ is the total number of injuries across all configurations and SF is the scale factor set to 100 as suggested by the authors.

2.4 Results

Looking at the injury distribution among the 13 body regions such as defined by the ISO13232:2005, in the PIONEERS dataset neck, upper extremities, chest, spine and pelvis showed a higher injury frequency than those in the ISO13232:2005 dataset (Figure 7).

In particular, the neck and spine shown a number of injuries about 6-time and 28-time higher, respectively. While for the upper extremities, the chest and the pelvis the injury frequency was 3-time greater. Even though less evident, lower extremities also showed a high injury frequency than in the ISO13232:2005 dataset. At the same time, the left-over body regions had similar as a trend and values.

Although dated, the MAIDS database still be the most representative database at European level. Similar results can be seen comparing the MAIDS and the ISO13232:2005 datasets. Neck, upper extremities and spine were more frequently injured as well as in the PIONEERS dataset. Vice versa, the MAIDS [Grassi et al. (2018)] subset showed a higher number of injuries at the lower extremities (e.g. leg, knee and thigh) than the ISO13232:2005 and the PIONEERS ones. On the other side, head seemed less injured than in the ISO13232:2005 and PIONEERS datasets.

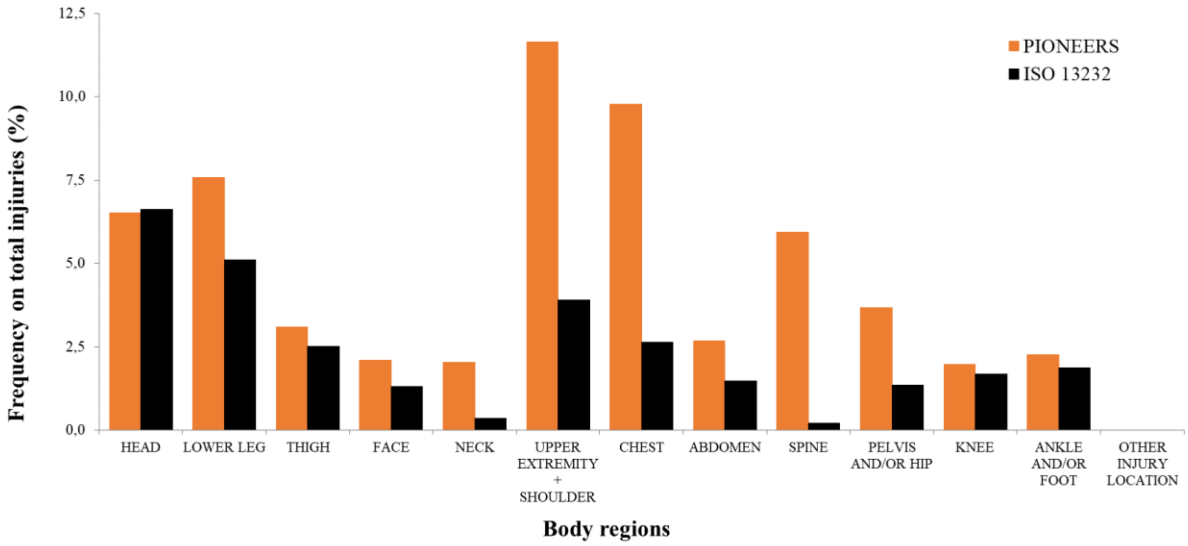

Figure 7. AIS2+ injury frequency distribution (percentage): PIONEERS vs. ISO13232

Most of the PIONEERS crashes occurred in the crash configurations 114 (frontal crash), 711 (rear crash) and 115 (frontal crash), followed by lateral crash configurations such as the 414, 313, 513, 314 and the 312. The trend was similar in both PIONEERS and ISO13232:2005 datasets. But differences can be found in the front-lateral crash configurations 143 and 413, where the ISO13232:2005 showed a twice percentage of occurrence frequency (Figure 7).

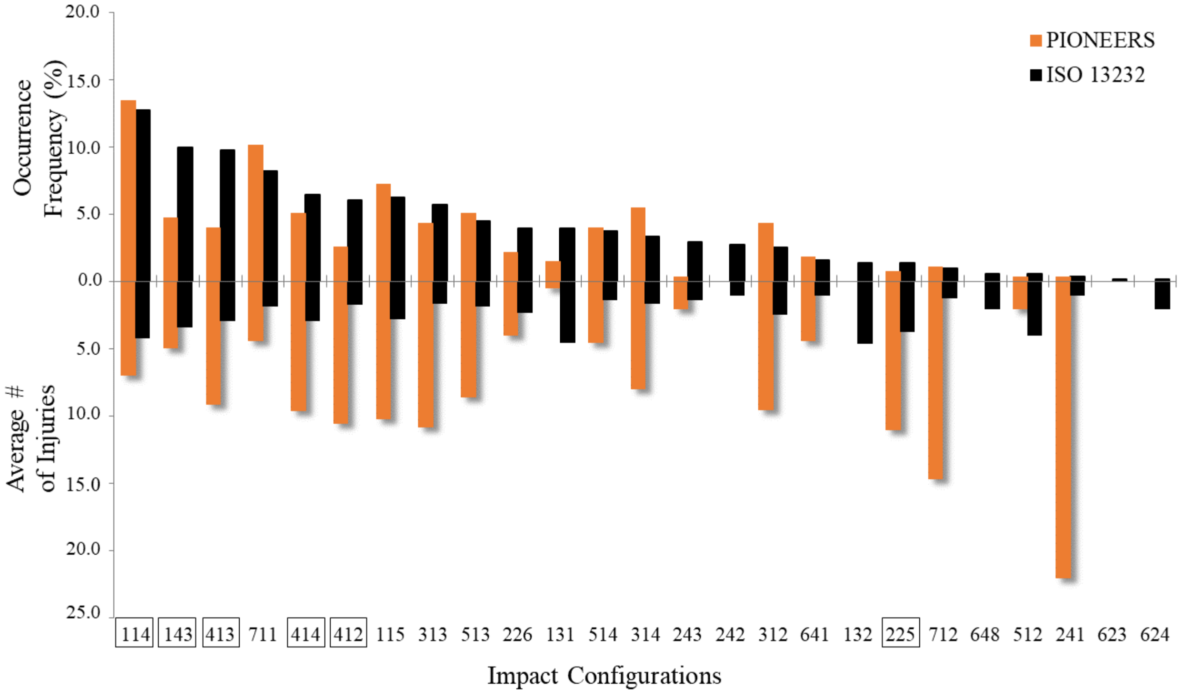

Figure 8. Configuration occurrence frequency (left) and average number of injuries per configuration (right), PIONEERS vs ISO13232 (required accident configurations are boxed)

Concerning the accident frequency, there were no similarities between the two datasets: only some crash configurations showed comparable frequencies. Moreover, the PIONEERS dataset did not include all the seven crash configurations proposed by the ISO13232 (Figure 7).

Looking at injuries, the PIONEERS dataset seemed to have collected a higher number of injuries. Many crash configurations showed a higher frequency than in the ISO 13232 dataset. In particular, the crash configuration number 241 showed a low accident frequency and a high number of injuries.

Comparing the crash configurations ranked by the occurrence frequency between PIONEERS and ISO13232 datasets, it can be seen that only two out of seven crash configurations were those suggested by the ISO13232 (143 and 414) (Figure 8). But comparing the PIONEERS and the MAIDS datasets, the number of common crash configuration grow at four (114, 711, 115, 314) out of seven.
More recent PIONEERS data confirmed the importance of the crash configuration number 114 (frontal impact), ranking it first as the ISO13232. On the other hands, the MAIDS dataset ranked first the crash configuration number 313 (Figure 8) which was instead dropped at the eighth position for both ISO13232 and PIONEERS datasets [Grassi et al. (2018)].

Using the CRI index to rank the crash configurations, the share grows more exponentially and the weight/importance of the first two/three crash configurations was predominant. In this case, the configuration number 114 was still first as in the ISO13232, followed by numbers 115 and 711. While the configuration 313, that was first for the MAIDS dataset, moved at the sixth position. Another example was the configuration number 143, which ranked seventh in the PIONEERS dataset by the crash occurrence frequency, dropped three positions (tenth) using the CRI.

This result pointed out that the most probable accident scenario is not necessarily the most dangerous. The results showing alterations in the ranking order and in the relative importance of the configuration compared to injury occurrence frequency.

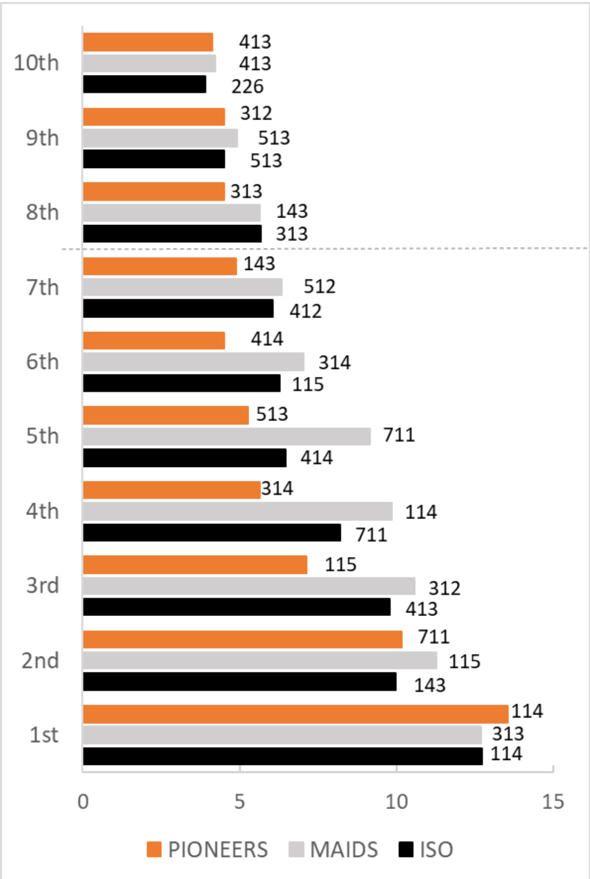

Figure 9. Comparison of configuration rankings by occurrence frequency (percentage of total crashes)

