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SAFERWHEELS

Study on Powered Two-Wheeler and Bicycle Accidents in the EU

Final Report

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Executive Summary (in English)

Road Safety remains a major societal issue within the European Union. In 2014, some 26,000 people died and more than 203,500 were seriously injured on the roads of Europe, i.e. the equivalent of a medium town. However, although there are variations between Member States, road fatalities have been falling throughout the EU. Over the last 20 years, most Member States have achieved an overall reduction, some more than 50%. During this period, research on road safety and accident prevention has predominantly focused on protecting car occupants, with significant results. However, at the same time the number of fatalities and injuries among other categories of road users has not fallen to the same extent, indeed, in some cases, they have risen. The "Vulnerable Road Users" (VRUs) in particular are a priority and represent a real challenge for researchers working on road safety and accident prevention. Accidents involving VRUs comprised approximately 48% of all fatalities in the EU during 2014, with Powered Two-Wheelers (PTWs) comprising 18% and cyclists comprising 8% of the total numbers of fatalities.

The Commission adopted in July 2010 its Policy Orientations on Road Safety for 2010-2020. One of the strategic objectifies identified by the Commission is to improve the safety of Vulnerable Road Users. With this category of road users, motorcycle and moped users require specific attention given the trend in the number of accidents involving them and their important share of fatalities and serious injuries.

The SaferWheels study was therefore conducted to investigate accident causation for traffic accidents involving powered two-wheelers and bicycles in the European Union.

The objective of the study was to gather PTW and bicycle accident data from in-depth crash investigations, obtain accident causation and medical data for those crashes, and to store the information according to an appropriate and efficient protocol enabling a causation-oriented analysis. The expected outcomes were:

- Collection of accident data for at least 500 accidents of which approximately 80% would involve Powered Two–Wheelers and the remainder bicycles. Equal numbers of cases were to be gathered in six countries; France, Greece, Italy, the Netherlands, Poland and the UK.
- In-depth investigation and reporting for each of the accidents on the basis of the data collected.
- Description of the main accident typologies and accident factors.
- Proposal of most cost-effective measures to prevent PTW and bicycle accidents.

Several results of this study confirm the results of previous studies on PTW accidents. In the current study, speed was a factor in the accidents for 22% of PTW riders, who were judged to travel at a speed too high for prevailing traffic and environmental conditions.

Alcohol intoxication was found for only 4% of PTW riders, 6% of bicyclists and 2% of other vehicle drivers. This decrease is in line with the general reduction in alcohol related accidents over the last decade [ETSC, in press].

Mechanical defects were also rare. In the current in-depth study, vehicle defects were found in only 5% of PTWs examined, though these did not necessarily contribute to the accident. The most common identified defects were tyres and brakes.

The three most common accident scenarios for fatally and seriously injured PTW riders were (1) scenarios where the opponent vehicle is turning left (or turning right in the UK) and the PTW is going straight and is coming from the opposite direction; (2) crossing scenario where the PTW was perpendicularly coming from the right side of the opponent vehicle; and (3) single vehicle accidents – of these, 64% lost control of their motorbike on a curve/bend. 25% of fatally and seriously injured PTW riders were involved in single-vehicle accidents.

Overall the results suggest that some interventions might be indicated, particularly in terms of reducing speed as a contributory/causal factor in PTW accidents. However, from a technology perspective, it is difficult to imagine what might work effectively. More tangible benefits might be derived through rider education, campaigns and more aggressive enforcement of speed limits. For non-speed related PTW accidents, particularly junction accidents (which is the most common accident scenario), technology might be more effective – particularly Intelligent Transport System-related functions which can inform vehicle drivers of the presence of the PTW.

The study also identified specific findings relating to cyclist accidents. Many collisions occurred on local or collector roads (69%), in 50kph zones (61%) and at junctions (56%).

Furthermore, many of the cyclists in the study did not use a cycle helmet. However, in total, the study included investigations of 118 cycle crashes and this relatively small number limits the conclusions that can be drawn.

The sample of bicycle accidents involved only 14 e-bikes collisions, but as their market penetration is rapidly increasing, further investigations of the causes of crashes involving e-bikes may be required.

Executive Summary (in French)

La sécurité routière reste un problème sociétal majeur au sein de l'Union européenne. En 2014, environ 26.000 personnes ont été tuées et plus de 203.200 ont été grièvement blessées sur les routes européennes, soit l'équivalent d'une ville de taille moyenne. Le nombre de tués sur les routes est en baisse dans toute l'Europe, bien qu'il y ait des écarts entre les États membres. Au cours des 20 dernières années, la plupart des États membres sont parvenus à une réduction globale de la mortalité, de plus de 50% pour certains. Les recherches sur la sécurité routière se sont focalisées principalement sur la protection des occupants de voiture, avec des résultats significatifs. Durant cette période, les nombres de tués et blessés parmi les autres catégories d'usagers de la route n'ont pas chuté dans les mêmes proportions, et ont même augmenté dans certains cas. En particulier, les usagers vulnérables constituent une priorité et représentent un véritable défi pour les chercheurs travaillant dans la sécurité routière, notamment sur la prévention des accidents. En Europe durant l'année 2014, les usagers vulnérables ont représenté 48% des tués, dont 18% de motocyclistes et 8% de cyclistes.

En juillet 2010, la Commission européenne a adopté sa politique d'orientation sur la sécurité routière pour la décennie 2010-2020. Un des objectifs stratégiques identifiés est l'amélioration de la sécurité des usagers vulnérables. Au sein de cette catégorie d'usagers, les utilisateurs de motocycles et de cyclomoteurs nécessitent une attention particulière compte tenu de l'évolution du nombre d'accidents les impliquant et de leur part importante parmi les tués et les blessés graves.

C'est dans ce but que l'étude SaferWheels a été initiée, afin d'analyser les causes des accidents de la route impliquant les deux-roues motorisés (2RM) et les vélos dans l'Union européenne.

L'objectif du projet était de collecter des données au travers d'études détaillées d'accidents de 2RM et de vélos, d'identifier les causes possibles et conséquences médicales de l'accident, et de stocker ces informations selon un protocole approprié et efficace, permettant d'analyser les causes des accidents.

Les résultats attendus étaient:

- La collecte d'au moins 500 cas d'accidents deux-roues, dont 80 % impliquant des 2RM.
- Les cas d'accidents proviennent en nombre égal des six pays partenaires du projet : France, Grèce, Italie, Pays-Bas, Pologne et Royaume Uni.
- Des études détaillées d'accidents et des rapports approfondis pour chacun des accidents de la base de données.
- La description des principales typologies d'accidents et des facteurs d'accidents.
- Des contremesures pour éviter les accidents de deux-roues motorisés et de vélos.

Plusieurs résultats de cette étude confirment les résultats d'études antérieures sur les accidents. Dans la présente étude, la vitesse du 2RM est un facteur observé dans 22% des accidents, où les 2RM ont été jugés comme roulant à une vitesse trop élevée compte tenu du trafic et des conditions environnementales.

La cause alcool n'a été identifiée que pour 4% des 2RM, 6% des cyclistes et 4% des autres véhicules. Cette réduction confirme la diminution d'impact de l'alcool sur les accidents durant la dernière décennie (publication ETSC).

La proportion de défauts mécaniques est faible. Des défauts véhicules ont été identifiés sur 5% seulement des 2RM étudiés, et ils n'ont pas nécessairement contribué à l'accident. Les défauts les plus fréquents concernaient les pneus et les roues.

Les trois scénarios d'accidents les plus fréquents chez les pilotes de 2RM tués ou blessés sont:
(1) scénario dans lequel le pilote 2RM qui continue tout droit est confronté à un autre usager circulant dans la direction opposée et en manœuvre de tourne à gauche;
(2) scénario de croisement en intersection dans lequel le conducteur 2RM arrive perpendiculairement au véhicule adverse du côté droit;
(3) les accidents 2RM seul, dont 64% des cas où le 2RM perd le contrôle dans un virage : 25% des pilotes 2RM tués ou blessés graves ont été impliqués dans un accident à un seul véhicule.

Dans l'ensemble, les résultats suggèrent que certaines interventions pourraient être préconisées, notamment celles visant à réduire la vitesse, qui apparait comme un facteur causal ou contributif des accidents 2RM, mais il est difficile d'imaginer une solution technologique sur ce point.

Des bénéfices plus concrets pourraient être obtenus par la formation des pilotes 2RM, et par des campagnes et contrôles plus sévères des limitations de vitesse.

Pour les accidents de deux-roues non liés à la vitesse, en particulier les accidents en intersection (scénario d'accident le plus fréquent), la technologie pourrait être plus efficace, comme par exemple des fonctions ITS* permettant d'informer les conducteurs de voitures de leur présence.

L'étude a aussi montré des résultats concernant les accidents cyclistes: beaucoup de collisions arrivent sur le réseau local (69%), dans les zones limitées à 50 km/h (61%) et aux carrefours (56%).

Beaucoup de cyclistes ne portent pas de casque, mais au global, l'étude n'a analysé que 118 accidents cyclistes, ce qui limite les conclusions qui peuvent en être tirées.

L'échantillon ne comporte 14 accidents de bicyclettes à assistance électrique, mais leur pénétration commerciale augmente rapidement, et mériterait, d'autres investigations sur les causes des accidents l'exercice d'e-bikes ainsi qu'une évaluation des besoins futurs en matière d'infrastructure routière pour ces types de bicyclettes peuvent maintenant être nécessaires.

*: Intelligent Transport System

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Introduction

Road Safety remains a major societal issue within the European Union. In 2014, some 26,000 people died and more than 203,500 were seriously injured on the roads of Europe, i.e. the equivalent of a medium town. However, although there are variations between Member States, road fatalities have been falling throughout the EU. Over the last 25 years, most Member States have achieved an overall reduction, some in excess of over 50%. During this period, research on road safety and accident prevention has predominantly focused on protecting car occupants, with significant results. However, at the same time the number of fatalities and injuries amongst other categories of road users has not fallen to the same extent, indeed, in some cases, they have risen. The "Vulnerable Road Users" (VRUs) in particular are a priority and represent a real challenge for researchers working on road safety and accident prevention. Accidents involving VRUs comprised approximately 48% of all fatalities in the EU during 2014, with Powered Two-Wheelers (PTWs) comprising 18% and cyclists comprising 8% of the total numbers of fatalities.

Powered Two-Wheelers (PTW) is the collective term for motorcycles, mopeds (including speed-pedelecs) and light mopeds (also called mofas). PTWs attract road users for a variety of reasons and their use has continued to increase over the past few years. One of the reasons why they are so appealing to road users is their compact size which permits them to park in small spaces. Their size also aids PTW users to easily move in and out of traffic. However, their small size also has a number of disadvantages. For example, they are lightweight which means that PTW riders can lose control easily. Control can be lost due to uneven road surfaces, an object in the road or inadequately placed street furniture (Van Elslande & Elvik, 2012).

There are many positive attributes of PTWs; they continue to provide a valuable contribution to mobility since their relatively small size and low cost enables them to blend efficiently into in the traffic flow while needing less space compared to other vehicles. However, as mentioned above, PTW riders form one of the most vulnerable groups of road users and road accidents involving injuries to them are a major social concern. It is therefore essential that all parties work together to understand and further improve the safety of this particular mode of transport.

Bicycles also have several advantages. For example, cycling is more environmentally friendly than driving a car and can help to ease congestion in urban areas. Riding a bike is also cheaper than running a car or using public transport and also boasts a variety of health benefits. On the other hand, cycling is relatively dangerous due to the lack of protection pedal bikes offer to individuals if they were to be involved in a crash. Additionally. cyclists can easily encounter obstacles in the road, thus leading to a loss of control. Compared with the occupants of motorised vehicles there are very few opportunities for protection and injury mitigation, and casualty reduction measures therefore focus predominantly on collision avoidance measures. Unlike other Vulnerable Road Users, however, cyclists do not usually have the segregation from traffic that are experienced by (for example) pedestrians but they do have more conflicts with motorised vehicles due to frequent speed differentials.

Objectives of Current Study

The aim of this study was therefore to have an updated database that can be used to study the causes of accidents involving PTWs and bicycles. This was considered necessary since no comprehensive analysis exists regarding accident causation within the EU, even though such up-to-date analysis is essential to define road safety measures and to evaluate their effectiveness. An integral part of this study was that in-depth motorcycle, moped and bicycle accident data was collected from discrete sampling areas within six European countries. As requested by the European Commission, the accident analysis is based on the in-depth road accident investigation methodology defined in

DaCoTA[1] project. The in-depth accident investigations were categorised into two main groups:

- In-depth accident investigations conducted at the scene of the accidents (within minutes to hours of crash occurrence).
- In-depth accident investigations conducted retrospectively (within a few days of the accident occurrence).

The primary objectives of this study were to gather PTW and bicycle accident data from in-depth crash investigations, obtain medical data for those crashes, and to store the information in a database according to an appropriate and efficient protocol enabling a collision causation-oriented analysis. The intended outcomes were:

- Collection of accident data for at least 500 accidents of which approximately 80% would involve powered two–wheelers and the remainder bicycles. Equal numbers of cases were to be gathered in six countries, France, Greece, Italy, the Netherlands, Poland and the UK.
- DaCoTA in-depth investigations and reporting for each of the accidents on the basis of the data collected.
- Description of the main accident typologies and accident factors.

Past Research Relating to PTWs and Bicycles

Several projects have recently examined the issue of motorcyclist safety, including; RIDERSCAN[2], MOSAFIM[3], PISA[4], 2-BE-SAFE 2[5], MAIDS[6], SAFECYCLE[7], BIKE PAL[8], MYMOSA[9] [10]and Safe2Wheelers. Many of these have been aimed at understanding the causes of PTW road accidents with injuries and deaths throughout the EU. These studies are analysed more critically and described in Annex 2.

Several of these projects also attempt to understand the causes of PTW and bicycle accidents within terms of injury and fatality. The causes identified in the literature are examined in the discussion section of this report wherein they are compared to the results of the SaferWheels study. A comparison of the findings of the current study with those from the MAIDS study can be found in Annex 5.

In addition, there are several on-going projects on PTWs and bicycles, including XCYCLE[11], InDeV[12] and MOTORIST[13].

[1] http://www.dacota-project.eu/

[2] http://www.fema-online.eu/riderscan/

[3] https://ec.europa.eu/transport/road_safety/sites/roadsafety/files/pdf/projects/mosafim.pdf

[4] http://www.pisa-project.eu/

[5] http://www.2besafe.eu/

[6] http://www.maids-study.eu/

[7] http://www.safecycle.eu/section/state-of-the-art/

[8] http://etsc.eu/projects/bike-pal/

[9] http://www.mymosa.eu/

[10] http://www.safe2wheelers.eu/

[11] http://www.xcycle-h2020.eu/

[12] http://www.indev-project.eu

[13] http://cordis.europa.eu/project/rcn/111466_en.html

Methodology

The Methodology used for data collection is fully described in http://dacota-investigation-manual.eu/pmwiki.php

Sampling

The study involved investigations of the causes of bicycle and PTW road accidents in six sample regions (Table 1) to give a representative view of such crashes in Europe. In 2014, France, Greece, Italy, The Netherlands, Poland, The United Kingdom represent 46% of bicycle road fatalities and 58% of PTW road fatalities in Europe.

Countries	Region	Investigation Team
France	Essonne	CEESAR
Greece	Thessaloniki	CERTH-HIT
Italy	Rome	CTL
The Netherlands	The Hague	SWOV
Poland	Mazowieckie	ITS
The United Kingdom	East and West Midlands	Loughborough University

Table 1: Sampling Areas

In the selection of the accidents to be included in the study, utmost care was taken to achieve a selection procedure that was random as far as possible. Figure 1 shows the estimated proportion of bicycle and PTW accidents that needed to be investigated by each team to achieve the project objective which was based on historical crash data in each of the selected sampling regions.

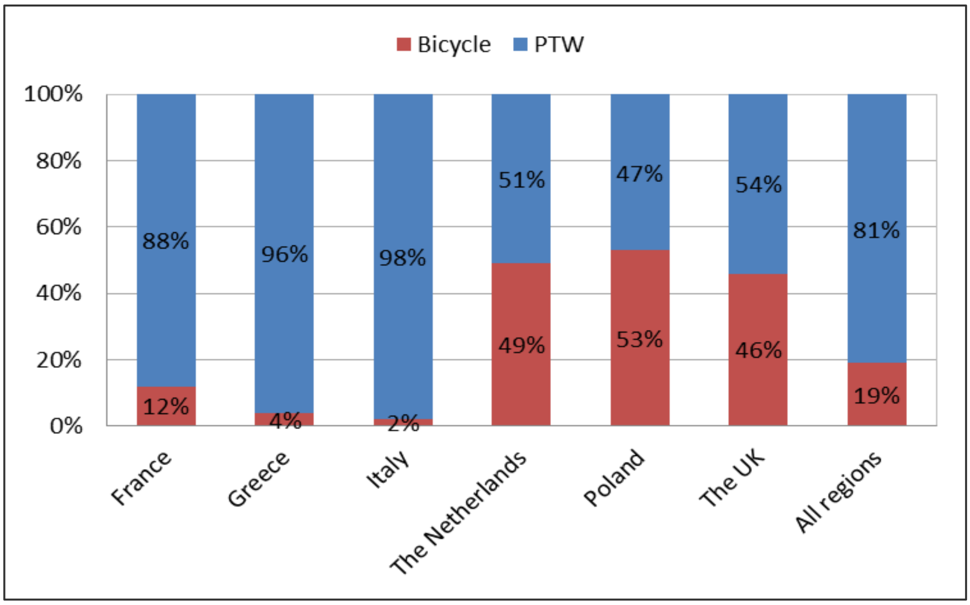


Figure 1: Estimated distribution of crashes involving bicycle and PTW

Relationship between each sample region and the national population

The selected sample regions covered by each team had a known relationship with the national accident population. To be representative, the distribution of key variables had to be close to that of the national data. The distributions for each sample region, together with details of the sample area show, are detailed in Annex 3 along with the specific data collection methods used by each team.

Representative-ness of Data

The main aim of the study was to investigate the causes of road accidents involving cyclists and PTWs in Europe. To achieve this aim, a purposive sampling method was adopted. The purposive sampling was based on the concept of *saturation*, defined as the point at which the data collection process no longer offers any new or relevant data.

In order to represent the major conditions potentially affecting the cyclist and PTW accidents, a proportional amount of accidents was gathered for each identified condition according to the distribution of accidents in the sampling regions.

The number of cases to be investigated in each area was determined from the distribution of accidents in the accident population in each area. In total, 500 cases were collected comprising 77% PTW and 23% bicycle crashes according to the DaCoTA methodology.

In the selection of the accidents to be included in the sample the utmost care was also taken to achieve a selection procedure that was random as far as possible. Figure 1 given previously shows the estimated proportion of bicycle and PTW accidents that needed to be investigated by each team to achieve the project objective which was based on the historical crash data in the selected sampling regions.

A synthesis of the approaches to case selection and investigation procedures is reported below.

The reference population is represented by local traffic police records in order to reflect the accident data within the CARE database. Fire rescue services also informed CEESAR of injury accidents. The Italian team, CTL, did not collect accidents from other Police forces (mainly on the urban motorways of Rome). The need for a rapid response to examine crashes on-scene meant that CEESAR (France), CTL (Italy), CERTH (Greece), ITS (Poland) and SWOV (Netherlands) could collect a number of accidents not included in official statistics. Finally, data privacy issues, legal investigation, accident involving police and explicit refusal by involved parties prevented the investigation of some accidents.

Case selection was random in all cases however factors such as traffic jam, team availability, and the presence of the vehicles on the scene all provided practical restrictions to the ideal selection. This is a normal situation and case selection in all in-depth investigations is limited by these practical issues. All partners, when feasible, were able to collect accident data retrospectively and this method was used to counteract other practical restrictions on sampling methods.

According to these restrictions, some teams experienced difficulties in reaching the target number of accidents planned in a specific time period for each day when using only on-scene investigation methods. In these circumstances, the investigation teams adopted retrospective accident investigation methods for the remaining time-periods not covered by on-the-spot methods.

Periodic meetings and comparison of the sample and local accident population enabled the teams to monitor the compliance of the sample against the criteria specified for the project.

Team Training

Attempts were made to ensure that the partners involved in data collection could take a consistent approach to data collection in the study. Most partners had been involved in the DaCoTA project and were therefore familiar with the approach to investigation stipulated in DaCoTA. However, some enhancements to the DaCoTA approach was deemed necessary within SaferWheels and therefore additional training sessions were held as follows;

Training Meeting Organised by DEKRA, January 2016

In January 2016, DEKRA organised a 3-day training meeting at their premises in Hannover, Germany. The purpose of the meeting was to share information regarding examination of motorcycles for the purpose of determining (a) whether a defect on the motorcycle had caused the accident; and/or (b) whether the motorcycle had been modified in such a way that it had contributed directly to the accident. The training course also involved a number of Case Studies and a thorough explanation of mechanical functioning of motorcycle components and how they could malfunction. As most investigation teams were not allowed to remove or test vehicle parts, DEKRA experts insisted on visible defects (chain state, sprocket state, braking system efficiency etc.)

DREAM Workshop, March 2016

A half-day web workshop was organised to train the crash investigators on the DREAM technique. The workshop was facilitated by an expert based at Loughborough University, who had previous experience in applying DREAM analysis in similar EU projects.

AIS workshop, The Hague February 2017

Abbreviated Injury Scale (AIS) is the coding used to describe each injury. A Certified Abbreviated Injury Scale Specialist (CAISS) from Loughborough University examined the AIS codings, organized a half day training to harmonize the coding, and checked a sample of the medical report codings (5-10 per team).

Data specification

The specified data collection system is derived from the DaCoTA project and involved approximately 1500 variables (or fields) per case that would potentially be available for collection during an accident investigation. It was mandatory for all teams to collect a set of core variables for each case with additional variables to be collected where possible. However, it was recognised that no single accident case would ever contain all of the variables stated in the data collection protocol.

A detailed methodology guideline was provided through an on-line manual and Wiki[14]. Variables to be collected could be viewed directly through a web browser and by accessing the database. Viewing variables through the database system was the best way of identifying groups of variables. The following list illustrates the categories of variables included in the data collection protocol manual. A brief description of the type of variables included in each category is given in brackets by way of an example.

- **Accident** (Date of accident, weather conditions)
- **Road** (Road layout, speed limit)
- **Road User** (Age, injury severity)
- **Vehicle** (General condition, general damage)
- **Car** (Safety technologies fitted, number of seats)
- **Truck** (Mirror type, underrun protection)
- **Bus** (Emergency exits, number of occupants)
- **Wheel** (Tyre depth, make)
- **Analysis** (Deformation measures, calculations)
- **PTW** (Rider clothing, make/model, mechanical inspection)
- **Photo** (visual information to capture)
- **Reconstruction** (Whether performed for case)
- **Dream** (Accident causation analysis)

[14] http://dacota-investigation-manual.eu/pmwiki.php

- **Injuries** (Injury severity according to AIS)

Accident Investigation and Data Collection

As indicated above, there were two different ways of working to gather information from the accident investigations: these were the "**On-scene**" and "**Retrospective**" methods. In SaferWheels, it was possible for teams to investigate accidents using either method, or a combination of both in order to gather data.

Regardless of the approach used, each team first established links with the Emergency Services based in their regions. A formal agreement between teams and their Emergency Services was drawn up for the purposes of accident notification and data accessibility. Further agreements were necessary to ensure data confidentiality with relevant authorities.

The accident investigation methodology developed within the DaCoTA project was followed. In the **"On-Scene"** approach, details of collisions provided to the teams by the Emergency Services (normally the Police) in each of the sampling regions. The Crash Investigators attended the scene with necessary data collection equipment following receipt of each notification. Attendance at the scene whilst crash participants, witnesses and the Police were still present proved to be an effective method to gather data on road user behaviour and vehicle damage.

Teams utilising the **"Retrospective"** methodology were able to gather data a few hours/days later (although some data were not available for some time after that). This method allowed more efficient use of available time as investigations could be grouped together according to geographical location and cases could be selected more effectively according to the sampling plan.

The type of accident investigation adopted by each team ("**On Scene**" and/or "**Retrospective**") was determined by both the team's strategy and the agreements made with the local emergency services. Whilst each partner had established notification protocols with their respective police forces, accident investigation reports from the Emergency Services were obtained wherever possible through data sharing agreements. Data from these were used to supplement the data that was collected by the SaferWheels Accident Investigators.

The data collected within the study were stored in separate files and a unique id number was allocated by country that allowed case-tracking until completion. Access to the data files was only available to the Accident Investigators and data were stored according to EU and individual Member State rules and regulations relating to data protection.

Annex 3 describes the specific approach utilised by each data collection team.

Explanation of legal categories and PTW styles

As part of the regulations for PTW operation in Europe, PTWs were divided into several different vehicle categories based upon their engine capacity and design speed. There are currently two dominant PTW legal categories: the L1 and L3 vehicle categories. L1 vehicles include mopeds while L3 vehicles include motorcycles. The definitions of these categories are as follows:

Moped: A two-wheel vehicle with a maximum design speed of not more than 45 km/h and characterised by an engine: whose cylinder capacity does not exceed 50 cm^3 or maximum continuous rated power is no more than 4kW in the cases of an electric motor. A moped is an L1 vehicle and might be designed to have pedals, or not to have pedals. In the Netherlands, two types of mopeds exist, a moped with a speed limit of 45 km/h and a light moped with a speed limit of 25 km/h. The light moped is similar to the Mofa that is also common in Germany, Belgium and Denmark. However, contrary to regulations in other countries, light moped riders in the Netherlands are not obliged to wear a helmet.

Motorcycle: A two wheeled vehicle with an engine cylinder capacity in the case of a thermic engine exceeding 50 cm3 or whatever the means of propulsion a maximum design speed exceeding 45 km/h. A motorcycle is an L3 vehicle.

In recent years, electric power assisted bicycles have emerged as a sustainable form of transport and can be categorised as "pedelecs" and "speed pedelecs". The former has a maximum speed of 25 km/h and the latter cannot exceed the speed of 45 km/h. Power assisted bicycles are considered as PTWs for this report but a separate analysis of them was undertaken to allow discrimination of the results.

It should be noted that there was a slight difference in selection between PTW cases and bicycle cases. Whilst PTW accidents included all types of accidents, bicycle accidents only included accidents in which a motorized vehicle was involved.

Accident Causation Analysis - DREAM

When all relevant information relating to each individual collision had been collected and the accident reconstruction had been completed, the next step was to undertake an Accident Causation Analysis. This was carried out using the Driving Reliability and Error Analysis Method (DREAM, version 3.0[15]).

The minimum criteria for making a DREAM-analysis was that there was information about the road users involved as well as information about the accident scene. The information about the road-users in SaferWheels was collected through interviews with the PTW riders and cyclists. Other collision participants including witnesses were also interviewed where possible.

DREAM also relies on information about the accident scene being collected as soon as possible following the collision, preferably before the involved vehicles had been moved and before the weather had changed, etc. Photographs were also an essential part of the DREAM analysis.

After the data collection had been completed, the first step in the analysis was to describe the accident in as much detail as possible based on data collected at the scene of the accident. After the collision circumstances had been determined, the next step was to evaluate all factors which were thought to have contributed to the accident. Based on this information, the actual DREAM-analysis was then performed.

DREAM was first developed in Sweden by Ljung et al[16]., based on CREAM (Hollnagel, 1998[17]). DREAM was used in previous European projects including SafetyNet and DaCoTA and for PTW accident analysis in 2BESAFE and it allows investigators to systematically classify and store accident causation information which has been gathered through in-depth investigations by providing a structured method of establishing the causal factors inherent within each accident into a set of formally defined categories of contributing factors.

The DREAM method was selected as the preferred method of determining accident causation in the SaferWheels project due to the following factors;

- Good inter-coder reliability;
- The possibility to make single case analyses and automated aggregated analyses;
- Having a theoretically established background;

[15] H. Wallén Warner, M. Ljung Aust, J. Sandin, E. Johansson, G. Björklund, Manual for DREAM 3.0, Driving Reliability and Error Analysis Method. Deliverable D5.6 of the EU FP6 project SafetyNet, TREN-04-FP6TRSI2.395465/506723, 2008

[16] Ljung, M., 2002. DREAM: Driving Reliability and Error Analysis Method. Master's Thesis, University of Linköping's. <http://urn.kb.se/resolve?urn=urn:nbn:se:liu:diva-2033>

[17] E. Hollnagel **CREAM: Cognitive Reliability and Error Analysis Method** Elsevier Science, Oxford (1998)

- Containing enough relevant causation factors;
- Clearly describing contribution factors/causes;
- Existence of a manual including examples and recommended applications;
- Having a clear 'start' and 'end' method;
- Offering the end-users a method to utilise the results to suggest countermeasures;
- Easy implementation into a database;
- Having the capability to describe all involved road users in the accident;
- Includes a time sequence.

Genotypes and Phenotypes

According to Phan et. Al. (2010[18]), the classification scheme in DREAM consists of "phenotypes" and "genotypes" – and the links between them (Warner et al, 2008[19]). Phenotypes are the "observable effects" of an accident and include human actions and system events. The purpose of the phenotypes is to classify the observable effects into a relatively limited set of categories from which the DREAM analysis can begin. In DREAM version 3.0 there are 6 general phenotypes which are all linked to one or more specific phenotypes (see Table 3). The 6 general phenotypes are - *timing, speed, distance, direction, force, and object*. The 10 specific phenotypes are: *too early action*; *too late action*; *no action*; *too high speed*; *too low speed*; *too short distance*; *wrong direction*; *surplus force*; *insufficient force*; and *adjacent object.* Genotypes are the factors that may have contributed to the observable effects – in other words, the contributing factors. Usually they cannot be observed, and hence must be deduced from both interviews with drivers and other evidence that is gathered during the investigation.

In DREAM 3.0, there are 51 general genotypes, some of which are linked with one or more specific genotypes. The genotypes are divided into 4 broad categories – *driver, vehicle, traffic environment and organisation* – and each of them has sub-categories (see Table 3). Driver categories include – observation, interpretation, planning, temporary personal factors, permanent personal factors. Vehicle categories include – temporary HMI problems; permanent HMI problems; and vehicle equipment failure. Traffic environment includes weather conditions, obstruction of view due to objects, state of the road and communication. Organisation categories include organisation, maintenance, vehicle design and road design.

Genotypes				A: Phenotypes
Driver	Vehicle	Traffic environment	Organisation	
B: Observation	G: Temporary HMI problems	J: Weather conditions	N: Organisation	Timing
C: Interpretation	H: permanent HMI problems	K: Obstruction of view due to object	O: Maintenance	Speed
D: Planning	I: Vehicle equipment failure	L: State of road	P: Vehicle design	Distance
E: Temporary personal factors		M: Communication	Q: Road design	Direction
F: Permanent personal factors				Force
				Object

Table 2: The main genotypes and phenotypes proposed by the DREAM methodology version 3.0 (letters A, B, C, etc are the codes used to name them).

The classification scheme in DREAM also includes links between the phenotypes and genotypes – as well as between different genotypes. These links represent existing

[18] Phan, V., Regan, M., Moutreuil, M., Minton, R., Mattsson, M. & Leden, L. (2010). Using the Driving Reliability and Error Analysis Method (DREAM) to understand Powered Two-Wheeler accident causa-tion. International Conference on Safety and Mobility of Vulnerable Road Users: Pedestrians, Motor-cyclists and Bicyclists. Jerusalem.

[19] H. Wallén Warner, M. Ljung Aust, J. Sandin, E. Johansson, G. Björklund, Manual for DREAM 3.0, Driving Reliability and Error Analysis Method. Deliverable D5.6 of the EU FP6 project SafetyNet, TREN-04-FP6TRSI2.395465/506723, 2008

knowledge about how different factors can interact with each other to contribute to an accident. These links are an important feature of the DREAM methodology. The links illustrate the relationship of cause and effect between a phenotype and a genotype, and between genotypes. Thus, the choice of genotypes and phenotypes is not subjective, but is based on specific rules which define these links. DREAM has rules for helping the user to know when to stop the analysis. These are called "stop rules". These prevent users from subjectively choosing the genotypes. The three rules (Warner et al, 2008) are:

1. Specific genotypes have the status of terminal events. Therefore, if a specific genotype is the most likely cause of a general consequence, that genotype is chosen, and the analysis stops.

2. If there are no general or specific genotypes that link to the chosen consequence, the analysis stops.

3. If none of the available specific or general genotypes for the chosen consequence is relevant, given the information available about the accident, the analysis stops.

The output of the DREAM analysis is a "DREAM-chart" (see Figure 2) which shows, from left to right, the genotypes (e.g., K1-parked vehicles) that contribute to other genotypes (K1-parked vehicles which contribute to the fact that the user did not see the car waiting to emerge from driveway (B1)) and the genotypes (e.g., C2-misjudged situation) that contribute to the phenotype (e.g., A1.2-timing-too late action)) that best describes the observable effects of the accident. One "DREAM-Chart" is defined for one driver involved in an accident. Hence, the analysis with DREAM of an accident involving a passenger car driver and a motorcycle rider will generate two "DREAM-Charts".

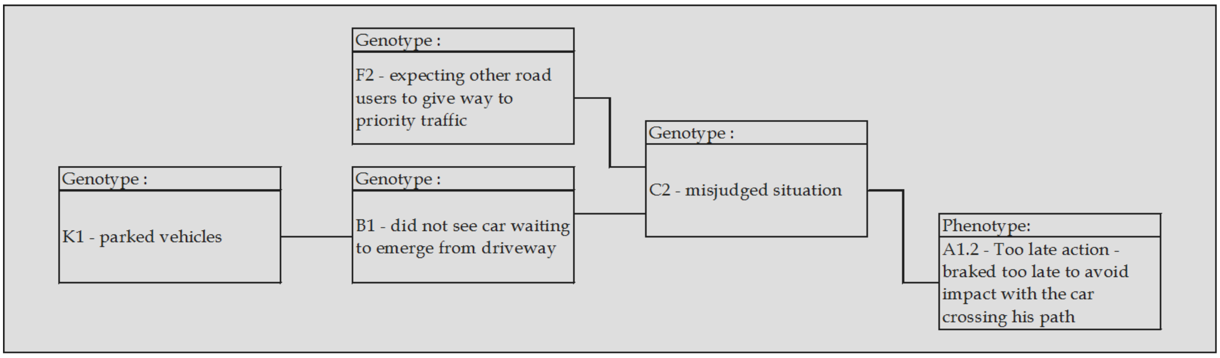


Figure 2: Example of one DREAM-chart for one user involved in an accident (the letters and figures such as A1.2, B1, C2, etc are first the codes used to name the phenotypes and genotypes categories (see Table 3) and then the codes to identify a more detailed phenotype or genotype).

During the DaCoTA-project, DREAM was extended to include a number of specific contributing factors (genotypes) related to problems of Powered Two-Wheelers. However, these additional factors were not integrated into the web application. This was therefore completed within the SaferWheels project. That is, during the set-up phase of SaferWheels, the genotypes, precipitating events and recovery phase coding were added to the web application. Furthermore, data entry was improved by adding links between contributory factors that exist in the manual but not in the web application.

During the team training, at least one member of each team was trained in DREAM-coding. This team member was responsible for DREAM coding of all cases that were completed by his or her team. In SaferWheels, aggregation of the DREAM coding was to allow the analysts and investigators to look for patterns of contributing factors that were present in the data and their relative frequencies (through analysis of the aggregated data). This provided insight into the main contributing crash factors and hence insight into needs for remedial measures.

The DREAM methodology for determining accident causation has been used previously in accident investigations (e.g. SafetyNet, 2BESAFE.) DREAM was therefore selected as the preferred method of accident analysis in SaferWheels because of the success of previous application of the method combined with the structured approach of establishing the causal factors inherent within each accident into a set of formally defined categories of contributing factors.

Database Application

The database used for SaferWheels is an improved and customised version of the DaCoTA database application (Carroccia et al (2012)[20]). This provides a rich user interface, supporting creation, modification and deletion of the accident data (text, images, documents) through an Adobe Flash (SWF) application. The database application was published on a server located in Rome at the CTL.

All partners were allocated with credentials to securely login to the application. During the data entry phase the database for this project could be accessed online at a web address. This allowed all partners to access the database from their home countries, and the benefit of having a centrally hosted database accessed via the web rather than each country having a localised version was that any modifications (such as adding new variables or security patches) could be made instantly for all partners.

Subsequently once the data was finalised, the full 500 cases were exported from the database as .csv files to be used for analysis.

Figure 3 and Figure 4 show the login and home page of the web database application used for data entry.

Figure 3: SaferWheels database application login web page

[20] Carroccia, R; Robibaro, M and Giustiniani, G. Specification of the Data System. DaCoTA Deliverable D2.2. DaCoTA project, 2012.