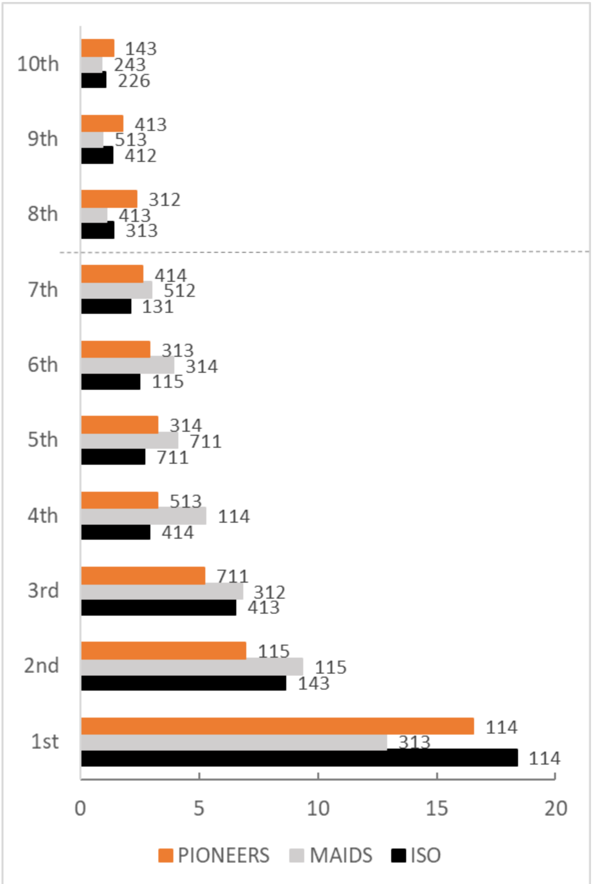

Figure 10. Comparison of configuration rankings by CRI

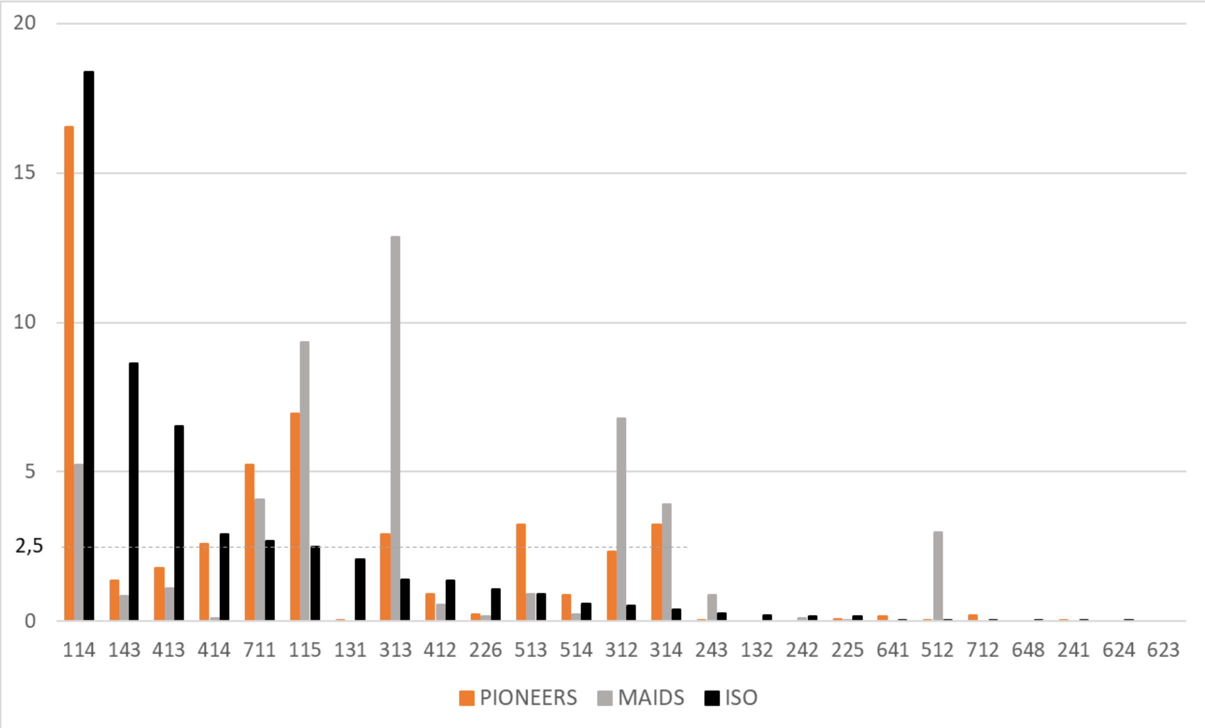

Figure 11. CRI distribution for PIONEERS and ISO13232 datasets

3 Future trends in EU accident scenario

The overall road accident data related to Powered Two Wheelers (PTW) in the EU has shown a reduction of the killed people during the last ten years (European Commission, 2018). Even though, still 663 moped riders and 3,644 motorcycle riders were killed during 2016, accounting for 17% of the total killed people involved in road traffic accidents in this year. This way, the gross number of fatalities in the whole European region in 2016 accounted for about 25,000 people considering drivers, passengers and pedestrians of any vehicle type, whilst almost 1.4 million people were reported as injured from the total number of road traffic accidents.

Furthermore, according to the CARE database (Community Road Accident Database, 2019), the proportion of national road fatalities has always had a strong variation between the different European countries. For instance, in 2016, a 4% of the total number of road fatalities in Romania involved one or more PTW users and, also during this year, the number of PTW fatalities accounted for a 32% of the total road fatalities in Greece. Despite this, the gap between national performances in terms of road fatalities has been narrowing year by year and, recently, the countries' fatality rates are, in general, reaching lower values, even though the population in the whole region is increasing.

Given this situation, the objectives of the Work Package 1 (WP1) in the PIONEERS project are to identify the key accident scenarios in terms of frequency and severity, to understand the relation between users and their PPE, and to define the current and future scenarios related to PTW fatalities in the European countries. This last objective is the main aim of the following section of this work, which determines a forecast of future trends in accident scenarios involving Powered Two Wheelers to develop guidelines for the policy making.

Therefore, current accident scenarios in the European region reported in Deliverable 1.1 of the PIONEERS project have been considered to obtain the baseline conditions whereby future trends in road fatalities can be predicted. These future scenarios shall be relevant for the development of PTW safety measures and; thus, the effectiveness of these new systems will have to be accounted for further analysis regarding future accident scenarios.

Future scenarios will be calculated using linear regressions of PTW accidents from the CARE database, and the forecast will provide a relevant overview of the road accident trends predicted for the next years. Thus, the output of this deliverable will be useful for other Work Packages of the project, especially for WP6, which will assess safety and economic benefits of the new PIONEERS systems and the new testing methods, considering the policy guidelines defined in this report.

3.1 EU fatalities – CARE database

A relevant analysis of accident fatalities requires accurate and consistent data. Thus, the CARE database has been the source of this work. It is based on detailed data of individual accidents, shared by the corresponding institutions (hospitals, police officers and emergency services) from the Member States, which are collected in Figure 12. The CARE database has become one of the most powerful accident databases to analyse the information reported from the overall road accidents occurred within these countries.

	Belgium	BE		Italy	IT		Romania	RO
	Bulgaria	BG		Cyprus	CY		Slovenia	SI
	Czech Republic	CZ		Latvia	LV		Slovakia	SK
	Denmark	DK		Lithuania	LT		Finland	FI
	Germany	DE		Luxembourg	LU		Sweden	SE
	Estonia	EE		Hungary	HU		United Kingdom	UK
	Ireland	IE		Malta	MT			
	Greece	EL		Netherlands	NL		Iceland	IS
	Spain	ES		Austria	AT		Liechtenstein	LI
	France	FR		Poland	PL		Norway	NO
	Croatia	HR		Portugal	PT		Switzerland	CH

Figure 12. Countries providing data to the CARE database and its abbreviations

When filtering the CARE database according to the modes of transport, different behaviours are observed depending on the type of vehicle. Within the database, the relevant cases for the current study are those named 'Moped' and 'Motorcycle', which represent PTW users of European roads.

According to D1.1 of the PIONEERS project, the definitions of 'Motorcycle' and 'Moped' are respectively equivalent to L1 and L3 vehicle types. In fact, these two denominations correspond to the following vehicle definitions in the CARE database:

- ***MOPED*** - Motor vehicle with two wheels, with an engine size of less than 50 cc. Design speed between 25 km/h and 50 km/h. One or two seats. Minimum age for driver between 14 and 18 (except IT). No driving licence required (ES, FR, FI, GB, IT, PT, SE). Unregistered vehicle (BE, DK, ES, FR, SE).

- ***MOTORCYCLE*** - Motor vehicle with two or three wheels (not three wheeled in DK), with an engine size of more than 50 cc. With a trailer possible (except DK). With a sidecar possible. Registered vehicle (except PT). Type A driving licence required. Includes motor scooter (except FR).

The most recent data from CARE (2007-2016) showed a decrease of 57% in the number of moped fatalities in Europe (see Figure 7). Similarly, figures of motorcycle fatalities have been reduced by 40% within the same period. Only in 2016, 3,644 riders (including drivers and passengers) were killed in the EU roads. Thus, in terms of number of fatalities, motorcycling is recently decreasing less compared to other modes of transport.

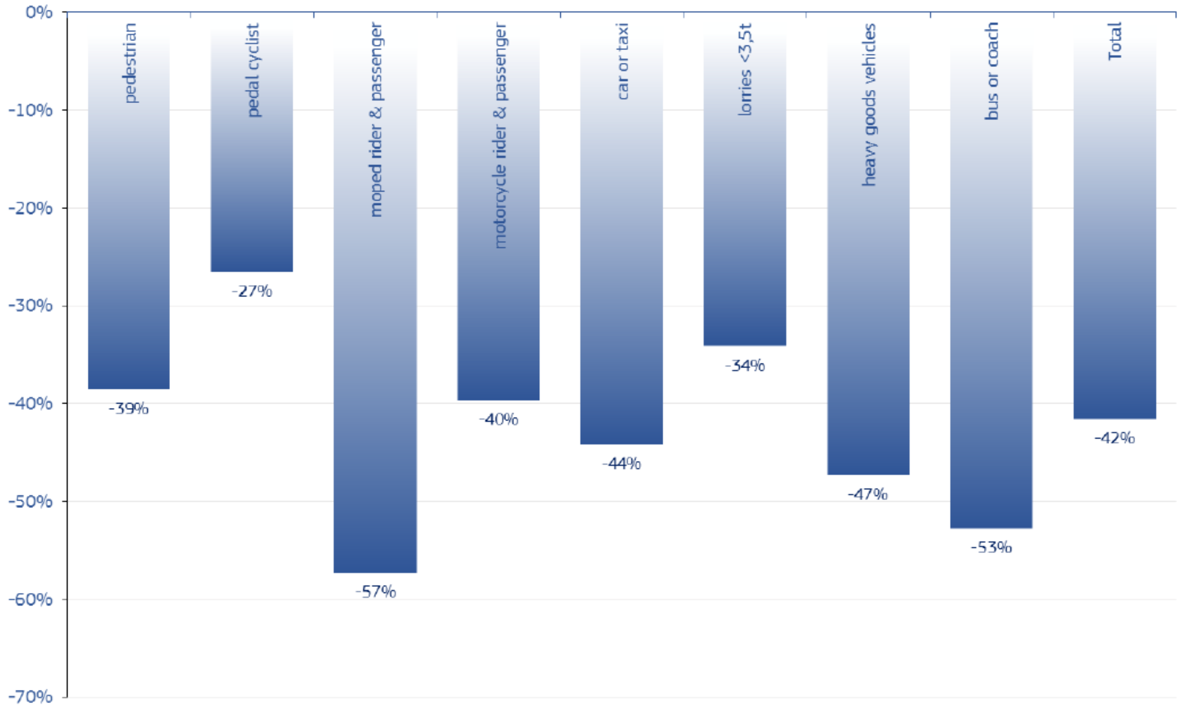

Figure 13. Percentage change in number of fatalities by mode of transport in the EU (2016-2007)

On the other hand, the road environments included in this work are the 'Urban' and the 'Rural' (excluding 'Motorway') scenarios, since it is there where most of the accidents involving PTW occurred. The distribution of PTW fatalities can also help to understand the share of mopeds and motorcycles by areas and road types. The use cases defined as a function of the road type in the analysis performed in D1.1 of the PIONEERS project are the following:

- ***Use Case 1 -*** Urban commute. This use case is particularly linked to scooters, urban areas and, therefore, lower impact speeds.

- ***Use Case 2 -*** Leisure ride. This use case is particularly linked to motorcycles, rural areas and, therefore, higher impact speeds.

In the CARE data, it has been observed that the major number of moped fatalities occurred in urban environments and, by contrast, most motorcycle fatalities occurred in rural environments. Because the number of PTW fatalities reported in EU countries has varied depending on the type of vehicle used and the riding environment, the current work will focus on these parameters to study future trends in PTW road accidents.

3.2 Baseline Scenario and future trends

One of the objectives in Task 1.3 is to provide a forecast of future PTW accident scenarios to be used as input for the benefit calculations in WP6 of the PIONEERS project. Thus, in this chapter, a method to predict future trends of PTW fatalities in European roads within the next years is explained.

The forecast is divided in three sections, considering the overall number of fatalities in the EU region, and then focusing on the rural and urban road cases. For each section, the obtained results are analysed and discussed.

3.2.1 Total fatalities future trends

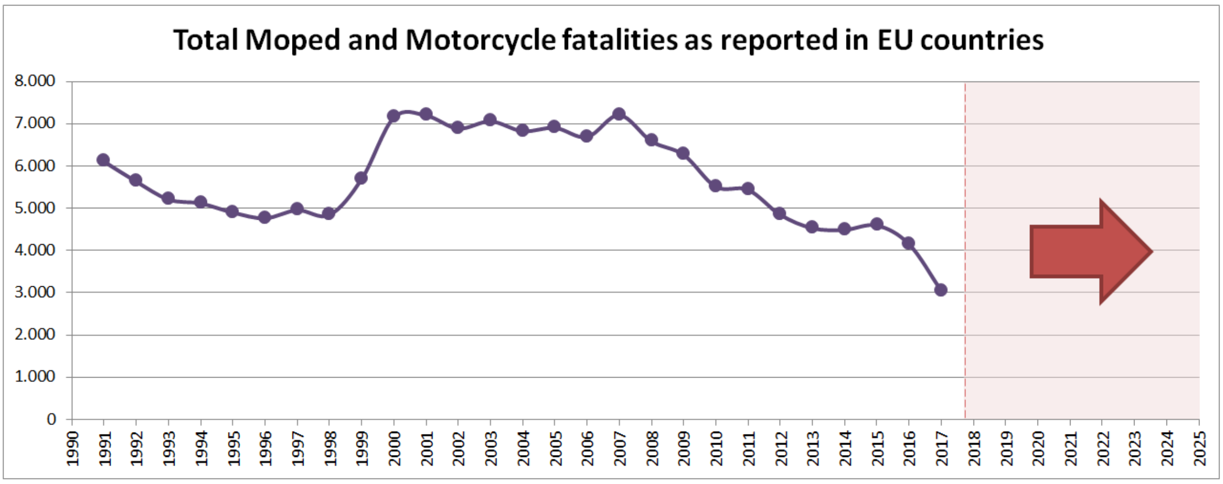

Figure 14. Total fatalities in EU countries between 1990 and 2017

In Figure 14, fatalities are yearly computed as a sum for each country. However, it is important to note that, for many cases, the number of fatalities is not available (see Appendix A.1).

There are two methods to analyse the results: time series analysis and linear regression models. The biggest advantage of using time series analysis is its capability to both understand the past and predict the future, identifying future trends and patterns through graphs. Although the forecast of times series is precise, this method needs periodic and seasonal data. Since a linear regression model provides a general trend of the data, and no data for all countries is available, a linear regression model will be applied instead of the time series.

A linear regression attempts to model the relationship between two variables (the independent and the dependent) by fitting a linear equation to observed data. In this case, the 'year' is the predictor or independent variable, and the 'number of fatalities' is the response or dependent variable.

The program *RStudio* has been chosen to forecast the total number of fatalities until 2030. This software is usually used in statistical studies because it offers different types of libraries and graphical resources to plot the results.

Through a linear regression model, several predictions will be made, such as the number of rural fatalities, the number of urban fatalities, and the total number of fatalities, which is the sum of both urban and rural fatalities.

To apply this kind of model, the total number of fatalities will be forecasted in a first instance and, after that, the single cases of rural and urban fatalities will be analysed. Figure 15 shows the total number of fatalities (black curve), moped fatalities (blue curve), and motorcycle fatalities (red curve) over time.

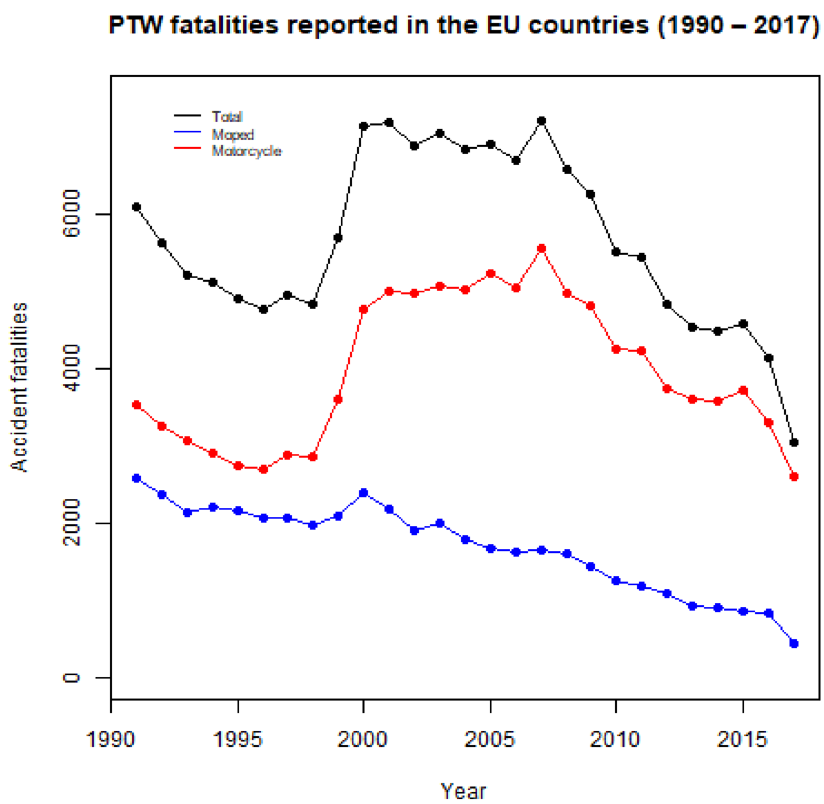

Figure 15. Plot of Total (black), Moped (blue) and Motorcycle (red) fatalities in EU countries between 1990 and 2017

To visualize the linear relationship between the predictor and the response, a scatter plot has been computed (Figure 16). A scatter plot is a two-dimensional visualization that uses dots to represent the values obtained for two different variables. Scatter plots are utilized to illustrate the relationship between two variables, including their correlation.

The trendline of total PTW fatalities, illustrated in Figure 16, further clarifies the changes in data over time. As it can be observed in the figure, the real data only follows this trendline starting from 2010 approximately. One reason could be that, because more information from the last years is available (see Appendix A.1), the trendline is more representative over this period.

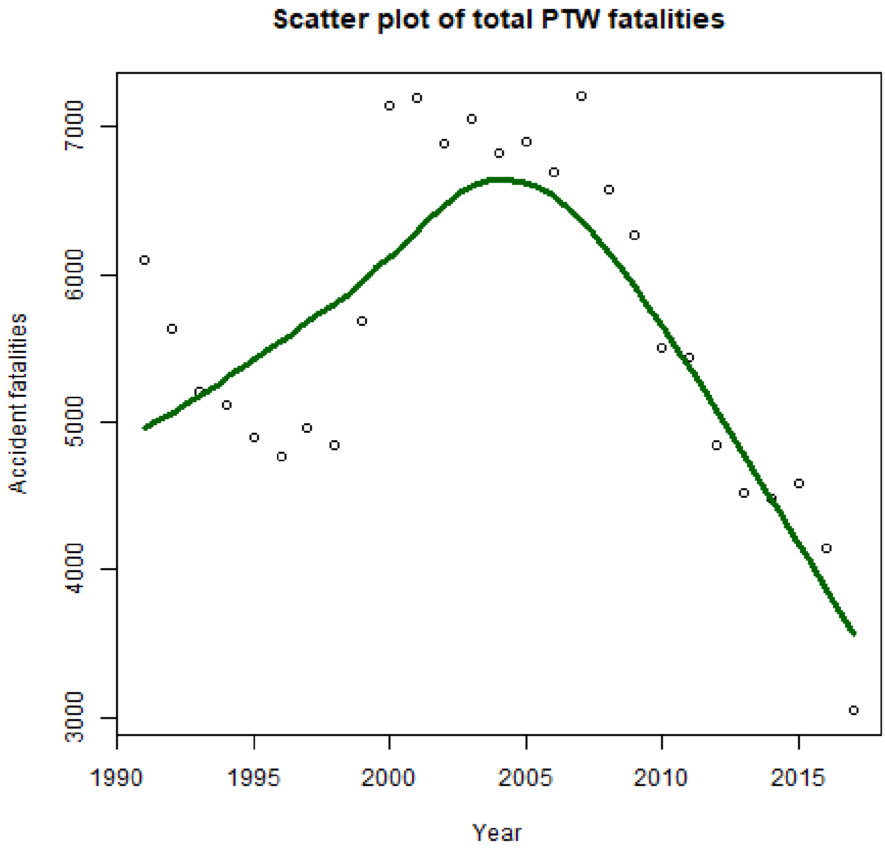

Figure 16. Scatter plot of total fatalities in EU countries between 1990 and 2017

The correlation coefficient between variables 'Year' and 'Total fatalities' has also been calculated. This measure is used in statistics to indicate how strong a relationship between two variables is, and the direction of their linear relationship. Thereupon, the correlation coefficient assumes values between -1 and 1. For the present computation, this value shows a weak downhill (negative) linear relationship (see the table below).

Correlation coefficient	Year
Total Fatalities	-0.2852951

In addition, the coefficient of determination or R-squared, denoted R^2, has been computed. This parameter is the proportion of the variance in the dependent variable that is predictable from the independent variable. It provides a measure of how well observed outcomes are replicated by the model. Therefore, the R^2 is a statistic that gives information about the goodness of fit.

R-squared	0.08139

As the analysis has been performed using an incomplete dataset (see Appendix A.1), both the values of the Correlation coefficient and the R-squared are not reliable. This means the forecast could be improved by obtaining more information about the lacking cases.

Figure 17 shows how the linear regression model that has already been calculated fits the data. In other words, it shows how the model tries to explain the data and finds the general trend. The blue line indicates the trendline of the data and the grey area shows the range of values in which the number of rural fatalities could be assumed.

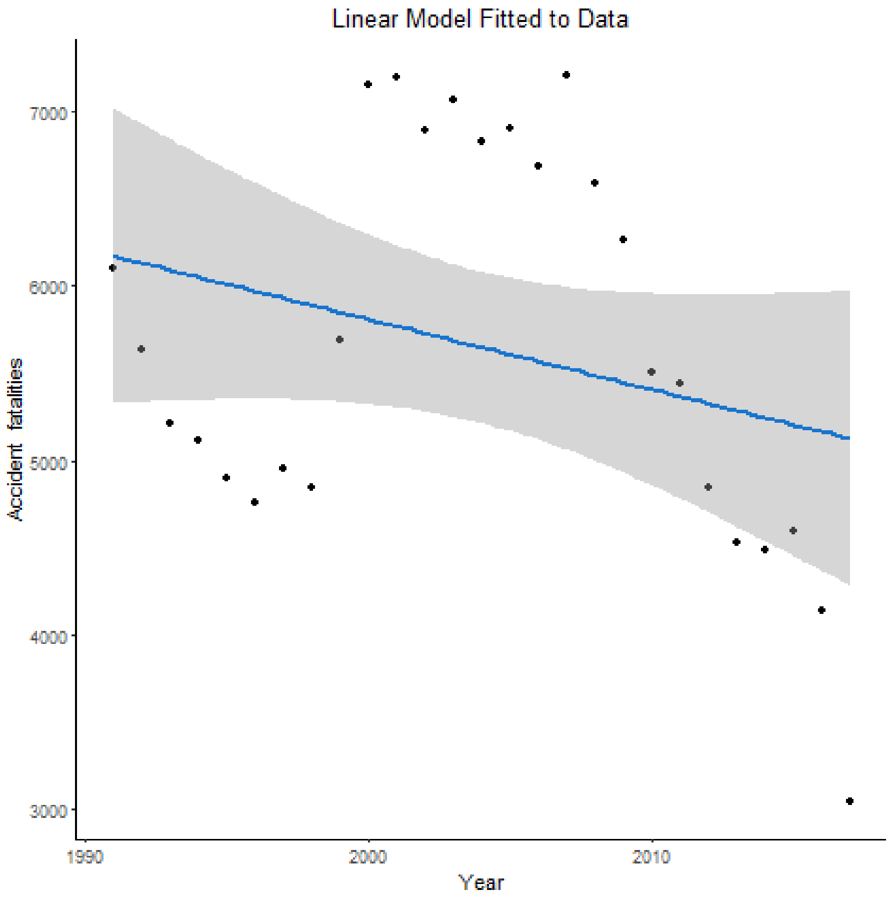

Figure 17. Linear Model Fitted to total number of fatalities in EU countries between 1990 and 2017

The confidence level is the probability that the value of a parameter, which is 'Total fatalities' in this case, falls within a specified range of values (the boundaries). This probability is higher when the confidence level is close to 1. As a confidence level of 95% is used in this analysis, a broad range will be needed to ensure the predicted value is captured by the interval. This means high confidence levels are associated with larger and more precise boundaries.

In the code, a function called *'predict'* has been included. This function allows to determine values for the future, as well as the boundaries, according to the model which has been previously defined.

Figure 18 shows the forecast of the number of fatalities for the next ten years. The black line represents real values until 2017, the blue line represents the trend, the orange line the upper bound of the forecast, and the red line the lower bound of the forecast.