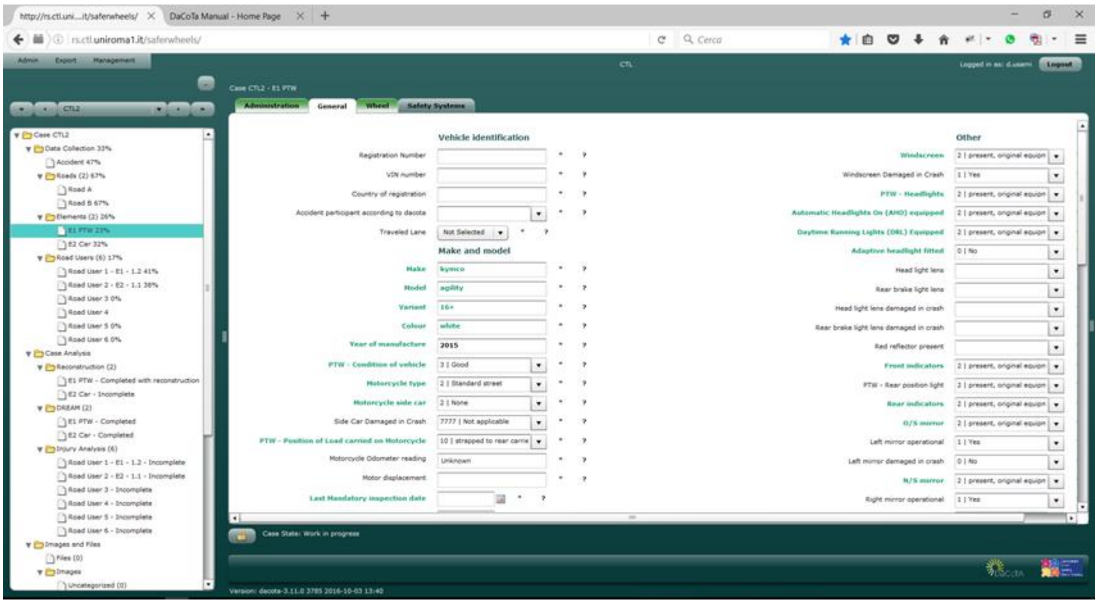
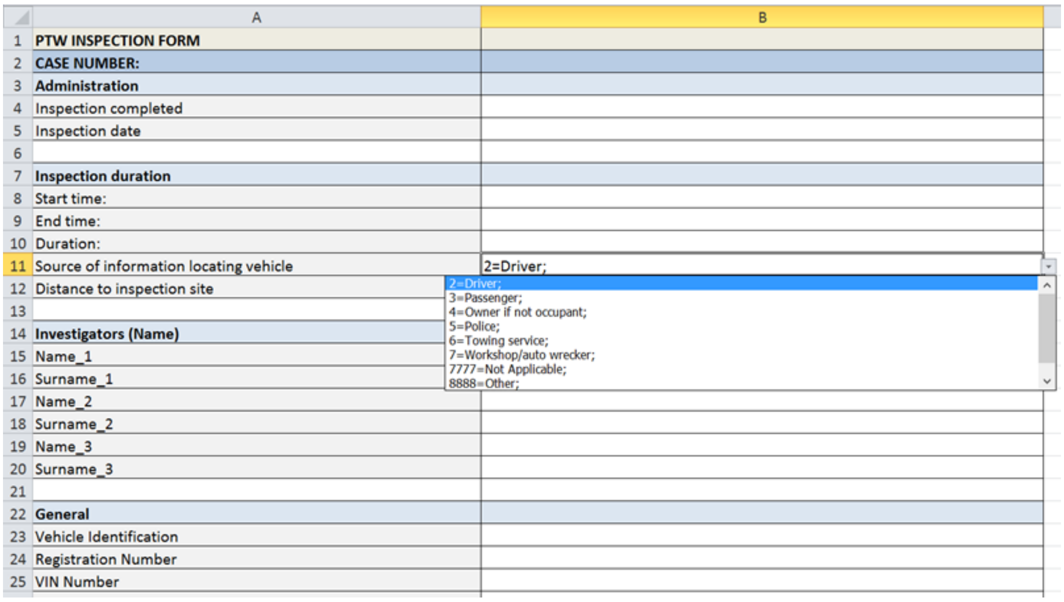


Figure 4: SaferWheels database application homepage

A glossary for the database and variables used within the project is provided using a dedicated on-line manual, which was published on the server located at the CTL. Again this was a modification of the original DaCoTA manual. The online manual can be accessed using the web address: http://rs.ctl.uniroma1.it:8081/saferwheels/pmwiki.php. All partners were provided with login credentials to edit the manual.

While upgrading the application, the system was made unavailable for a certain period of time. To avoid delays in this period, Excel templates were created which allowed the teams to code data in the Excel file which was then transferred into the database once available. Figure 5 shows an example of template used to code PTW inspection form.



	A	B
1	PTW INSPECTION FORM	
2	CASE NUMBER:	
3	Administration	
4	Inspection completed	
5	Inspection date	
6		
7	Inspection duration	
8	Start time:	
9	End time:	
10	Duration:	
11	Source of information locating vehicle	2=Driver;
12	Distance to inspection site	2=Driver; 3=Passenger; 4=Owner if not occupant; 5=Police; 6=Towing service; 7=Workshop/auto wrecker; 7777=Not Applicable; 8888=Other;
13		
14	Investigators (Name)	
15	Name_1	
16	Surname_1	
17	Name_2	
18	Surname_2	
19	Name_3	
20	Surname_3	
21		
22	General	
23	Vehicle Identification	
24	Registration Number	
25	VIN Number	

Figure 5: PTW inspection Excel template

The database application was upgraded continuously to add new variables and to improve the performance. The PTW and bicycle inspection forms and the road user forms in the database were extensively modified to better suit the purpose of the project. Approximately 205 new variables were added containing more than 797 new values (plus 1434 new values - 7777, 8888, 9999 - on the old variables). Moreover, for better performance, the Random-Access Memory (RAM) of the application was improved from 2GB to 3GB and the space on disk of the server was upgraded to 126GB from 25GB, allowing seamless upload of accident images into the database.

The details about all the updates are provided in the Annex 4, in addition to list of all activities performed to upgrade the DaCoTA database in chronological order.

In addition, the Driver Reliability and Error Analysis Method (DREAM) application in the database was updated to the latest version 3.2 from the earlier version 3.0. Figure 6 shows an example of a DREAM analysis within the database.

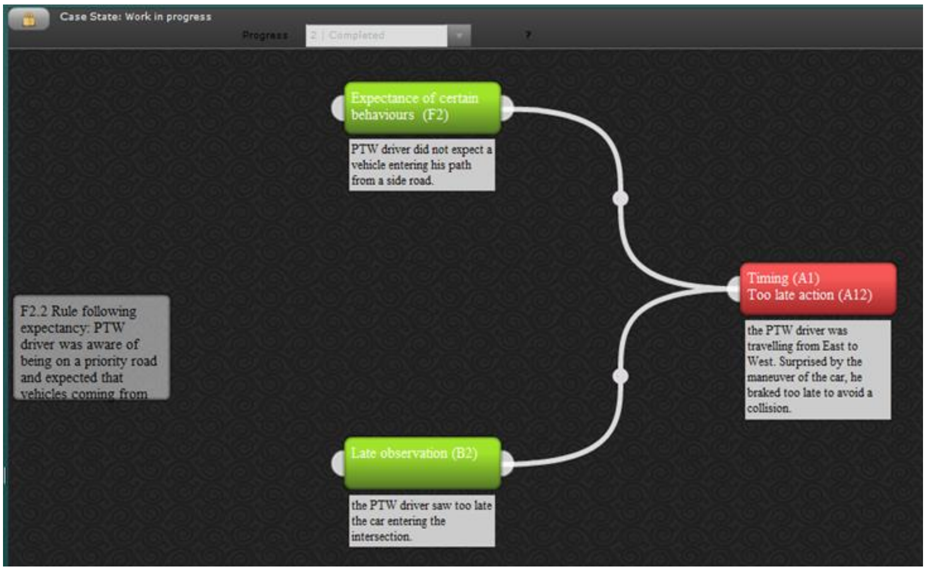


Figure 6: Example of a DREAM chart

Quality Assurance

Quality control and quality assurance were two important attributes that were applied within the SaferWheels project to ensure data collection consistency, reconstruction quality and consistency, data analysis quality, and language quality.

The checks that were applied were therefore as follows:

- During the project, a minimum of two members per team were trained to use the DaCoTA protocol for in-depth investigation. Team training ensured that all teams collected and coded data in the same manner.
- A series of checks on data coding consistency was carried out involving case reviews.
- At least one member of each team was trained in DREAM-coding. This team member was responsible for DREAM coding of all cases completed by that team.
- After the main data gathering phase, a total of 8-10 cases per investigation team were randomly selected and checked by a member of one of the other teams.
- During the data gathering phase, data completion for each case was monitored automatically and case completion ('sign-off') was not possible if a predefined set of vital elements was not entered onto the database.
- During the analysis phase, a data-cleaning process was initiated.

Additionally, each organisation was responsible for checking language quality in the delivered work; however, Loughborough University, UK was the final reviewer in order to assure the overall language consistency.

Data Analysis

For the primary analysis of the data descriptive statistics have been used. Parameters were cross tabulated in multiple layers when needed, in order to provide the proportional differences and to underline the dominant factors that appear most frequently in accident scenarios.

The graphical presentation of the findings contains tables, pies and bar graphs, as well as pictograms that illustrate more clearly the accident configurations and the contributing accident factors. MS Excel, SPSS and R-studio were mainly used for the analysis of the data. Full results are presented in Annex 1 and summarised in the results section below.

Statistical Analysis

Firstly, a cluster analysis was carried out on the accident level variables. The selected type of clustering method was the Two Step Cluster Analysis. This method of clustering is able to produce solutions based on both continuous and categorical variables. The clustering algorithm is based on a distance measure. The first step of the two-step procedure is the formation of pre-clusters. The goal of pre-clustering is to reduce the size of the matrix that contains distances between all possible pairs of cases. In the second step, the standard hierarchical clustering algorithm is applied on the pre-clusters. The two-step cluster algorithm requires that all continuous variables are standardised. As far as the distance measure is concerned, the log-likelihood method was selected in order to account for both categorical and continuous variables. The clustering criterion (in this case the BIC – Bayesian Information Criterion) is computed for each potential number of clusters. Smaller values of the BIC indicate better clustering outcome. Also, a satisfactory solution should have a large ratio of BIC Changes and a large ratio of distance measures.

As a second part of the more in-depth statistical analysis, it was aimed to give insight on the parameters affecting injury severity of occupants (dead against no-dead). For that reason, the Random Forests analysis was chosen in order to rank the explanatory variables according to their relative importance. A random forest is a classifier including a collection of tree-structured classifiers $\{h(x, \Theta k), k = 1,...\}$, where the $\{\Theta k\}$ are independent identically distributed random vectors and each tree casts a unit vote for the most popular class at input x (Breiman, 2001). Strobl and Zeileis, (2008) suggest a number of bootstrap samples from the original sample have to be drawn and afterwards a classification tree to each bootstrap sample has to be fitted (number of trees). In our analyses 100 trees were used.

Results

The data analysis is based on the complete dataset of 500 cases.

Annex 1 presents the detailed analysis results and figures; analysis was carried out on the overview sample characteristics (Part 1), accident scenarios (Part 2), human factors (Part 3), vehicle factors (Part 4) infrastructure or environment factors (Part 5) and an eBike accident analysis (Part 6).

Part 1: Overview of the Aggregated Data

The key results from the overview data analysis can be summarised as follows;

- In total 500 cases were collected, of which 385 involved PTWs and 116 involved manual bicycles. Additionally, 14 cases involved an E-bike, which were analysed separately.
- 18% of PTW cases (n=385) resulted in 'Fatal' outcomes to the PTW rider. A further 27% involved 'Serious' injuries, with the remaining sample involving 'Slight' or 'No injury' (Figure 12).
- For cases involving bicycles (n=116), 13% resulted in 'Fatal' outcomes and 41% involved 'Serious' injuries with the remaining sample involving 'Slight' or 'No injury' (Figure 12).
- The most frequent months of accident occurrence for PTWs in the sample were May (12%) and September (11%) (Figure 13).
- The most frequent months of accident occurrence for cyclists in the sample were July (17%) and September (16%) (Figure 13).
- PTW accidents in the sample were least likely to occur in January and December, and cyclist accidents were least likely to occur in March and October, although this could be related to the fact that most teams only collected cases in one month of December and January (only 2015 and 2016 respectively due to the study duration -Figure 13).
- Both PTW and Cyclists, accidents were least likely to occur on Saturdays and Sundays, with Wednesday being the day on which the highest numbers of PTW accidents occurred and Friday being the day on which the highest numbers of cyclist accidents occurred (Figure 14).
- PTW accidents showed two peaks in terms of time of day of accident occurrence; these were 7am to 9am and 2pm to 5pm. For cyclists, the peaks were around 8am-9am, 11am-12pm, and 5pm-7pm (Figure 15).

Cluster Analysis

Two step cluster analysis was performed on the 500 cases (see Annex 1 for full results). Two clusters were produced, and the model quality was considered 'good'.

- Cluster 1 (398/500 cases): "No wind, no drugs, lighting" – contains mostly cases from all countries except the Netherlands, and almost all of the alcohol involvement cases despite the lack of drug involvement.
- Cluster 2 (99/500 cases): "Windy, lighting, unknown DUI condition" – contains mostly cases from the Netherlands and the UK, cases with mild or strong wind conditions, and the majority of the cases where alcohol/drug use was unknown.

Part 2: Accident Scenario Analysis

The Accident scenario analysis (n=500) takes into consideration the number of vehicles/pedestrians involved in the accident, their manoeuvre, the positions of vehicles/pedestrians prior to the crash, and their directions. No road parameters were included in the accident scenario definition except for single vehicle accidents where the road layout was considered. All accident scenarios were derived from "DaCoTA Accident Type" variable[21]. Furthermore, no scenario was defined for accidents involving more than 3 vehicles/pedestrians as their occurrence was very low (see Figure 7).

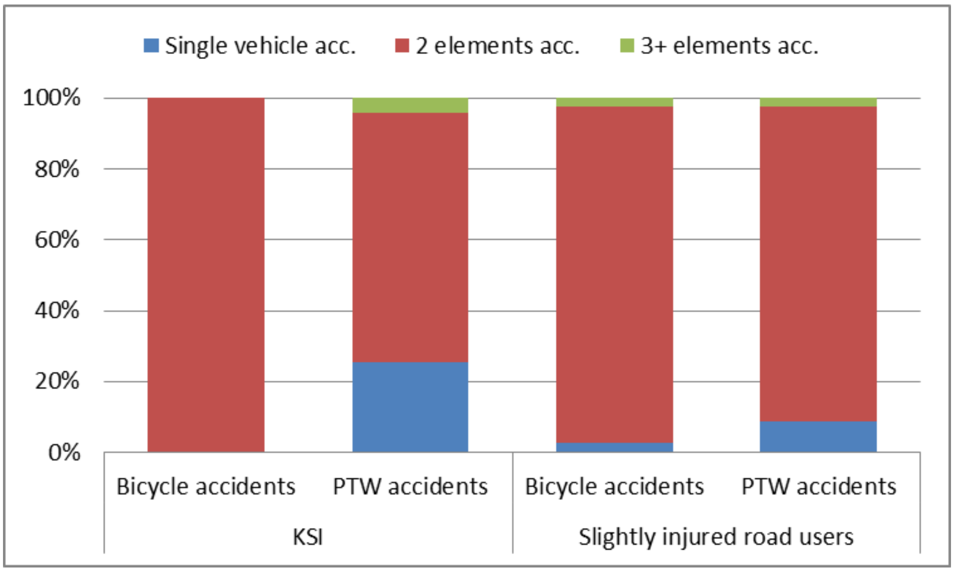


Figure 7: Killed and Seriously Injured road users (KSI) and slightly injured road-users distribution according to the number of vehicles/pedestrians (elements) involved in the accident

Figure 7 shows that most PTW or bicycle accidents involved at the most 2 vehicles/ pedestrians; it should be added that bicycle accidents were always two-vehicle interactions as this was a pre-requisite for case inclusion. Therefore;

- Bicycle accidents (including pedelecs/e-Bikes) always occurred as a result of interaction with another vehicle. However, this was not the case for PTWs.
- Killed and Seriously Injured road users were over-represented in single PTW accidents (comparing to Slightly Injured road users).

Accident scenarios description

Around 30 accident scenarios were created. They were all derived from the DaCoTA accident configuration variable. These new scenarios have been created to reduce the numbers and simplify the descriptions of the DaCoTA accident types (see link below[22]). All the accidents investigated were then assigned to one of these accident scenarios, and several them were used for the analysis (the most frequent accident scenarios for PTW and bicycle accidents). The remaining accidents were all gathered in the 'other accident scenario' category.

[21] http://dacota-investigation-manual.eu/English/41

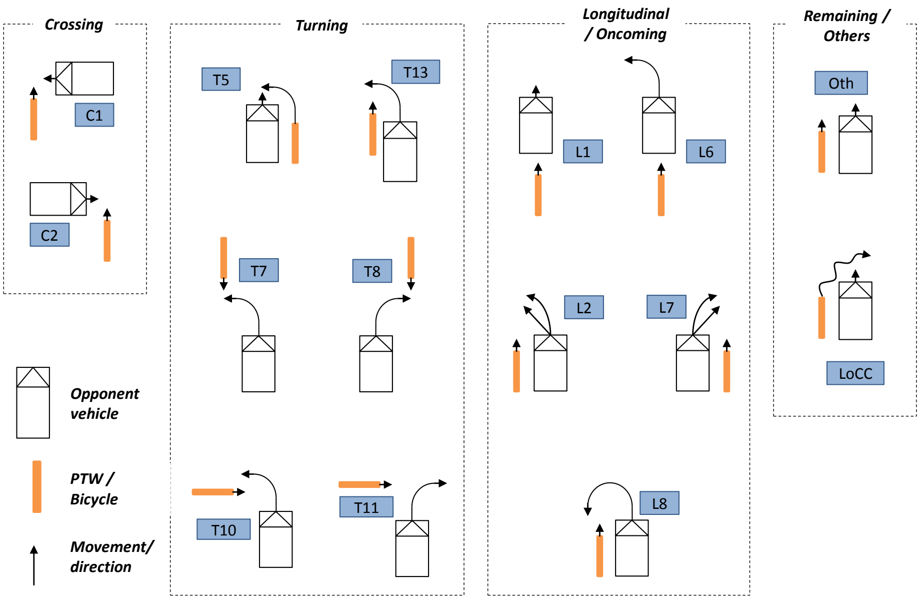


Figure 8: Overview of accident scenarios between a PTW or a bicycle and an opponent vehicle

The scenarios are shown in the following table;

Table 3: Description of condensed accident scenarios

Scenario	Description
C1	• PTW/bicycle driving straight • Opponent vehicle crossing the PTW/bicycle path from the right side
C2	• PTW/bicycle driving straight • Opponent vehicle crossing the PTW/bicycle path from the left side
T5	• PTW/bicycle turning to the left, crossing the (straight) opponent vehicle path • Opponent vehicle is riding straight in the same direction as the heading of the PTW/bicycle before turning
T7	• Opponent vehicle turning to the left, crossing the (straight) PTW/bicycle path • PTW/bicycle coming from the opposite direction, riding straight
T8	• Opponent vehicle turning to the right, crossing the (straight) PTW/bicycle path • PTW/bicycle coming from the opposite direction, riding straight
T10	• Opponent vehicle turning to the left, crossing the (straight) PTW/bicycle path • PTW/bicycle is riding straight, coming from the left side of the opponent vehicle
T11	• Opponent vehicle turning to the right, crossing the (straight) PTW/bicycle path • PTW/bicycle is riding straight, coming from the left side of the opponent vehicle
T13	• Opponent vehicle turning to the left, crossing the (straight) PTW/bicycle path • PTW/bicycle is riding straight in the same direction as the heading of the opponent vehicle before turning
L1	• Opponent vehicle and PTW/bicycle driving in the same direction • PTW/bicycle is riding straight and hit by the opponent vehicle (going straight) from the rear

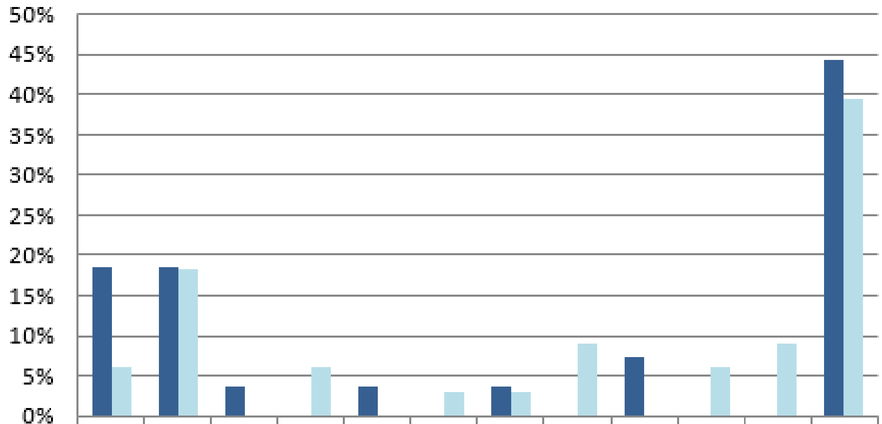
L2	• Opponent vehicle and PTW/bicycle driving in the same direction • Opponent vehicle is swerving to the left in front of the PTW/bicycle and hit by the PTW/bicycle
L6	• Opponent vehicle and PTW/bicycle driving in the same direction • PTW/bicycle is riding straight and hit by the opponent vehicle (turning left) from the rear
L7	• Opponent vehicle and PTW/bicycle driving in the same direction • Opponent vehicle is swerving to the right in front of the PTW/bicycle and hit by the PTW/bicycle
L8	• Opponent vehicle and PTW/bicycle driving in the same direction • Opponent vehicle is u-turning from the right to the left in front of the PTW/bicycle and hit by the PTW/bicycle
LoCC	• The driver of the PTW/bicycle loses the control of his vehicle, in a curve, and crashes an opponent vehicle
Oth	• All other scenarios that are not covered by any of the previously described scenarios.

Scenario Analysis - Results for Bicycle Accidents

Single bicycle accidents represented a very low issue in this study (because of the sampling approach used.) Although it is recognised that single-vehicle bicycle accidents are generally quite problematic, they are not analysed at an in-depth level in this study. All of those that occurred in this study were pedelecs so no accident description was available and relevant.

C1, C2 and T5 accident scenarios were the three most frequently occurring accident scenarios for killed and seriously injured road users involved in a bicycle accident (45% of fatalities and seriously injured road users were involved in a two-vehicles accident mainly due to the selection criteria used). 'C' accident scenarios are crossing scenarios, i.e. vehicles are coming from perpendicular directions. T5 is part of the turning scenarios cluster where the bicyclist was turning right just in front of the opponent vehicle.

For slightly injured road users involved in a bicycle accident, the three most common accident scenarios differ somewhat. C2 was still the main accident configuration – 18% of slightly injured road users involved in a two-vehicle accident (the bicyclist is perpendicularly coming from the right side of the opponent vehicle), but the next most frequent were T8 (9%) and T11 (9%). In these cases, the opponent vehicle was turning right, and the bicyclist was coming from its left side or from the opposite direction.



	C1	C2	L1	L6	L7	L8	T10	T11	T5	T7	T8	Other
KSI	19%	19%	4%	0%	4%	0%	4%	0%	7%	0%	0%	44%
Slightly injured road users	6%	18%	0%	6%	0%	3%	3%	9%	0%	6%	9%	39%

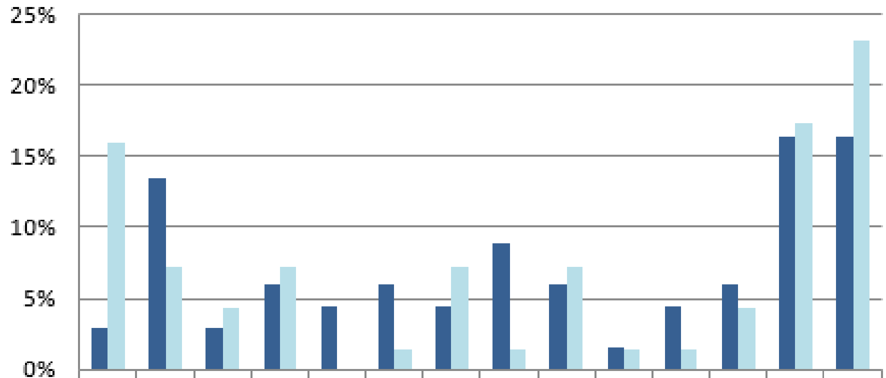
Figure 9: Distribution of fatally, seriously and slightly injured road users, in 2 vehicle accidents involving a bicycle, according to the accident scenario

Scenario Analysis - Results for PTW Accidents

25% of fatally and seriously injured PTW users were involved in a single PTW accident. 64% of these lost control of their vehicle on a curve.

The three most common accident scenarios for fatally and seriously injured PTW riders were T7, C2 and LoCC (38% of fatalities and seriously injured road users involved in a two-vehicles accident). T7 is a scenario where the opponent vehicle was turning left and the PTW was going straight and was coming from the opposite direction. C2 is a crossing scenario where the PTW was perpendicularly coming from the right side of the opponent vehicle. And the last accident scenario, the PTW driver lost the control of their vehicle and crashed into an opponent vehicle.

For slightly injured PTW riders, the two most common accident configurations were T7 and C1. The remaining accidents were "similarly" distributed among the other accident scenarios.



	C1	C2	L1	L2	L6	L7	L8	LoC C	T10	T11	T13	T5	T7	Other
KSI	3%	13%	3%	6%	4%	6%	4%	9%	6%	1%	4%	6%	16%	16%
Slightly injured road users	16%	7%	4%	7%	0%	1%	7%	1%	7%	1%	1%	4%	17%	23%

Figure 10: Distribution of fatally, seriously and slightly injured road users, in 2 vehicles accidents involving a PTW, according to the accident scenario

The Scenario Analyses suggest that certain intervention strategies are called for in terms of PTW accident prevention. In particular, as the most common multi-vehicle accidents are (1) scenarios where the opponent vehicle is turning left and the PTW was going straight and was coming from the opposite direction; (2) crossing scenario where the PTW was perpendicularly coming from the right side of the opponent vehicle, ITS technology (e.g. PTW2V) installed into both passenger vehicles and PTWs could serve to warn drivers and riders of the presence of each other and thus that caution is required. However, the interventions required for single vehicle accidents are much less clear-cut.

Part 3: Human Factors/Road User Analysis

The **database** contains 1012 involved road users, of which 917 were drivers or riders of the vehicle. A further 74 road users were passengers in vehicles, and 21 were pedestrians.

The **analysis sample** included 394 PTW riders, 132 riders of bicycles, and 391 "other interacting road users (OIRUs)" (drivers of car/van/truck/bus/other). Passengers and pedestrians have been excluded from analyses unless otherwise specified.

PTW Rider characteristics

- Most PTW riders in the sample were male (90%), and the most frequently observed age categories were 18-25 and 25-35 (Figure 16).
- Regarding personal protective equipment, the majority of riders wore a helmet (81%), though only 13% wore reflective clothing (Figure 29, Figure 35). It should be noted that in The Netherlands, helmet use is not compulsory for moped riders.
- In the majority of cases PTW riders used their headlights (72%), though there was considerable variation between countries, which could be attributable to whether or not novice drivers in different EU Member States are instructed to use headlights during the daytime (Figure 32).

Bicycle rider characteristics (including E-bike riders)

- A higher proportion of cyclists were females (67% female) compared with PTW riders (10% female) (Figure 17).
- The most frequently observed age categories were 46-55 and 56-65 (Figure 17).
- Regarding personal protective equipment, only 32% of bicycle riders wore a fastened helmet, whilst a further 14% wore a helmet but did not fasten it (Figure 34). Similarly, only 21% of riders wore reflective clothing (Figure 35).

Contributory Factors Analysis

Factors determined by the investigators to be contributory to the accident have been analysed. The analysis compared contributory factors between PTW riders, bicycle riders (including e-bike riders) and the drivers of other interacting vehicles.

Influence of substances

The prevalence of alcohol as a contributing factor was low, being present for only 4% of PTW riders, 6% of bicycle riders, and 2% of interacting road users.

Incidents of narcotics used were even lower with narcotics use being a contributing factor for only 3% of PTW riders, 2% of bicycle riders, and 1% of interacting road users (Figure 20).

Illegal and Inappropriate Speed

The issue of speed is a key area of focus in road safety, and for PTW riders in particular. The following table examined the speed of PTW riders, bicycle riders, and other interacting road users.

Speeding was a contributing factor for 22% of riders; in the majority of these cases the rider was travelling above the posted speed limit. Speeding in bicycle riders was less common, being a contributing factor for only 7% of riders; however, it should be noted that excess speed is more difficult to achieve on a non-motorised bicycle compared to a PTW (Figure 21).

When speeding was determined to be a contributory factor for PTW riders, there was a relatively higher proportion of younger riders when compared with all riders analysed (37% of speeding riders were aged <=25 compared with 27% of all riders), and the accidents resulted in relatively more severe injuries (49% of speeding riders received fatal injuries) (Figure 22).

The following table shows firstly, whether or not the road user travelled above or below the speed limit (illegal / legal speed), and secondly, whether or not excess speed was contributory to the collision. Road users were only included in these tables if both these variables were known.

Where speed was considered to be a contributory factor to the accident, in the vast majority of cases the PTW was riding above the legal speed limit for the road. In the majority of cases, the speed of the other road-user was not seen as contributory to the accident.

Interestingly, in 18% of cases (n=72), the PTW rider was riding above the legal road-speed and the speed of the PTW was thought to have been a contributing factor to the accident.

Table 4: Incidence of speeding among PTW and bicycle riders and OIRUs

PTW Riders (280/394 known)	Riding at Legal Speed	Riding at Illegal Speed
Speed not contributory to accident	197 (50%)	6 (2%)
Speed contributory to accident	14 (4%)	72 (18%)
Bicycle Riders (116/132 known)	**Riding at Legal Speed**	**Riding at Illegal Speed**
Speed not contributory to accident	107 (81%)	-
Speed contributory to accident	6 (5%)	3 (2%)
OIRUs (347/391 known)	**Driving at Legal Speed**	**Driving at Illegal Speed**
Speed not contributory to accident	331 (85%)	3 (1%)
Speed contributory to accident	5 (1%)	8 (2%)

Fatigue and distraction

Fatigue did not appear to be a contributing factor in many accidents, being a contributing factor for 2%-4% of road users.

Distraction was more prevalent; in particular, over one-third (34%) of interacting road users were distracted. 16% of bicycle riders and 10% of PTW riders were distracted (Figure 23).

Impairments

Psychological impairments, and emotions such as fear or stress, were a contributing factor for 9% of PTW riders and 6% of bicycle riders.

Medical conditions and physical impairments were not a significant factor, being contributory for only 1%-3% of road users (Figure 24).

Risk-taking behaviour

Risk-taking behaviour, such as excitement seeking or risky overtaking, was a factor for both 5% of PTW riders and bicycle riders. It should be noted that factors such as alcohol, drugs and speeding are separate to this, though these factors could also be considered as risk-taking behaviours (Figure 25).

Rider inexperience

Inexperience was more prevalent among PTW riders than bicycle riders (13% compared with 7%). Whilst this figure is not especially high, it still indicates that further training could be beneficial in reducing PTW accidents (Figure 25).

Amongst riders who were considered ‘inexperienced’, 13% (n=53) were generally younger (aged up to 17-years), with 52% aged under 25 years, though nearly a quarter were also aged 26-35 years (23%). Inexperienced riders were relatively more likely to be speeding compared with all riders (31% compared with 22%) (Figure 26).

Observation errors and sight obstructions

Errors of observation, including for example 'looked but failed to see' accidents were very prevalent, being a contributing factor for over one-third of PTW (38%) and bicycle (39%) riders, and two thirds of interacting road users (66%).

However external sight obstructions, such as trees, other traffic, or dazzling from low sun, were also a common factor, being present for 18% of PTW riders, 15% of cyclists, and 28% of interacting road users (Figure 27).

Statistical Analysis

Random Forests analysis was undertaken to examine the relative importance of variables on determining injury severity (fatal vs non-fatal) (see Annex 1).

According to the analysis, we can observe that the most important variables that effect injury severity are contributory excess speed, driving above the speed limit and medication use.

Part 4: Vehicle Defects Analysis

Powered Two-Wheeler

The database contains 393 PTW elements coded and available for analysis. The distribution of different motorcycle types and motor displacement is shown in Annex 1; the most common types examined were scooters (47%), followed by road race replicas (19%) and standard street bikes (13%) (Figure 36). 50% of the vehicles had a motor displacement of 250cc or less, while 40% were over 500cc (Figure 37).

To identify vehicle defects, a certain number of variables and values were analysed separately. The parameters covered all possible aspects related to the general condition of the vehicles as well as the mechanical condition of vehicle systems. For example, the investigation methodology included inspection of the following PTW parts;

- Drive line (sprockets and chain)
- Front and rear suspension
- Front and rear brakes
- Steering adjustment
- Cable conditions
- Front and rear indicators
- Mirrors
- Front and rear wheel axles
- Wheels and tyres

Additionally, a text-box available in the database in which the investigator could describe any mechanical failure together with potential cause of failure found during the inspection.

As expected, the technical defects are limited. They can be localized to brakes, tyres, sprockets, brake lights and indicators. There was also no relation found between mandatory inspection and general condition of the vehicle. However poor condition and some of the identified defects are related, even though the sample was very low to draw statistically strong conclusions. For example, there were two cases of poor vehicle condition with a loose steering stem adjustment. Also, poor condition is slightly associated with brake light and indicator defects. Again, the number of defects is very low for concrete results. With regard to mechanical failures described by the inspectors, excessive brake-pad wear, brake system defects, badly maintained suspension and worn out tyres were all listed in the database. Therefore, the main findings in this regard were as follows;

- In the majority of cases (80%), the condition of the PTW was found to be good or excellent; only 4% of vehicles were considered to be in poor condition (Figure 38).
- In 60% of vehicles, there was no reported mechanical problem in the free text field; only in 5% were defects listed (Figure 39).
- When looking at the condition of specific components of the PTW, there were only very isolated few cases where the sprockets, chain, throttle, clutch and brake levers were badly worn or had failed entirely (Figure 40, Figure 41).
- Similarly, the wheel and tyres were generally in good condition, with defects being present in only 2-5% of examined vehicles; however this does not imply the defect contributed to the accident (Figure 41).
- A suspension oil leakage was found in 9% of vehicles, but again this does not imply it is a contributory factor in the accident (Figure 41).

Bicycle

The database contains 132 bicycle elements coded and available for analysis. Of these, 117 are manual bicycles and 15 are e-bikes. This section presents results for manual bicycles only.

The mechanical examination for bicycles was less in depth than for PTWs, primarily because bicycles have fewer components. However, similarly to PTWs, various components were examined for vehicle defects, including; gear and gear cables, front and rear brakes and cables, wheels and tyres, overall condition.

In general, for bicycles mechanical defects were limited; when found they were most frequently associated with the tyre condition, specifically a worn tread on the tyre (11%-12% of bicycles) (Figure 44). The overall condition of the bicycle was described as good or excellent in 72% of cases (Figure 43).

Part 5: Infrastructure / Environmental Factors Analysis

The analysis was carried out on 725 roads across 500 cases. This included 548 roads that involved PTW accidents, and 176 roads that involved bicycle accidents. For this section, analysis was done on a mixture of "accident" and "road" level.

- Around half (52%) of PTW accidents occurred in residential areas and 29% in commercial areas. Bicycle accidents were evident in a higher proportion of commercial areas (42%), and less in residential areas (39%). In all accidents there was a low proportion in Industrial areas (Figure 45).
- Both PTW and bicycle accidents tended to occur during daylight hours (respectively 78% and 81%) (Figure 46).
- Most of the accidents occurred under fine dry conditions, with rain, snow or fog being present in less than 10% of cases (Figure 47).
- High winds (>10m/s) were present in 22% of cases, although this was not necessarily a factor as to why the accident occurred (Figure 47).
- Half of accidents occurred in local roads, specifically 50% of roads for all accidents and 52% of accidents where PTWs were involved were local roads. A comparatively large share of bicycle accidents occurred in collector roads (34%). Only a quarter of accidents (25%) occurred on principle or secondary arterial roads (Figure 48).
- As expected given the result above, most of the accidents occurred on roads with a speed limit of 50km/h or less (79%) (Figure 49).
- Half of accidents (50%) did not occur at or within 20m of junctions; when an accident did occur at a junction, it was most frequently at a T or Y junction (23%) or crossroads (21%). Bicycle accidents occurred at junctions more often than PTW accidents (Figure 50).
- In total 82/500 cases occurred where road barriers are present, in 10 of these cases, the PTW rider collided with the barrier (2% of all cases). When a road barrier wasstruck, the injury outcome was fatal (7/10) or serious (3/10).