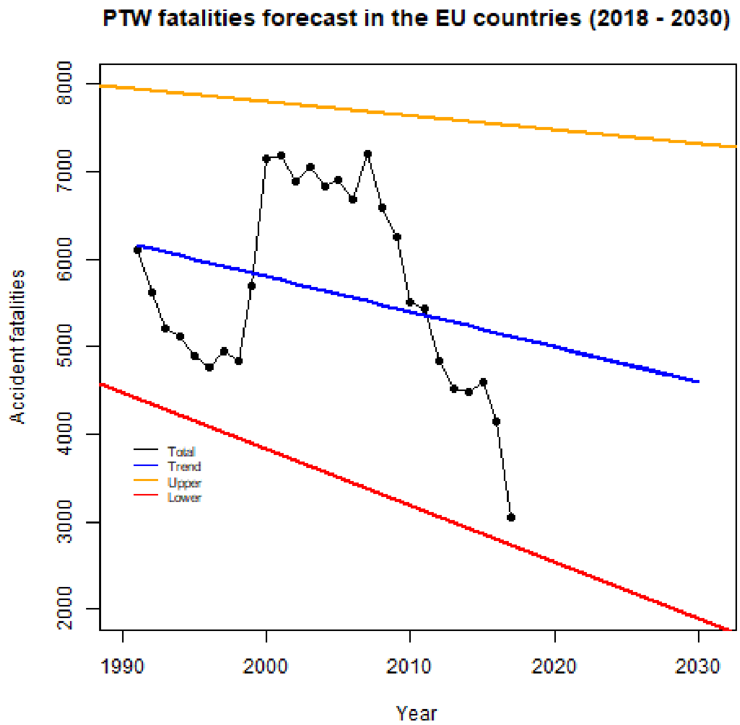

Figure 18. Forecast of total fatalities in EU countries between 2018 and 2030

Table 6 also shows the predicted values and their corresponding boundaries for the period between 2018 and 2030. It should be highlighted that the prediction shown in both Figure 18 and Table 6 is only a trend and not a precise result, due to the lack of information in the dataset.

Table 6. Predicted values and boundaries for the total number of fatalities in EU countries between 2018 and 2030

Year	Predicted value	Lower Bound	Upper Bound
2018	5086	2665	7507
2019	5046	2607	7485
2020	5006	2547	7464
2021	4965	2486	7445
2022	4925	2424	7426
2023	4885	2361	7409
2024	4845	2297	7392
2025	4805	2232	7377
2026	4764	2166	7363
2027	4724	2100	7349
2028	4684	2032	7336
2029	4644	1963	7325
2030	4604	1894	7314

3.2.2 Rural fatalities future trends

After showing the results predicted for the total number of fatalities, next steps involve forecasting the total number of rural fatalities and urban fatalities until 2030.

In Figure 19, the black curve represents the total number of rural fatalities, the blue curve represents the number of rural moped fatalities, and the red curve represents the number of rural motorcycle fatalities over time. As shown in in Figure 19, for rural fatalities there are also several cases without information (see Appendix A.1).

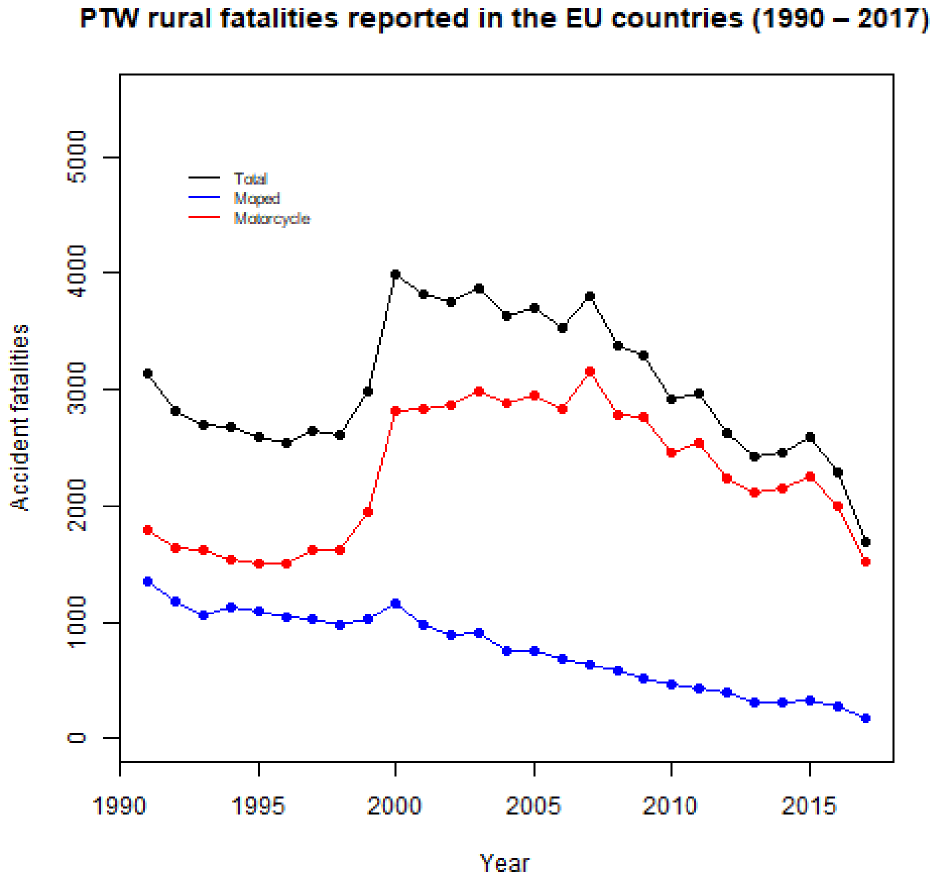

Figure 19. Plot of Total (black), Moped (blue) and Motorcycle (red) rural fatalities in EU countries between 1990 and 2017

To visualize the linear relationship between the total number of rural fatalities over time, a scatter plot has been computed (Figure 20).

In a similar way as in the total number of fatalities in the previous section, the real data only follows the trendline shown in the scatter plot starting from 2010 approximately. This is probably because not enough data is available from the first years (see Appendix A.1).

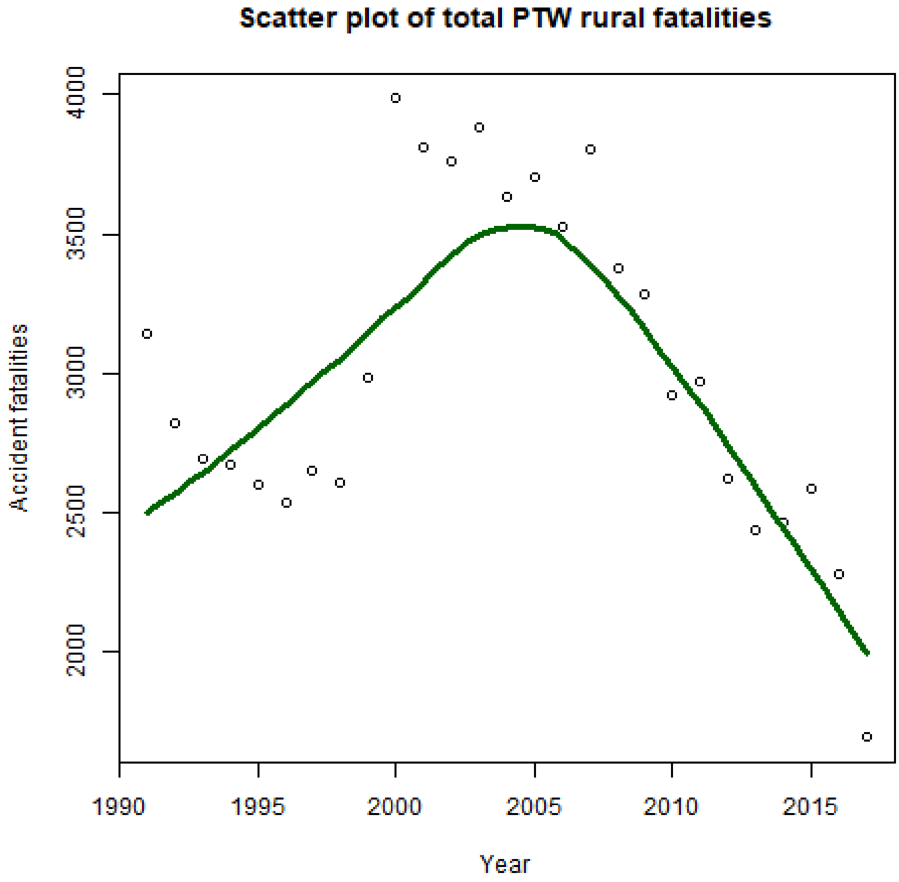

Figure 20. Scatter plot of rural fatalities in EU countries between 1990 and 2017

The correlation coefficient between variables 'Year' and 'Total rural fatalities' has also been calculated. For the present computation, this value shows a weak downhill (negative) linear relationship (see the table below).

Correlation coefficient	Year
Total Rural Fatalities	-0.2203268

In addition, the coefficient of determination (R^2) has been computed.

R-squared	0.04854

Like in the case of predicting the total number of fatalities, both the values of the correlation coefficient and the R-squared are not reliable. Because the analysis has been performed using an incomplete dataset (see Appendix A.1), the forecast could be improved by obtaining more information about the lacking cases.

Figure 21 shows how the linear regression model that has already been calculated fits the data. The blue line indicates the trendline of the data and the grey area shows the range of values in which the number of rural fatalities could be assumed.

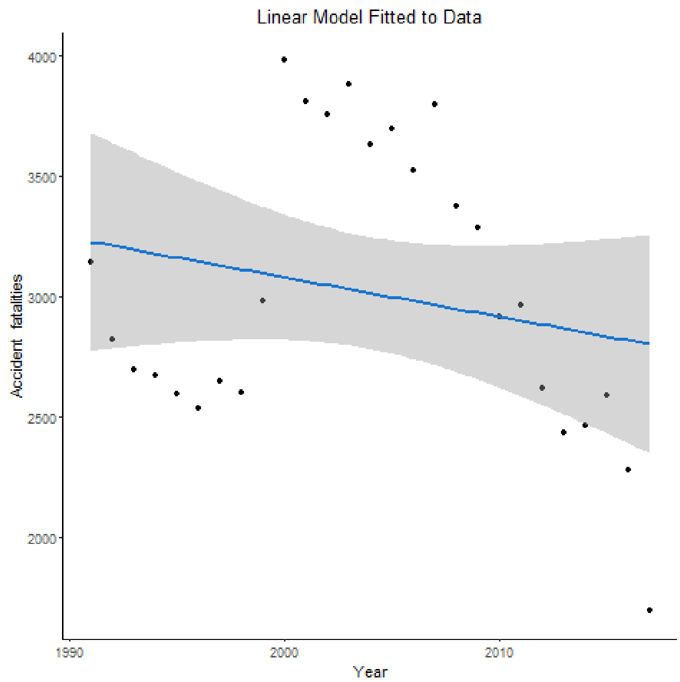

Figure 21. Linear Model Fitted to number of rural fatalities in EU countries between 1990 and 2017

Figure 22 shows the forecast of the number of rural fatalities for the next ten years. The black line represents real values until 2017, the blue line represents the trend, the orange line the upper bound of the forecast, and the red line the lower bound of the forecast.