Part 6: E-Bike Analysis

The database contains 14 cases involving E-Bikes. Due to the small sample size, it is not robust to derive absolute conclusions from the distribution of these accidents, however some of the main characteristics are described below.

- 11 out of the 14 E-bike accidents have occurred in the Netherlands, which were serious in injury severity. The remaining 3 accidents, which occurred in France, Poland and the UK, resulted in slight injuries (Figure 51).
- 6 of the accidents involved only E-bikes or bicycles, 8 involved a collision with another motorised vehicle (Figure 52).
- Just under two thirds of E-bike accidents occurred at junctions (64%), which is relatively higher compared with all accidents. Similarly to all accidents, E-bike accidents most mostly occurred in urban environments, in either residential or commercial areas, and during the day under dry fine conditions.

Discussion

The SaferWheels study was conducted with the intention of developing a database of aggregated data relating to PTW and bicycle accidents within the European Union.

The objective of the study was to gather PTW and bicycle accident data from in-depth crash investigations, obtain accident causation and medical data for those crashes, and to store the information according to an appropriate and efficient protocol enabling an accident causation-oriented analysis.

Many of the past research projects in this area have raised issues concerning better understanding of the causation of accidents involving powered two-wheelers and bicycles. Relevant accident causation factors that have been identified include: speed, alcohol, filtering between lanes, vehicle defects, conspicuity/reflectivity/visibility of the vehicle and its rider, protective equipment, experience – riding, with licence, roadside barriers, road marking and grip/slippage.

However, there is a paucity of research relating to more recent motorcycle and bicycle crashes. The SaferWheels study therefore developed more recent knowledge relating to factors associated with such accidents. The data analysis supports the view that common factors such as speed, alcohol, distraction and 'look but failed to see' accidents were the most prevalent factors in the SaferWheels study. The following sections therefore discuss these factors based on analysis of the aggregated data.

However, whilst analysis of aggregated data based on keyword search (including 'illegal manoeuvres', 'licencing', 'red-light running') did reveal anecdotal cases where such factors were prevalent, these were few in number compared to the main factors above. Further analysis of the circumstances of such accidents on a case-by-case basis might be of benefit.

Human Factors

Speed

Several results of this study confirm the results of previous studies on PTW accidents. In the current study, speed was a contributing factor for 22% of PTW riders.

Where speed was determined to be a contributory factor to the accident (i.e. in 86/394 riders) in the majority of these cases the PTW was riding above the legal speed limit for the road. For **bicycle riders**, in the vast majority of cases **speed was not contributory to the accident,** only 7% of riders were found to be speeding. In the majority of accidents the speed of the other road-user was not seen as contributory to the accident (contributory for only 4% of other vehicle drivers).

Speed as a factor was also analysed in the RIDERSCAN project due to the future development of PTW accident prediction models. Furthermore, according to the MAIDS results there were relatively few cases in which excess speed was an issue related to accident causation. A difference in speed compared to the surrounding traffic was identified as a contributing factor for PTWs in 18% of all cases and a contributing factor for the OV (other vehicle) in 4.8% of all cases.

Riding Between Lanes

Riding 'between lanes' was not found to be a factor in the SaferWheels study. This is in line with the findings of the MAIDS study in which both longitudinal and lateral motion was a very slight problem in terms of accident causation (only 3 crashes from 921).

Gender of Cyclists

In the SaferWheels study, the PTW accident sample was dominated by males, with 89% of PTW riders being male. This was slightly different to the data relating to cyclists where 67% of the sample of cyclists were male. Previous research has found that males are more likely to be involved in a cycling accident (Bíla, et al. 2010; Beck, et al. 2016) probably because of greater use of cyclists by males versus females. Furthermore, men are more likely to sustain a fatal injury in comparison to women. In terms of the age of cyclists, the likelihood of being involved in a fatal cycling accident increases with age, probably because of frailty (Bíla, et al. 2010).

Use of Protective Equipment

PTW Rider Helmet Use

Helmet-use was examined specifically for PTW riders in SaferWheels. While most riders seem to recognise the value of using helmets (81%), a non-negligible percentage did not (15%), hinting at margins for awareness-raising for safety equipment. When excluding unknown cases, helmets did stay on during the majority of accidents, proving the high value of their effectiveness.

Haworth and Debnath (2013) found that motorcyclists were more likely to wear a helmet in comparison to cyclists, probably because of legislation. Dubos, et al. (2016) found that when the helmet was worn properly and fastened, it remained on the motorcyclist after impact in 87% of cases. However, in 13% of instances, the helmet did not remain on the rider after impact. When the helmet was worn but not properly fastened, the helmet stayed on the head after impact in 4% of cases. In 96% of cases, the helmet became detached from the head after impact. Collectively, these figures highlight the importance of wearing and correctly fastening a helmet when riding a motorcycle. Other research has found that wearing a helmet can reduce injury severity amongst motorcyclists by 70% (WHO, 2006).

Cyclist Helmet Use

In SaferWheels, 32% of riders wore a helmet and had it fastened, a further 14% wore one but did not fasten it. However, 45% were not wearing one at all.

A bicycle helmet decreases the risk of severe head injury by more than 65%. This was the conclusion of the meta-analysis of Olivier & Creighton [38] (link is external), which included 40 case-control studies and compared the injuries of a total of 64,000 bicycle casualties who did or did not wear a bicycle helmet. However, the protective effect of the helmet gradually declines to a lesser extent as the impact speed exceeds the 20 km/h to a greater extent. Some studies show adverse effects of bicycle helmets on crash involvement. Due to 'behavioural adaptation' cyclists may feel safer wearing a bicycle helmet and as a result they may show more risky cycling behaviour. It is unclear what this could mean for the safety effects of helmet wearing; several studies contradict each other.

Robinson (2006) indicates that cyclists wearing a helmet show riskier cycling behaviour or encounter more risky driver behaviour. It is not clear to what extent this is actually the case in practice. The study by Robinson is too limited. Walker (2007) found that drivers showed more risky behaviour towards a cyclist wearing a helmet: when overtaking they were closer to the cyclist with a helmet than to the cyclist without a helmet. As a possible explanation he mentions that the driver sees helmeted cyclists as more skilled than cyclists not using a helmet, and therefore uses smaller safety margins. Phillips et al. (2011) found indications for (unsafe) behavioural adaptation by experienced helmet users: they experienced less risk while wearing a helmet and they cycled faster than when they did not wear a helmet during the same ride. Cycling with or without a helmet had no effect on the risk or cycling speed of inexperienced helmet users.

On the basis of a questionnaire study in Norway, Fyhri et al. (2012) conclude that cyclists do not show more risky cycling behaviour because of the helmet, but that the causal relationship is reversed: just because these cyclists tend to cycle in a risky manner, they use protective equipment such as the bicycle helmet. Other studies indicate that young helmet wearing cyclists take no additional risks (see Hagel et al., 2006). Elvik (2013) concludes that there is insufficient clarity on this subject.

Finally, bicycle helmets are occasionally assumed to increase the risk of neck injury (Elvik, 2013), but the meta-analysis by Olivier & Creighton (2016) found no evidence for this assumption (see also under the heading Do bicycle helmets protect against (fatal) head injury among cyclists?).

Mandatory helmet use will increase helmet use and will protect more cyclists against head and/or brain injury in a bicycle crash. Yet there is almost no support for mandatory helmet use in the Netherlands, not even from traffic organisations (Aarts et al., 2014b). For specific target groups that run a slightly more risk in traffic, such as children and the elderly, SWOV has made an estimate of possible injury reductions due to mandatory helmet use. SWOV expects that a mandatory bicycle helmet for young children (0-11 years) in the Netherlands can lead to annual savings of 5 deaths and 140 serious road injuries. Mandatory helmet use for older cyclists can lead to annual savings of 5 deaths and 220 serious road injuries (Aarts et al., 2014a).

A possible downside is that mandatory helmet use reduces bicycle use, which can be negative for public health. De Jong (2012) calculated that this outweighs the potential benefits of more bicycle safety. Sieg (2014) also concludes that bicycle helmet legislation for Germany leads to more costs than benefits. Newbold (2012), who extended the calculation model of De Jong, concludes that mandatory helmet use in the United States will indeed result in an improvement in public health.

Furthermore, Olivier et al. (2014; 2016) conclude that there is no convincing evidence that that bicycle helmet legislation would lead to less cycling. Berenbaum et al. (2015) conclude that there are mixed results about the effects of bicycle helmet legislation on bicycle use. Based on US data Kraemer (2016) concludes that helmet use among students increased due to mandatory helmet use, whereas the evidence on the effects on bicycle use was ambiguous.

Conspicuity/Reflectivity and Visibility

In the SaferWheels study, PTW rider use of reflective clothing was low overall with only 13% of riders using reflective clothing and 65% not wearing such clothing. Whether this was a factor in terms of accident causation could not be ascertained in the study. Again, there was some consistency with data from other studies. The 2-BE-SAFE project also recommended more visual conspicuity on PTW rider clothing. In the MAIDS study, one of the most frequent human errors was the low conspicuity of the PTW rider (due to dark clothing); in 3% of MAIDS cases visibility was limited by environmental conditions for both the PTW operator and the OV operator. Furthermore, 18.0% of the PTW riders and 20.5% of the OV operators caused accidents due to the stationary view obstructions (vegetation, parked vehicles) whereas mobile view obstructions (cars, trucks, buses) accounted for 9.5% of the PTW riders and 11.6% of the OV drivers.

Protective Equipment

In the SaferWheels study, use of protective equipment was not a factor in terms of crash causation but may have been a factor in injury causation although given the dynamic nature of crashes, injury causation is always difficult to determine. In the RIDERSCAN project a recommendation was to develop and test personal safety equipment whereas in the MOSAFIM project, better performance of such equipment (e.g. helmets, jackets, gloves, neck protectors, back protectors) was called for. More recent safety measures that have been introduced include jackets fitted with airbags and anti-lock braking systems. In future, the road infrastructure needs to be adapted for motorcyclist and cyclist use. Furthermore, car and truck modification, such as the requirement to have additional mirrors, could prove to be extremely effective in increasing cyclist visibility and reducing the number of VRU accidents (Constant & Lagarde, 2010).

Vehicle Factors

Vehicle Defects

Vehicle defects were not prevalent in the SaferWheels study. Vehicle defects were found in only 5% of PTWs and these did not necessarily contribute to the accident. The most common identified defects were tyres and brakes. Other defects were localized to brakes, tyres, sprockets, brake lights and indicators. However poor condition of the PTW and some of the identified defects were related in isolated cases even though the sample was very low to draw statistically strong conclusions. For example, there were two cases of poor vehicle condition with a loose steering stem adjustment. Also, poor condition was slightly associated with brake lights and indicators defects. However, again, the number of defects is very low for robust results. In terms of mechanical failures as described by the vehicle examiners, brake-pad excessive wear, brake system defects, badly maintained suspension and worn out tyres were all listed in the database, but these were rare occurrences overall.

The data from other studies shows some consistency with the data presented in the SaferWheels study. For example, PTW vehicle defects in MAIDS appeared in only 6% of all accidents, and within these, only 0.4% were considered to be contributory. Of the 6% defects, 3.7% of PTW defects were related to the tyre or wheel and most often this was reported as a tyre blowout or a tyre failure. There were 1.2% reported cases of brake problems.

Engine Capacity

In SaferWheels, over a third of the PTW sample (40%) consists of larger motorcycles (≥500cc). One fifth of the sample appears to be smaller mopeds or motorcycles (≤50cc) and over a quarter appears to be medium displacement models.

Clarke, et al. (2007) found a correlation between rider age and engine capacity. Generally, younger riders tended to have a PTW with an engine capacity of 100-250CC. Conversely, older riders tended to have a PTW with an engine capacity of >900CC. Piantini, et al. (2016) found that the largest percentage of PTWs involved in crashes had an engine capacity of 150cc or less.

Motor Power Modification

Motor Power Enhancement is defined as any modification to the vehicle that increases the horsepower (either coming from the factory as a non-original part or as an aftermarket part or as tuning by a technician).

In SaferWheels, after-market fitment of motor power enhancement modifications were observed in approximately 7% of PTWs. However, it should be added that as it is often difficult to clearly identify whether or not a PTW has been modified to increase power without an extensive dis-assembly of the PTW.

Motor Power Restriction in France

Based on the data analysis in SaferWheels, it can be concluded that motor power enhancement does not appear to be a significant issue in PTWs subject to the caveat regarding dis-assembly. However during the analysis process some related issues were identified which are discussed below.

Since the law of 5 July 1985, "Badinter law", any motorcycle with a power of more than 100 horsepower must be registered in France. This was aimed at reducing the mortality and accidents of PTWs. However, France, with this law, is a European and almost worldwide exception.

In 2012, the European Parliament put in place a regulation on the approval of vehicles, applicable from January, 1st, 2016. To meet these standards, motorcycles must be approved "Euro 4". The regulation allows motorcycles with a power of more than 100 horsepower to operate at their rated power.

Therefore, since January 1st, 2016, PTW users have been able to move freely on vehicles with a power of over 100 horsepower, under certain conditions.

Indeed the authorized PTWs are those meeting the standard "Euro 4"; in addition, these are equipped with an ABS system (anti-lock brakes).

Tuning of Light Mopeds

In the Netherlands, two types of mopeds exist: a moped with a speed limit of 45 km/h and a light moped with a speed limit of 25 km/h. The light moped is similar to the Mofa that is also common in Germany, Belgium and Denmark. However, contrary to regulations in other countries, light moped riders in the Netherlands are not obliged to wear a helmet. The absence of the obligation to wear a helmet, in combination with the introduction of the scooter model and traffic congestion is one of the reasons why Mofas have become more and more popular in the Netherlands. However, many riders prefer to ride faster than the speed limit of 25 km/h. Unfortunately, modification of the maximum speed of a light moped is very easy, especially in case of scooters, as these vehicles are often build as moped scooters or even motor scooters and then tuned down to light mopeds. Instructions and vehicle parts for increasing the maximum speed of a light moped scooter are widely available on the internet and retailers also openly offer to increase the maximum speed. In a Dutch in-depth study on light moped accidents it was found that 55% of the examined light mopeds could ride faster than the legal speed limit (Davidse et al., 2017). Maximum speed varied between 25 and 58 km/h. Studies by Møller & Haustein (2016) and Kühn et al. (2013) show that tuning of light mopeds is also common in Denmark and Germany. In the Danish study it was found that 40% of the light mopeds involved in the investigated crashes of 16- and 17-year old light moped riders was tuned (Møller & Haustein, 2016). The German study reports a share of 14% (Kühn et al., 2013).

Road Environment Factors

Barriers

In 16% of cases there was a road barrier present. In 10 of these cases, the PTW rider collided with the barrier (2% of all cases). When a collision occurred with a road barrier, the injury outcome was Fatal (7/10) or Serious (3/10). However, the positive effects of barriers in terms of reducing head-on/crossover collisions, should be considered.

The MAIDS project concluded that roadside barriers (reducing the severity of off-road environmental collisions and avoiding collisions with opposing traffic at motorways) work quite effectively for passenger cars, but that they present significant obstacles when struck by the PTW rider. 60 cases were analysed in which there was contact between PTW riders and barriers. In 12 of these, injuries were to the head and in eight of these cases, head injuries were categorised as severe or higher (e.g., AIS >3). One quarter of the injuries were found to be to the lower extremities and the majority of these lower extremity injuries were found to be minor and moderate in severity (e.g., abrasions, minor lacerations and contusions). Therefore a more in-depth investigation of the effectiveness of roadside barriers for PTW riders may be required.

Accident Location

In Saferwheels, the vast majority of accidents occurred in residential and commercial environments (81% combined), in primarily urban areas (79%).

Previous studies have found patterns in relation to accident location and motorcycle type. For example, heavy motorcycles tend to crash in more rural areas whereas light motorcycles are more likely to have an accident in urban environments (Dubos, et al. 2016). Møller & Haustein (2016) found that a larger number of fatal motorcycle accidents occurred in urban areas and involved multiple vehicles.

Time of Day

Several studies have found that PTW and pedal bike accidents have a tendency to take place during the day in clear weather conditions (Piantini, et al., 2016; Beck, et al., 2016; Bíla, et al., 2010). This finding was directly repeated in the SaferWheels study.

Speed Limit

In SaferWheels, the vast majority of PTW accidents occurred on roads with a speed limit of 50km/h or less. The majority of PTW accidents analysed in the literature took place in 50km/h zones and often involved a right of way violation. If the accident occurred in a 100km/h area, this usually took place on a bend (Clarke, et al., 2007). In a large number of motorcycle accidents, the speed limit was exceeded (Dubos, et al. 2016; Møller & Haustein, 2016.)

Crash Configurations

The three most common accident scenarios for fatally and seriously injured PTW riders were (1) scenarios where the opponent vehicle was turning left and the PTW was going straight and was coming from the opposite direction; (2) crossing scenario where the PTW was perpendicularly coming from the right side of the opponent vehicle; and (3) single vehicle accidents. Of these, 64% lost control of their motorbike on a curve/bend. In total, 25% of fatally and seriously injured PTW riders were involved in single-vehicle accidents.

In SaferWheels, several accident scenarios were determined. However, as with previous studies, junction accidents were quite prevalent in PTW accidents with 50% of accidents occurring at a junction (either crossroads, roundabout or T-junction).

Single PTW rider accidents tend involve the PTW leaving the road on a bend. For accidents involving multiple vehicles, research has found that a common crash configuration involves two vehicles travelling along a road in opposite directions. The PTW will either turn right in front of the oncoming car or vice versa (Dubos, et al., 2016). Clarke, et al. (2007) found that the majority of right of way violations tend to occur at T junctions and the motorcyclist is not usually at fault. Fredriksson & Sui (2015) found that the largest percentage of accidents involved the PTW losing control or an oncoming vehicle turning or overtaking. With regards to pedal bikes and PTWs, previous research has found that these vehicles were most likely to crash at an intersection when another vehicle was travelling from an adjacent road (Haworth & Debnath, 2013).

In relation to pedal bike accidents, the most common impact partner in multi-vehicle crashes tended to be a motor vehicle or another cyclist. The most common crash configurations were found to involve a motor vehicle and a cyclist travelling in opposite directions, a motor vehicle and a cyclist approaching an intersection from adjacent approaches or both vehicles travelling in the same direction (Beck, et al. 2016).

In summary, the main causation factors identified in the study include excessive speed (contributing to 22% of PTW accidents), distraction (contributing to 10% of PTW accidents and 16% of bicycle accidents), impairments (contribution to 9% of PTW accident and 6% of bicycle accidents), risk-taking behaviour (contributing to 5% of PTW and bicycle accidents) and rider inexperience (contributing to 13% of PTW accidents) were the main human factors responsible for accidents. Vehicle factors and road infrastructure factors, although evident in the data at an anecdotal level did not appear to be significant. The scenario analysis undertaken suggests that fatally and seriously injured PTW riders are prone to accidents in three common accident scenarios, (1) where the opponent vehicle was turning left and the PTW was going straight having travelled from the opposite direction; (2) crossing scenario where the PTW was perpendicularly coming from the right side of the opponent vehicle; and (3) single vehicle accidents where the PTW rider lost control of the vehicle (most commonly on a bend.) The scenario analysis in particular supports the view that in many cases, the PTW rider is not responsible for the accident.

However, whilst the aggregate data analysis reported here reveals some interesting findings regarding PTW and bicycle accidents, it should be remembered that such findings are based on aggregated analysis of data to look for trends in accident causation and accident involvement. There may be more that could be gained from an evaluation of each individual accident investigation on a case-study basis to derive more in-depth insight and elaboration into specific factors (some of which are evident in this report) that may be relevant. The next section proposes recommended measures based on the outcomes of the aggregated data analysis.

Recommended Measures

Overall Recommended Measures

1. Crashes involving powered two wheeled vehicles and pedal cycles remain common on European roads and coordinated strategies should be deployed to reduce fatalities and seriously injured casualties. A strategy based on the Safe System approach to road safety management is recommended that brings road user, infrastructure and vehicle measures together with a results-based framework.
2. Regular monitoring of the development of PTW and cycle safety should be conducted to identify the impact of changes in road safety policy, the introduction of specific measures, changes in vehicle design and regulation and changes in the user population. This requires an EU level initiative potentially coupled with support from Member states.
3. The results of the SaferWheels Study have validated the value of a coordinated approach to crash investigation and the development of in-depth collision data resources as is conducted on other continents. However, a significant resource cost is required when commencing a study with no pre-existing national investigation infrastructure and it is recommended that in-depth crash investigations in support of EU road safety policy are conducted on a routine basis across Member States. In many countries a significant proportion of seriously injured casualties are not included in police reporting systems. It is recommended future studies should take account of serious injury under-reporting and adopt appropriate case selection procedures.
4. PTW and cycle crashes are typically a result of several causation factors relating to the rider, other road users and their vehicles as well as infrastructure and other elements. There is no single measure that will prevent all crashes however system level measures such as compliance with speed and alcohol consumption limits, restrictions on mobile phone use by drivers and bicyclists as well as infrastructure design factors are expected to benefit all road users.

Recommended Measures - PTW

Rider Behaviour

1. PTW travel speeds prior to the crash were observed to be too high for the prevailing traffic in 22% of the collisions and 55% of crashes with speed as a contributory factor were fatal. The importance of maintaining travel speeds below legal limits is reinforced by the SaferWheels data and it is recommended that speed enforcement, technical measures, infrastructure improvements and training measures should be prioritised.
2. 16% of riders were identified not to be wearing a helmet. This number includes many moped riders in jurisdictions where helmet use is not mandatory. Nevertheless, the benefits of helmet use are clear with a reported 44% reduction in fatal head injuries[22] and therefore the data indicates that continued efforts to improve helmet use by PTW riders will be highly beneficial. Furthermore, measures to increase the use of protective clothing are recommended, riders in the sample rarely used specialist clothing yet the measures are recorded as reducing injuries by between 33% and 50%.
3. Common crash causation factors include errors in observation and planning by both PTW riders and the drivers of other vehicles. It is recommended that driver training include elements to improve the understanding and expectations that

[22] Elvik et al, Handbook of Road Safety Measures. 2009

drivers may have of PTWs, also that riders are trained to have a better understanding of driver perspectives and constraints.

4. More research is required to improve the knowledge of the factors behind drivers failing to recognise PTWs and to predict their trajectories. Further countermeasures are required to address this risk factor but improved conspicuity of riders is proposed as a relevant countermeasure.
5. Alcohol consumption by PTW riders was observed as a causation factor in only 2% of the SaferWheels crashes. The level in their collision partners was unknown. This is probably an underestimate of the true levels but nevertheless the very high crash risks associated with alcohol consumption support the recommendation that existing interventions should be reinforced and expanded.
6. Single vehicle, loss of control collisions are common amongst PTW crashes and form 25% of fatal and serious outcomes. While speed is probably a principal factor it is also recommended that dedicated measures, including vehicle based measures, are further developed. Anti-lock Braking Systems have been mandatory on European PTW with engine capacity over 125cc since 2016 and have been shown to reduce fatal crashes by 31% [23] The common occurrence of single vehicle crashes in the SaferWheels data supports the value of ABS and it is recommended the fitment be extended to PTWs with smaller capacity engines.
7. In some jurisdictions such as The Netherlands, riders of certain categories of PTW including mopeds, mofas and high-speed pedelecs were not required to wear helmets. It is recommended that the existing mandatory helmet use for motorcyclists should be extended to all PTW riders including light mopeds, mofas and pedelecs.
8. More research is required to look more closely at the specific manoeuvres undertaken by the PTW riders. Aggregated accident data do not reveal major specific issues relating to contributory factors and rider behaviour. However individual case-by-case analysis of each individual SaferWheels accident investigation report may allow determination of factors that are not evident in the aggregated data.

Vehicles

1. Vehicle defects were observed to be 4% of the total vehicles examined however the limitations of a visual-only inspection indicates this is a minimum level.
2. Speeding is common amongst PTW riders resulting in increased numbers of fatal and seriously injured casualties. Technical measures such as voluntary or mandatory Intelligent Speed Adaptation and speed alert systems have the potential to reduce speeds and systems have been developed suitable for PTWs. It is recommended that these systems should be further developed and evaluated along with other technical measures to support riders in maintaining appropriate speeds.
3. In the SaferWheels data 74% of PTW crashes occur in urban areas and 49% were at junctions, observation, detection and prediction errors are frequent. Technical measures that enable PTW riders and vehicle drivers to be aware of the presence of the other have the potential to reduce these collisions, but technologies are not yet sufficiently developed. It is recommended that appropriate technical systems be developed, taking advantage of the capabilities of communication technologies and best practice for human machine interface design.
4. 25% of fatal and seriously injured PTW riders were involved in single vehicle collisions and loss of control. Speed is a principal factor, but technical measures

[23] Effects of Antilock Braking Systems on Motorcycle Fatal Crash Rates: An Update, May 2013 Eric R. Teoh, Insurance Institute for Highway Safety

may also have potential to reduce injuries. It is recommended that vehicle based measures be developed, based on the best knowledge of risk homeostasis, that will mitigate the likelihood of single vehicle crashes.

5. The head, thorax and lower extremities are thought to be common sites of serious and fatal collisions (not demonstrated in SaferWheels). Helmets and protective clothing are known to mitigate injuries but other systems such as PTW-mounted airbags, airbag jackets and neck protection are available. The effectiveness and therefore benefits to riders are largely unevaluated however and it is recommended that further research be conducted to evaluate the benefits both experimentally, using biomechanical approaches, and in real-world collisions.

Infrastructure

1. The common occurrence of intersection collisions within the SaferWheels data and the frequent errors by riders and vehicle drivers indicates that infrastructure based technologies may have the capability to prevent collisions. It is recommended that Co-operative Intelligent Transport Systems be developed to enable road users to become aware of the approach and the presence of PTWs.
2. The highest proportion of PTW crashes occurred on local roads although collector and secondary arterial roads were also common. The SaferWheels project did not gather exposure data to enable risks to be assessed for each road type, however the data supported the findings of other studies that in many instances road designs did not fully take account of the needs of PTWs. The SaferWheels study supports the recommendations of other reviews that self-explaining roads, designed for all road user types, have the potential to reduce PTW collisions.

Recommended Measures - Bicycle Safety

1. The SaferWheels study has identified large numbers of cycle collisions that occurred on local or collector roads (69%), in 50kph zones (61%) and at junctions (56%). The data supports the results of other studies that demonstrate the benefits of infrastructure that is designed for cycle use. Specific factors found to contribute to this improvement (Schepers 2017[24]) include the establishment of a road hierarchy with large traffic-calmed areas where through traffic is kept out; a heavily used freeway network that shifts motor vehicles from streets with high cycling levels, therefore reducing exposure to high-speed motor vehicles; separated bicycle paths and intersection treatments that decrease the likelihood of bicycle–motor vehicle crashes. It is recommended that these infrastructure improvements be adopted widely to improve cycle safety.
2. Many of the cyclists in the study did not use a cycle helmet. Other studies (Olivier and Creighton[25]) have shown the use of helmets reduces brain injuries by more than 65% with reducing effectiveness above 20km/h impact speeds. While some studies have suggested the possibility of associated increases in risky behaviour with helmet use the evidence is inconclusive. Other studies of mandatory helmet use have suggested that total cycling may be reduced resulting in an overall dis-benefits from the combination of crash risks and health benefits. With only one European study on the effectiveness of mandatory helmet use and with weaknesses in other studies of changes in cycle use it is recommended that the use of cycle helmets should be strongly actively promoted. Also, the disaggregated

[24] P. Schepers, D. Twisk, E. Fishman, A. Fyhri, A. Jensen. The Dutch road to a high level of cycling safety, Safety Science 92 (2017) 264–273. http://dx.doi.org/10.1016/j.ssci.2015.06.005

[25] Olivier, J., Creighton, P. Bicycle injuries and helmet use: a systematic review and meta-analysis. International Journal of Epidemiology, Volume 46, Issue 1, 1 February 2017, Pages 278–292, https://doi.org/10.1093/ije/dyw153

risks and benefits of cycling should be more closely analysed with a view to mandating helmet use.
3. The SaferWheels study included investigations of 118 cycle crashes according to the required sample plan, this relatively small number limits the conclusions that can be drawn from the sample and it is recommended that a further study be made involving larger numbers (>500) cyclists.
4. Many of the wider road safety measures that address speeding, alcohol and other systemic risks will benefit all road users. It is recommended that emphasis be maintained on reducing these systemic risks in order to also reduce risks to cyclists.
5. Previous studies (eg Elvik 2017) [26] have shown a "safety in numbers" effect for cyclists whereby the numbers of cycle accidents increases less than proportionally to increasing exposure. This factor is one that indicates the desirability to increase cycling generally nevertheless it does not support a rationale that the current levels of collision risk for cyclists should not be reduced. The SaferWheels study has presented some information about cyclist accident causation and risk factors and has indicated that existing risks must be further reduced. It is recommended that the reduction of cyclist risks remain a priority area despite health benefits of increased cycling.
6. Only 16 pedelec and speed pedelec collisions were investigated for this sample and therefore firm conclusions over crash causation factors cannot be made. It is recommended that further investigations of the causes of crashes involving this rapidly increasing group of vehicle types be made to identify specific countermeasures that may be required.

Priority recommendations

1. Widespread implementation of infrastructure, including intersections, designed for cycle use. *(cycle safety 1, PTW infrastructure 1)*
2. Elimination of speeding behaviour of all road users including PTW riders *(PTW rider behaviour 1)*
3. Improved intersection safety for PTW riders and cyclists *(PTW infrastructure 3)*
4. Active promotion of the use of cycle helmets and mandatory helmet use for all PTW and bicycle riders including mopeds, light mopeds, pedelecs and speed pedelecs. *(PTW rider behaviour 2, cycle safety 2)*
5. Routine monitoring at in-depth level of the developments of PTW and cycle safety in the EU *(Overall recommendations 2)*

[26] Rune Elvik, Torkel Bjørnskau, Safety-in-numbers: A systematic review and meta-analysis of evidence. Safety Science 92 (2017) 274–282

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Annex 1 - Analysis - Tables and Figures

The overview analysis is based on 500 published accident 'cases'. More than 500 PTWs/bicycles may have been examined within the study overall since it was possible that a case involved multiple PTWs and/or an accident between a PTW and a bicycle.

Part 1: Overview of the Data

In total 500 cases were collected across the six data collection teams, with an average of 83 cases per team. The graphs and tables in this section, and the sections following, describe these cases in more detail.

Table 5: Contribution of each data collection team to total database sample, by severity

Team	Not Injured	Slight	Serious	Fatal	Unknown	Total
France	1	43	32	7	3	**86**
Greece	5	63	4	13		**85**
Italy	16			2	57	**75**
The Netherlands	1		84	1	1	**87**
Poland		59	19	7	2	**87**
United Kingdom		16	10	54		**80**
Total	**23**	**181**	**149**	**84**	**63**	**500**

Due to data collection procedures, some teams relied more on using police notifications and incident reports and hence collected a larger proportion of serious and fatal accidents. This does not reflect the true severity distribution of accidents that occur in those regions but is a result of the difficulties encountered in collecting in depth accident data. The overall distribution of the 500 cases comprises 36% slight injuries, and 47% serious or fatal injuries, with the remainder being no injury or unknown severity.

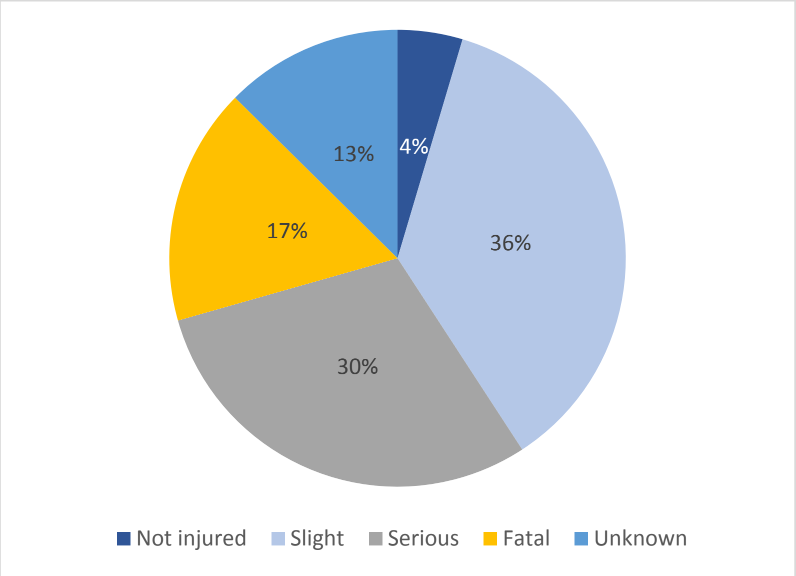


Figure 11: Distribution of cases across injury severity (n=500)

The 500 collected cases resulted in a total of 514 "case" vehicles, as there were some cases that involved multiple PTWs or bicycles, or involved a PTW and a bicycle and so can be considered both a PTW accident and a bicycle accident for analysis purposes. The distribution of PTW, bicycle and E-bike accidents can be seen below; in total 77% of the 500 accidents involved a PTW and 26% involved a bicycle or E-bike.

Table 6: Contribution of each data collection team to total database sample, by two-wheeler type

Team	PTW Cases	Bicycle Cases	e-Bike Cases	Total
France	81	4	1	86
Greece	78	7		85
Italy	71	4		75
The Netherlands	57	32	11	100*
Poland	48	40	1	89*
United Kingdom	50	29	1	80
Total	385	116	14	515*

*Greater than the total case number as some cases involve PTWs and Bicycles

The distribution of injury severity for the different vehicle types is shown in the table and figure below. For bicycles the collected data contains a higher proportion of slight and serious accidents compared to PTW accidents, whereas the PTW data has a slightly higher proportion of fatal accidents compared with bicycle accidents. This could be due to sampling and data collection methods, but may indicate the cyclists are involved in relatively lower severity accidents than PTW riders.

Table 7: Injury severity of all accidents and cases involving PTWs, bicycles or E-bikes

Vehicle Type	Not Injured	Slight	Serious	Fatal	Unknown	Total
All Cases	23	181	149	84	63	500
PTW Cases	22	134	103	69	57	385
Bicycle Cases	1	46	48	15	6	116
E-Bike Cases	0	3	11	0	0	14

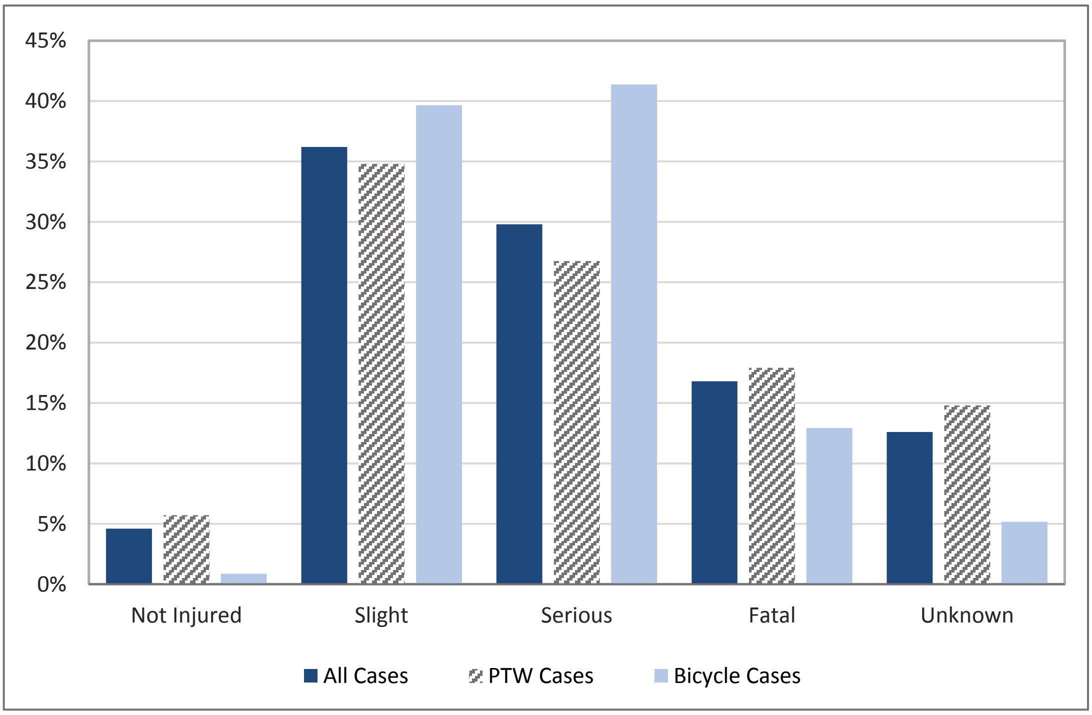


Figure 12: Distribution of injury severity across all cases and cases involving PTWs or Bicycles

The figure below shows that most PTW and bicycle accidents occur mainly in the period from May to September. This is expected considering the relatively good weather in that period of time during which two-wheelers are used, and perhaps increased exposure due to tourism, especially in countries such as Greece and Italy.