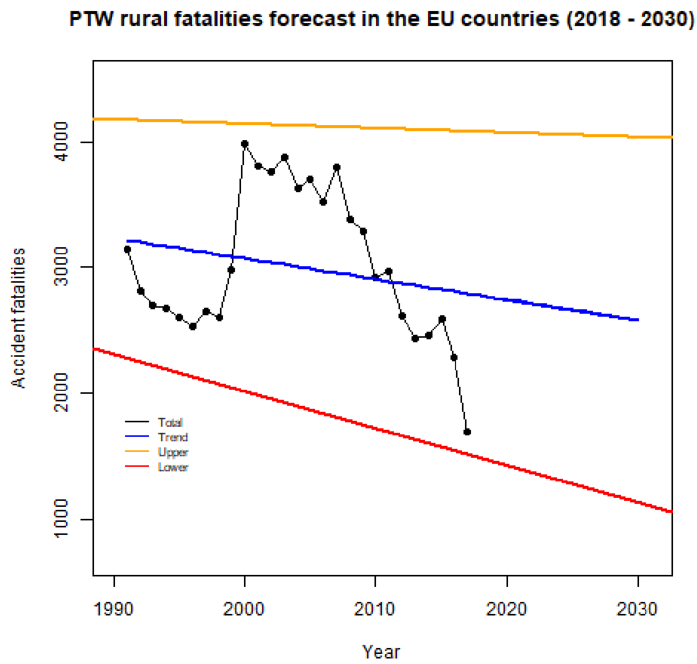

Figure 22. Forecast of total rural fatalities in EU countries between 2018 and 2030

Table 7 also shows the predicted values and their corresponding boundaries for the period between 2018 and 2030. In a similar way to the total number of fatalities, this prediction is only a trend and not a precise result, due to the lack of information in the dataset.

Table 7. Predicted values and boundaries for the total number of rural fatalities in EU countries between 2018 and 2030

Year	Predicted value	Lower Bound	Upper Bound
2018	2787	1486	4088
2019	2771	1460	4081
2020	2754	1433	4075
2021	2738	1406	4070
2022	2722	1378	4065
2023	2705	1349	4061
2024	2689	1320	4058
2025	2672	1290	4055
2026	2656	1260	4052
2027	2640	1229	4050
2028	2623	1198	4048
2029	2607	1167	4047
2030	2590	1134	4047

3.2.3 Urban fatalities future trends

Finally, an analysis of the number of urban fatalities has been performed.

In Figure 23, the black curve represents the total number of urban fatalities, the blue curve represents the number of urban moped fatalities, and the red curve represents the number of urban motorcycle fatalities over time. As can be observed in Figure 23, for urban fatalities there are also several cases without information (see Appendix A.1).

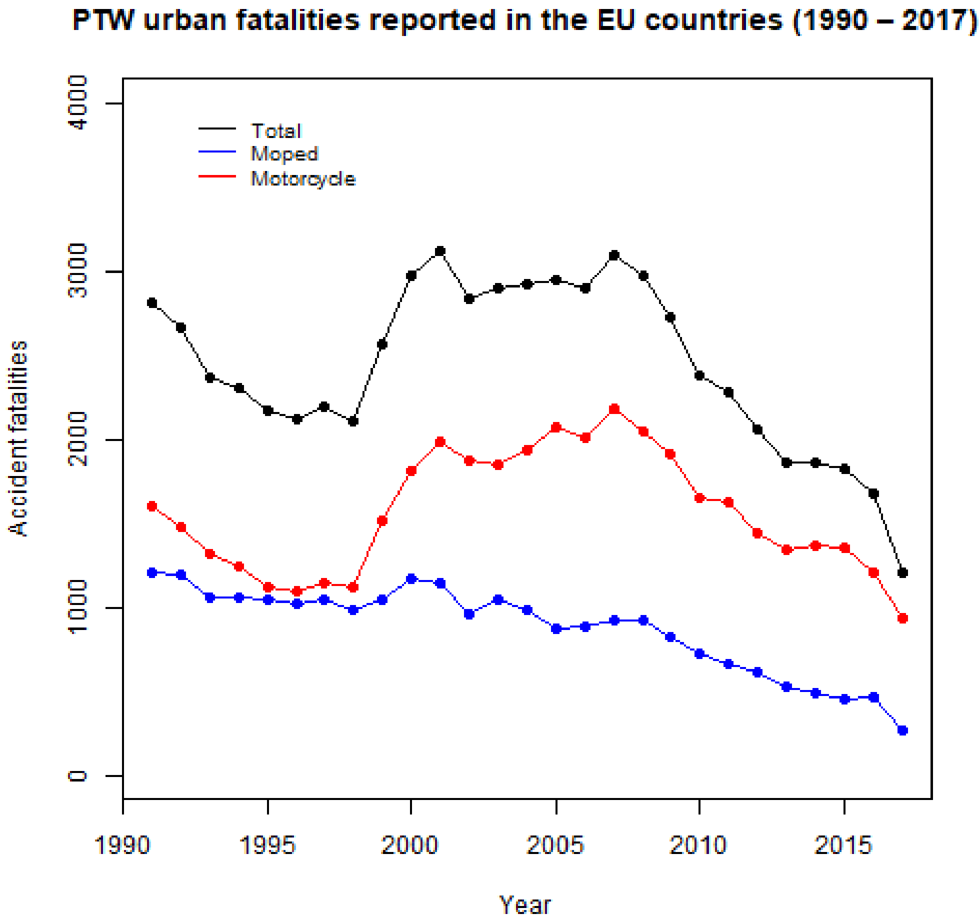

Figure 23. Plot of Total (black), Moped (blue) and Motorcycle (red) urban fatalities in EU countries between 1990 and 2017

Like previous cases, to visualize the linear progression of the total number of urban fatalities over time, a scatter plot has been computed (Figure 24).

As happened before, the real data only follows the trendline shown in the scatter plot starting from 2010 approximately. This is probably because not enough data from the first years is available (see Appendix A.1).

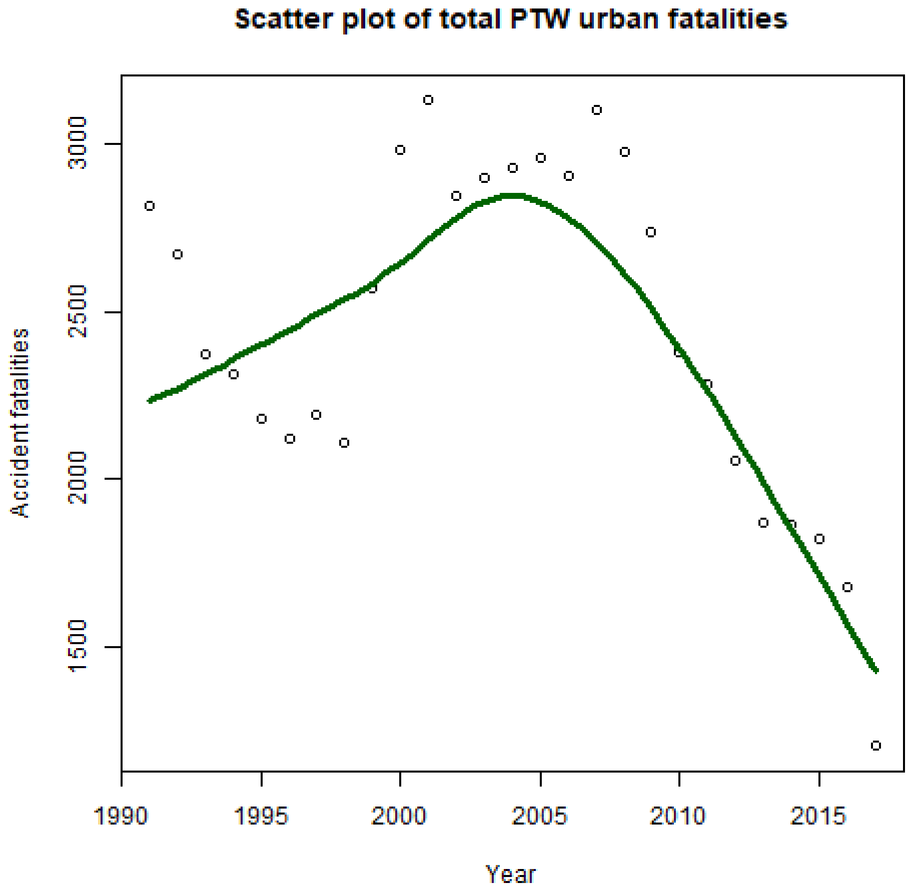

Figure 24. Scatter plot of urban fatalities in EU countries between 1990 and 2017

The correlation coefficient between variables 'Year' and 'Total urban fatalities' has also been calculated. For the present computation, this value shows a weak downhill (negative) linear relationship (see the table below).

Correlation coefficient	Year
Total Urban Fatalities	-0.4198654

In addition, the coefficient of determination (R^2) has been computed.

R-squared	0.1763

It is possible to state that both the correlation coefficient and the R-squared are slightly better in the case of urban fatalities, as the absolute value of these parameters is closer to 1 than in previous sections. This can be explained by the fact that more information regarding urban fatalities is available (see Appendix A.1). However, the forecast could be improved by obtaining more information about the lacking cases.

Figure 25 shows how the linear regression model that has already been calculated fits the data. The blue line indicates the trendline of the data and the grey area shows the range of values in which the number of urban fatalities could be assumed.

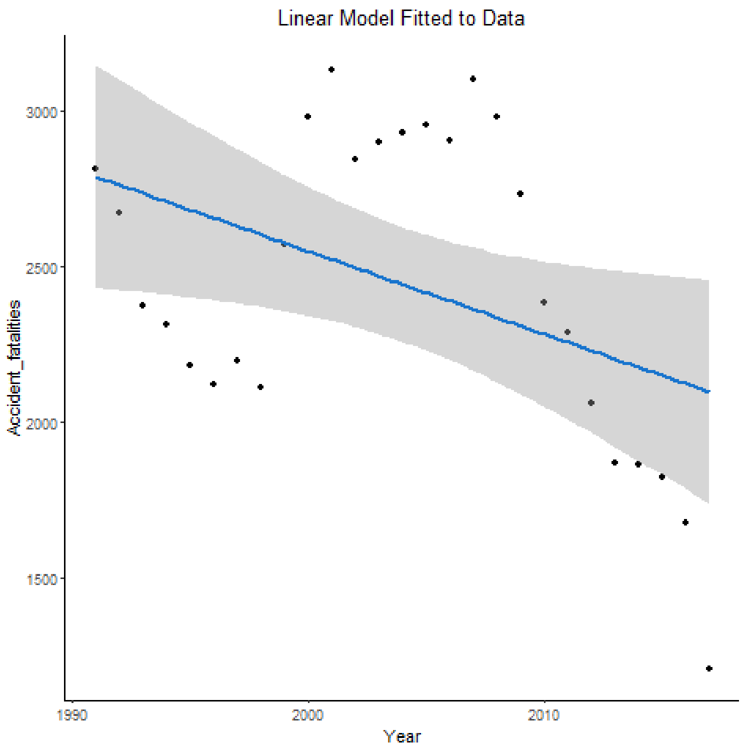

Figure 25. Linear Model Fitted to number of urban fatalities in EU countries between 1990 and 2017

Figure 26 shows the forecast of the number of urban fatalities for the next ten years. The black line represents real values until 2017, the blue line represents the trend, the orange line the upper bound of the forecast, and the red line the lower bound of the forecast.

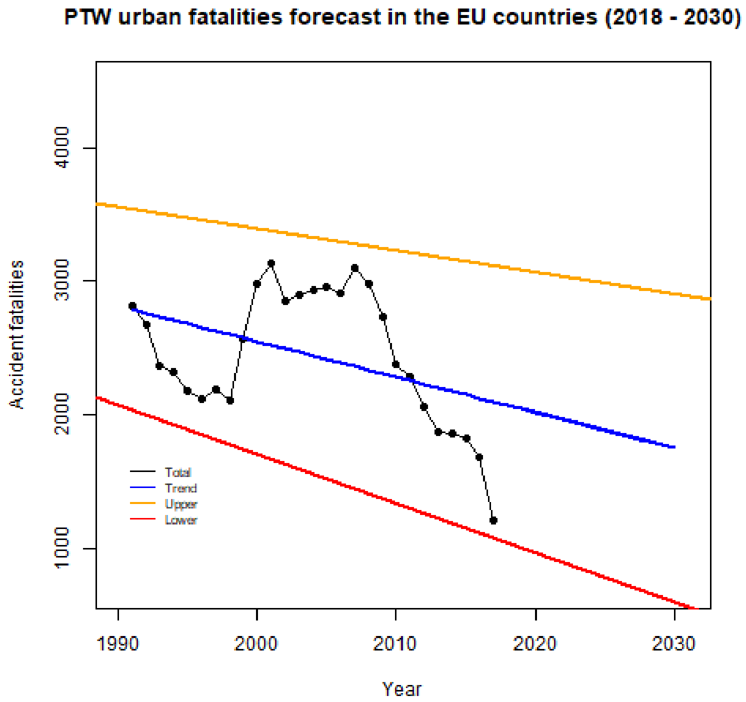

Figure 26. Forecast of total urban fatalities in EU countries between 2018 and 2030

Table 8 also shows the predicted values and their corresponding boundaries for the period between 2018 and 2030. In a similar way to previous sections, this prediction is only a trend and not a precise result, due to the lack of information in the dataset.