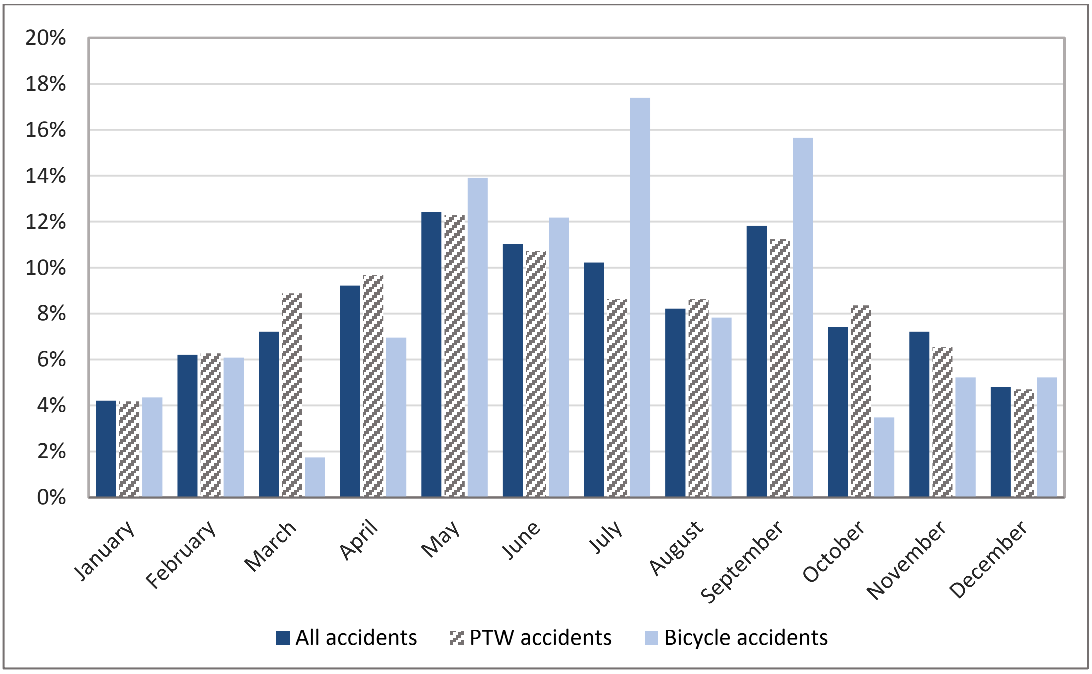


Figure 13: Distribution of month of the year of accident occurrence

Regarding the day of the week, it can be observed that the majority of accidents (total, PTW, bicycles) occur in working days (Mon-Fri) as expected perhaps due to the higher number of trips and traffic flow observed in road networks.

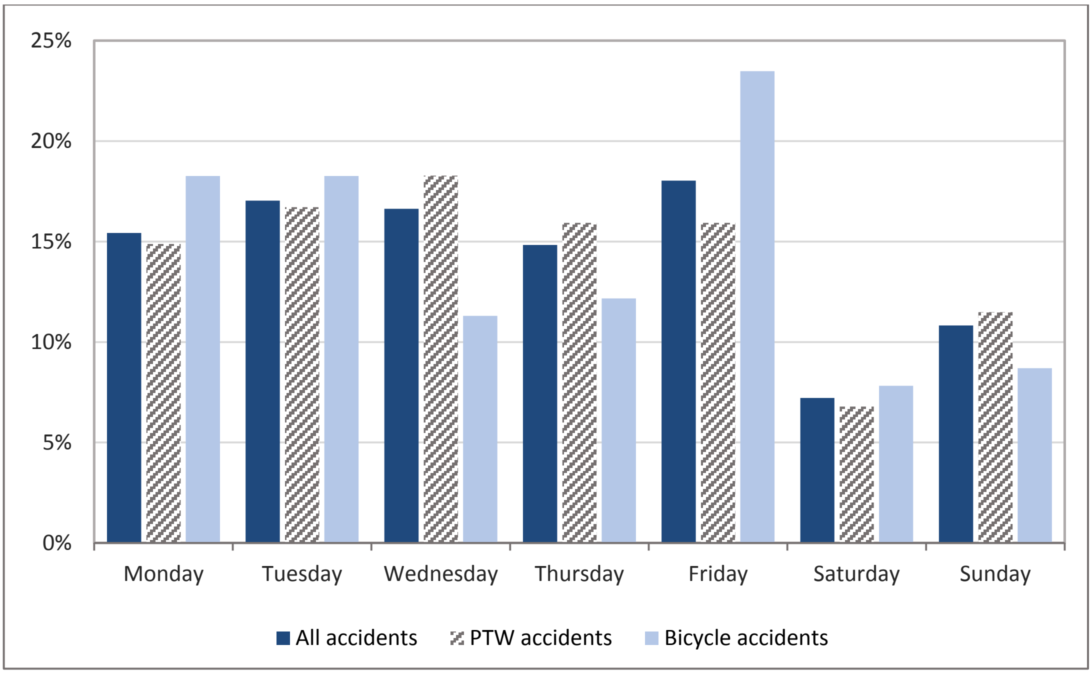


Figure 14: Distribution of day of the week of accident occurrence

The proportion of accidents that occur within the day seems to follow a circa normal distribution which indicates that between 20:00 and 06:00 the least amount of accidents occur.

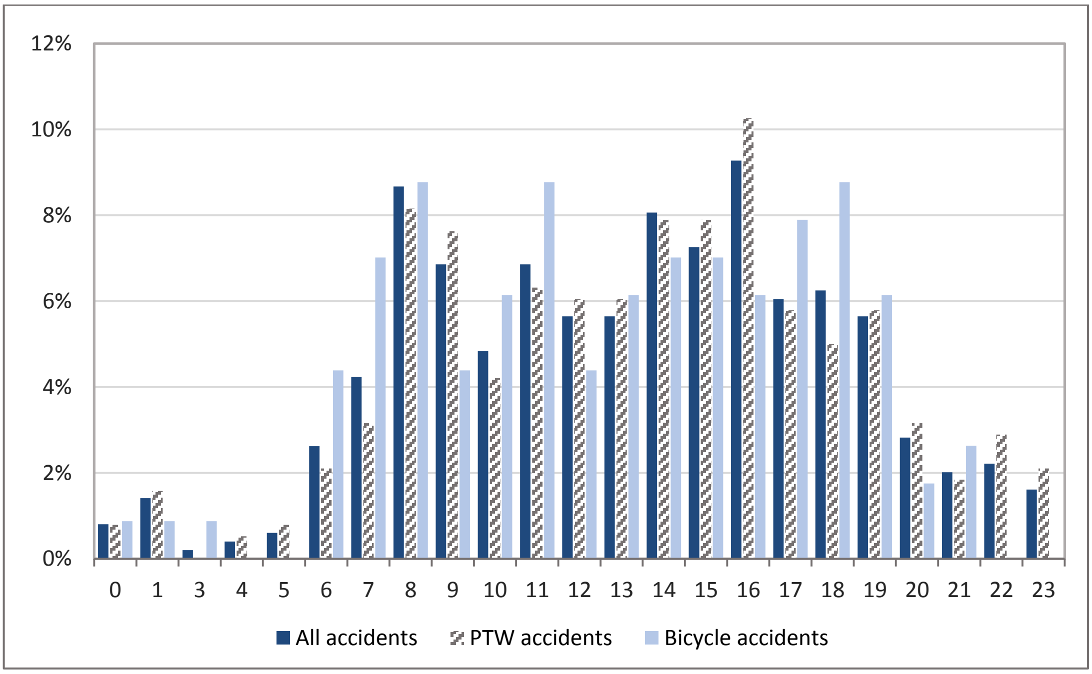


Figure 15: Distribution of time of accident occurrence

Cluster Analysis

The method of cluster analysis that was chosen was the Two Step Cluster Analysis. This method of clustering is most appropriate for very large data files and it can produce solutions based on both continuous and categorical variables. The clustering criterion (in this case the BIC - Bayesian Information Criterion) is computed for each potential number of clusters. Smaller values of the BIC indicate better clustering outcome. Also, a satisfactory solution should have a large ratio of BIC Changes and a large ratio of distance measures.

Cluster Distribution

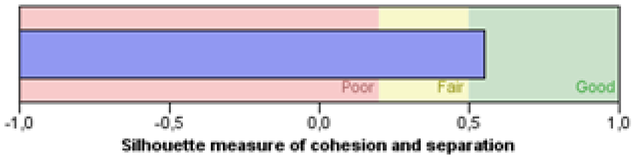
		N	% of Combined	% of Total
Cluster	1	398	80.1%	79.6%
	2	99	19.9%	19.8%
	Combined	497	100.0%	99.4%
Excluded Cases		3		.6%
Total		500		100.0%

It can be observed that 2 clusters were produced. The first cluster involves 398 while the second 99. The overall model quality is considered good.

Model Summary

Algorithm	TwoStep
Inputs	5
Clusters	2

Cluster Quality



Cluster Characteristics

country

		Frequency						Percent					
		France	Greece	Italy	Netherlands	Poland	United Kingdom	France	Greece	Italy	Netherlands	Poland	United Kingdom
Cluster	1	83	79	75	4	87	70	96.5%	96.3%	100.0%	4.6%	100.0%	87.5%
	2	3	3	0	83	0	10	3.5%	3.7%	0.0%	95.4%	0.0%	12.5%
	Combined	86	82	75	87	87	80	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%

accident_strong_wind

		No		10-15m/s		15-20 m/s		20-25 m/s		25+ m/s		Unknown		514		NA	
		Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent
Cluster	1	327	89.3%	23	36.5%	15	57.7%	11	73.3%	2	100.0%	17	85.0%	1	50.0%	2	66.7%
	2	39	10.7%	40	63.5%	11	42.3%	4	26.7%	0	0.0%	3	15.0%	1	50.0%	1	33.3%
	Combined	366	100.0%	63	100.0%	26	100.0%	15	100.0%	2	100.0%	20	100.0%	2	100.0%	3	100.0%

drug_involvement

		No		Yes		Unknown		Suspected	
		Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent
Cluster	1	384	100.0%	12	100.0%	2	2.0%	0	0.0%
	2	0	0.0%	0	0.0%	98	98.0%	1	100.0%
	Combined	384	100.0%	12	100.0%	100	100.0%	1	100.0%

light_condition

		Daylight		Twilight		Darkness		Electric light		with electric light		Other		NA	
		Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent
Cluster	1	319	81.0%	18	85.7%	17	85.0%	42	77.8%	0	0.0%	0	0.0%	2	66.7%
	2	75	19.0%	3	14.3%	3	15.0%	12	22.2%	1	100.0%	4	100.0%	1	33.3%
	Combined	394	100.0%	21	100.0%	20	100.0%	54	100.0%	1	100.0%	4	100.0%	3	100.0%

alcohol_involvement

		No		Yes		Unknown		Suspected		Not Applicable		Other	
		Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	Percent
Cluster	1	368	98.4%	27	87.1%	0	0.0%	1	33.3%	1	100.0%	1	33.3%
	2	6	1.6%	4	12.9%	85	100.0%	2	66.7%	0	0.0%	2	66.7%
	Combined	374	100.0%	31	100.0%	85	100.0%	3	100.0%	1	100.0%	3	100.0%

vehicle_type * TwoStep Cluster Number Crosstabulation

Count

		TwoStep Cluster Number		Total
		1	2	
vehicle_type	Bicycle	90	37	127
	NA	5	0	5
	ptw	303	62	365
Total		398	99	497

Cluster Profiles

Cluster 1 "No wind, no drugs, lighting": This cluster mainly consists of cases of all countries except for Netherlands (UK, France, Italy, Greece and Poland). Moreover, 327 out of 398 cases concern no windy conditions at all. Similarly, 384 cases involve no drug involvement. Despite the fact that 368 cases out of 398 regard no alcohol involvement, it is interesting that almost all alcohol involvement cases are also included in that group. Finally, the vast majority of cases of this group include some type of lighting conditions, either natural (daylight, twilight) or artificial (electric light).

Cluster 2 "Windy, lighting, unknown DUI condition": This cluster mainly consists of Netherlands and some UK cases. Moreover, 55 out of 99 cases concern mild or strong windy conditions. However, no information is known about DUI conditions (alcohol or drugs) Finally, the vast majority of cases of this group include some type of lighting conditions, either natural (daylight, twilight) or artificial (electric light).

Part 2: Accident Scenario Analysis

The accident scenario analysis is contained within the main text of the report.

Part 3: Driver / Rider Analysis

The database contains 1012 road users, of which 917 are drivers or riders of the vehicle. A further 74 road users are passengers in vehicles, and 21 are pedestrians.

The analysis sample currently includes 394 PTW riders, 132 riders of bicycles, and 391 "other interacting road users (OIRUs)" (drivers of car/van/truck/bus/other). Passengers and pedestrians have been excluded from analyses unless otherwise specified.

Sample Characteristics

Table 8: Age distribution of all road users, PTW riders and bicycle riders

Age Band	All Road Users	PTW Riders	Bicycle Riders
0-17	60	18	19
18-25	169	87	13
26-35	199	99	13
36-45	175	76	16
46-55	148	60	26
56-65	117	35	25
>65	72	15	20
Unknown	72	4	
Total	**1012**	**394**	**132**

From the below figure some useful information can be perceived: PTWs seem to be used more often by younger people, as the respective percentages drop when rider ages increase. Furthermore, it would seem that males dominate PTW ridership as opposed to females across all ages, and especially at the oldest rider group.

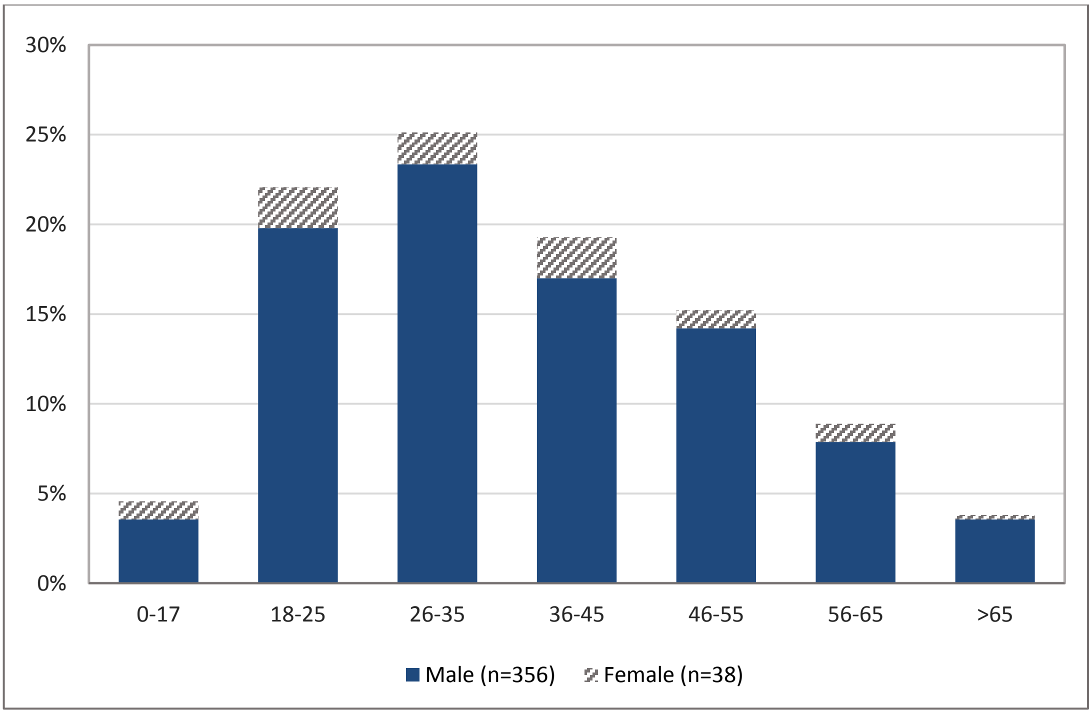


Figure 16: Age and Gender distribution of PTW riders (excluding age unknown)

The below figure indicates that regarding bicycles, the highest rider percentages are observed to belong to the age groups of 46-55 and 56-65. The relative proportion of age groups can be said to almost supplement those of PTWs inversely, indicating a shift from PTW to bicycle for people of very young and then older ages.

In all age groups, female riders are outnumbered by males, however the difference between the two genders is not as pronounced as in the PTW ridership.

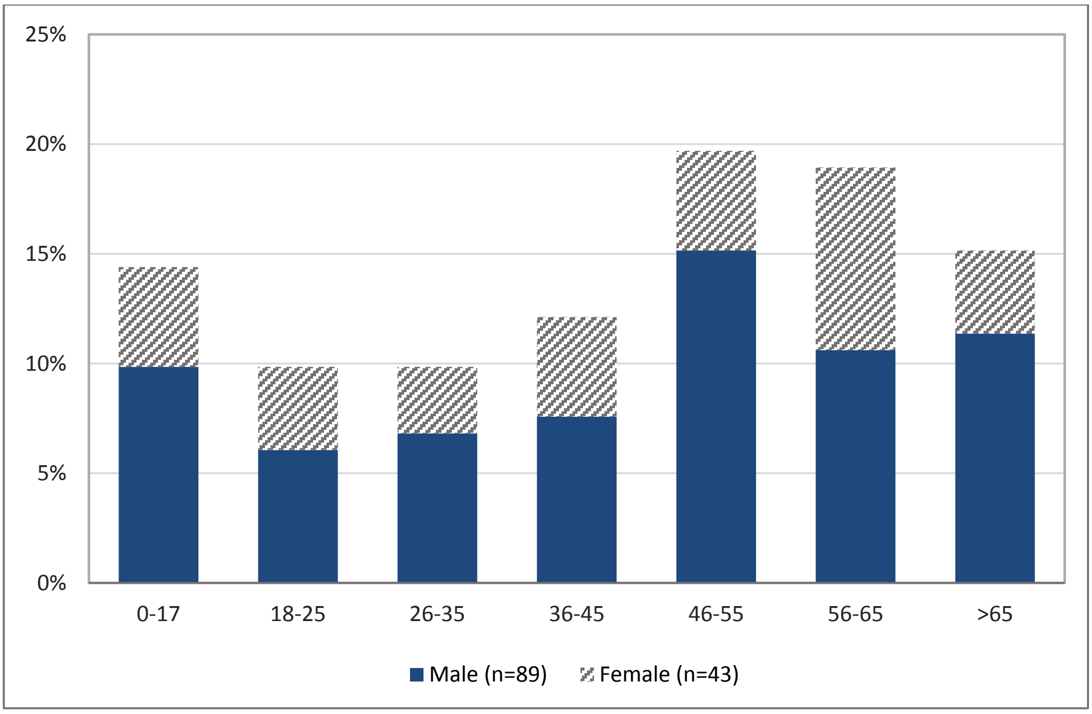


Figure 17: Age and Gender distribution of Bicycle riders (excluding age unknown)

It appears that the majority of two-wheeler interactions are with cars. This figure can be considered to follow the overall trends of traffic composition found in more urban settings, where two wheelers are more common.

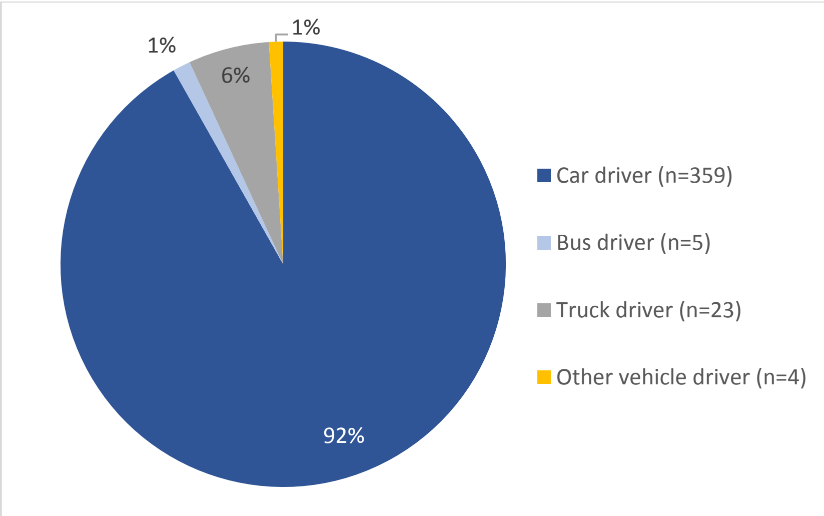
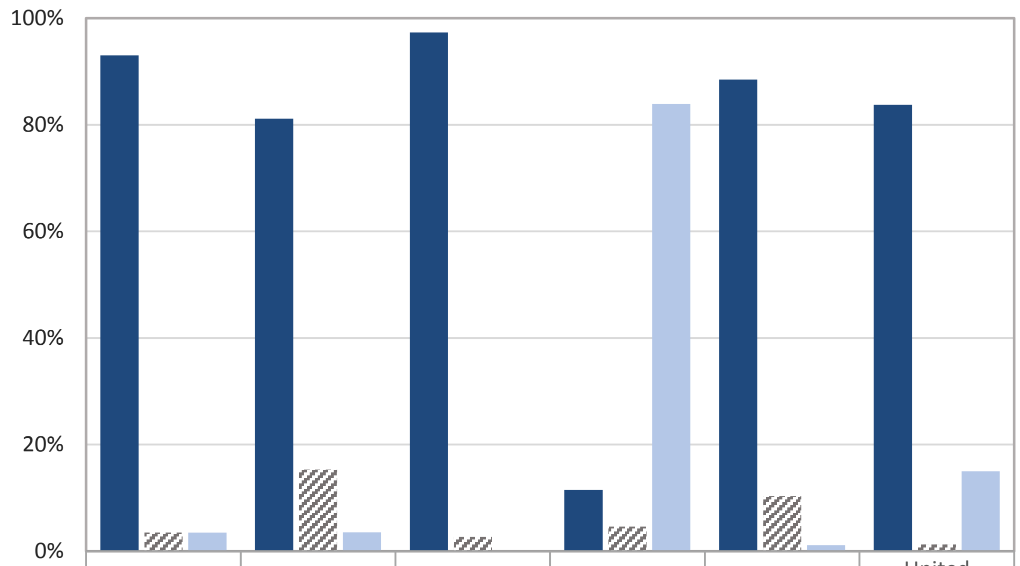


Figure 18: Distribution of interacting road user type

Contributory Factors

The vast majority of accidents have occurred without any alcohol involvement of drivers. It should be noted that, unfortunately, most of the accidents in the Netherlands (84%) have missing information. Moreover, Greece and Poland have the highest alcohol involvement proportions, namely 15% and 10% respectively.



	France	Greece	Italy	Netherlands	Poland	United Kingdom
No	93%	81%	97%	11%	89%	84%
Yes	3%	15%	3%	5%	10%	1%
Unknown	3%	4%	0%	84%	1%	15%

Figure 19: Distribution of alcohol involvement in the accident across countries (n=500)

Alcohol and drug involvement can also be examined on a road user level. The relative proportions of alcohol and drug involvement of PTW riders, bicycle riders, and interacting road users can be seen below. Two wheeler riders showed a relatively higher incidence of alcohol or drug involvement compared to the interacting road users, though overall the proportion of riders that were intoxicated was very low.

Table 9: Intoxication of PTW and Bicycle riders and Other Interacting Road Users

INTOXICANTS		PTW Riders	%age	Bicycle Riders	%age	OIRUs	%age
Alcohol	No	342	87%	112	85%	344	88%
	Yes	16	4%	8	6%	6	2%
	Unk	36	9%	12	9%	41	10%
Narcotics	No	357	91%	122	92%	356	91%
	Yes	12	3%	2	2%	2	1%
	Unk	25	6%	8	6%	33	8%

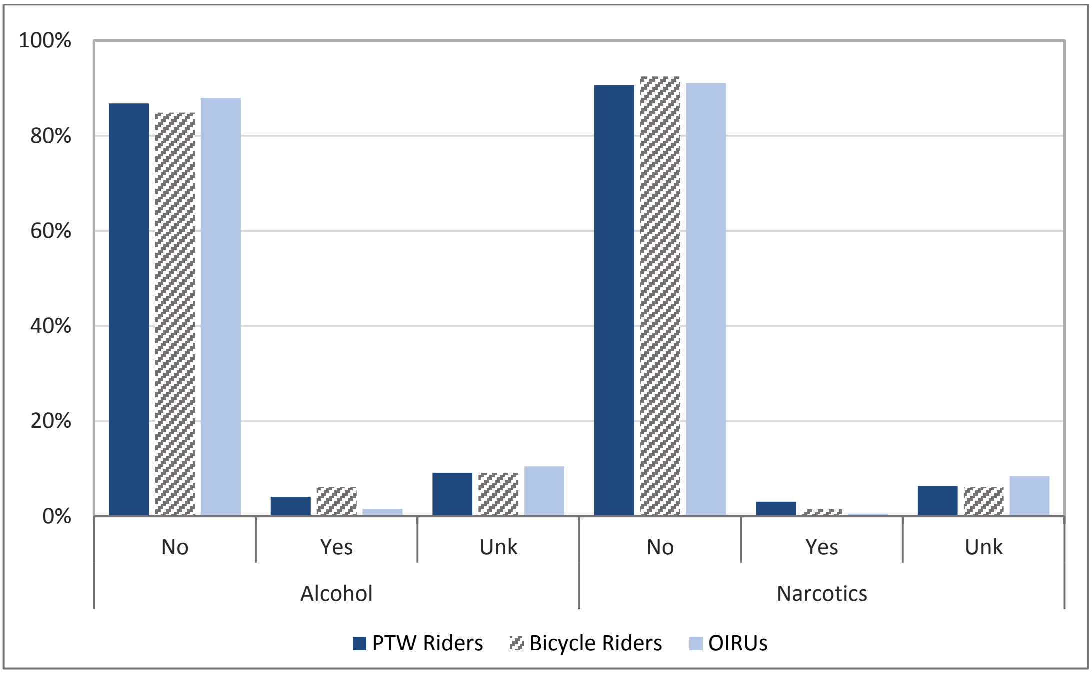


Figure 20: Alcohol and Drug use of PTW and Bicycle riders and Other Interacting Road Users

Speeding is one of the most critical contributions for accident occurrence and severity. The figures below depict speeding contributions for PTW and other riders. Firstly, for the majority of cases, speeding was not recorded as an accident contributor. However, PTW riders showed a much higher proportion of speeding issues compared with bicyclists and interacting road users.

When speeding was a factor for PTW riders they were almost always above the respective speed limit. On the contrary, bicyclists were below the respective speed limit; however, the nature of bicycles can be said to involve their occupants in crashes when speed is less than the speed limit but relatively high.

Table 10: Speeding of PTW and Bicycle riders and Other Interacting Road Users

SPEED IS A CONTRIBUTING FACTOR	PTW Riders	%age	Bicycle Riders	%age	OIRUs	%age
No	215	55%	112	85%	346	88%
Yes, and above speed limit	72	18%	3	2%	8	2%
Yes, and below speed limit	5	1%	6	5%	4	1%
Yes, and speed limit unknown	9	2%	0	0%	2	1%
Unknown	93	24%	11	8%	31	8%

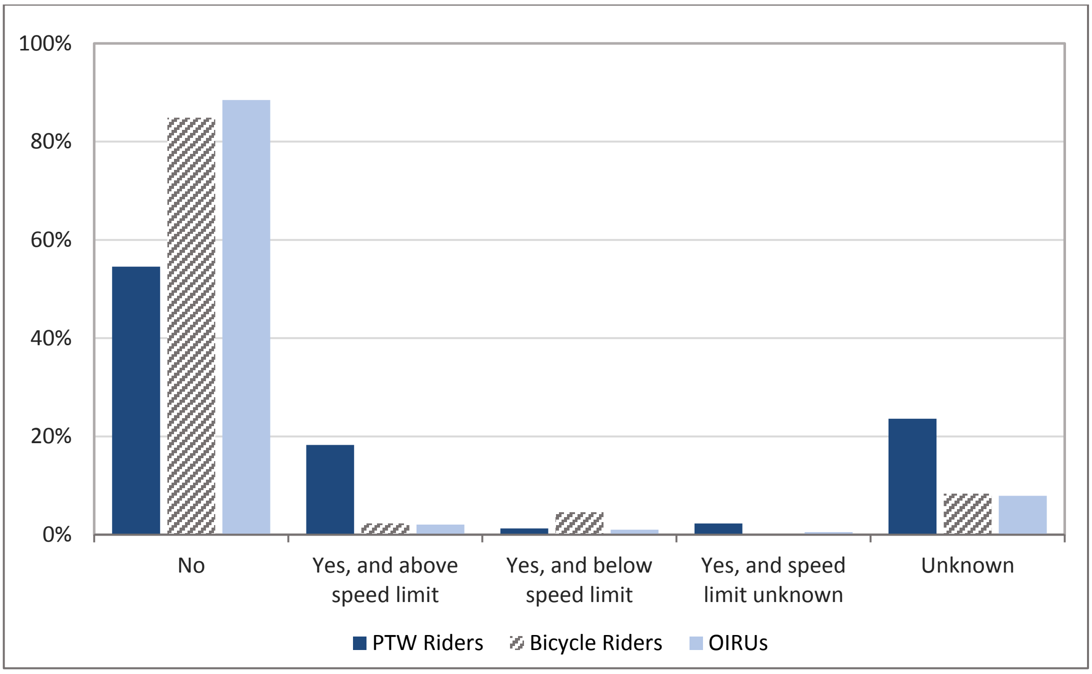
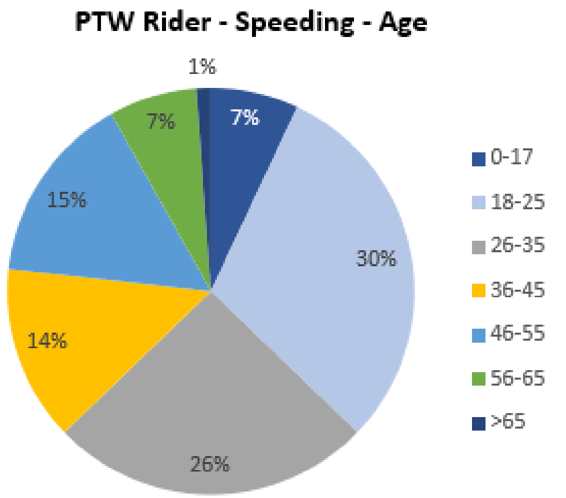


Figure 21: Distribution of speed as a contributing factor for PTW and Bicycle riders and OIRUs

The PTW riders that were identified as having speed as contributing factor (n=86) have been further analysed to determine if there are any trends or commonalities within these riders.

As shown in the figures below, younger riders appear to speed more frequently, indicating a higher propensity towards risk taking or reckless riding. Speed is also directly correlated with increased injury severities, leading to a relatively high proportion of fatal/serious injury accidents over slight/no injury accidents.



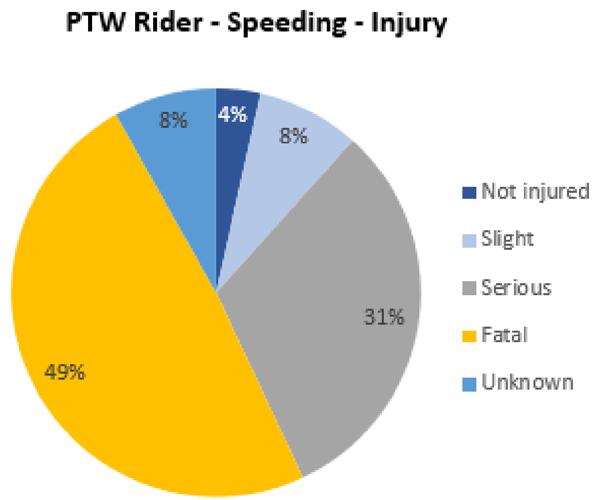


Figure 22: Age and injury severity distributions of PTW riders for which speed was a contributing factor in the accident (n=86)

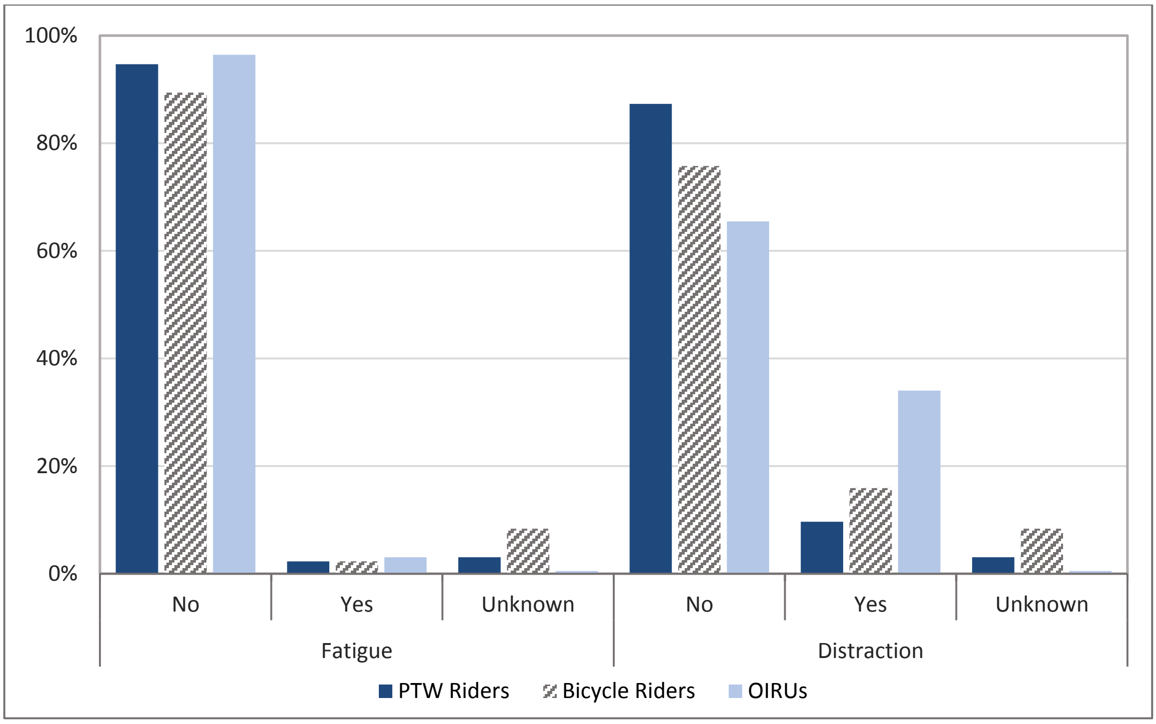


Figure 23: Distribution of fatigue and distraction as a contributing factor

Fatigue did not appear to be a contributing factor in many accidents. Distraction was more prevalent, in particular over a third (34%) of interacting road users were distracted. 16% of bicycle riders and 10% of PTW riders were distracted.

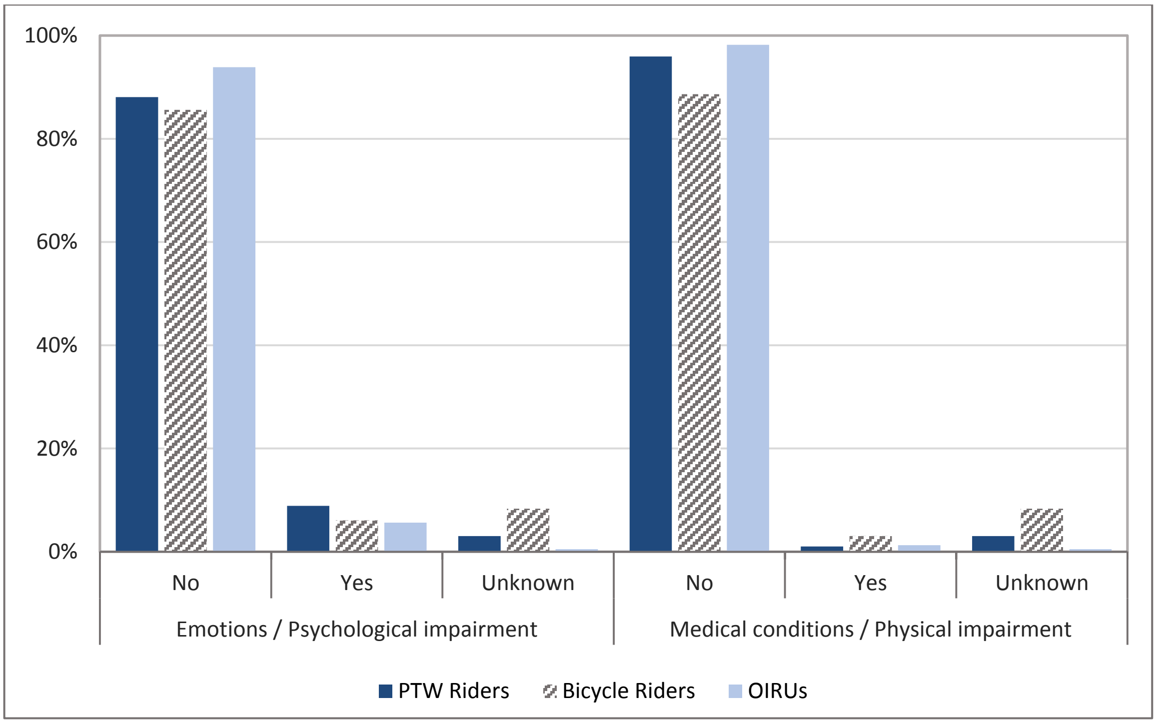


Figure 24: Distribution of psychological and physical impairments as a contributing factor

Psychological impairments, and emotions such as fear or stress, were a contributing factor for 9% of PTW riders and 6% of bicycle riders. Medical conditions and physical impairments were not a significant factor.

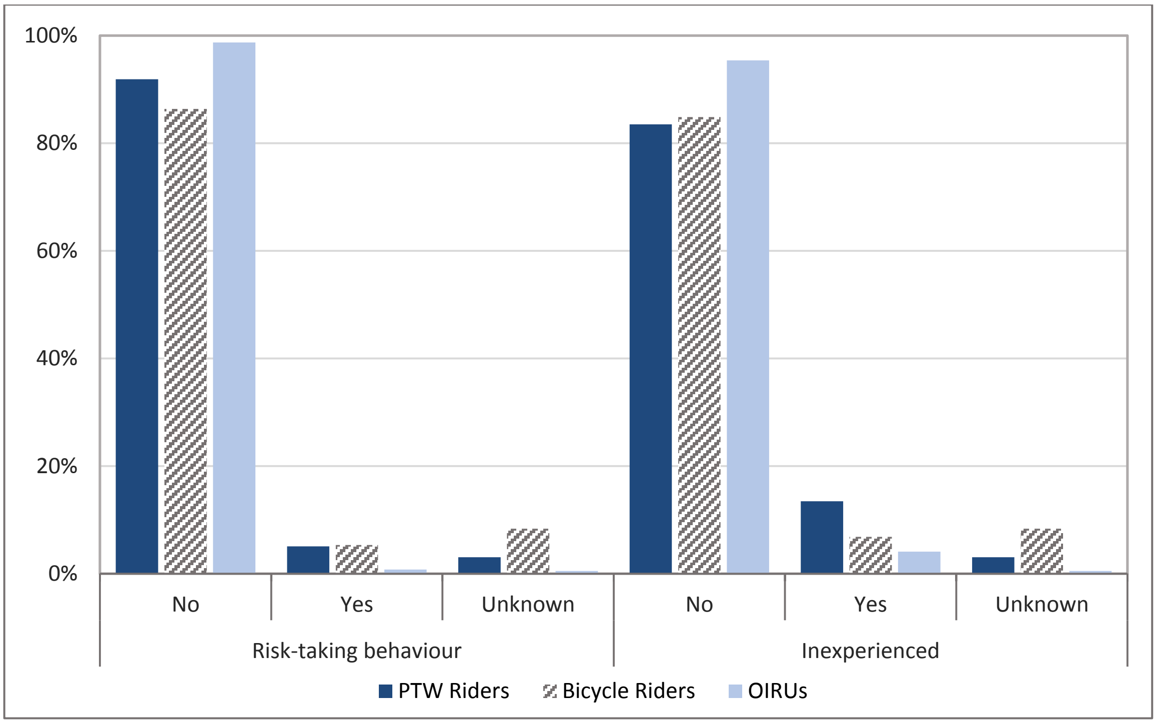


Figure 25: Distribution of risk-taking behaviour and inexperience as a contributing factor

Risk-taking behaviour, such as excitement seeking or risky overtaking, was a factor for both 5% of PTW riders and bicycle riders. It should be noted that factors such as alcohol, drugs and speeding are separate to this, though can also be considered as risk-taking.

Inexperience was more prevalent among PTW riders than bicycle riders (13% compared with 7%). Whilst this figure is not especially high, it still indicates that further training could be beneficial in reducing PTW accidents.

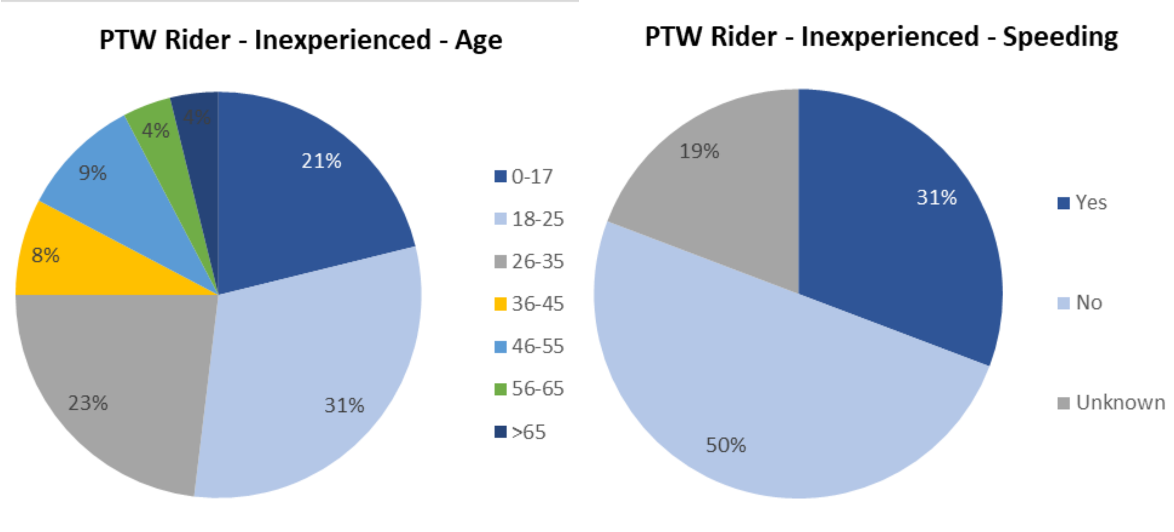


Figure 26: Distribution of age and excess speed of inexperienced PTW riders (n=53)

The 13% of riders who were inexperienced (n=53) were generally younger, with 52% aged under 25, though nearly a quarter were 26-25 (23%). Inexperienced riders were relatively more likely to be speeding compared with all riders (31% compared with 22%).

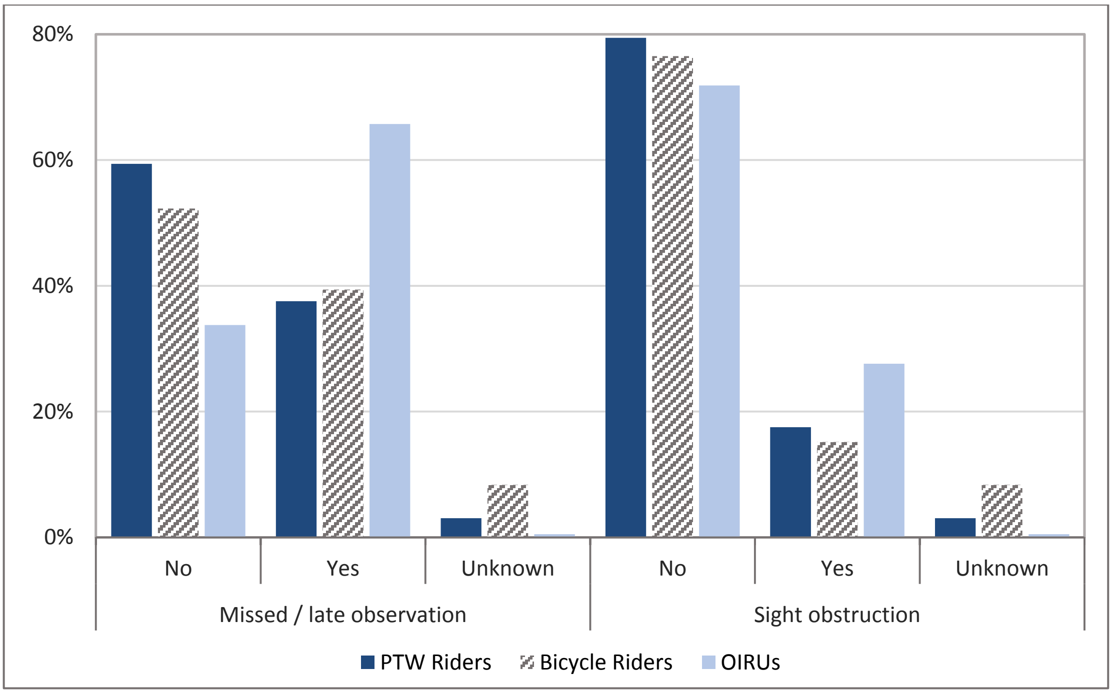


Figure 27: Distribution of observation errors and sight obstructions as a contributing factor

Errors of observation, for example 'looked but failed to see' were very prevalent, being a contributing factor for over a third of PTW (38%) and bicycle 39%) riders, and two thirds of interacting road users (66%). However external sight obstructions, such as trees, other traffic, or dazzling from low sun, were also a common factor, being present for 18% of PTW riders, 15% of cyclists, and 28% of interacting road users.

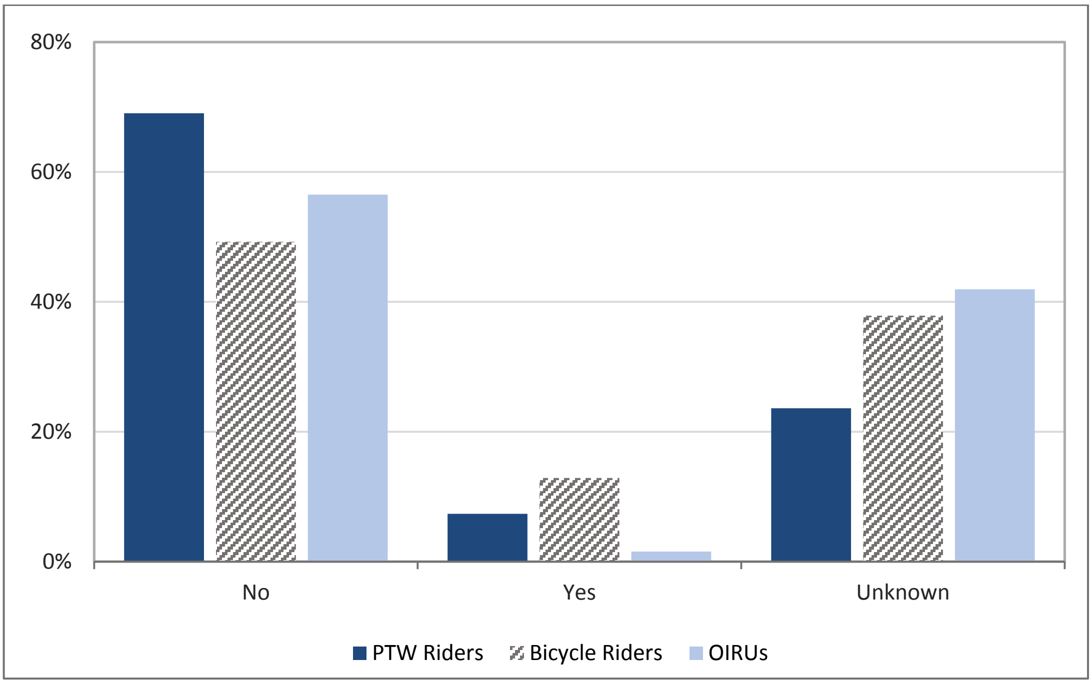


Figure 28: Pre-existence of any medical condition prior to the accident

Regarding medical history, it appears that most riders had not any recorded pre-existing medical condition; less than 15% of road users. The large number of unknown entries in addition to its very broad scope should be noted for this variable, however.

Personal Protective Equipment

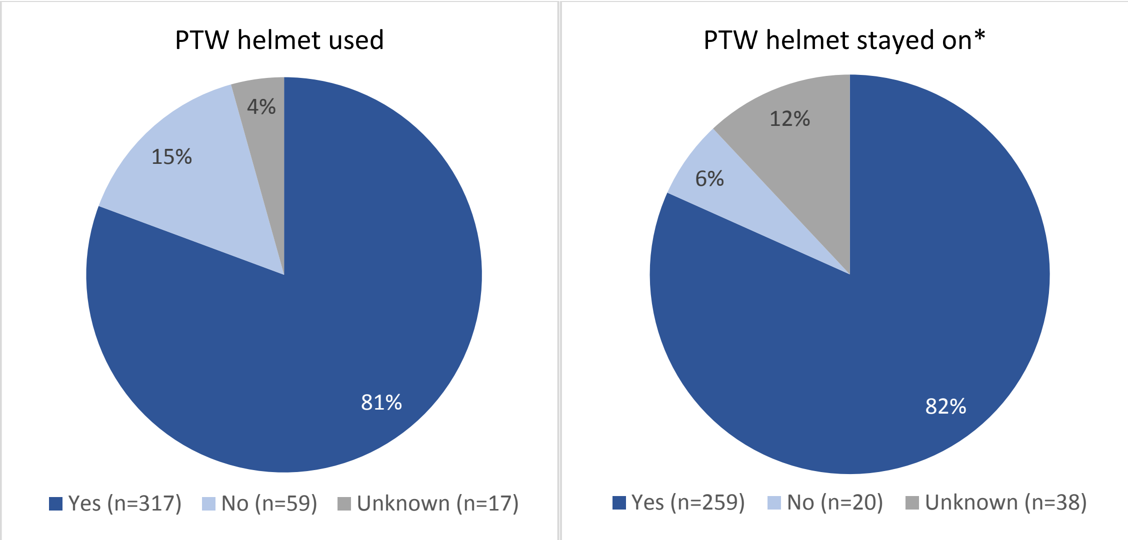


Figure 29: Helmet usage of PTW Riders (*helmet stayed on examined only for riders who wore a helmet)

Protective equipment such as helmets were examined specifically for PTW riders. While most riders seem to recognise the value of using helmets (81%), a non-negligible percentage did not (15%), hinting at margins for awareness raising for safety equipment. When excluding unknown cases, helmets did stay on during the majority of accidents, proving their high effectiveness levels.

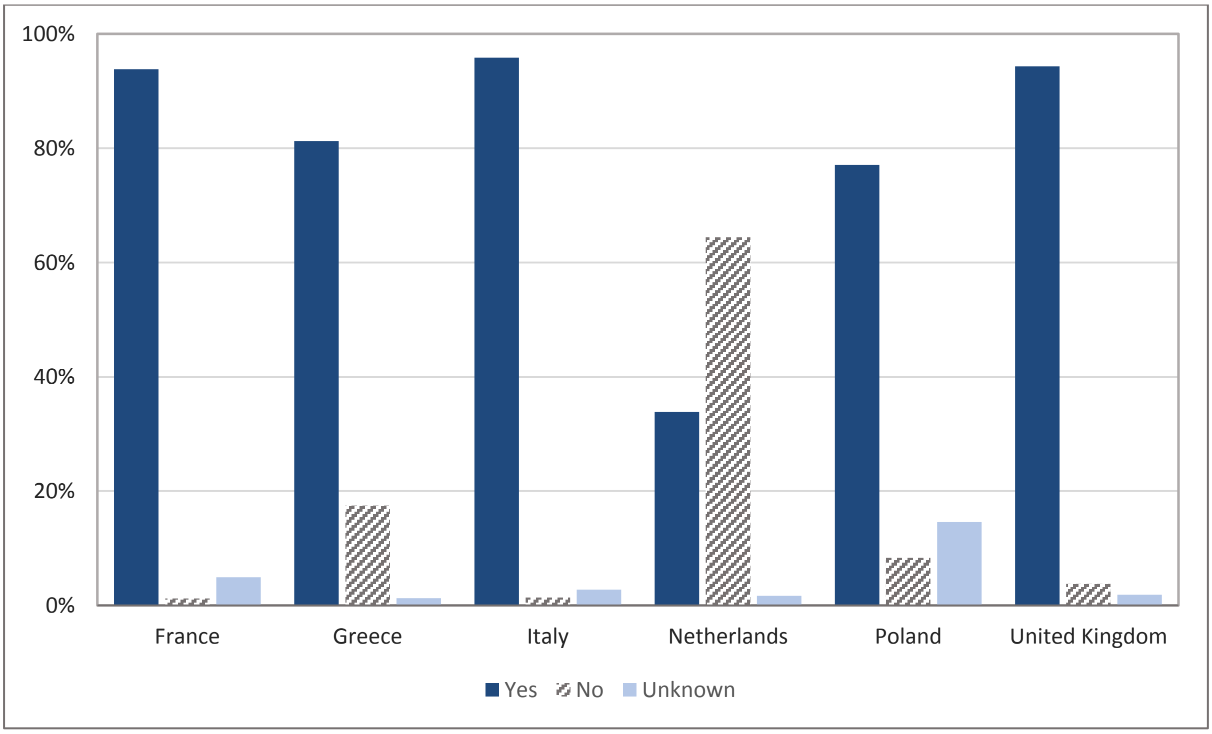


Figure 30: Helmet usage of PTW riders per country

However, when the helmet usage is broken down by country, it can be observed that helmet usage is significantly lower in the Netherlands compared to the other sample areas. This is in part due to legislative differences, as detailed earlier in this report.

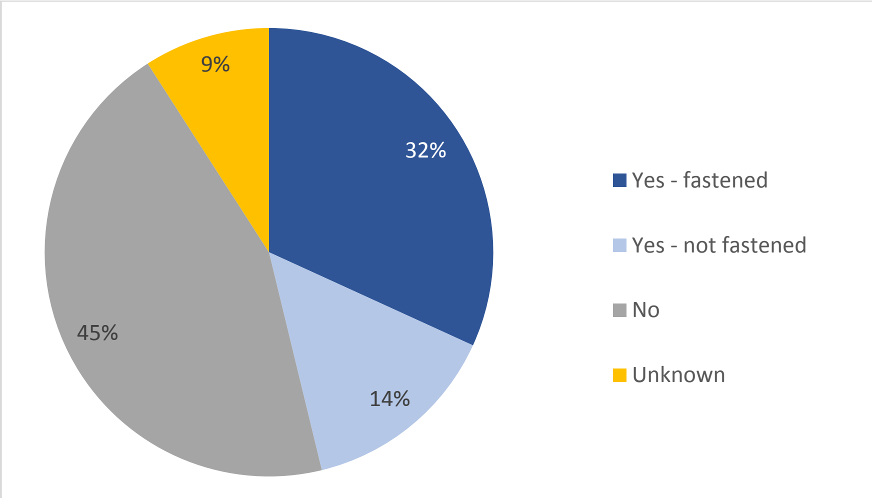


Figure 31: Helmet usage of bicycle riders (n=132)

For bicyclists, the figure shows that 32% (n=42) of riders were wearing a helmet and had it fastened. 45% were not wearing one at all. For 14%, a helmet was worn but not fastened.

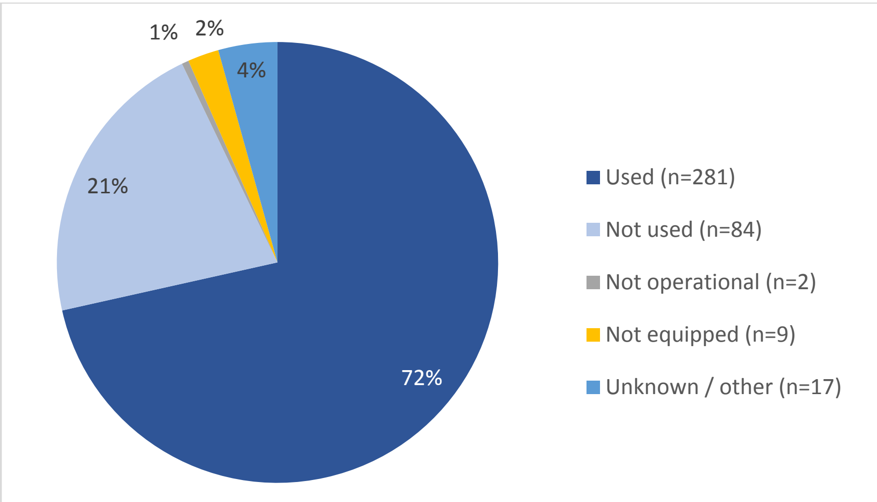


Figure 32: PTW headlight usage

In the majority of cases (72%), PTWs riders did use their headlights. However, there was considerable variation among countries, ranging from 90% of riders using headlights in Italy to only 35% in Greece.

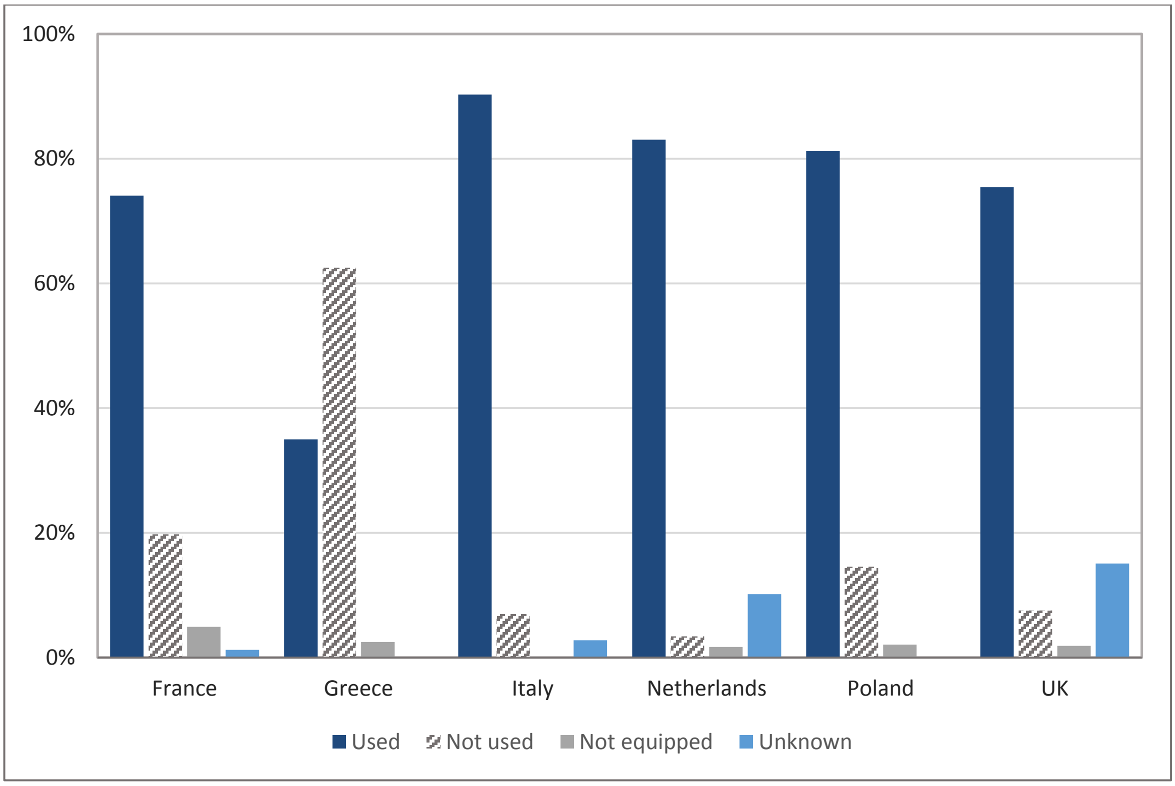


Figure 33: PTW headlight usage by country (excluding 'not operational' due to small number)

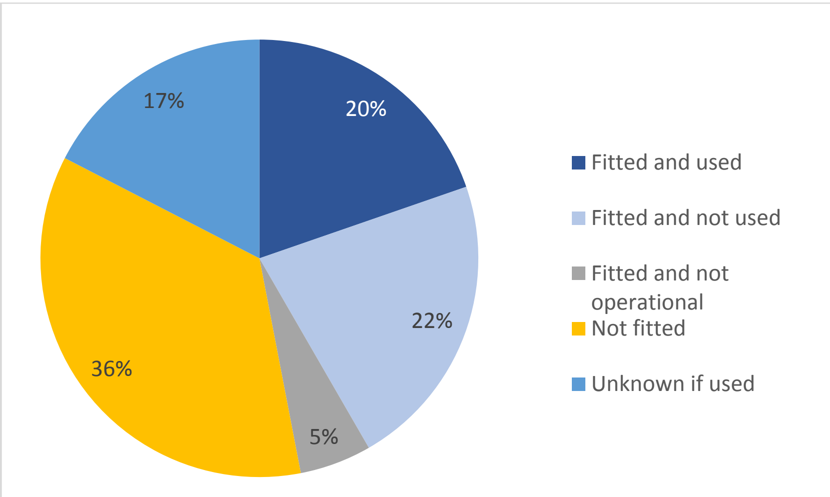


Figure 34: Bicycle headlight usage (n=132)

Over a third of riders (36%, n=47) had no lights fitted to their bicycle. A further 22% had lights fitted but they were not in used at the time of the accidents. Only 20% of riders had lights in use, though this does not take into account the daylight conditions at the time.

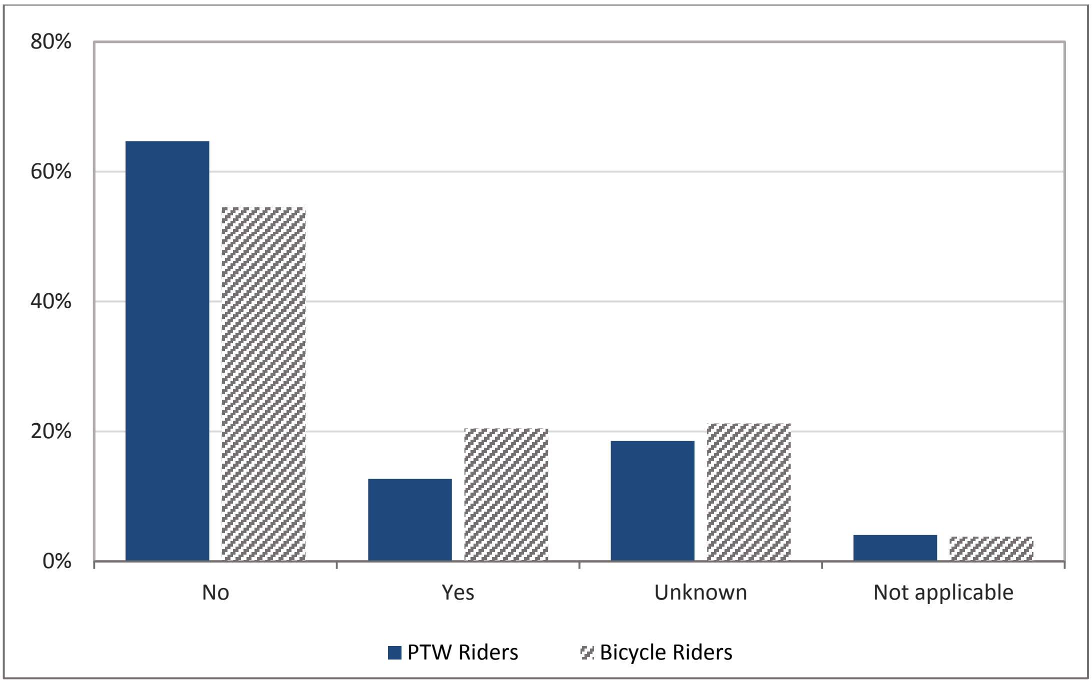
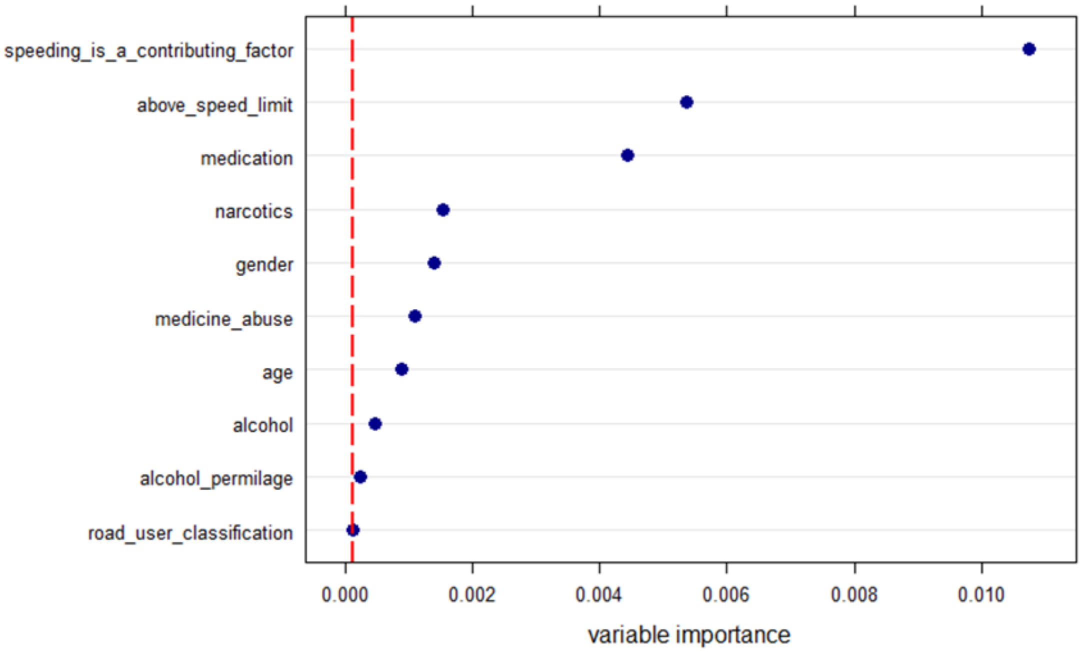


Figure 35: Reflective clothing worn by PTW riders or bicyclists

When examining the recorded data, it would appear that most two-wheeler riders do not use reflective clothing at all times. This percentage is somewhat decreased for bicycle riders (from 65% to 55% of the respective totals), though still high. There is therefore considerable room for reaching higher usage levels of reflective clothing from riders.

Random Forests Analysis

Relative importance of variables when examining injury severity (Fatal vs non-Fatal):



The graph above shows the final results of variable importance rankings when examining injury severity (Fatal vs non-Fatal). It was produced by the method of Random Forests. The variable importance as unveiled from the RF models are extremely helpful to define which variables are significant. However, the magnitude of the effect and the sign of each variable are not identified. It should be noted that variable importance should be interpreted as a relative ranking of predictors, since the absolute values of the importance scores should not be interpreted or compared over different studies (Strobl, et al., 2009a[27] and 2009b[28]).

Variables to the right of dashed red vertical line are identified to be significant in an ascending order. This red vertical line on the plot is set at the value of the lowest important variable.

Therefore, we can observe that the most important variables are speeding, driving above speed limit and medication.

[27] Strobl, C., Malley, J., Tutz, G. (2009a). An introduction to recursive partitioning: Rational, application, and characteristics of classification and regression trees, Bagging, and Random Forests. Psychological Methods 14(4), 323-348.

[28] Strobl, C., Malley, J., Tutz, G. (2009b). Supplement to 'An introduction to recursive partitioning: Rational, application, and characteristics of classification and Regression trees, bagging, and random forests. Retrieved from: http://dx.doi.org/10.1037/a0016973.supp.

Part 4: Vehicle Factors

Vehicle - PTW

The database contains 393 PTW elements coded and available for analysis. The distribution of different motorcycle types and motor displacement is shown in the figures below.

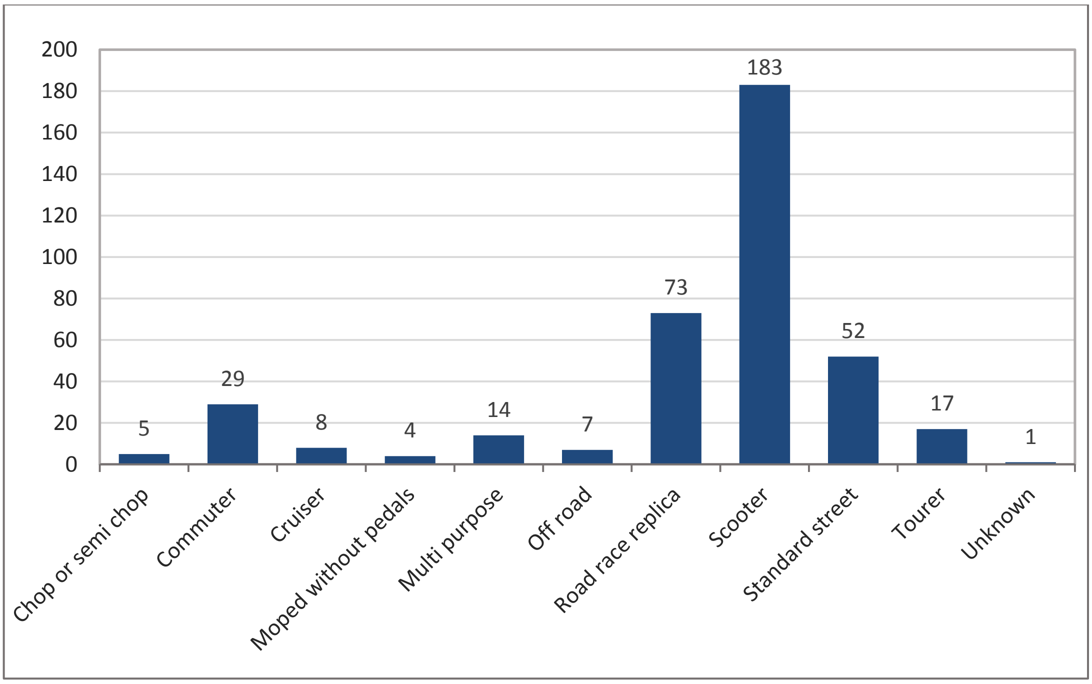


Figure 36: Distribution of PTW vehicle type

Nearly half of the examined PTWs were scooters (47%), with road race replicas accounting for 19%, standard street 13%, and commuter bikes 7%.

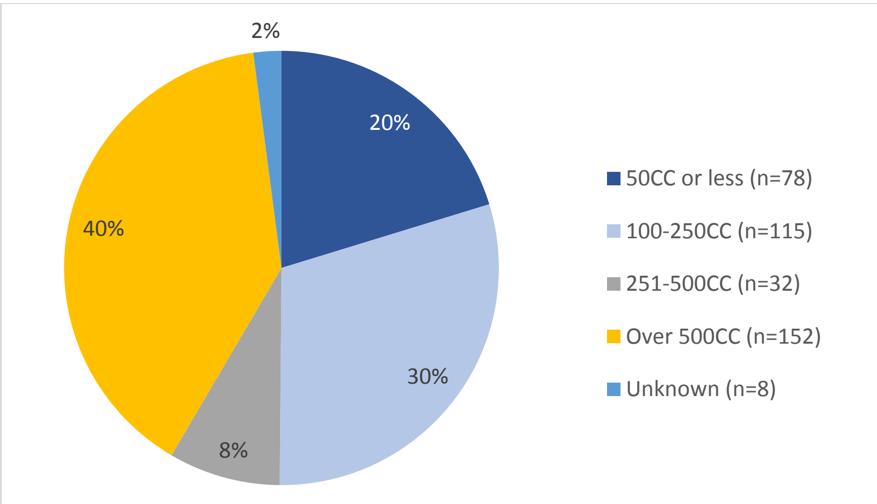


Figure 37: Distribution of PTW motor displacement

When examining PTWs by motor displacement (essentially their engine size), over a third of the sample (40%) consists of larger motorcycles (≥500cc). 20% of the sample were to be smaller mopeds or motorcycles (≤50cc) and over a quarter appears to be medium displacement models.