Table 8. Predicted values and boundaries for the total number of urban fatalities in EU countries between 2018 and 2030

Year	Predicted value	Lower Bound	Upper Bound
2018	2072	1042	3102
2019	2045	1007	3083
2020	2019	972	3065
2021	1992	937	3047
2022	1966	901	3030
2023	1939	865	3013
2024	1912	828	2997
2025	1886	791	2980
2026	1859	754	2965
2027	1833	716	2950
2028	1806	677	2935
2029	1779	639	2920
2030	1753	600	2906

3.3 New PIONEERS Scenario

New safety systems will be implemented in a percentage of the total PTW fleet in the EU in coming years. Collaboration from partners will be crucial to ensure these new safety systems are effectively brought to market.

To determine future accident scenarios, clear information concerning the two road environments previously defined (rural and urban) must be collected. For this purpose, it is important to understand the evolution of motorcycle, moped and electric PTW registrations in the EU.

Motorcycle registrations in the EU grew by 9.1% during the first half of 2019, compared with the same period last year. This means 618,502 units were registered, according to the latest figures of the European Association of Motorcycle Manufacturers (ACEM).

With 138,650 registered units (a 6.2% increase on a year-on-year basis), Italy remains the largest European motorcycle market, followed by France (109,606 motorcycles, +12.5%), Germany (105,970 motorcycles, +8.5%), Spain (88,690 motorcycles, +12.6%) and the UK (56,611 motorcycles, +2.3%).

About moped registrations in the EU, they reached 147,826 units during the first half of 2019, which represents a 19.5% increase compared with the same period last year. The largest markets for mopeds in Europe were France (41,230 units), the Netherlands (31,154 units), Germany (14,629 units), Belgium (13,119 units) and Poland (10,427 units).

Finally, combined registrations of electric PTWs (mopeds, motorcycles and quadricycles) in the EU experimented a significant growth of 70%, from 21,062 registered units during the first half of 2018 to 35,810 units during the first half of 2019.

It should be mentioned that most of the electric L-category vehicles registered in the first half of 2019 were mopeds (28,577 units), followed by motorcycles (5,812 units) and quadricycles (1,421 units).

The largest European markets in terms of volume were France, where combined registrations of mopeds, motorcycles and quadricycles totalled 8,723 units (+60.6% on a year-on-year basis), followed by Belgium (8,087 vehicles, +111.0%), the Netherlands (6,321 vehicles, +62.1%), Spain (4,052 vehicles, +35.8%) and Italy (2,426 vehicles, +86.2%).

4 Guidelines for policy makers

The outcome of the overall PIONEERS project is aimed at aiding Policy Makers in prioritising the test procedures, regulations and PTW safety measure implementations to take enforcement actions to improve safety for Powered Two Wheelers drivers; thus, reducing the number of casualties and injuries on European roads. With this objective in mind, this section intends to summarize some of the main findings in this deliverable and indicate the next steps to follow to pursue PTW safety.

Firstly, as an initial step towards improving PTW safety, the ISO 13232:2005 procedure should be reviewed according to the outcome of section 2 of this work. According to more recent crash data, the crash configurations suggested by the ISO do not seem to represent the real crash configurations. Therefore, a larger number of recent crashes would be necessary.

On the other hand, in order to have full availability of data and elaborate more precise accidentology trends, it would be highly recommended to future promote and encourage real accident scenario data collection regarding crashes involving PTWs. Current data bases are lacking information from previous years which complicates the elaboration of a trustworthy estimation of future accident scenario trends.

However, the results from this work show that there is room for improvement in the area of safety for PTWs as the future accident scenario prediction estimates a total of 4604 fatalities in EU roads in year 2030 (predicted value without accounting for confidence intervals). This vast amount of fatalities is expected to be split in 2590 fatalities in rural roads and 1753 fatalities in urban roads.

Furthermore, it is important to evaluate which of the safety measures that are being proposed in the PIONEERS project (and in the PTW and PPE market as a whole) should be enforced by policy makers as well as identifying the priority level between the different technologies and approaches.

To aid in this difficult task, the PIONEERS project will develop a Safety and Economical Benefit Analysis in Deliverable 6.2, according to the methodology defined in Deliverable 6.1. This Impact analysis will consider the future trends estimations that have been performed in this task as well as the expected safety benefit from each countermeasure in order to evaluate the overall benefit accounting for reduction in terms of injuries and casualties and its corresponding economic impact.

5 Summary

In line with the aim to reduce the number of PTW fatalities and severe injuries by increasing the safety, performance, comfort and usage rate of PPE, as well as the development of new on-board safety devices, the main objective of this deliverable is to develop guidelines for the policy making.

To this end, the most critical scenarios identified in D1.1 have been compared with the ISO13232:2005 standard. Moreover, KASE for the development of safety measures in PTW vehicles have been defined, and a forecast of PTW accident scenarios within the next years has been provided.

The comparison between results of D1.1 and ISO13232:2005 has deliver the following outcomes: the application of the ISO13232:2005 methodology in recent crash data triggered some consideration on the crash configurations suggested by the ISO standard. Both literature and PIONEERS data processed using the ISO13232:2005 methodology, showed differences in the selection of the crash configurations to be tested. But unfortunately, the question if these crash configurations are still representative of the current European accident configurations is still open.

To define KASE, according to the results obtained from D1.1 and the CARE database as well, two PTW vehicles (moped and motorcycle) and two road environments (urban and rural) have been considered. As can be seen in the CARE dataset, many moped fatalities occurred in urban environments and most motorcycle fatalities occurred in rural environments. This shows the number of PTW fatalities reported in EU countries has varied depending on the type of vehicle used and the riding environment. Therefore, future trends in PTW road accidents have been calculated focusing on these four parameters.

Regarding the method used to forecast trends in PTW fatalities, a linear regression model has been selected since it provides a general trend of the data and no periodic and seasonal figures are needed. Results for total PTW fatalities, rural fatalities and urban fatalities show unreliable values for the correlation coefficient and the R-squared, as an incomplete dataset from the CARE database was used. However, a weak negative linear relationship is observed for the three different cases.

Predicted values for PTW fatalities in the EU within 2030 are found to be 4,604 for the case of total number of accidents; 2,590 for the case of rural scenarios; and 1,753 for the case of urban scenarios. As compared to their corresponding forecasted values for 2018, this means a reduction of 9.5%, 7.1%, and 15.4%, respectively, in the accident occurrence.

Finally, the PIONEERS project faces a future scenario in which registrations of PTW vehicles (this is motorcycle, moped, and even electric PTWs) are rising year on year in all EU countries. At a more detailed level, motorcycle registrations have increased by 9.1% during the first half of 2019, compared with the same period last year; moped registrations have increased by 19.5%; and electric PTW registrations have increased by 70%. In general, some EU countries in which this growth has been more significant are France, Germany, The Netherlands, Belgium, Italy, and Spain.

The output of this deliverable will be especially useful for WP6, which will assess safety and economic benefits of the new PIONEERS systems and the new testing methods, considering the policy guidelines defined in this report.

6 References

EU project PIONEERS - WP1 - Critical accident scenarios and rider needs, "D1.1 Powered Two-Wheelers – Road Traffic Accident scenarios and common injuries" [Report]. - [s.l.]: European Commission, Grant Agreement No. 769054, 2019.

European Commission, Annual Accident Report - European Commission, Directorate General for Transport, June 2018.

EU Commission, Traffic Safety Basic Facts 2018, Motorcycles and Mopeds - European Commission, Directorate General for Transport, June 2018. Available at: https://ec.europa.eu/transport/road_safety/specialist/statistics_en#

International Organisation for Standardisation (ISO), Motorcycles – Test and analysis Procedures for Research Evaluation of Rider Crash Protective Devices Fitted to Motorcycles, Part 1 to 8. 2nd ed. 2005, Available at: https://www.iso.org/standard/37426.html. Accessed September 30, 2019.

Gennarelli, T., & Wodzin, E. (1990) - The abbreviated injury scale. Association for the Advancement of Automotive Medicine (AAAM).

Grassi, A., Baldanzini, N., Barbani, D., & Pierini, M. (2018) - A comparative analysis of MAIDS and ISO13232 databases for the identification of the most representative impact scenarios for powered 2-wheelers in Europe. *Traffic injury prevention*, 19(7), 766-772.

7 Acknowledgments

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 769054.

Appendix A.1

Total fatalities as reported in EU countries - European Commission - Source: CARE Database - Update: 19/12/2018