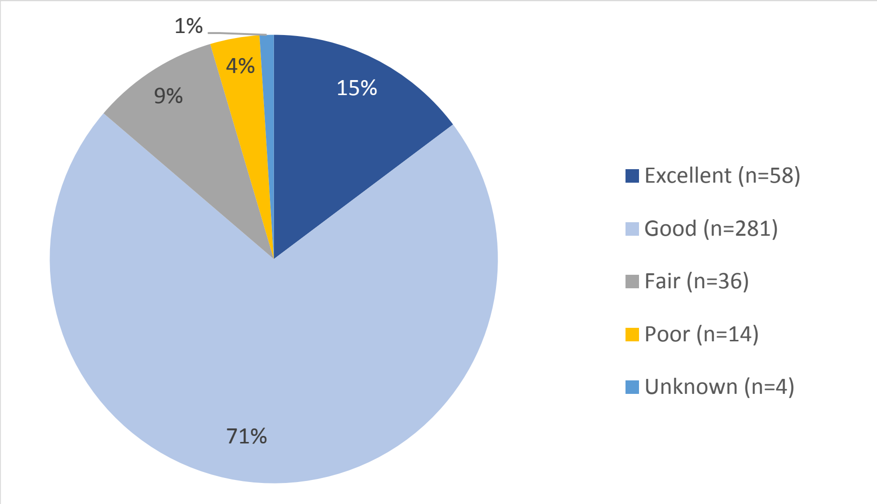


Figure 38: PTW - Overall condition of vehicle

In the vast majority of cases (86%), the general condition of the vehicle (PTW) was described as good or excellent. Only 4% of the vehicles were considered to be in poor vehicle condition.

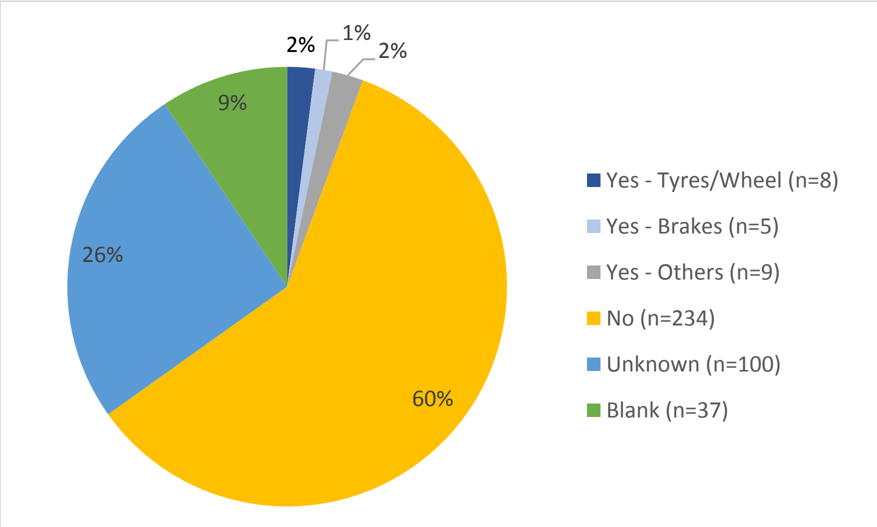
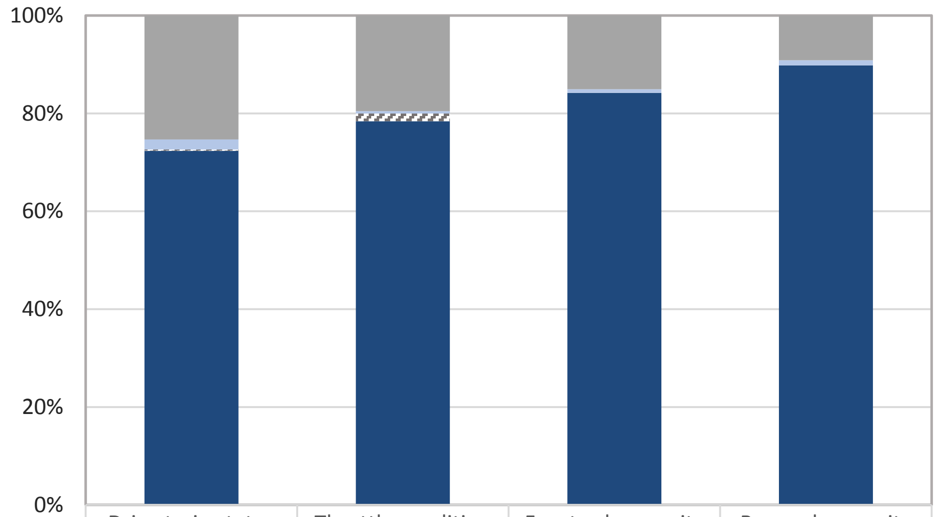
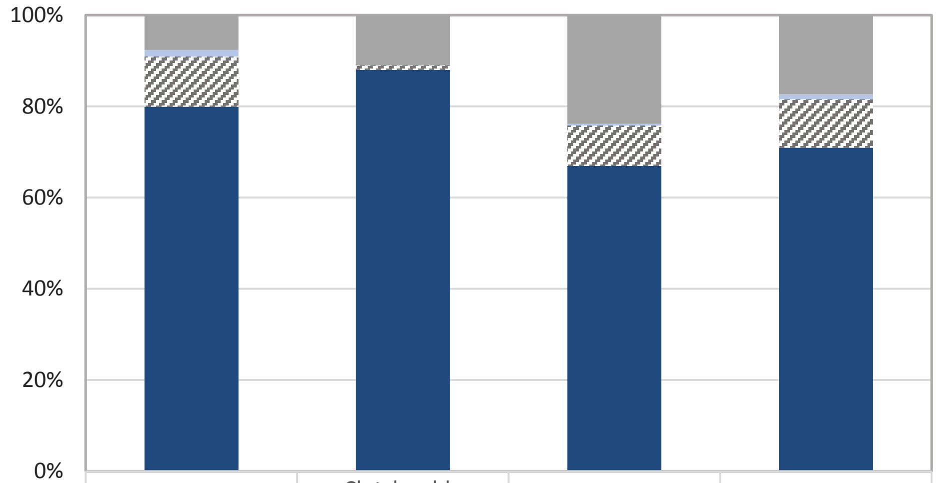


Figure 39: Overall occurrence of PTW mechanical problem / defect

The above figure shows that for 60% of the vehicles examined there were no mechanical defects, defects were only found in 5% of vehicles. However, it is important to note that in 35% of vehicles there is unknown or missing relevant information.



	Drive train status	Throttle condition	Front axle security	Rear axle security
Unknown	25,3%	19,5%	15,1%	9,2%
Worn / failed	2,1%	0,5%	0,8%	1,0%
Average condition	0,3%	1,5%	0,0%	0,0%
Good / correct	72,4%	78,4%	84,2%	89,8%



	Chain condition	Clutch cable condition	Front sprocket	Rear sprocket
Unknown	7,7%	11,1%	23,8%	17,4%
Worn / failed	1,4%	0,0%	0,4%	1,1%
Average condition	11,0%	1,0%	8,9%	10,6%
Good / correct	79,9%	88,0%	66,9%	70,9%

Figure 40: Condition of specific PTW mechanical components (1)

The figure above shows the condition of some of the specific mechanical components of the PTWs examined. Across all these components, only between 0-2.1% were in poor condition (completely worn or had failed), the majority were in good or correct condition (67-90%). Amongst these components, 'average' condition was most often observed in the chain or sprocket components. Again however, the higher proportion of 'unknown' values should be noted for most of the components.

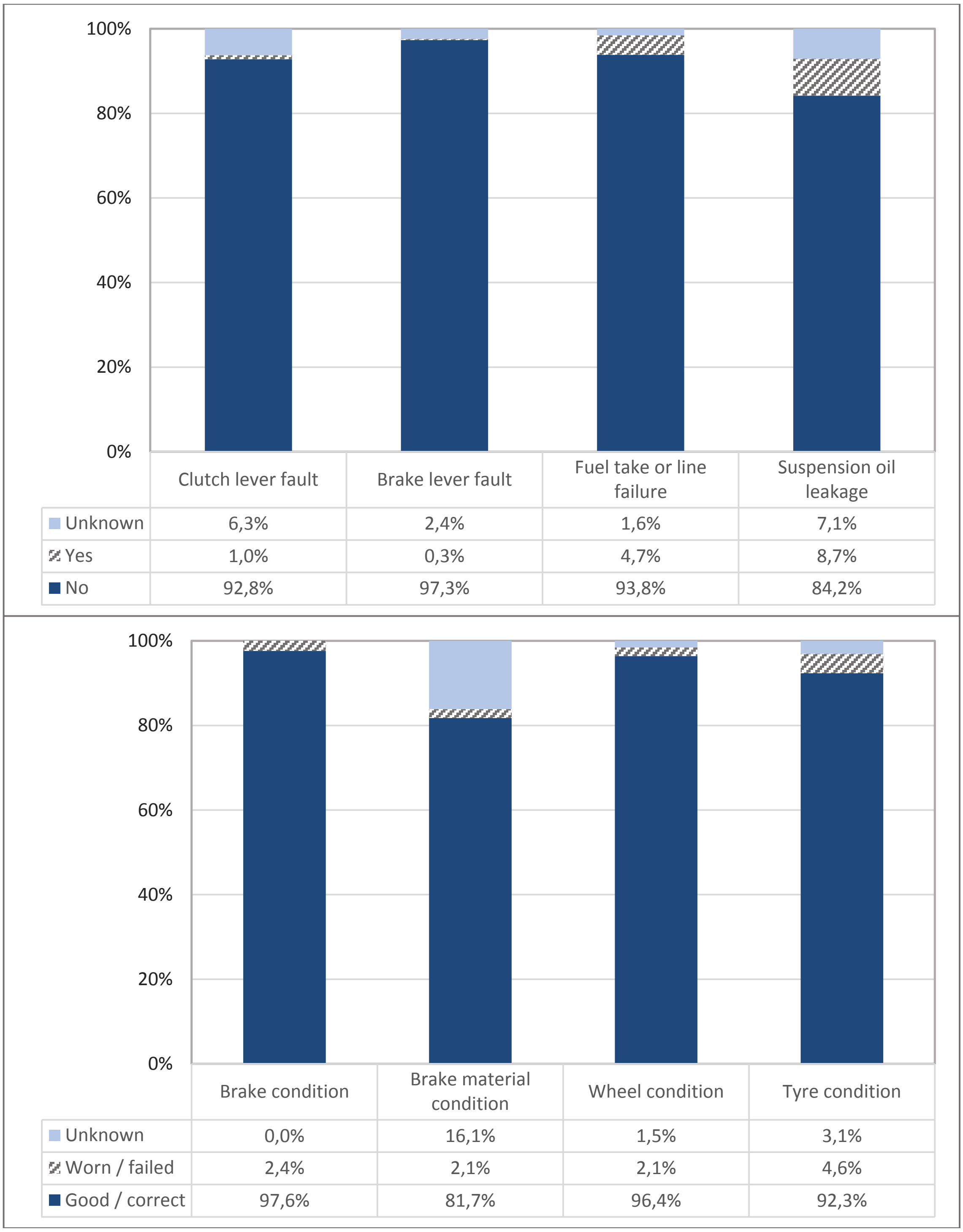


Figure 41: Condition of specific PTW mechanical components (2)

The figure above again shows the status of (different) individual mechanical components. Defects in the brake components, clutch lever and wheel were seen in less than 3% of vehicles. Tyre defects and failures to the fuel tank or line were observed in just under 5% of vehicles, and interestingly a suspension oil leakage was found in 9% of vehicles, though this does not imply the defect contributed to the accident. In general for these components good condition is observed (82%-98% of vehicles).

Vehicle - Bicycle

The database contains 132 bicycle elements coded and available for analysis. Of these, 117 are manual bicycles and 15 are e-bikes. This section presents results for manual bicycles, E-bikes are examined separately.

The distribution of different manual bicycle types is show in the figure below.

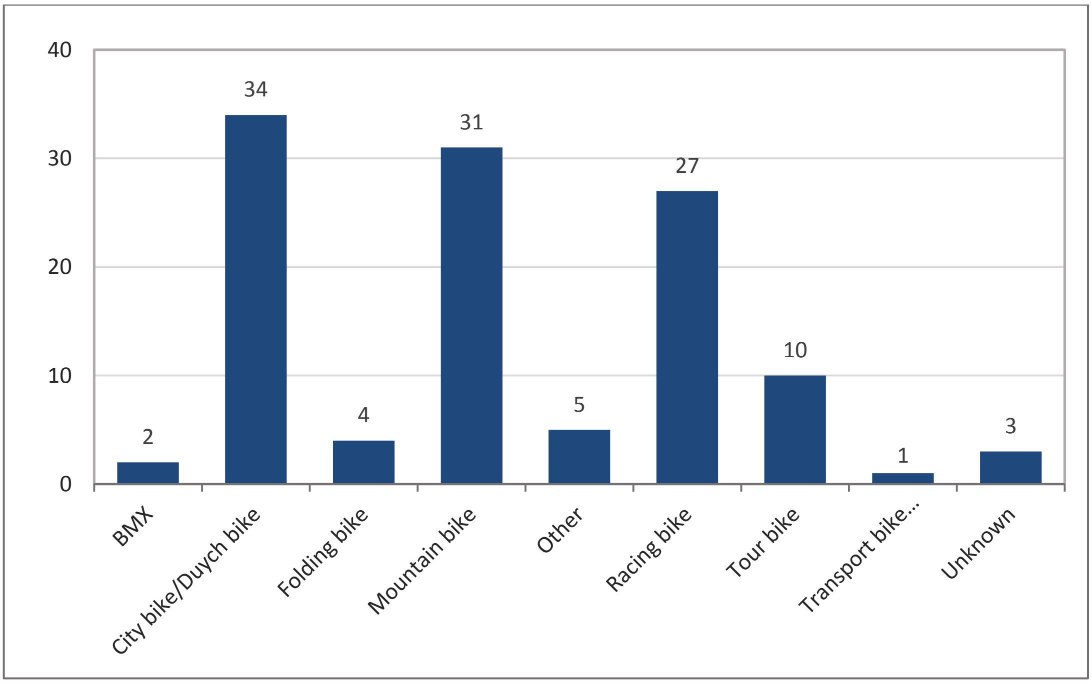


Figure 42: Distribution of bicycle type

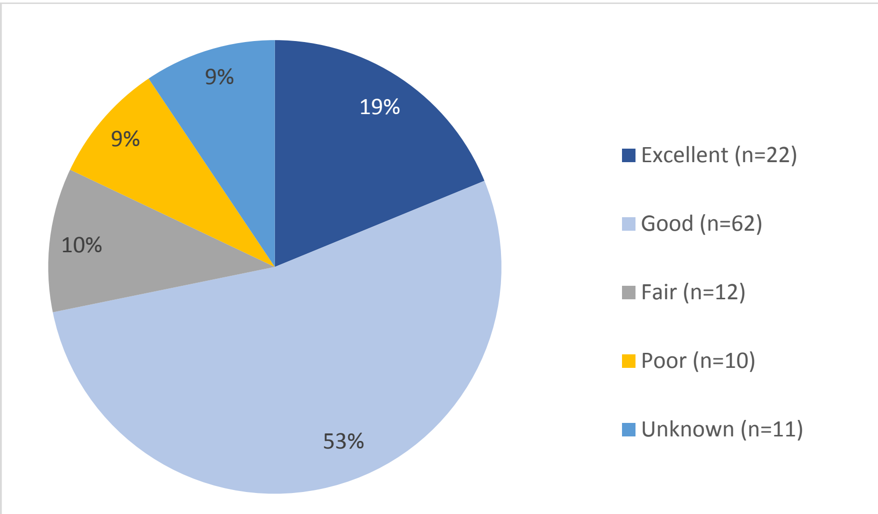
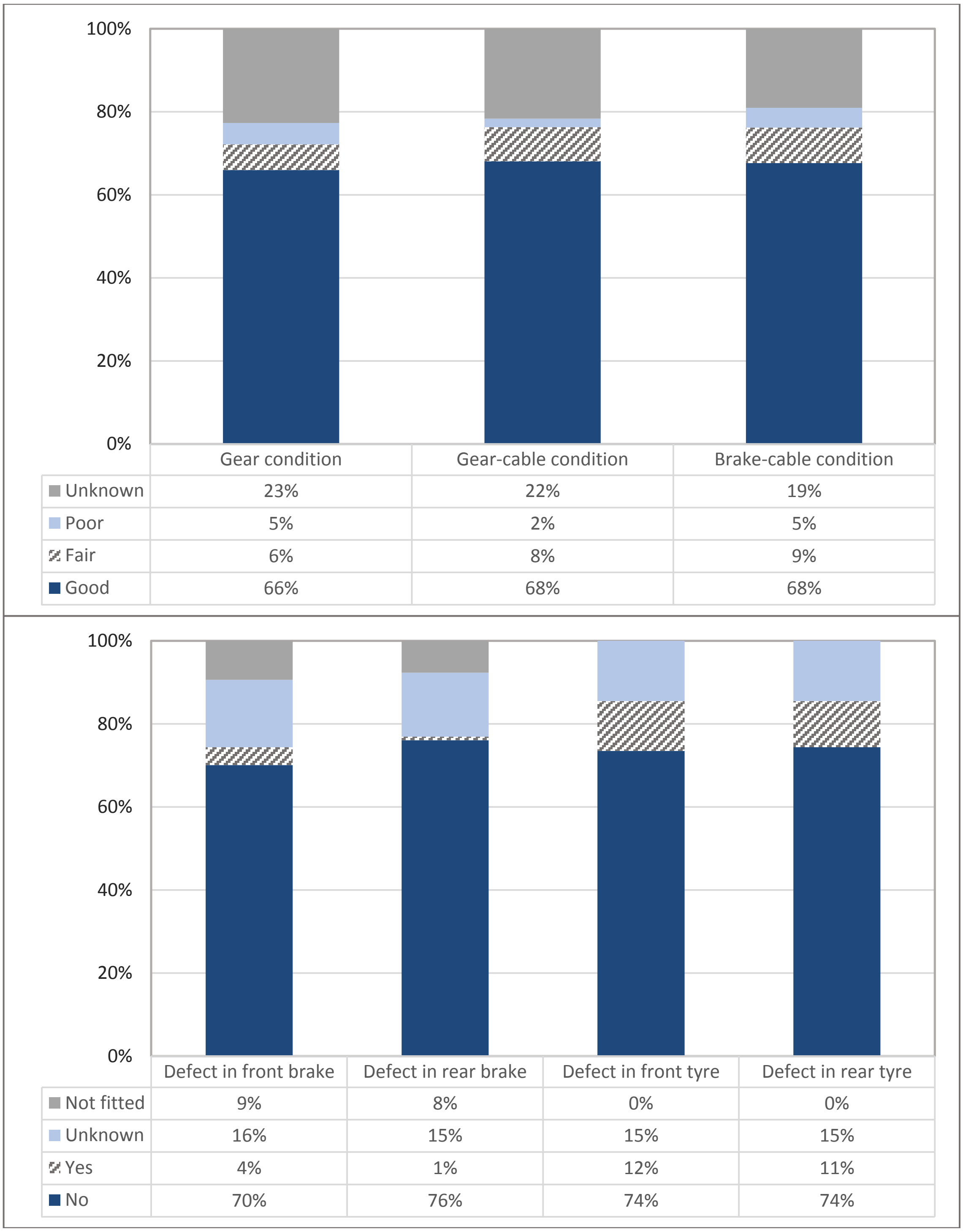


Figure 43: Bicycle - Overall condition of vehicle

In the majority of cases (72%), the general condition of the vehicle (bicycle) was described as good or excellent. Only 9% of the vehicles were considered to be in poor vehicle condition.



	Gear condition	Gear-cable condition	Brake-cable condition
Unknown	23%	22%	19%
Poor	5%	2%	5%
Fair	6%	8%	9%
Good	66%	68%	68%

	Defect in front brake	Defect in rear brake	Defect in front tyre	Defect in rear tyre
Not fitted	9%	8%	0%	0%
Unknown	16%	15%	15%	15%
Yes	4%	1%	12%	11%
No	70%	76%	74%	74%

Figure 44: Condition of specific bicycle mechanical components

The condition of specific bicycle components is show in the figure above. Generally, the gears and brakes were in good condition (66%-76%). Poor condition and defects were only observed in 1%-5% of gear or brake elements examined.

Tyres showed higher proportions of defects, with problems found in 11-12% of bicycles examined, and almost all of these defects related to a worn tread on the tyre.

Part 5: Infrastructure / Environment Factors

The analysis was carried out on 725 roads across 500 cases. This included 548 roads that involved PTW accidents, and 176 roads that involved bicycle accidents.

For this section, analysis is done on a mixture of "accident" and "road" level.

Table 11: Environment at accident location for all accidents and PTW and bicycle specific accidents

ACCIDENT ENVIRONMENT	All Accidents	%age	PTW Accidents	%age	Bicycle Accidents	%age
Residential	244	49%	199	52%	45	39%
Commercial	161	32%	112	29%	49	42%
Industrial	37	7%	31	8%	5	4%
Other	55	11%	42	11%	15	13%
Unknown	3	1%	1	0%	2	2%

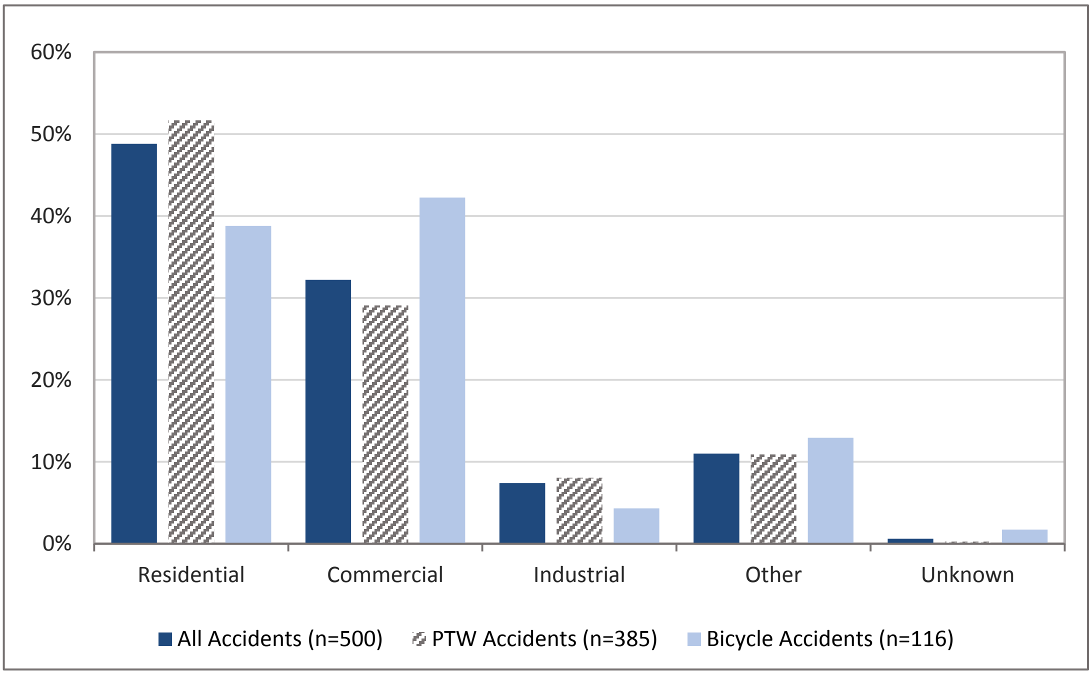


Figure 45: Distribution of environment at accident location

The highest proportions of accidents occurred in residential and commercial areas (combined 81% of total). Specifically, PTW accidents most often occurred in residential areas (52%), while bicycle accidents most often occurred in commercial areas (42%).

Table 12: Environment class at accident location for all accidents and PTW and bicycle specific accidents

ENVIRONMENT CLASS	All Accidents	%age	PTW Accidents	%age	Bicycle Accidents	%age
Urban	394	79%	299	78%	96	83%
Rural	106	21%	86	22%	20	17%

For all accident types, the majority occurred in urban areas. PTWs had a higher proportion of rural accidents than bicyclists.

Table 13: Light condition at accident location for all accidents and PTW and bicycle specific accidents

LIGHT CONDITION	All Accidents	%age	PTW Accidents	%age	Bicycle Accidents	%age
Daylight	395	79%	302	78%	94	81%
Twilight	21	4%	15	4%	6	5%
Darkness	20	4%	15	4%	6	5%
Electric Light	57	11%	49	13%	9	8%
Other / Unk	7	1%	4	1%	1	1%

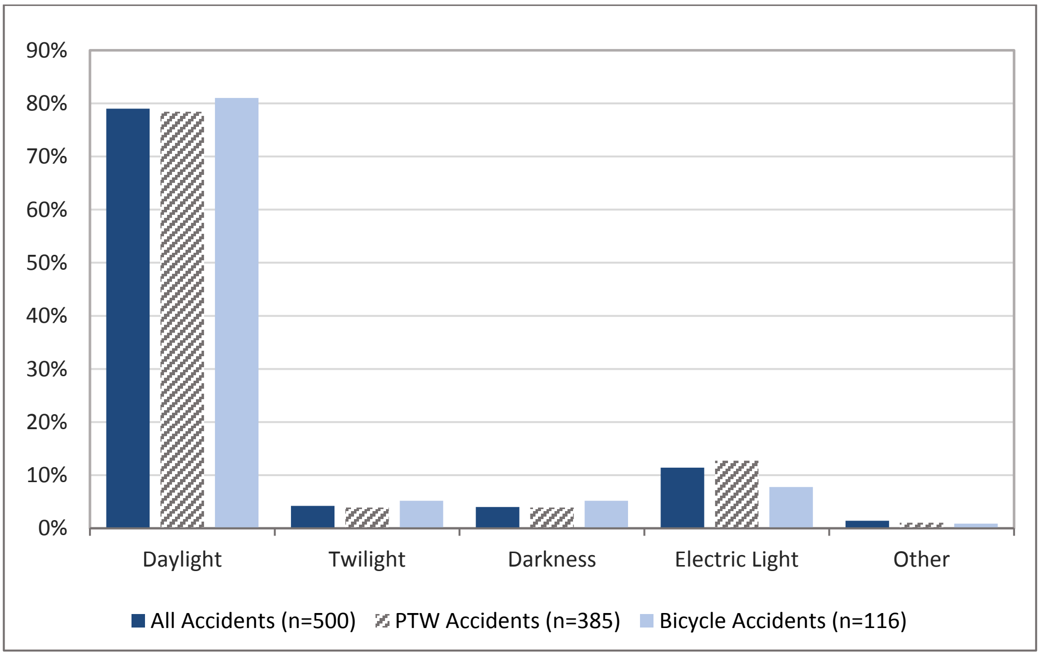


Figure 46: Light Condition at the time of the accident

Regardless of the type of the vehicle, it is observed that about of 80% of accidents happen during daylight. A higher proportion of PTW accidents happen at night (darkness, electric light) compared with bicycle accidents.

Table 14: Weather condition at accident location for all accidents and PTW and bicycle specific accidents

WEATHER CONDITION		All Accidents	%age	PTW Accidents	%age	Bicycle Accidents	%age
Rain	Yes	35	7%	23	6%	13	11%
	No	462	92%	360	94%	102	88%
	Unk	3	1%	2	1%	1	1%
Snow	Yes	3	1%	2	1%	1	1%
	No	493	99%	380	99%	115	99%
	Unk	4	1%	3	1%	0	0%
Fog	Yes	7	1%	4	1%	3	3%
	No	489	98%	378	98%	113	97%
	Unk	4	1%	3	1%	0	0%
High wind	10-15m/s	63	13%	39	10%	29	25%
	<15m/s	43	9%	25	6%	19	16%
	No	369	74%	300	78%	65	56%
	Unk	25	5%	21	5%	3	3%

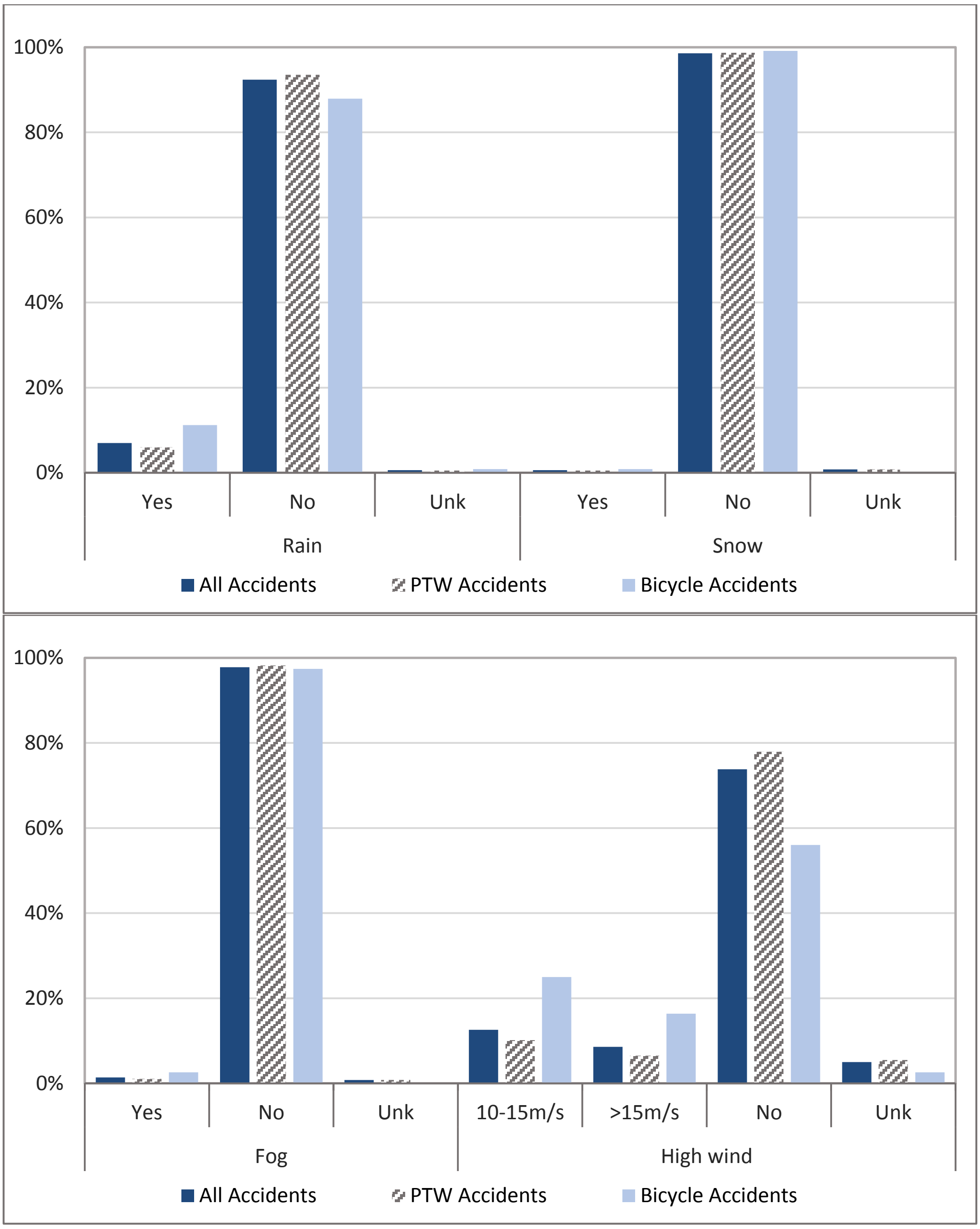


Figure 47: Weather Conditions (rain, snow, fog, wind) at the time of the accident

As expected the vast majority of accidents occur under good weather conditions regardless of the vehicle type (PTW, bicycle). The figure above shows that fog was not present in almost all accident cases. On the other hand, although the majority of accident occurred under no wind, a non-negligible proportion occurred under 10-15km/h wind speed (it more than 10%) and under 15-20km/h (about 5%).

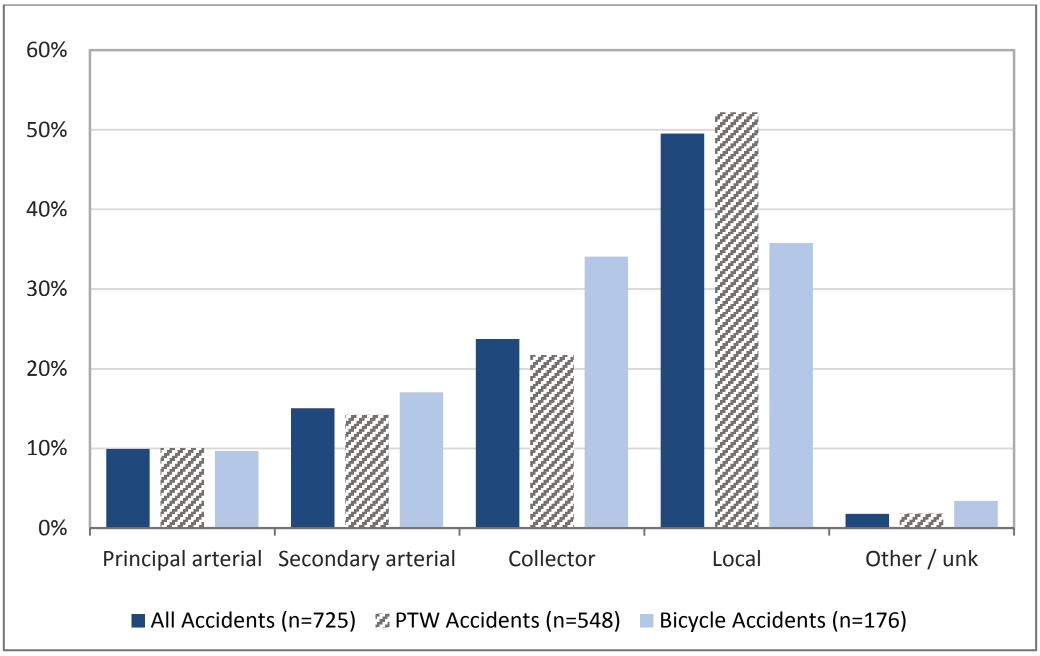


Figure 48: Road type at accident location

Half of accidents occurred in local roads, specifically 50% of roads for all accidents and 52% of accidents where PTWs were involved were local roads. It is interesting to see that a relatively large share of bicycle accidents occurred in collector roads (34%).

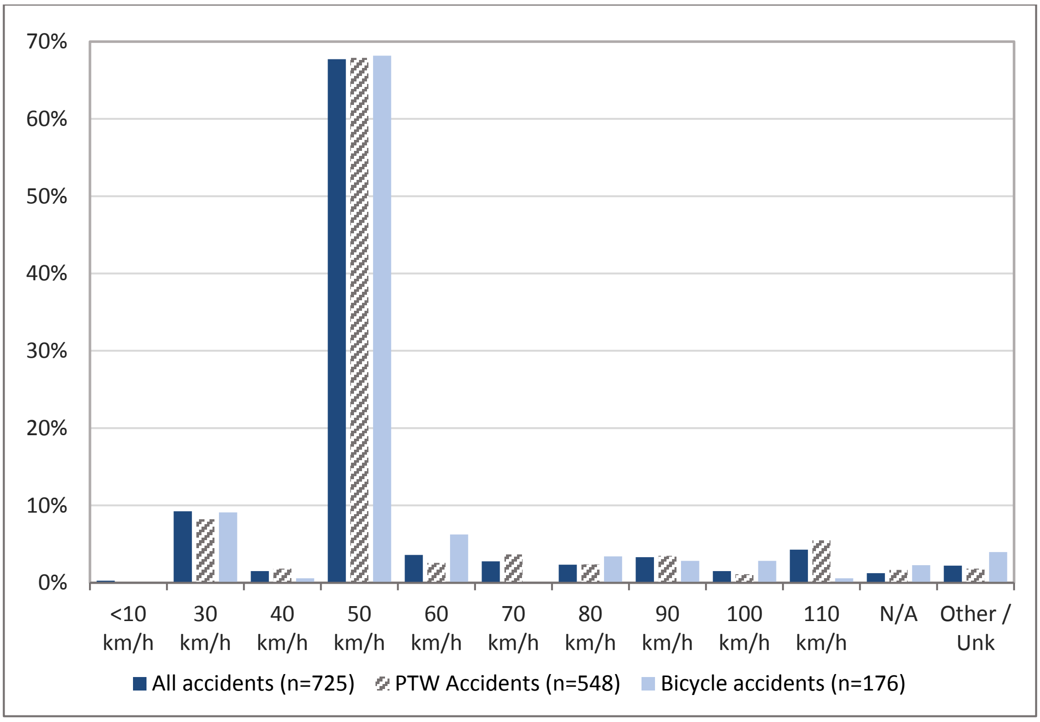


Figure 49: Speed limit at accident location

The majority (over 60%) of accidents happened on 50km/h roads, less than 15% occurred in speed limits of 70km/h or higher.

Table 15: Junction type at accident location for all accidents and PTW and bicycle specific accidents

JUNCTION TYPE	All Accidents	%age	PTW Accidents	%age	Bicycle Accidents	%age
Single Road	250	50%	199	52%	50	43%
Crossroads	106	21%	81	21%	29	25%
Roundabout	24	5%	15	4%	8	7%
Junction – T or Y	114	23%	84	22%	29	25%
Other	6	1%	6	2%	0	0%

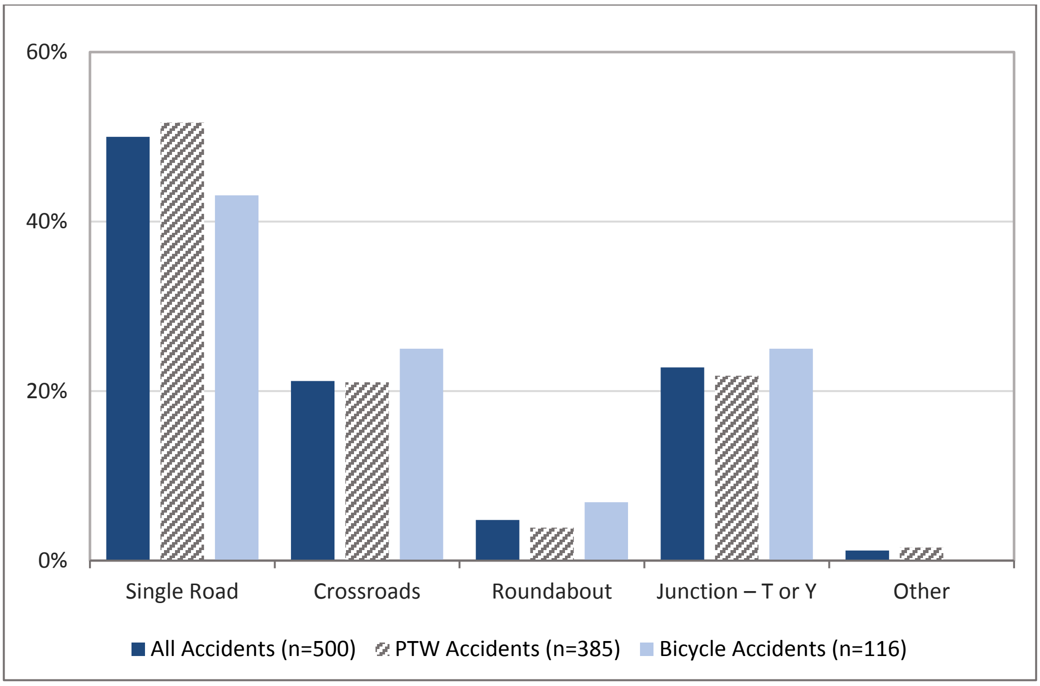


Figure 50: Type of junction at accident location

Half of accidents did not occur at or within 20m of junctions. When an accident did occur at a junction, it was most frequently at T or Y junctions (23%) or crossroads (21%). Bicycle accidents occurred at junctions relatively more often than PTW accidents.

Table 16: Incidence of road barriers and collision outcomes for PTW and bicycle riders

Road Barrier Status		PTW Accidents	Bicycle Accidents
#cases where road barriers present		63	22
#cases where two-wheeler rider collided with road barrier		9	1
Injury severity of two-wheeler rider when road barrier collided with	Fatal	6	1
	Serious	3	-

In total 82/500 cases had road barriers present, in 10 of these the two wheeler rider collided with the barrier (2% of all cases). When a road barrier was collided with, the injury outcome was fatal (7/10) or serious (3/10).

Part 6: E-Bike Analysis

The database contains 14 cases involving E-Bikes. Due to the small sample size, it is not robust to derive absolute conclusions from the distribution of these accidents, however some of the main characteristics are described below.

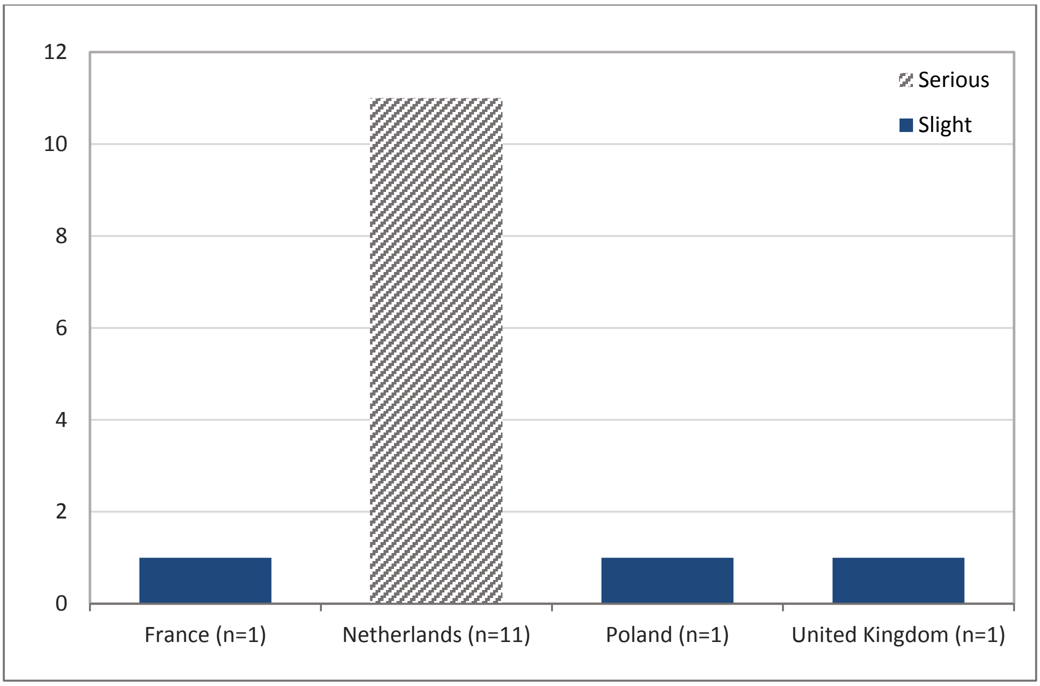


Figure 51: Distribution of E-Bike accidents by country and injury severity

11 out of the 14 E-bike accidents have occurred in the Netherlands, which were serious in injury severity. The remaining 3 accidents, which occurred in France, Poland and the UK, resulted in slight injuries.

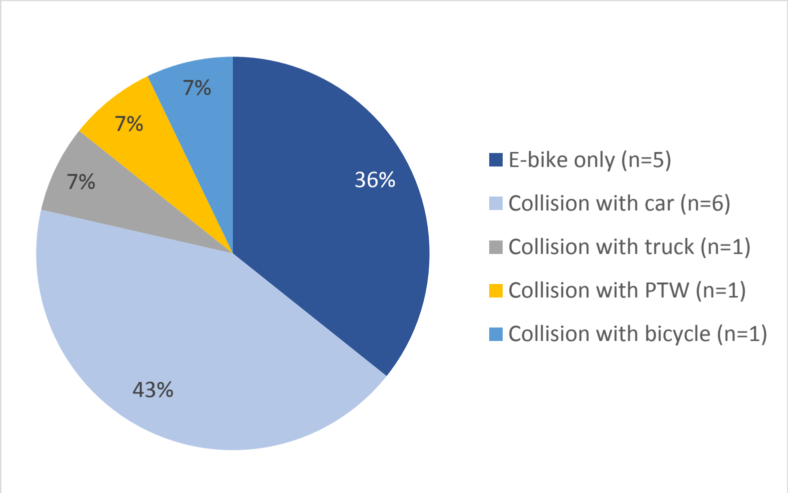


Figure 52: Distribution of E-Bike accidents by interacting vehicle

Regarding accident scenarios, 6 accidents involved only E-bikes or bicycles, 6 accidents involved a collision with a car, 1 with a PTW, and 1 with a truck.

Table 17: Environment and infrastructure characteristics of E-bike accidents

JUNCTION TYPE	All Accidents	%age	E-Bike Accidents	%age
Single Road	250	50%	5	36%
Crossroads	106	21%	1	7%
Roundabout	24	5%	2	14%
Junction – T or Y	114	23%	6	43%
Other	6	1%	0	0%
ACCIDENT ENVIRONMENT	**All Accidents**	**%age**	**E-Bike Accidents**	**%age**
Residential	244	49%	8	57%
Commercial	161	32%	5	36%
Industrial	37	7%	1	7%
Other	55	11%	0	0%
Unknown	3	1%	0	0%
ENVIRONMENT CLASS	**All Accidents**	**%age**	**E-Bike Accidents**	**%age**
Urban	394	79%	11	79%
Rural	106	21%	3	21%

Just under two thirds of E-bike accidents occurred at junctions (64%), which is relatively higher compared with all accidents. Similarly to all accidents, E-bike accidents most mostly occurred in urban environments, and in either residential or commercial areas.

Table 18: Lighting and weather conditions of E-bike accidents

LIGHT CONDITION		All Accidents	%age	E-Bike Accidents	%age
Daylight		395	79%	10	71%
Twilight		21	4%	2	14%
Darkness		20	4%	0	0%
Electric Light		57	11%	0	0%
Other / unknown		7	1%	2	14%
WEATHER CONDITION		**All Accidents**	**%age**	**E-Bike Accidents**	**%age**
Rain	Yes	35	7%	1	7%
	No	462	92%	12	86%
	Unk	3	1%	1	7%
Snow	Yes	3	1%	0	0%
	No	493	99%	13	93%
	Unk	4	1%	1	7%

As with the population of all accidents, E-bike accidents mostly occurred during fine dry conditions. All of the accidents where the light condition was known occurred during the day or at twilight, none were recorded as occurring at night, however the small total sample must be remembered.

Conclusions regarding the findings of Annex 1

The results of the in-depth analyses for the 500 cases of accidents investigated in the SaferWheels project can offer some useful insights when viewed collectively. It is noted that reading the following conclusions should take in to account the lack of the respective exposure data (vehicle kilometres per each user, road, traffic and vehicle type). Some key points are presented in the following:

1. It appears that regardless of origin, two-wheeler occupants remain vulnerable road users, with a considerable amount of serious and fatal injury accidents (despite several unknown cases in the data).
2. There seem to be more active periods of time in which more accidents occur. For two-wheelers, these are the months between May and September, which are generally periods of good weather for the countries examined. Furthermore, in general tourism increases during that period, especially for southern European countries such as Greece and Italy. Additionally, more accidents seem to be caused during weekdays as opposed to weekends, and more accidents seem to be caused during working hours than non-working (off-peak) hours.
3. It can be thus assumed that more active periods with increased two-wheeler trips (and thus exposure) lead to more accidents.
4. Regarding the average profiles of riders that are involved in accidents, PTWs seem to be used more often by younger, male people overall. Perhaps this is explained via the criteria of each age group: speed, manoeuvrability and sensation seeking can be said to be the needs of younger people. Conversely, elder individuals might seek the comfort of a car, switch to a bicycle or on foot, or limit their exposure altogether (by travelling in fewer trips). Males considerably outnumber females, though not as much in bicycle ridership. For bicycle riders, the age profile was shifted more towards elder riders, specifically those over 45, and approximately a third of riders were female.
5. Considering accident causes, intoxication by alcohol and narcotics was not a common causation factor. Interestingly enough, speeding contributions (speeding above the speed limit and whether speed was a contributing factor) alone did not appear to be too detrimental as well. It should be noted at this point that all the circumstances of an accident must be analysed with speeding in mind in order to reach a verdict; for instance, for a distracted PTW rider, a speed of half of the speed limit might be enough to cause an accident; that would not be registered as "speeding" in the descriptive statistics, however. To that end, speeding might require further separate and dedicated in depth analyses.
6. In line with the current scientific literature, younger age groups displayed higher instances of speeding during the accident, and speeding in turn led to more serious injuries in accidents (more fatal/serious injury accidents compared to slight/no injury accidents). Lastly, when riding a high-powered PTW, speeding was found to cause accidents more frequently.
7. As for the usage of protective equipment, most two-wheeler riders recognise the essentiality of helmet use while riding. The same cannot be said for reflective clothing. Helmets were also found to stay on during the accident. For the aspect of conspicuity, headlights were also used by the majority of PTW riders.
8. While there was considerable diversity in the PTW fleet (several different motor displacement categories were recorded), the overall condition of that fleet can be said to be good or excellent (86% in total). Furthermore, in very few instances were mechanical problems explicitly recorded in the vehicles, thus hinting that vehicle problems are not primary factors of accident occurrence.
9. When looking at accident circumstances, it was found that the highest amount of accidents was recorded in residential and commercial areas, during daylight conditions, in good weather and dry surface conditions and in local or collector roads. Again, this is explained via exposure, as these conditions are the more

favourable ones for two-wheeler trips. The majority of accidents happen within areas with a speed limit of a 50km/h followed by 30 km/h, again indicating that two-wheelers are favoured for more urban uses. A noteworthy find is the very low accident numbers reported in roundabouts, as opposed to crossroads, T or Y junctions, and most importantly, single roads.

10. E-bikes were a rare vehicle category, which was treated separately for the analysis. They were found primarily in the Netherlands (11 of the 14 reported e-bikes in accidents). Approximately a third were single vehicle accidents, the rest involved collisions with other (motorised or non-motorised) vehicles, and they tended to show similar characteristics as compared with all accidents.

Annex 2 – Past research relating to PTWs and Bicycles

Studies Relating to PTWs

The RIDERSCAN European Scanning Tour for motorcycle safety (2011-2014), project was aimed at gathering existing knowledge, identifying needs and disseminating collected information to relevant stakeholders to promote motorcycle safety throughout Europe. It reported on areas for European action (legislation, standardization, research and political needs), but also disseminated conclusions to relevant stakeholders at national level (Delhaye at el., 2015).

The main objectives of the project included the identification and comparison of national initiatives on PTWs, and the identification of best practices. Another important objective was to collect and structure existing knowledge at European level to identify critical gaps that future efforts should focus on. Finally, the project aimed at identifying the critical needs for policy action, whether at European or national level, with a view to dissemination to a wide range of relevant stakeholders in Europe in the coming years.

The MOSAFIM project examined Motorcyclist road safety improvement through better performance of the protective equipment and first aid devices (2012-2013). The study project has contributed to motorcyclists' road safety by focusing on the following two areas:

- Improvement of road safety for motorcyclists through a better performance of their protective equipment including helmets, jackets, gloves, shoots, neck protectors and back protectors. This project has analysed through in-depth accident databases the relationship between the dynamics of motorcyclist accidents, the injuries and the type of motorcyclist equipment with the aim of knowing the effectiveness of these passive safety systems in terms of the seriousness of injuries.
- Improvement of "Post-injuries Services" (PIS) and so-called "Emergency medical systems (EMS)".

Once the relation between severity of injuries and the EMS responding time has been estimated, two EMS have been analysed: an "emergency medical dispatch" so called "photosafety" which sends accident photographs to hospitals before the motorcyclist arrives by ambulance; and an "in vehicle emergency notification systems" as eCall, through the definition of recommendations (previous to standardization) about the characteristics that e-call devices should have, with the aim of helping to define a possible legislative approach to eCall on PTWs (Molinero at el. ; 2013).

Regarding injury mechanisms, it has been found that the object most frequently struck by a PTW is a car, followed by the road or roadside furniture resulting from single vehicle loss of control. Nevertheless, the most common impact opponent cause of injuries is the ground/roadway, for all the body regions. On the other hand, the literature review led to define a list of queries to be answered by using four in-depth accident databases: MAIDS, NASS, LMU and DIANA. As a result of a preliminary exploration of these databases and with the support of previous conclusions extracted from literature, it has been concluded that further research is needed into Thorax, Neck/Cervical Spine and Spine body regions:

The PISA Powered Two Wheeler Integrated Safety (2006-2009) was aimed at the development and implementation of "reliable and fail-safe" integrated safety systems for a range of Powered Two Wheelers, which would greatly improve the performance and primary safety (handling and stability) and could link to secondary safety devices (Grant et al. 2008).

The system components included sensors, a PTW state estimator, logic control, warning devices, and advanced/intelligent actuators within brakes and suspensions elements to assist the rider. Specific sensors and actuators were to be developed and integrated into an operational safety system for PTW ’s to allow for driver warning and assistance to improve handling and stability, to be innovative and to go beyond current state-of-the-art. The developed systems were to be implemented on PTWs and evaluated by executing road and track tests and performing simulations. The cost savings in terms of reduction in accidents and injuries were to be related to the costs of fitting the integrated safety systems to PTWs.

The 2-BE-SAFE 2-Wheeler Behaviour and Safety (2009-2011) project’s main objective was to target behavioural and ergonomics research to develop countermeasures for enhancing PTWs, riders safety, including research on crash causes and human errors and to be the world’s first naturalistic riding study involving instrumented PTWs.

Another aim of the 2-BE-SAFE project was to design and implement a broad-ranging research program that produced fundamental knowledge on PTW riding behaviour, performance, and safety - alone and when interacting with other road users - that could be used to inform the development of a broad and integrated package of countermeasures/public policies for improving the safety of PTW riders in Europe.

Guidelines and recommendation were drawn up for the observation of PTW behaviours and for the determination of countermeasures towards improvement of PTWs' road safety, based on the fundamental knowledge acquired in the project's research work packages. A set of countermeasures were proposed that cover the safety problems that were identified during the in-depth studies related to: infrastructure and weather conditions, riders’ behaviour and interactions with other road users and conspicuity issues. The potential impacts of each proposed countermeasure, as well as its expected costs and implementation barriers as well as acceptance. The proposed countermeasures have been ranked and key success factors have been proposed.

Dissemination activities inform various stakeholders about the potential activities of a multi-facet project such as 2BESAFE. Diffusing information and knowledge to various interested groups could yield unpredictably interested future research opportunities. For example, the potential for creating countermeasures and guidelines for methodologies and tools could serve as a basis for future research activities or continuation of the work undertaken with 2BESAFE.

MAIDS In-depth investigations of accidents involving powered two wheelers (2001-2002), was an extensive in-depth study of motorcycle and moped accidents in five sampling areas and led to a conclusion that the main cause of the majority of PTW accidents was found to be human error (due to the driver inattention, temporary view obstructions or the low conspicuity of the PTW). Collected data demonstrated that the use of alcohol increased the risk of being in an accident, although the percentage was lower than in other studies. Unlicensed PTW operators who were illegally riding PTWs that required a licence, were also found to be at greater risk of being involved in an accident when compared to licenced PTW riders (Final report – MAIDS - In-depth investigations of accidents involving powered two wheelers, 2002).

The data collected during this study represents the most comprehensive in-depth data currently available for PTW accidents in Europe. It was expected that this data would provide much needed information for developing future research in relation to public policy issues.

Studies Relating to Bicycles

The SAFECYCLE-ICT applications for safe cycling in Europe (2011-2012), project's main objectives were identifying e-safety applications that would enhance the safety of cyclists in Europe, creating knowledge and awareness concerning e-safety applications in the domain of cycling (policy, industry, users) and speeding up the adoption of (new) e-safety applications in cycling (De Joung et al. 2012).

Some of the recommendations for a research agenda included the further comparative research into national frameworks on supportive policies in cross-cutting SAFECYCLE-issues (cycling-ITS-safety) and investigation of possibilities for national demonstration projects, research on HMI (human machine interface) between cyclists and their bicycle, the risk impact for cyclists who are not equipped with applications in case a lot of cyclists do use ICT and ITS applications. Another recommendations was the further research in the causes of bicycle accidents (e.g. use of data from in-depth investigations) and harmonisation of accident data across Europe, which seems to be fulfilled through SaferWheels project.

2 BIKE PAL Cyclists' Best Friend (2011-2014) was a pan European project that aimed to offer cyclists a package of information, resources, and awareness raising experiences to help them significantly improve their safety on the roads, thus effectively becoming cyclists' best friend! The project also aimed at mobilising students to run a concrete action to improve cyclists' safety (i.e. a local cycling safety campaign, for example the treatment of a high risk site for cyclists); this was done by recruiting students from across European Member States. These university lectures were also accompanied by an HGV (Heavy Goods Vehicle) field of vision demonstration. The idea was to bring a truck on campus and let students/cyclists climb inside the cab of a truck and experience first-hand the limited direct field of vision of truck drivers (Final reports, 2014).

Annex 3 – Data Collection Methodology

Relationship between each sample region and the national population

The selected sample regions covered by each team had a known relationship with the national accident population. To be representative, the distribution of key variables had to be close to that of the national data. The following tables show these distributions for each sample region and the corresponding national population together with brief details of the sample areas shown in the corresponding figures.

France – Essonne

Essonne has an area of 1,804 km² (France (metropolitan) is 640,679 km²). Retrospective in-depth investigations were performed in all of the Essonne area while on the spot accident analysis was performed within a radius of some 350 km² (highlighted area).

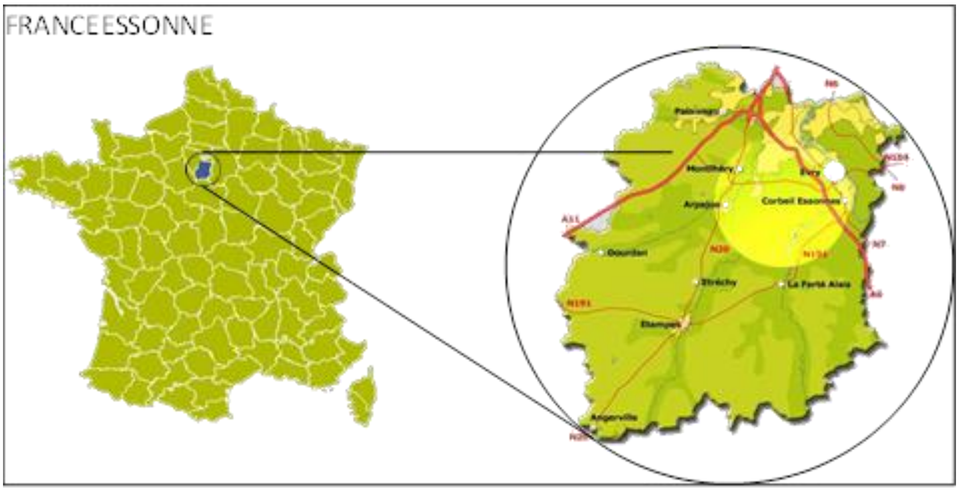


Figure 53: France Sample Region - Essonne Region

Greece – Thessaloniki

The Greek cases have been collected by the CERTH/HIT accident investigation lab. The team has started the in-depth accident analysis activities in 2006. The investigation team collects all type of accidents. CERTH/HIT was one of the DaCoTA partners which has contributed to the development and testing of the proposed methodology and protocol.

Catchment Area for SaferWheels

The Greek catchment area is located around the city of Thessaloniki. The Thessaloniki regional unit is subdivided into 14 municipalities and the region is 3,683 km2 wide. The Metropolitan area size is 1,090km2. The sampling region is a mixture of urban and rural areas. There is also a long path of a highway link and this is the reason of a special Highway Traffic Police unit.

According to the national accident statistics, the selected area is quite representative of the whole country for both PTW and bicycle accidents. The only significant variation form the country statistics is the 12% higher PTW accident occurrence between 08:00-19:59, which can be justified by the fact that Thessaloniki is a highly populated city (1.1Million inhabitant) and the second largest in Greece. This time slot corresponds to the period that most activities take place in an urban environment.

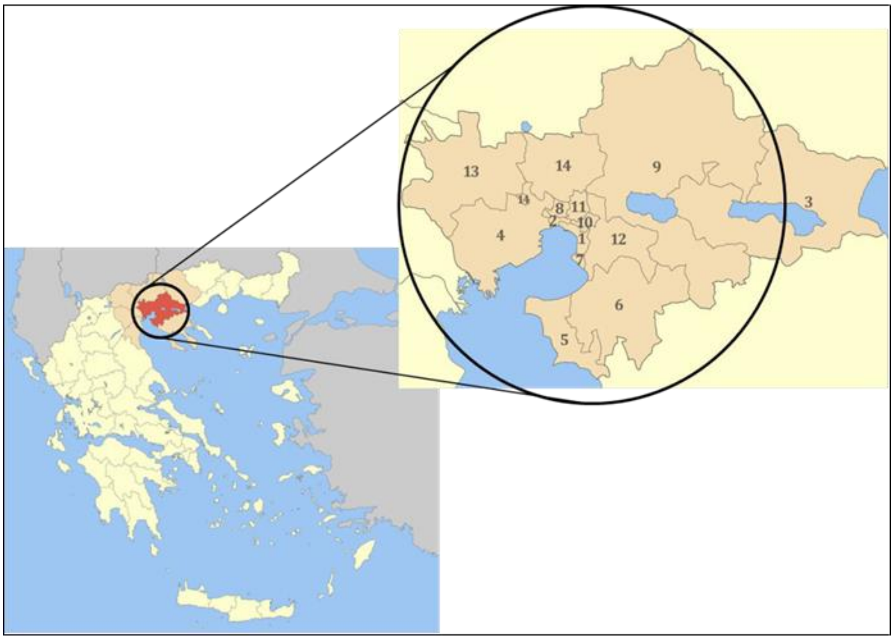


Figure 54: Greek Sample Area - Thessaloniki Region

Accident notification for SaferWheels

The CERTH team had established a notification system via phone with the Traffic Police districts, but mainly the notification derived by the headquarters, especially in severe accidents. In order to keep the police officers alert, frequent follow up calls and visits to the police stations took place during the whole duration of the project. Except the police notification, the team daily visited internet pages with local news and reports about traffic accident occurred in the region. Immediately after, the team contacted the police district in order to identify how this case will be further processed by the police and consequently by the investigation team. It should be noted that material damage accidents are registered by the police if the police is called by the involved parties. Otherwise these accidents will appear only in the vehicle insurance register, similarly if there is an accident notification to the insurance companies. Beyond the police and press path of notification, CERTH has disseminated the project to its employees. Unfortunately, 5 employees were involved in 5 PTW accidents during the collection phase, 3 of which were severe enough in order to appear in the CARE database. In principal the team was reachable 24 hours a day, through mobile phone, for an accident notification by the police.

Selection criteria

The selection criteria that CERTH had to fulfil were the same as for all other teams: accidents involving at least one PTW or involving a bicycle and a motor vehicle. The team randomly collected cases every month. However for cases that have been retrospectively investigated, before any further steps, the case was discussed with the police officers in charge for deciding its acceptance or rejection. Of course the rejection of a case was done only if more than 60% of the data was missing (about 20 cases were rejected). In order not to bias the sample, cases that not all data were available have been accepted.

Data collection

About one third of the 85 cases has been investigated on scene. Removing the vehicle to the road side is a often phenomenon in PTW and certainly in bicycle accidents. This is a typical problem in a busy urban environment where the traffic flow should become normal as soon as possible. More specifically, six out the seven bicycle accidents in the

Greek sample were investigated retrospectively. In only one case the bicycle was still at the rest position when the police arrived (fatal one).

The police dossier which is further forward to the D.A. contains essential information that have been used in the accident analysis phase. Most importantly, the dossier contains medical information directly by the hospital to which the victim was transported. However, the police dossier was available to a specific team member (for all cases), under the presence of a police officer, in order the investigator to keep notes and to fill in the SaferWheels worksheets. This was done in accordance to the protection of person data rules.

Visiting the accident scene was the most less effort task, because the location and accident traces were recorded detailed by the police. The inspection of the vehicle was performed in most cases at the towing company premises in duty at that week. There were also some cases where the vehicles inspected at the police premises. However, reaching the other vehicle is a major concern, especially in light damage accidents like those involving a PTW/bicycle and a car in a city environment. Cross and T- junction accidents with brake slide outs that led to slight damages were commonly met. As far as the interviews is concerned, this was possible only if the team met the victims/witnesses on scene. Of course detailed police interviews/statements were available through the police. Even though contact details were available for most people involved, no contact was attempted with them, because such action would be a major violation of the data privacy law. Regarding the codification of the medical data, this was done by a certified AIS team member. Additionally an orthopedist was engaged in case of complex traumas codification.

Italy - Rome

The Italian cases were collected by CTL using the equipment and tools adopted for the DaCoTA and SafetyNet research projects. The CTL team investigation area was the whole District n.7 of Rome and the municipality area of Ciampino.

Initially, on-scene data collection was planned for the sole Rome area, however, to meet with the project time-frame it was necessary to extend the area of investigation including Ciampino municipality and adopt retrospective methods within the CTL data collection protocol. More specifically the following were adopted.

1) On-scene investigation

For selected days the team is located at the local police station of Rome District n.7 or Ciampino municipality and receives the accident notification in real time. After Police notification, if the crash fits the inclusion criteria defined in SaferWheels, the team immediately follows the Police to the crash scene and starts to collect data after confirmation from the Police. If people involved refuse to be interviewed on-scene or further aspects of the collision need to be clarified (e.g. vehicle inspection), the team organises a second meeting with interested parties.

About 15% of cases were investigated through on-scene investigation.

2) Retrospective investigation

Both Ciampino and Rome Police units agreed to contact PTW riders, bicyclists and the other collision partners in the District 7th of Rome and Ciampino areas on behalf of Sapienza University to ask to participate to the study. It was not possible to directly contact road users due to data protection agreements. If a road user consented to participate, they were given details to contact the CTL team who then arranged a meeting.

These meetings usually took place during the weekly visits to the police districts in Ciampino and Rome. During a meeting, interviews were then conducted by a member of the CTL team, and the vehicle examined with the permission of the participant. Priority was given to those accidents for which a vehicle inspection was feasible.

Police support were provided to CTL team to extract the relevant information for SaferWheels purposes for coding and entry onto the database.

Through the retrospective method it was possible to investigate weekend accidents and nighttime accidents.

The Rome area sample region itself is representative of the country in terms of road user types, traffic population and severity of collisions in terms of injury outcome. However, due to the involvement of Local Police units (usually not collecting crashes on rural roads and motorways) the collected sample is over-represented in terms of accidents occurring in urban roads and slight injuries.

Among the investigated crashes, 5% of them involved bicycles and 95% involved PTWs. This is a slightly higher percentage of bicycles than was originally planned probably due to an increase of cyclists in Italy in general and Rome in particular.

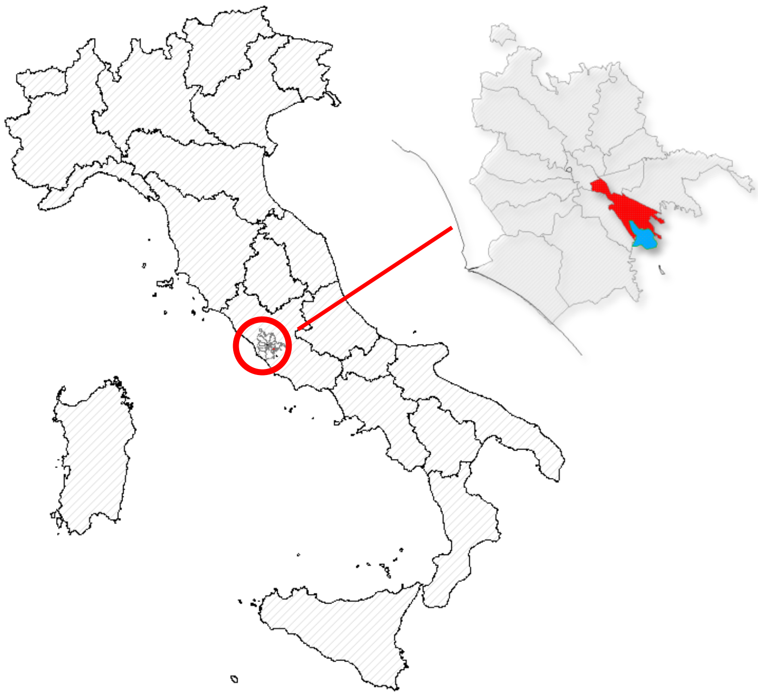


Figure 55: Italian sampling area – Rome Municipality

The Netherlands – The Hague

Data collection in the Netherlands was carried out by the SWOV-team for in-depth crash investigation. This team was established in 2008 and has carried out thematic in-depth studies on topics including single-vehicle cyclist accidents, accidents involving pedelecs and speed pedelecs, and light moped accidents on urban bicycle paths.

Catchment area for SaferWheels

The general catchment area for the SWOV team was the area of the national police unit The Hague (see Figure 1). This area is very well defined and follows the borders of the province of South-Holland except for the southern part of the area, which is part of another police unity (Rotterdam). The catchment area contains both urban and rural areas. About 15% of all PTW and bicycle accidents in the Netherlands occur in this area. Moreover, the PTW and bicycle accidents in this region are representative of the

Netherlands in terms of injury severity, road type and time of occurrence (see Table 5 and Table 6).

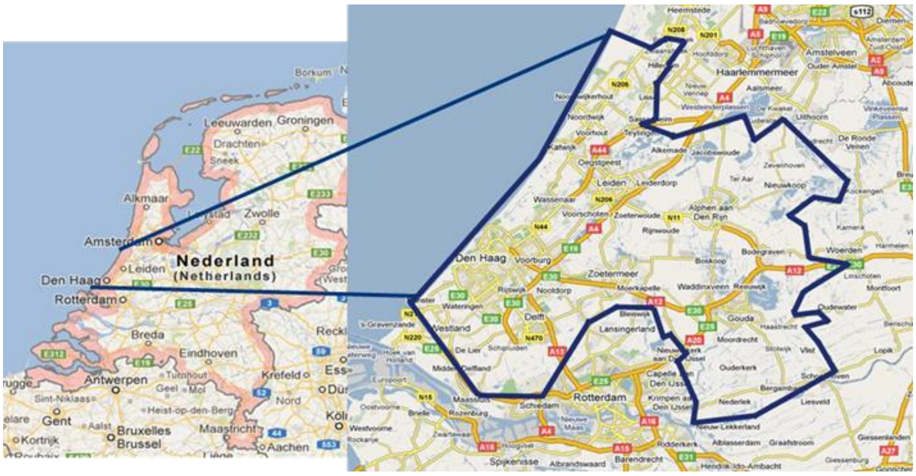


Figure 56: Sampling area in The Netherlands – The Hague Region

Criterion	% in data collection area*	% in country*
Fatal accident	2%	4%
Injury accident (non-fatal)	98%	96%
Truck involved	2%	2%
Pedestrian involved	3%	4%
Motorway	2%	4%
Rural	14%	18%
Urban (but not on Motorway)	67%	65%
Unknown	16%	14%
January – April	33%	34%
May – August	45%	42%
September – December	22%	24%
08:00 – 19:59	78%	76%
20:00 – 07:59	22%	23%
Total number of injury accidents (100%)	969 (three years)	6.585 (three years)

* Percentage calculated with reference to total injury accidents.

Table 19: Road accidents with at least a PTW involved (COUNTRY: Netherlands 2010-2012)

Criterion	% in data collection area*	% in country*
Fatal accident	3%	7%
Injury accident (non-fatal)	97%	93%
Truck involved	3%	3%
Pedestrian involved	2%	2%
Motorway	0%	1%
Rural	8%	13%
Urban (but not on Motorway)	79%	75%
Unknown	14%	11%
January – April	41%	39%
May – August	36%	36%
September – December	22%	25%
08:00 – 19:59	84%	83%
20:00 – 07:59	16%	17%
Total number of injury accidents (100%)	940 (three years)	6.317 (three years)

* Percentage calculated with reference to total injury accidents.

Table 20: Road accidents with at least a bicycle involved (COUNTRY: Netherlands 2010-2012)

In addition to the area of police unit The Hague, fourteen accidents were sampled from the area of police unit of Amsterdam. These fourteen acidents were all accidents involving light mopeds.

Accident notification for SaferWheels

Every day of the week, one hour after midnight, SWOV received an automatic e-mail from the police that contained all police reports of possibly relevant accidents that had occurred on the previous day. In addition, SWOV checked the internet every day to look for information on crashes that the police had not mentioned yet. The accidents of which SWOV was notified by the police may or may not be included in the national road traffic accident database, as not all police reported road traffic accidents are registered as such.

Selection criteria

The team checked all accidents on relevance for the SaferWheels project: involving at least one PTW or involving a bicycle and a motor vehicle. Every 6th relevant case was selected for data collection in principle. However, the team only started data collection if it was sure that it would be able to collect enough information about the pre-crash phase. This means that the team only selected an accident for inclusion in the SaferWheels database if it was able to interview one or more of the people involved in the accident and/or had received the transcripts of police interrogations. Information about the two-wheeler was also one of the prerequisites for selecting the accident for investigation.

Data collection

All accidents were investigated retrospectively. However, the team also received all information collected by the police, which includes volatile information (skid marks, pictures of vehicle positions immediately after the crash).

For each selected case, the team first checked whether the vehicle(s) were taken to the police station for further investigation. If so, the vehicle specialist immediately went to the police station to inspect the vehicle. If not, one of the psychologists of the team contacted the people involved in the crash as soon as possible and made an appointment for an interview. If the vehicle was at their home, the vehicle was inspected after the interview had taken place. Based on information about the exact location of the accident, two team members including one road safety engineer carried out a scene investigation. Additionally, the police was asked to provide all the information they had collected, and the hospitals were asked for AIS information on the injuries of the people involved (only when those people had given permission to do so).