Country	Mode	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Belgique	moped	101	98	87	93	71	67	68	78	56	66	63	68	45	33	30	36	26	32	25	22	20	15	13	17	19	16	24
Belgique	motor cycle	114	92	147	141	116	107	125	121	142	118	147	158	124	120	123	130	139	108	137	102	127	87	102	85	100	77	77
Bulgaria	moped																		9	5	5	10	4	6	8	11		
Bulgaria	motor cycle																		67	48	42	35	48	49	47	50		
Cesko	moped									10	16	9	17	11	5	8	3	3	2	9	7	7	7	6	8	6	1	2
Cesko	motor cycle									108	100	86	117	101	97	116	113	136	121	85	92	77	86	66	88	91	62	69
Danmark	moped	35	40	35	36	28	26	27	39	41	47	43	38	43	46	29	24	48	30	15	11	14	14	11	13	19	8	9
Danmark	motor cycle	32	41	26	40	35	23	19	21	26	24	12	24	25	23	16	21	36	40	27	22	23	10	15	18	19	26	11
Deutschland	moped										157	138	131	134	122	107	107	100	110	99	74	70	93	73	87	62	68	59
Deutschland	motor cycle										945	964	913	946	858	875	793	807	656	650	635	708	586	568	587	639	536	583
Eesti	moped															2	2	4	6	3	0		1	0	0	0	3	1
Eesti	motor cycle															5	5	10	1	2	0	0	0	0	0	0	1	0
Ireland	moped	0	0	0	0	0																						
Ireland	motor cycle	63	59	53	55	57	58	68	37	43	40	50	44	55	49	56	29	33	29	25	17	18	19	26	24	22		
Éllada	moped									108	90	77	55	53	55	58	57	43	41	28	36	34	35	25	20	32	25	
Éllada	motor cycle									453	406	426	341	310	379	399	440	420	394	405	367	305	282	271	278	237	240	
España	moped	467	351	288	309	308	310	322	372	382	363	355	285	299	281	235	229	173	134	122	76	66	63	52	53	56	54	
España	motor cycle	706	588	506	409	409	393	378	350	326	344	322	348	316	349	409	414	558	411	366	327	326	293	290	285	329	343	
France	moped	504	504	490	472	471	478	471	418	465	431	426	366	372	321	356	317	324	291	299	248	220	179	159	165	155	121	117
France	motor cycle	980	944	889	841	799	760	870	933	930	912	1.033	1.006	835	819	892	789	853	817	908	734	786	692	658	649	614	613	669
Hrvatska	moped																	20	27	15	15	10	16	14	11	14	10	8
Hrvatska	motor cycle																	96	100	81	51	76	62	49	44	58	38	42
Italia	moped	622	630	625	685	635	625	651	626	611	637	578	452	520	456	385	346	358	292	212	206	165	127	125	112	105	116	92
Italia	motor cycle	722	702	606	548	466	481	482	479	569	770	848	907	1.035	1.139	1.120	1.127	1.182	1.085	1.037	950	923	847	728	704	773	657	735
Kypros	moped															9	5	8	8	4	3	3	3	0	4	2	2	
Kypros	motor cycle															14	20	16	16	19	18	13	11	15	9	13	10	
Latvija	moped														4	5	6	4	4	1	4	5	3	3	6	6	6	6
Latvija	motor cycle														21	11	10	10	14	10	17	6	7	10	10	7	12	1
Lietuva	moped																							4	1	3		
Lietuva	motor cycle																							15	13	13		
Luxembourg	moped	1	0	0	1	2	0	1	1	0	0	0	0	0	1	0	0	1	0	0	0	0	0	0	0	0	0	0
Luxembourg	motor cycle	8	3	2	4	2	6	2	6	5	8	6	0	13	10	6	8	5	9	7	1	3	5	8	8	6	3	7
Magyarország	moped													36	22	40	42	31	26	23	19	31	25	24	17	27	16	17
Magyarország	motor cycle													66	72	100	89	112	91	73	49	52	39	58	58	50	48	43
Malta	moped																									0	0	
Malta	motor cycle															3	2	4	3	2	3					2	9	
Nederland	moped	113	100	92	98	118	107	88	89	107	107	78	98	94	57	56	63	60	51	47	32	36	40	41	32	35	34	36
Nederland	motor cycle	88	91	104	112	90	91	92	76	75	89	76	93	95	84	77	57	64	67	68	60	50	53	29	51	43	44	53
Österreich	moped	77	84	77	65	67	47	58	33	48	44	37	46	47	44	41	39	24	25	30	18	18	19	15	16	8	8	14
Österreich	motor cycle	108	80	96	94	85	84	111	87	103	112	107	89	109	98	98	95	96	91	87	68	67	68	87	76	83	85	83
Polska	moped										178	169	167	145	181	157	164	215	262	290	259	292	261	253	237	208	244	
Polska	motor cycle										21	18	13	14	10	7	7	4	1	1	5	4	1	3	8	4	12	
Portugal	moped	589	522	391	398	408	368	338	277	222	197	161	127	138	106	93	85	62	62	51	77	71	57	51	43	42	44	43
Portugal	motor cycle	96	133	166	185	202	196	185	211	222	186	201	197	187	159	165	120	127	102	101	126	116	104	78	91	73	59	106
România	moped									1	3	4	6	10	1	20	45	81	150	122	114	87	99	39	30	34	33	17
România	motor cycle									12	15	9	13	8	19	23	35	73	90	74	59	69	62	52	45	55	46	52
Slovenija	moped										22	16	5	4	5	5	12	12	8	3	7	2	3	4	2	1	3	4
Slovenija	motor cycle										19	36	18	25	27	33	42	41	40	28	17	25	18	17	15	25	22	25
Slovensko	moped																											
Slovensko	motor cycle											33	37	35	34	45	37	54	39	34	27							
Suomi/Finland	moped	28	15	13	22	20	17	16	16	8	9	7	7	12	14	4	13	11	13	11	9	10	7	5	3	2	5	
Suomi/Finland	motor cycle	34	22	13	10	13	16	8	9	13	10	16	22	23	22	32	26	32	36	27	18	29	21	24	17	20	17	
Sverige	moped	12	17	14	10	9	14	13	12	12	10	9	12	9	18	8	15	14	11	11	8	11	8	3	8	5	8	1
Sverige	motor cycle	37	33	42	31	32	40	36	40	36	39	38	37	47	56	46	55	60	51	47	37	46	31	40	31	44	36	39
United Kingdom	moped	23	20	23	17	19	11	17	10	17	15	14	21	25	26	23	29	18	21	16	10	10	12	4	6	8	8	
United Kingdom	motor cycle	543	460	421	437	435	436	508	499	539	597	580	607	690	581	561	583	596	488	472	403	359	320	337	347	361	316	
	Sum Moped	2.549	2.361	2.112	2.189	2.137	2.059	2.053	1.961	2.071	2.377	2.170	1.880	1.972	1.772	1.648	1.610	1.622	1.594	1.425	1.250	1.182	1.079	926	893	852	825	450
	Sum Motor cycle	3.494	3.215	3.029	2.876	2.709	2.651	2.848	2.829	3.566	4.716	4.970	4.947	5.012	4.970	5.186	4.992	5.504	4.916	4.774	4.210	4.197	3.721	3.555	3.557	3.687	3.276	2.556
	Sum	6.103	5.629	5.206	5.113	4.897	4.761	4.954	4.840	5.690	7.147	7.192	6.885	7.056	6.824	6.903	6.686	7.204	6.582	6.262	5.507	5.435	4.843	4.525	4.487	4.591	4.145	3.045
	Total	152.512																										

PIONEERS

INNOVATION FOR RIDER SAFETY

Motorway fatalities as reported in EU countries - European Commission - Source: CARE Database - Update: 19/12/2018

Country	Transport mode	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Belgique	moped	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	1
Belgique	motor cycle	3	1	9	8	9	8	11	10	9	7	8	8	6	4	6	9	9	9	14	9	8	2	2	1	9	4	7
Bulgaria	moped																								1			
Bulgaria	motor cycle																		0	0	1	0	0	1	1	3		
Cesko	moped																			0							0	
Cesko	motor cycle									1	0	3	0	1	1	1	1	1	1	2	3	0	0	1	0	1	1	1
Danmark	moped				1			0				0		0					0	0	0		0				0	
Danmark	motor cycle	0	0	1	2	0	2	2	2	2	0	1	1	1	1	0	0	2	4	1	3	1	0	0	0	1	2	2
Deutschland	moped										0	0	1	0	0	0	0	0	0	1	0	0	1	2	1	0	0	0
Deutschland	motor cycle										58	49	63	61	56	64	48	55	40	44	40	48	36	47	38	27	40	39
Eesti	moped																											
Eesti	motor cycle																											
Ireland	moped																											
Ireland	motor cycle			1		1	0	0	0	0	0	0	0	1	1		2	1	0	0	0	0	0	2	0	1		
Éllada	moped									3	0	2	0		1	2	6	0	0	1	0	1	1	0	1	0	2	
Éllada	motor cycle									5	7	10	8	11	14	19	30	33	35	17	16	22	18	17	10	11	8	
España	moped	2	2	1	4	1	1	2	1	5	2	22	12	14	10	2	13	7	6	4	2	4	2	1	2	0	2	
España	motor cycle	27	22	15	15	9	12	5	7	8	12	45	51	44	50	52	45	66	45	52	42	31	33	38	42	40	62	
France	moped	0	1	1	3	1	1	3	1	1	0	2	0	1	0	1	2	1	0	1	1	0	1	0	0	3	0	1
France	motor cycle	61	51	43	40	37	27	26	44	33	38	51	46	39	37	42	42	42	27	29	28	39	42	38	22	39	38	39
Hrvatska	moped																		0								1	
Hrvatska	motor cycle																	7	1	1	1	1	1	3	2	0	1	0
Italia	moped	0	0	3	2	2	3	1	2	0	0	0	0					0		0	1	0	0	1	0	0	0	0
Italia	motor cycle	26	23	24	13	26	17	20	24	24	45	33	62	61	62	46	43	52	54	53	43	35	25	35	24	31	29	25
Kypros	moped															0	0			0	0			0		0		
Kypros	motor cycle															1	0	0	0	1	2		0	0	0		0	
Latvija	moped																											
Latvija	motor cycle																											
Luxembourg	moped				0	0								0						0	0							
Luxembourg	motor cycle	0	1	1	0	0	1	0	0	0	0	2	0	0	0	0	1	1	0	6	1	0	1	0	0	0	1	1
Magyarország	moped														0		0		1		0				0	0		
Magyarország	motor cycle													1	1	1	1	1	8	2	1	3	0	2	0	0	0	1
Malta	moped																											
Malta	motor cycle																											
Nederland	moped	0	0	1	1	2	0	0	1	1	1	1	0	1						0		0				0	0	0
Nederland	motor cycle	5	8	13	15	7	14	15	9	15	9	1	16	21						7	12	4	8	3	9	7	5	10
Österreich	moped	1	0	1	0	0	0	1		0	0	0	0	0				0	0			0	0	0	0	0	1	
Österreich	motor cycle	6	5	1	8	3	1	7	3	3	2	5	4	4	5	1	3	1	2	1	5	1	0	1	0	0	2	3
Polska	moped										0	1	0	0	0	0	1	1	0	3	0	2	2	6	5	2	4	
Polska	motor cycle														0	0												
Portugal	moped	0	0	0	0	0	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	0	0	2	0	0	0	0
Portugal	motor cycle	1	4	3	4	8	5	2	2	10	10	18	9	5	15	8	5	13	7	8	12	5	9	4	4	7	2	8
România	moped																	0		0								
România	motor cycle																0	2	0	1	0	0	1	0	0	0	0	1
Slovenija	moped												0			0	1	0		0		0						
Slovenija	motor cycle										0	4	0	2	1	0	1	2	0	2	0	2	0	1	0	2	1	1
Slovensko	moped																											
Slovensko	motor cycle											0	0		0	3	0	0	0	0	1							
Suomi/Finland	moped						0						0							0		0						
Suomi/Finland	motor cycle	0	0	0		0		0	0	2	0	0	1	0	2	1	2	3	2	2	0	1	4	0	0	0	0	
Sverige	moped			0		0		0	0	0	0	0	0		0	0	0	0	0	0		0	0			0		1
Sverige	motor cycle	0	1	1	0	1	1	3	4	0	2	1	0	1	1	2	0	1	2	3	4	2	2	0	4	0	4	2
United Kingdom	moped	1	0		0	0	0	0	0	0	0	0	0	0	0		0		0				0			0		
United Kingdom	motor cycle	13	15	6	9	11	4	7	14	15	21	16	20	21	14	18	21	15	14	12	11	7	5	14	4	5	7	
	Sum Moped	4	4	7	11	6	5	7	5	10	4	28	13	17	11	5	23	10	8	10	4	7	7	12	10	5	10	3
	Sum Motor cycle	142	131	118	114	112	92	98	119	127	211	247	289	280	265	265	254	307	251	258	235	210	187	209	161	184	207	140
	Sum	146	135	125	125	118	97	105	124	137	215	275	302	297	276	270	277	317	259	268	239	217	194	221	171	189	217	143
	Total 5.459																											

Urban fatalities as reported in EU countries - European Commission - Source: CARE Database - Update: 19/12/2018

Country	Transport mode	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Belgique	moped	49	53	41	41	31	31	40	35	32	38	26	35	23	16	13	18	8	21	18	11	11	9	4	9	8	8	14
Belgique	motor cycle	46	53	54	53	40	37	41	37	45	44	46	45	41	38	35	49	45	34	35	30	51	19	18	22	32	24	22
Bulgaria	moped																		5	5	3	4	2	4	5	9		
Bulgaria	motor cycle																		33	21	28	20	28	27	23	26		
Cesko	moped									3	7	6	9	7	3	4	1	1	2	4	3	4	1	5	4	1	0	1
Cesko	motor cycle									43	47	44	53	38	52	51	46	61	52	27	35	25	21	27	30	21	21	20
Danmark	moped	19	22	14	19	13	15	15	17	20	22	23	18	16	28	14	14	21	19	8	6	5	8	4	8	10	1	4
Danmark	motor cycle	12	20	8	12	9	9	4	4	6	12	4	6	8	7	6	5	8	8	2	5	10	5	4	6	8	4	4
Deutschland	moped										70	58	58	57	58	39	55	38	47	47	29	26	46	25	44	31	38	32
Deutschland	motor cycle										200	186	194	189	184	214	201	163	165	143	141	152	135	126	122	138	101	115
Eesti	moped															0	2	2	1	1	0				0		0	0
Eesti	motor cycle															3	1	6	0	1	0	0			0		0	0
Ireland	moped	0	0	0	0	0																						
Ireland	motor cycle	34	23	24	23	15	21	22	12	16	19	16	12	17	19	12	5	10	7	8	3	3	5	4	4	7		
Éllada	moped									48	36	47	32	34	36	37	33	25	27	20	26	21	22	20	16	17	18	
Éllada	motor cycle									236	207	264	215	212	261	260	273	258	253	258	228	184	174	181	182	145	161	
España	moped	166	111	84	85	85	105	105	113	113	136	133	118	123	128	93	84	70	51	49	32	30	21	18	32	28	28	
España	motor cycle	201	180	145	149	118	112	109	101	91	85	90	89	83	75	90	90	133	104	82	83	80	85	88	98	82	109	
France	moped	212	256	240	232	225	223	219	202	224	198	198	174	160	159	178	157	182	148	138	123	122	91	80	77	75	60	58
France	motor cycle	506	463	453	392	381	350	399	396	399	391	411	385	320	309	346	294	308	292	333	279	264	232	206	219	215	203	232
Hrvatska	moped																	12	24	13	13	9	16	12	6	12	7	7
Hrvatska	motor cycle																	41	62	46	26	43	38	25	26	32	22	26
Italia	moped	363	376	369	395	369	369	402	420	373	392	375	263	332	289	236	221	231	189	131	135	99	73	79	74	61	73	61
Italia	motor cycle	400	390	314	293	220	251	239	231	297	394	499	438	475	541	581	603	626	555	533	453	468	415	354	359	389	316	364
Kypros	moped															8	5	6	8	4	3	2	2	0	3	2	1	
Kypros	motor cycle															12	14	11	13	11	15	12	8	13	7	11	9	
Latvija	moped														2	0	3	2	4	0	2	3	1	0	4	1	1	2
Latvija	motor cycle														7	3	7	4	7	7	7	4	3	3	5	3	3	1
Luxembourg	moped	1	0	0	1	1	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0
Luxembourg	motor cycle	6	1	1	0	1	0	1	1	1	1	1	0	3	2	1	1	0	0	1	0	1	0	2	3	0	0	0
Magyarország	moped													25	17	22	30	20	17	19	9	17	13	14	8	20	13	8
Magyarország	motor cycle													34	36	51	34	61	39	21	19	19	20	17	25	21	18	10
Malta	moped																										0	
Malta	motor cycle															3	2	4	3	2	3					1	3	
Nederland	moped	51	50	46	52	66	61	43	46	61	57	39	51	55	27	23	29	46	32	25	15	19	24	28	12	12	21	22
Nederland	motor cycle	41	39	24	36	32	28	33	23	17	24	22	27	22	22	17	21	16	17	16	20	18	12	10	14	12	14	16
Österreich	moped	30	26	29	19	23	19	19	14	16	17	19	20	21	19	12	16	8	14	13	7	9	10	8	6	2	2	8
Österreich	motor cycle	20	9	19	14	20	11	11	12	17	20	14	21	19	17	17	18	16	17	23	7	7	9	11	18	10	11	11
Polska	moped										82	101	100	80	110	94	98	121	141	167	159	156	146	148	127	112	127	
Polska	motor cycle										12	12	4	4	4	2	5	1	1	1	4	4	1	3	6	3	7	
Portugal	moped	290	277	208	204	221	189	182	132	136	91	95	62	78	64	62	49	42	41	33	48	50	39	36	32	29	35	30
Portugal	motor cycle	48	72	85	92	114	95	93	105	133	100	103	117	102	84	93	65	71	64	64	78	73	69	58	61	38	34	63
România	moped									1	3	4	5	9	1	18	35	62	118	105	89	60	76	32	21	27	24	15
România	motor cycle									11	14	8	8	8	15	18	23	56	65	55	42	50	43	40	29	35	31	35
Slovenija	moped										8	10	2	2	1	3	7	6	5	3	5	1	2	3	2	0	2	4
Slovenija	motor cycle										7	10	5	5	7	12	13	17	5	7	8	9	3	6	2	3	7	8
Slovensko	moped																											
Slovensko	motor cycle											20	10	16	12	26	23	31	18	19	13							
Suomi/Finland	moped	9	5	6	5	9	7	5	4	2	2	1	2	3	6	1	3	3	4	5	5	6	3	3	2	1	3	
Suomi/Finland	motor cycle	18	7	8	4	5	5	5	4	1	3	4	6	5	7	12	5	7	10	7	6	10	6	9	5	4	5	
Sverige	moped	7	8	6	3	4	4	5	5	5	3	6	4	5	7	4	7	7	2	2	1	3	3	1	3	1	3	0
Sverige	motor cycle	14	14	11	7	13	9	9	10	11	9	15	10	18	19	14	16	15	21	12	14	11	7	11	6	10	8	13
United Kingdom	moped	14	10	13	9	8	4	8	4	10	7	6	10	17	17	17	19	7	11	13	4	3	5	2	2	2	4	
United Kingdom	motor cycle	256	207	171	176	157	169	186	184	201	222	214	238	236	223	200	205	213	203	177	107	108	108	99	96	117	97	
	Sum Moped	1.211	1.194	1.056	1.065	1.055	1.027	1.043	992	1.044	1.169	1.147	963	1.047	989	878	886	920	931	823	728	660	613	526	497	461	469	266
	Sum Motor cycle	1.602	1.478	1.317	1.251	1.125	1.097	1.152	1.120	1.525	1.811	1.983	1.883	1.855	1.941	2.079	2.019	2.182	2.048	1.912	1.654	1.626	1.446	1.342	1.368	1.363	1.208	940
	Sum	2.813	2.672	2.373	2.316	2.180	2.124	2.195	2.112	2.569	2.980	3.130	2.846	2.902	2.930	2.957	2.905	3.102	2.979	2.735	2.382	2.286	2.059	1.868	1.865	1.824	1.677	1.206
	Total	65.987																										

Rural fatalities as reported in EU countries - European Commission - Source: CARE Database - Update: 19/12/2018

Country	Transport mode	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Belgique	moped	52	44	46	52	39	36	28	43	24	28	37	33	22	17	17	18	17	11	7	11	9	6	9	8	11	8	9
Belgique	motor cycle	65	38	84	80	67	62	73	74	88	67	93	105	77	78	82	72	85	65	88	63	68	66	82	62	59	49	48
Bulgaria	moped																		4	0	2	6	2	2	2	2		
Bulgaria	motor cycle																		34	27	13	15	20	21	23	21		
Cesko	moped									7	9	3	8	4	2	4	2	2	0	5	4	3	6	1	4	5	1	1
Cesko	motor cycle									64	53	39	64	62	44	64	66	74	68	56	54	52	65	38	58	69	40	48
Danmark	moped	16	18	21	16	15	11	12	22	21	25	20	20	27	18	15	10	27	11	7	5	9	6	7	5	9	7	5
Danmark	motor cycle	20	21	17	26	26	12	13	15	18	12	7	17	16	15	10	16	26	28	24	14	12	5	11	12	10	20	5
Deutschland	moped										87	80	72	77	64	68	52	62	63	51	45	44	46	46	42	31	30	27
Deutschland	motor cycle										687	729	656	696	618	597	544	589	451	463	454	508	415	395	427	474	395	429
Eesti	moped															2	0	2	5	2							3	1
Eesti	motor cycle															2	4	4	1	1							1	0
Ireland	moped	0	0	0	0	0																						
Ireland	motor cycle	29	36	28	32	41	35	43	25	27	21	34	32	37	29	44	22	22	22	17	14	15	14	20	20	14		
Éllada	moped									57	54	28	23	19	18	19	18	18	14	7	10	12	12	5	3	15	5	
Éllada	motor cycle									212	192	152	118	87	104	120	137	129	106	130	123	99	90	73	86	81	71	
España	moped	299	238	203	220	222	204	215	258	264	225	200	155	162	143	140	132	96	77	69	42	32	40	33	19	28	24	
España	motor cycle	478	386	346	245	282	269	264	242	227	247	187	208	189	224	267	279	359	262	232	202	215	175	164	145	207	172	
France	moped	292	247	242	237	245	254	249	215	240	233	226	192	211	162	177	158	141	143	160	124	98	87	79	88	77	61	58
France	motor cycle	413	430	387	409	381	383	445	493	498	483	571	575	476	473	504	453	503	498	546	427	483	418	414	408	360	372	398
Hrvatska	moped																	8	3	2	2	1	0	2	5	2	2	1
Hrvatska	motor cycle																	48	37	34	24	32	23	21	16	26	15	16
Italia	moped	259	254	253	288	264	253	248	204	238	245	203	189	188	167	149	125	127	103	81	70	66	54	45	38	44	43	31
Italia	motor cycle	296	289	268	242	220	213	223	224	248	331	316	407	499	536	493	481	504	476	451	454	420	407	339	321	353	312	346
Kypros	moped															1	0	2	0	0	0	1	1	0	1	0	1	
Kypros	motor cycle															1	6	5	3	7	1	1	3	2	2	2	1	
Latvija	moped														2	5	3	2	0	1	2	2	2	3	2	5	5	4
Latvija	motor cycle														14	8	3	6	7	3	10	2	4	7	5	4	9	0
Luxembourg	moped	0	0	0	0	1	0	1	1	0	0		0	0	0	0	0	1	0			0	0	0	0	0	0	0
Luxembourg	motor cycle	2	1	0	4	1	5	1	5	4	7	3	0	10	8	5	6	2	9			2	4	6	5	6	2	6
Magyarország	moped													11	5	18	12	11	8	4	10	14	12	10	9	7	3	9
Magyarország	motor cycle													31	35	48	54	50	44	50	29	30	19	39	33	29	30	32
Malta	moped																									0	0	
Malta	motor cycle																									1	6	
Nederland	moped	62	50	45	45	50	46	45	42	45	49	38	47	38	30	33	34	14	19	22	17	17	14	11	18	19	13	14
Nederland	motor cycle	42	44	67	61	51	49	44	44	43	56	53	50	52	61	59	36	48	49	44	27	28	32	16	25	21	25	27
Österreich	moped	46	58	47	46	44	28	38	19	32	27	18	26	26	25	29	23	16	11	17	11	9	9	7	10	6	5	6
Österreich	motor cycle	82	66	76	72	62	72	93	72	83	90	88	64	86	76	80	74	79	72	63	56	59	59	75	58	73	72	69
Polska	moped										42	32	31	33	24	30	23	20	36	30	38	37	35	20	38	36	38	
Polska	motor cycle										96	67	67	65	71	63	65	93	121	120	100	134	113	99	105	94	113	
Portugal	moped	299	245	183	194	187	179	156	145	86	105	66	65	59	42	31	36	20	20	18	29	21	18	13	11	13	9	13
Portugal	motor cycle	47	57	78	89	80	96	90	104	79	76	80	71	80	60	64	50	43	31	29	36	38	26	16	26	28	23	35
România	moped											0	1	1	0	2	10	19	32	17	25	27	23	7	9	7	9	2
România	motor cycle									1	1	1	5	0	4	5	12	15	25	18	17	19	18	12	16	20	15	16
Slovenija	moped										14	6	3	2	4	2	4	6	3	0	2	1	1	1	0	1	1	0
Slovenija	motor cycle										12	22	13	18	19	21	28	22	35	19	9	14	15	10	13	20	14	16
Slovensko	moped																											
Slovensko	motor cycle											13	27	19	22	16	14	23	21	15	13							
Suomi/Finland	moped	19	10	7	17	11	10	11	12	6	7	6	5	9	8	3	10	8	9	6	4	4	4	2	1	1	2	
Suomi/Finland	motor cycle	16	15	5	6	8	11	3	5	10	7	12	15	18	13	19	19	22	24	18	12	18	11	15	12	16	12	
Sverige	moped	5	9	8	7	5	10	8	7	7	7	3	8	4	11	4	8	7	9	7	5	8	5	2	4	3	4	0
Sverige	motor cycle	23	18	30	24	18	30	24	26	25	28	22	27	28	36	30	39	44	28	32	19	32	22	27	21	33	24	23
United Kingdom	moped	8	10	10	8	11	7	9	6	7	8	8	11	8	9	6	10	11	10	3	6	7	7	2	4	6	4	
United Kingdom	motor cycle	274	238	244	252	267	263	315	301	323	354	350	349	433	344	343	357	368	271	283	285	244	207	224	247	239	212	
	Sum Moped	1.357	1.183	1.065	1.130	1.094	1.038	1.020	974	1.034	1.165	974	889	901	751	755	688	637	591	516	464	428	390	307	321	328	278	181
	Sum Motor cycle	1.787	1.639	1.630	1.542	1.504	1.500	1.631	1.630	1.950	2.820	2.839	2.870	2.979	2.884	2.945	2.837	3.163	2.788	2.770	2.456	2.540	2.231	2.126	2.146	2.260	2.005	1.514
	Sum	3.144	2.822	2.695	2.672	2.598	2.538	2.651	2.604	2.984	3.985	3.813	3.759	3.880	3.635	3.700	3.525	3.800	3.379	3.286	2.920	2.968	2.621	2.433	2.467	2.588	2.283	1.695
	Total	**81.445**																										