Poland – Mazowieckie

Region

In Poland, Mazovian Voivodship have been designated for in-depth investigations. This is Poland's biggest region for size (35 558,47 km2) and population (5,29 millions). Its principal city is Warsaw – the capital of Poland.

An analysis of motorcyclist and cyclist accidents in Mazovian Voivodship has shown that the distribution was very similar to national distribution in Poland. Therefore, this region may be treated as being representative of Poland.

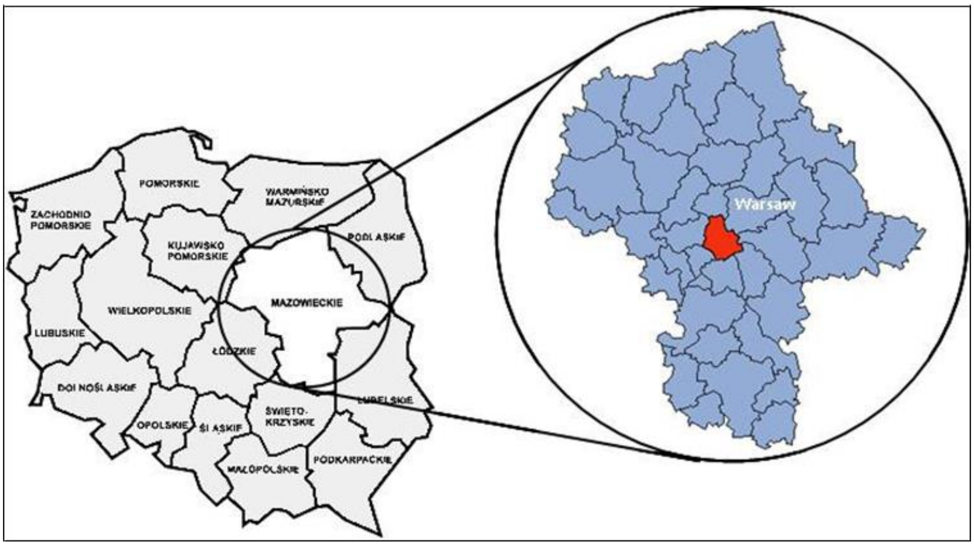


Figure 57: Poland sampling region – Mazowsze region

Criterion	% in Mazowieckie region	% in country
Fatal accident Injury accident (non-fatal)	10% 90%	7% 93%
Truck involved Pedestrian involved	10% 4%	8% 5%
Motorway Rural roads Urban area (but not on motorway) Unknown	0% 21% 78% 1%	0% 15% 84% 1%
January-April May – August September - December	16% 50% 33%	15% 53% 32%
08:00 – 19:59 20:00 – 07:59 Unknown	77% 22% 1%	80% 20% 0%

Table 21: Road accidents with at least a bicycle involved (Poland: 2011-2013)

Criterion	% in Mazowieckie region	% in country
Fatal accident Injury accident (non-fatal)	10% 90%	8% 92%
Truck involved Pedestrian involved	6% 6%	6% 5%
Motorway Rural roads Urban area (but not on motorway) Unknown	0% 22% 70% 1%	0% 22% 77% 1%
January-April May – August September - December	15% 60% 24%	14% 58% 22%
08:00 – 19:59 20:00 – 07:59 Unknown	78% 21% 1%	78% 20% 2%

Table 22: Road accidents with at least a PTW involved (Poland: 2011-2013)

Research population

The data collection in Poland was carried out from January 2015 to November 2016. In total, the data on nearly 100 road accidents involving cyclists and motorcyclists were collected. However, in some cases, the collection all the pieces of information required by the project was not possible in for too little time. Therefore, finally, no more than 87 accidents have been entered into the SaferWheels project database.

Of these, 46% (n=40) were bicycles and 54% (n=47) were PTWs. The number of accidents involving cyclists and motorcyclists was slightly different from the one defined in the SaferWheels project distribution of accidents involving cyclists and PTWs (53% of accidents involving cyclists, 47% - with participation of PTWs). The difference was mainly due to the availability of all pieces of data during the established period of the implementation of the project.

Method of research

Information on road accidents involving PTWs and cyclists was collected in Poland using two methods: on-scene investigation (48 accidents, 55% of total investigated accidents) and retrospective investigation (39 accidents, 45%).

1) On-Scene Investigation

This type of research was conducted in Warsaw. Motor Transport Institute (ITS) employees were on duty throughout the whole week. As soon as they received the information from the police about an accident involving a PTW rider or a cyclist, they tried to reach the accident scene as soon as possible. In accordance with the established procedure at the accident site, they carried out photographic documentation of the accident site, all visible traces and the vehicles participating in the accident. They also collected the information about how the accident happened and about its participants. They interviewed accident participants and witnesses present at the accident scene. PTW riders and cyclists were interviewed either in the hospital or by phone after they returned home from the hospital (usually in 1-2 days after the accident). Unfortunately, almost all motorcyclists and bicyclists involved in road accidents had been taken to hospital for examination before the arrival of the ITS team at the scene of the accident. The data collected in this way were verified and/or supplemented with information contained in the documentation prepared by the police, prosecutors and courts of law. ITS employees obtained from the police the sketches of the accident site, photos, as well as the exact data on the results of sobriety tests. They also received data on emergency rescue operations from the Provincial Health Department. The information about the injuries suffered by accident victims was received from the health service and from forensic experts. The data on victim injuries were subsequently coded according to AIS 2005 scale (Update 2008). All information collected in this way was coded and entered into the database.

2) Retrospective Investigation

Retrospective research was conducted when an accident involving a cyclist or motorcyclist did not take place in Warsaw itself but within the boundaries of Mazovian Voivodship. ITS employees obtained from the district prosecutors detailed lists of accidents involving PTWs and cyclists that had happened in Mazovian Voivodship in the period of time from 2015 to 2016. They also got the access to documentation gathered in court proceedings. During visits to the relevant prosecutors' offices and courts of law, ITS employees had the opportunity to copy the documentation of road accidents. They also received the copies of photos taken by the police at the scene of the accident. Court documentation often contained expert opinions on technical condition of vehicles involved in road accidents and, more rarely, expert opinions on the course of the accident itself. Unfortunately, due to the necessity of protection of personal data, it was not possible to conduct interviews with participants of road accidents. During the process of analysis of accidents, the testimonies of participants and witnesses of road accidents collected by the police, prosecutors and courts of law were used. Furthermore, during their visits to the relevant prosecutors' offices and courts in Mazovian Voivodship, Motor Transport Institute employees also visited places of road accidents and carried out photographic documentation of the place and performed basic measurements. ITS employees analysed, organized and entered the collected data into the database.

Difficulties encountered in the process of implementation of the SaferWheels project

In Poland there are no legal regulations enabling the collection of information on road accidents at directly at the place of the event by the institutions other than the police. Hence, the implementation of SaferWheels research was possible only thanks to the enormous support of the police, prosecutors and courts of law. The experience we gained indicates that the gathering adequate means (including funds) for training and maintaining teams awaiting for reporting an accident and organizing a quick notification system on the occurrence of a road accident will be the main problem for all new teams implementing in-depth research. In Poland, Motor Transport Institute received the information from the police about an incident on average 30-40 minutes after its occurrence. Another problem was also access to the place of the accident, especially when the accident occurred in Warsaw during rush hours and/or when the place of the incident was far away from the headquarters of Motor Transport Institute. Every so often, ITS employees were able to reach the scene no sooner than an hour after the accident. As a result, the vehicles involved in the accident were placed on the roadside and road traffic was restored on the roadway. Undoubtedly, the protection of personal data is still a huge problem. Conducting interviews with the participants of the accident was possible only when they were at the scene of the accident and agreed to it, or when their family members or friends provide us their telephone numbers. It is practically impossible to carry out more detailed technical inspections of vehicles involved in an accident at the crash site. Their owners generally do not agree to more thorough examination of the vehicles or to visits of specialists in their place of residence. Furthermore, expert opinions carried out at appropriate Vehicle Inspection Stations are usually costly and can be performed in Poland only at the request of the prosecutor's office or a court of law. It also applies to toxicological analyses during which the presence of illegal psychoactive substances is examined. Thus, there is considerable evidence to suggest that many assumptions of conducting in-depth studies should be analysed once again.

The UK – Midlands region

The UK cases were gathered by Loughborough University using the pre-existing infrastructure developed for the DaCoTA and SafetyNet collision research projects. The Loughborough University investigators gathered data from collisions within the Midlands region, specifically the counties of the West Midlands, Nottinghamshire, and Derbyshire.

Initially, on-scene data collection was planned with members from the Loughborough team attending the collision scene immediately after collision occurrence; however alternative methods had to be sought in order to meet with the project time-frame. As such, the UK cases were collected via two methods:

1) In-depth police investigation reports of fatal or critical injury collisions.

In-depth police reports were provided by several local Police Forces (Derbyshire, Nottinghamshire, West Midlands), and were examined by members of the Loughborough University team to extract the relevant information for SaferWheels purposes for coding and entry onto the database. Specific data protection agreements and vetting procedures were drawn up between the Police forces and the Loughborough team to enable this.

To further elaborate, in the UK the Police conduct an in-depth investigation into a road traffic collision in cases where a road user is injured ether fatally or near-fatally. The resultant in-depth reports contain information such as detailed vehicle examinations, collision reconstruction reports, road user interviews, scene surveys, etc. This is a much greater level of detail than is captured by the Police for Slight or Moderately Serious collisions which do not provide enough information for the SaferWheels protocol. Therefore, only in-depth reports were requested.

Approximately three quarters of the Loughborough Cases were collected via this method, and this led to a higher proportion of fatal and serious injury cases than was originally anticipated in the sampling plan.

2) Interviews with PTW and bicycle riders involved in slight or serious accidents.

In addition to providing in-depth reports, Derbyshire Police also agreed to contact PTW riders and bicyclists that had been injured in collisions in the Derbyshire region on behalf of Loughborough University to request participation in the study. It was not possible for the Loughborough team to contact road users directly due to data protection agreements, but if a road user consented to participate, they were given details to contact the Loughborough team who then arranged an interview.

The road user interviews were then conducted by a member of the Loughborough team, and the vehicle examined with the permission of the participant. This method of data collection has limitations in that less information was known about the collision partners, but it did allow the team to ask detailed and specific questions during the interview to capture as much information as possible, including some information that was not routinely captured by the police.

The Midlands sample region itself is representative of the UK in terms of road user types, traffic population and severity of collisions in terms of injury outcome. However due to the original difficulties in data collection that necessitated using large numbers of police investigation reports, the collected sample is over-represented in terms of fatalities and serious injuries.

For the UK, 38% of the investigated collisions involved Bicycles and 62% involved PTWs. This was a slightly lower percentage of bicycles than was originally planned, as during monitoring of the overall project sample it was discovered near the end of data collection that the total sample of bicycles was higher than originally anticipated, so Loughborough prioritised PTW data collection for the final case numbers.

Figure 58: UK sampling region – Midlands area

Annex 4 – Database Improvements

Id	Table_name	Column_name	Variable_id	Short_description	Timestamp
1843	road_user_interview	interview_summary	1621	To Complete	16/09/2015
1844	road_user	road_user_interview	1622	To Complete	08/01/2016
1845	ptw	ptw_category	1623	To Complete	04/03/2016
1846	ptw	ptw_last_mandatory_inspection_date	1624	To Complete	04/03/2016
1847	ptw	ptw_next_mandatory_inspection_date	1625	To Complete	04/03/2016
1848	ptw	ptw_last_technical_maintenance_inspection_date	1626	To Complete	04/03/2016
1849	ptw	ptw_reason_for_last_technical_maintenance_inspection	1627	To Complete	04/03/2016
1850	ptw	ptw_completed_inspection	1628	Completed Inspection	04/03/2016
1851	ptw	ptw_inspection_date	1629	Inspection date	04/03/2016
1852	ptw	ptw_start_time	1630	Start time	04/03/2016
1853	ptw	ptw_end_time	1631	End time	04/03/2016
1854	ptw	ptw_inspection_duration	1632	Inspection duration	04/03/2016
1855	ptw	ptw_source_of_information_in_locating_vehicle	1633	Source of information in locating vehicle	04/03/2016
1856	ptw	ptw_distance_to_inspection_site	1634	Distance to inspection site	04/03/2016
1857	ptw	ptw_registration_n	1635	Registration number	04/03/2016
1858	ptw	ptw_vehicle_identification_n	1636	Vehicle identification number	04/03/2016
1859	ptw	ptw_country_of_registration	1637	Country of registration	04/03/2016
1860	ptw	ptw_accident_participant_according_to_dacota	1638	Accident participant according to DaCoTA	04/03/2016
1861	ptw	ptw_vehicle_wheel_base	1639	Vehicle Wheel Base	04/03/2016
1862	ptw	ptw_vehicle_width	1640	Vehicle width	04/03/2016
1863	ptw	ptw_vehicle_height	1641	Vehicle height	04/03/2016
1864	ptw	ptw_kerb_weight	1642	Kerb weight	04/03/2016
1865	ptw	ptw_throttle_cables_slack	1643	Throttle cables slack	04/03/2016

1866	ptw	ptw_steering_damper_fitted_securely	1644	Steering damper fitted securely	04/03/2016
1867	ptw	ptw_handle_bar_lock_to_lock_movement	1645	Handle bar lock to lock movement	04/03/2016
1868	ptw	ptw_handle_bar_grips_bonded_securely	1646	Handle bar grips bonded securely	04/03/2016
1869	ptw	ptw_clutch_cables	1647	Clutch cables	04/03/2016
1870	ptw	ptw_clutch_cable_slack	1648	Clutch cable slack	04/03/2016
1871	ptw	ptw_head_light_lens	1649	Head light lens	04/03/2016
1872	ptw	ptw_rear_brake_light_lens	1650	Rear brake light lens	04/03/2016
1873	ptw	ptw_head_light_lens_damaged_in_crash	1651	Head light lens damaged in crash	04/03/2016
1874	ptw	ptw_rear_brake_light_lens_damaged_in_crash	1652	Rear brake light lens damaged in crash	04/03/2016
1875	ptw	ptw_red_reflector_present	1653	Red reflector present	04/03/2016
1876	ptw	ptw_motor_power_enhancement_type	1654	Motor power enhancement type	04/03/2016
1877	ptw	ptw_exhaust_system_muffler	1655	Exhaust system/muffler	04/03/2016
1878	ptw	ptw_aftermarket_exhaust_system_suited_for_road_use	1656	Aftermarket exhaust system suited for road use	04/03/2016
1879	ptw	ptw_cp1	1657	CP1	04/03/2016
1880	ptw	ptw_cp2	1658	CP2	04/03/2016
1881	ptw	ptw_cp3	1659	CP3	04/03/2016
1882	ptw	ptw_cp4	1660	CP4	04/03/2016
1883	ptw	ptw_cp5	1661	CP5	04/03/2016
1884	ptw	ptw_investigators	1662	PTW Investigators	04/03/2016
1885	ptw_wheel	ptw_wheel_brake_mechanism_condition	1663	Brake mechanism condition	04/03/2016
1886	ptw_wheel	ptw_wheel_suspension_oil_leakage	1664	Suspension oil leakage	04/03/2016
1887	ptw_wheel	ptw_wheel_damper_springs	1665	damper_springs	04/03/2016
1888	ptw_wheel	ptw_wheel_wheel_type	1666	Wheel type	04/03/2016
1889	ptw_wheel	ptw_wheel_wheel_condition	1667	Wheel condition	04/03/2016
1890	ptw_wheel	ptw_wheel_are_front_and_rear_tyres_compatible	1668	Are front and rear tyres compatible	04/03/2016
1891	bicycle	bicycle_make_of_the_vehicle	1669	Make of the vehicle	04/03/2016

1892	bicycle	bicycle_model_of_the_vehicle	1670	Model of the vehicle	04/03/2016
1893	bicycle	bicycle_bicycle_type	1671	Bicycle type	04/03/2016
1894	bicycle	bicycle_power_assistance	1672	Power assistance	04/03/2016
1895	bicycle	bicycle_shape	1673	Shape	04/03/2016
1896	bicycle	bicycle_colour_of_the_bike	1674	Colour of the bike	04/03/2016
1897	bicycle	bicycle_baker_s_rack_above_front_wheel	1675	Baker's rack (above front wheel)	04/03/2016
1898	bicycle	bicycle_box_in_front_of_bicycle_with_seats_for_children	1676	Box in front of bicycle with seats for children (parent bike)	04/03/2016
1899	bicycle	bicycle_carrying_rack_above_rear_wheel	1677	Carrying rack (above rear wheel)	04/03/2016
1900	bicycle	bicycle_front_basket	1678	Front basket	04/03/2016
1901	bicycle	bicycle_panniers_on_front_wheel	1679	Panniers on front wheel	04/03/2016
1902	bicycle	bicycle_panniers_on_rear_wheel	1680	Panniers on rear wheel	04/03/2016
1903	bicycle	bicycle_bell	1681	Bell	04/03/2016
1904	bicycle	bicycle_map_stand	1682	Map stand	04/03/2016
1905	bicycle	bicycle_navigation_system	1683	Navigation system	04/03/2016
1906	bicycle	bicycle_speedometer	1684	Speedometer	04/03/2016
1907	bicycle	bicycle_telephone_stand	1685	Telephone stand	04/03/2016
1908	bicycle	bicycle_mirror	1686	Mirror	04/03/2016
1909	bicycle	bicycle_child_seat_on_handle_bar	1687	Child seat on handle bar	04/03/2016
1910	bicycle	bicycle_information_on_front_child_seat_text_on_sticker	1688	Information on front child seat (text on sticker)	04/03/2016
1911	bicycle	bicycle_belt_available_on_front_child_seat	1689	Belt available on front child seat	04/03/2016
1912	bicycle	bicycle_pegs_available_on_front_child_seat	1690	Pegs available on front child seat	04/03/2016
1913	bicycle	bicycle_child_seat_above_rear_wheel	1691	Child seat above rear wheel	04/03/2016
1914	bicycle	bicycle_information_on_rear_child_seat_text_on_sticker	1692	Informtaion on rear child seat (text on sticker)	04/03/2016
1915	bicycle	bicycle_type_of_back_child_seat	1693	Type of back child seat	04/03/2016
1916	bicycle	bicycle_belt_available_on_back_child_seat	1694	Belt available on back child seat	04/03/2016
1917	bicycle	bicycle_pegs_available_on_back_child_seat	1695	Pegs available on back child seat	04/03/2016
1918	bicycle	bicycle_flag_orange_flag_on_kid_s_bike	1696	Flag (orange flag on kid's bike)	04/03/2016
1919	bicycle	bicycle_side_wheels_kid_s_bike	1697	Side wheels (kid's bike)	04/03/2016

1920	bicycle	bicycle_other	1698	Other	04/03/2016
1921	bicycle	bicycle_type_of_stand	1699	Type of stand	04/03/2016
1922	bicycle	bicycle_frame_size	1700	Frame size	04/03/2016
1923	bicycle	bicycle_vehicle_length	1701	Vehicle length	04/03/2016
1924	bicycle	bicycle_vehicle_width	1702	Vehicle width	04/03/2016
1925	bicycle	bicycle_vehicle_width_measured_at	1703	Vehicle width measured at	04/03/2016
1926	bicycle	bicycle_vehicle_height	1704	Vehicle height	04/03/2016
1927	bicycle	bicycle_vehicle_height_measured_at	1705	Vehicle height measured at	04/03/2016
1928	bicycle	bicycle_pedals	1706	Pedals	04/03/2016
1929	bicycle	bicycle_retro_reflective_area_on_pedals	1707	Retro-reflective area on pedals	04/03/2016
1930	bicycle	bicycle_braking_system_front	1708	Braking system front	04/03/2016
1931	bicycle	bicycle_braking_system_rear	1709	Braking system rear	04/03/2016
1932	bicycle	bicycle_condition_of_front_brakes	1710	Condition of front brakes	04/03/2016
1933	bicycle	bicycle_condition_of_rear_brakes	1711	Condition of rear brakes	04/03/2016
1934	bicycle	bicycle_condition_of_brake_cables	1712	Condition of brake cables	04/03/2016
1935	bicycle	bicycle_type_of_gears	1713	Type of gears	04/03/2016
1936	bicycle	bicycle_number_of_gear	1714	Number of gear	04/03/2016
1937	bicycle	bicycle_gear_at_time_of_crash	1715	Gear at time of crash	04/03/2016
1938	bicycle	bicycle_condition_of_gears	1716	Condition of gears	04/03/2016
1939	bicycle	bicycle_condition_of_gear_cables	1717	Condition of gear cables	04/03/2016
1940	bicycle	bicycle_type_of_tyres	1718	Type of tyres	04/03/2016
1941	bicycle	bicycle_information_on_tyre_incl_size_in_inches	1719	Information on tyre (incl. size in inches)	04/03/2016
1942	bicycle	bicycle_front_tyre_condition	1720	Front tyre condition	04/03/2016
1943	bicycle	bicycle_rear_tyre_condition	1721	Rear tyre condition	04/03/2016
1944	bicycle	bicycle_retro_reflective_on_front_tyre	1722	Retro-reflective on front tyre	04/03/2016
1945	bicycle	bicycle_retro_reflective_on_front_tyre	1723	Retro-reflective on rear tyre	04/03/2016
1946	bicycle	bicycle_motor_location	1724	Motor location	04/03/2016
1947	bicycle	bicycle_power_watt	1725	Power (Watt)	04/03/2016
1948	bicycle	bicycle_speed_limit	1726	Speed limit	04/03/2016
1949	bicycle	bicycle_battery_location	1727	Battery location	04/03/2016

1950	bicycle	bicycle_type_of_sensor	1728	Type of sensor (you can look this up on the internet using make and model of the bike; power on demand is an e-bike)	04/03/2016
1951	bicycle	bicycle_number_of_support_modes	1729	Number of support modes	04/03/2016
1952	bicycle	bicycle_mode_at_the_time_of_crash	1730	Mode at the time of crash	04/03/2016
1953	bicycle	bicycle_type_of_headlights	1731	Type of headlights	04/03/2016
1954	bicycle	bicycle_headlight_fitted_to_bicycle	1732	Headlight fitted to bicycle	04/03/2016
1955	bicycle	bicycle_headlights_operational	1733	Headlights operational	04/03/2016
1956	bicycle	bicycle_headlights_in_use_at_time_of_accident	1734	Headlights in use at time of accident	04/03/2016
1957	bicycle	bicycle_type_of_rear_lights	1735	Type of rear lights	04/03/2016
1958	bicycle	bicycle_rear_lights_fitted_to_bicycle	1736	Rear lights fitted to bicycle	04/03/2016
1959	bicycle	bicycle_rear_lights_operational	1737	Rear lights operational	04/03/2016
1960	bicycle	bicycle_rear_lights_in_use_at_time_at_accident	1738	Rear lights in use at time of accident	04/03/2016
1961	bicycle	bicycle_reflective_clothing_new	1739	Reflective clothing	04/03/2016
1962	bicycle	bicycle_type_of_the_helmet_make_model	1740	Type of the helmet (make/model)	04/03/2016
1963	bicycle	bicycle_information_on_sticker_in_helmet	1741	Information on sticker in helmet	04/03/2016
1964	bicycle	bicycle_helmet_fastened	1742	Helmet fastened	04/03/2016
1965	bicycle	bicycle_damage_to_helmet	1743	Damage to helmet	04/03/2016
1966	bicycle	bicycle_cp1	1744	CP1	04/03/2016
1967	bicycle	bicycle_cp2	1745	CP2	04/03/2016
1968	bicycle	bicycle_cp3	1746	CP3	04/03/2016
1969	bicycle	bicycle_cp4	1747	CP4	04/03/2016
1970	bicycle	bicycle_cp5	1748	CP5	04/03/2016
1971	bicycle	bicycle_gloves	1749	Gloves	04/03/2016
1972	bicycle	bicycle_type_of_load	1750	Type of load	04/03/2016
1973	bicycle	bicycle_load_weight	1751	Load weight	04/03/2016
1974	bicycle	bicycle_location_of_load	1752	Location of load	04/03/2016
1975	bicycle	bicycle_type_of_trailer	1753	Type of trailer	04/03/2016
1976	road_user_interview	accident_summary	1754	Accident summary according to driver	05/04/2016

1977	road_user_interview	weather	1755	Weather according to driver	05/04/2016
1978	road_user_interview	date_of_interveiw	1756	date of interview	05/04/2016
1979	road_user_interview	how_did_intact_get_the_contact_information	1757	How did Saferwheels get the contact information?	05/04/2016
1980	road_user_interview	dazzling_lights	1758	Dazzling lights	05/04/2016
1981	road_user_interview	rui_did_rider_receive_any_additional_training_for_riding	1759	Did rider receive any additional training for riding	05/04/2016
1983	ptw	ptw_ppe_passenger_reflective_clothing	1761	PTW & Bicycle reflective apparel status.	30/09/2016
1984	ptw	ptw_ppe_passenger_dedicated_motorcycle_upper_body_clothing	1762	Specifically designed PTW occupant upper extremity wear status.	30/09/2016
1985	ptw	ptw_ppe_passenger_dedicated_motorcycle_lower_body_clothing	1763	Specifically designed PTW occupant lower extremity status.	30/09/2016
1986	ptw	ptw_ppe_passenger_dedicated_motorcycle_footwear	1764	Specifically designed PTW occupant footwear status.	30/09/2016
1987	ptw	ptw_ppe_passenger_dedicated_motorcycle_gloves	1765	Specifically designed PTW occupant glove status.	30/09/2016
1988	ptw	ptw_ppe_passenger_did_the_rider_clothing_contain_armour_ppe	1766	PTW PPE armour status.	30/09/2016
1989	ptw	ptw_ppe_passenger_was_the_ppe_fitted_correctly_and_worn_in_the_	1767	PTW PPE fit status.	30/09/2016
1990	ptw	ptw_ppe_passenger_did_the_gloves_have_knucle_protectors	1768	PTW occupant glove knuckle protector status.	30/09/2016
1991	ptw	ptw_ppe_passenger_did_the_trousers_have_built_in_shin_protector	1769	PTW road user lower extremity apparel status.	30/09/2016
1992	ptw	ptw_ppe_passenger_helmet_examined	1770	PTW helmet examination status.	30/09/2016
1993	ptw	ptw_ppe_passenger_helmet_used	1771	PTW road user helmet status.	30/09/2016
1994	ptw	ptw_ppe_passenger_helmet_type	1772	PTW road user helmet type.	30/09/2016
1995	ptw	ptw_ppe_passenger_helmet_make	1773	PTW helmet make.	30/09/2016
1996	ptw	pptw_ppe_passenger_helmet_model	1774	PTW helmet model type.	30/09/2016

1997	ptw	ptw_ppe_passenger_year_of_helmet_manufacture	1775	PTW helmet manufacture year.	30/09/2016
1998	ptw	ptw_ppe_passenger_helmet_owned_by	1776	PTW helmet owner.	30/09/2016
1999	ptw	ptw_ppe_passenger_helmet_ce_approved	1777	PTW helmet approval status.	30/09/2016
2000	ptw	ptw_ppe_passenger_helmet_size	1778	The size of the PTW helmet according to the international standards.	30/09/2016
2001	ptw	ptw_ppe_passenger_helmet_fit	1779	PTW road user helmet fit.	30/09/2016
2002	ptw	ptw_ppe_passenger_exterior_damage_to_helmet	1780	Describe any PTW & Bicycle helmet damage.	30/09/2016
2003	ptw	ptw_ppe_passenger_helmet_chin_strap_damage	1781	PTW and bicycle road user helment chin strap damage.	30/09/2016
2004	ptw	ptw_ppe_passenger_visor	1782	PTW helmet visor status.	30/09/2016
2005	ptw	ptw_ppe_passenger_visor_colour	1783	PTW helmet visor colour.	30/09/2016
2006	ptw	ptw_ppe_passenger_tint	1784	PTW helmet degree of tint.	30/09/2016
2007	ptw	ptw_ppe_passenger_coating_or_decals	1785	Describe the coating or decals of the PTW helmet visor (i.e. stickers).	30/09/2016
2008	ptw	ptw_ppe_passenger_visor_condition	1786	PTW helmet visor condition.	30/09/2016
2009	ptw	ptw_ppe_passenger_visor_marked_for_day_time_use_only	1787	PTW helmet visor usage status.	30/09/2016
2010	ptw	ptw_ppe_passenger_boots_with_shin_protectors	1788	PTW boot shin protector status.	30/09/2016
2011	ptw	ptw_ppe_passenger_strap_on_armour	1789	PTW road user strap on armour equipment status.	30/09/2016
2012	ptw	ptw_ppe_passenger_helmet_sustained_previous_knocks	1790	Pre-accident PTW helmet damage.	30/09/2016
2013	ptw	ptw_ppe_passenger_helmet_stayed_on	1791	PTW road user helmet status.	30/09/2016
2014	ptw	ptw_ppe_passenger_rider_wearing_photochromic_sunglasses	1792	PTW photochromic sunglasses status.	30/09/2016
2015	ptw	ptw_ppe_passenger_cp1	1792	CP1	30/09/2016
2016	ptw	ptw_ppe_passenger_cp2	1792	CP2	30/09/2016
2017	ptw	ptw_ppe_passenger_cp3	1792	CP3	30/09/2016
2018	ptw	ptw_ppe_passenger_cp4	1792	CP4	30/09/2016
2019	ptw	ptw_ppe_passenger_cp5	1792	CP5	30/09/2016
2020	ptw	ptw_ppe_passenger_antifogging	1798	PTW Anti-fogging	30/09/2016
2021	ptw	ptw_reconstruction_parameters	1799	PTW Reconstruction parameters	30/05/2017
2022	ptw	ptw_CDC12	1800	PTW CDC12	30/05/2017

2023	ptw	ptw_CDC3	1801	PTW CDC3	30/05/2017
2024	ptw	ptw_travelled_above_the_speed_limit	1802	PTW travelled above the speed limit	30/05/2017
2025	ptw	ptw_impact_speed	1803	PTW impact speed	30/05/2017
2026	ptw	ptw_is_tolerance_range	1804	PTW impact speed tolerance range	30/05/2017
2027	ptw	ptw_is_source	1805	PTW impact speed source	30/05/2017
2028	ptw	ptw_travelling_speed	1806	PTW travelling speed	30/05/2017
2029	ptw	ptw_ts_tolerance_range	1807	PTW travelling speed tolerance range	30/05/2017
2030	ptw	ptw_ts_source	1808	PTW travelling speed source	30/05/2017
2031	ptw	ptw_closing_speed	1809	PTW closing speed	30/05/2017
2032	ptw	ptw_cs_tolerance_range	1810	PTW closing speed tolerance range	30/05/2017
2033	ptw	ptw_cs_source	1811	PTW closing speed source	30/05/2017
2034	bicycle	bicycle_reconstruction_parameters	1812	BICYCLE Reconstruction parameters	04/07/2017
2035	bicycle	bicycle_CDC12	1813	BICYCLE CDC12	04/07/2017
2036	bicycle	bicycle_CDC3	1814	BICYCLE CDC3	04/07/2017
2037	bicycle	bicycle_travelled_above_the_speed_limit	1815	BICYCLE travelled above the speed limit	04/07/2017
2038	bicycle	bicycle_impact_speed	1816	BICYCLE impact speed	04/07/2017
2039	bicycle	bicycle_is_tolerance_range	1817	BICYCLE impact speed tolerance range	04/07/2017
2040	bicycle	bicycle_is_source	1818	BICYCLE impact speed source	04/07/2017
2041	bicycle	bicycle_travelling_speed	1819	BICYCLE travelling speed	04/07/2017
2042	bicycle	bicycle_ts_tolerance_range	1820	BICYCLE travelling speed tolerance range	04/07/2017
2043	bicycle	bicycle_ts_source	1821	BICYCLE travelling speed source	04/07/2017
2044	bicycle	bicycle_closing_speed	1822	BICYCLE closing speed	04/07/2017
2045	bicycle	bicycle_cs_tolerance_range	1823	BICYCLE closing speed tolerance range	04/07/2017
2046	bicycle	bicycle_cs_source	1824	BICYCLE closing speed source	04/07/2017
2047	road_user	above_speed_limit	1825	Above speed limit	04/07/2017
2048	road_user	speeding_is_a_contributing_factor	1826	Speeding is a contributing factor	04/07/2017

Type of update \ Form	On Scene Accident	On Scene Road	PTW Inspection Form	Bus Inspection Form	Car Inspection Form	Truck Inpection Form	Bicycle Inspection Form	Interview Form	Road_User_Child_Form	Reconstruction Form	TOTAL
Add a variable	12	2	84				85	32			215
Add a value	1		1							1	3
Modify the existing variable name	1	1									2
Add a value in drop down list		3									3
Add a new Topic (e.g. Copy from BUS inspection form)			4								4
Delete a variable				29	30	20				20	99
Add a Topic/ Variable as similar to impact/pedestrian				1	1	1					3
Add a Mask			1					1			1
Total number of updates	14	6	89	30	31	21	85	33	0	21	330

The table below lists all actions taken to update the SaferWheels database in chronological order.

Date	Details
03-04-2015	Publication of SaferWheels database on a virtual server
09-10-2015	Publication of SaferWheels WiKi
27-11-2015	Preparation of access credentials to edit the WiKi of SaferWheels database
17-12-2015	Development of Excel templates to support data recording activities
07-03-2016	Second Release of Saferwheels database
29-04-2016	Improvement of application performance
26-07-2016	Update of values "Unknown", "Other", "Not Applicable" in all variables
03-10-2016	Third Release of SaferWheels database
05-10-2016	Fourth Release of SaferWheels database
25-01-2017	Publication of the SaferWheels database on a physical server in order to improve the performance and the security
14-04-2017	Fifth Release of SaferWheels database
31-05-2017	Sixth Release of SaferWheels database
04-07-2017	Seventh Release of SaferWheels database

Table 23: Actions performed to upgrade the Database application

Annex 5 – Comparison of MAIDS and SaferWheels Projects

SaferWheels could be considered as a "successor" of the MAIDS study. However, whilst there are certain similarities, there are significant methodological differences. Some of the outcomes are comparable because both studies investigated in-depth two-wheeler accidents according to the infrastructure-vehicle-person principle.

A comparison of the studies is summarised in the below Table.

Table 24: Methodological differences between MAIDS and SaferWheels

Activity	MAIDS	SaferWheels	Comments
Project initiator	ACEM	EU (service contract)	
Number of teams involved	5	6	
Teams nationality	Italy, Spain, The Netherlands, France, Germany	Italy, Spain, The Netherlands, France, UK, Greece	
Team experience	Except for the French and German teams, the other three teams were conducting large scale in-depth for the first time	The teams were familiar with each other as well as with the investigation protocol from the DaCoTA project.	The SaferWheels teams were not conducting any large scale in-depth activities until the project started, thus the proper infrastructure had to be re-enabled
Duration of program	1999-2002	2015-2017	
Number of collected cases	921	500	
Case rejection criteria	At least 40-50% of the data are missing	At least 50% of the data are missing	
Collection period	1999-2001	2015-2017	
Type of accidents	Only PTWs with injuries involved	Both PTW and bicycle accidents. Injury accidents were not required per se	For bicycle accidents, the involvement of another motor vehicle was required for case inclusion
Investigation method	On-scene and retrospective within 24h average time	On-scene and retrospective	
Methodology used	RS9/TEG/CM-4A	DaCoTA, modified to include additional PTW and bicycle related parameters	In SaferWheels, many of the MAIDS parameters have been implemented for data compatibility
Number of parameters collected by accident	More than 1000	More than 1000	
Exposure data	Yes, for every case	No	In MAIDS exposure data have been collected either via one-hour video filming of the location a week later the same time under the same conditions or via interviewing PTW rider at tank stations
Training of teams	Technical, accident reconstruction and injury coding	Technical, accident reconstruction and injury coding	

Familiarization phase with the protocol	First 5-10 cases	First 5 cases	
Experience with reconstruction techniques prior the project	2 out of 5 teams	3 out of 6 teams	
Quality assurance	Random cases were reviewed by an independent expert	Random cases (about 10 per team) have been reviewed by consortium partners	
Data entry - database	Worksheets	Use of the DaCoTA database interface. Export of data in MS Excel sheets	The DaCoTA interface has been significantly improved in terms of "user friendliness" during the SaferWheels project
Statistical tool-software for data analysis	SPSS package	SPSS package	

Accident Causation

In MAIDS, accident causation was determined at the end of each case investigation. At this point, the investigation team decided on the **primary** accident contributing factor of the accident. This was the human, vehicle or environmental factor which the research team considered to have made the greatest contribution to the overall outcome of the accident. In addition to the **primary** accident contributing factor, each research team identified up to four additional **contributing** factors for each accident.

Comparison of results

In the MAIDS study, a difference in speed compared to the surrounding traffic was identified as a contributing factor for PTWs in 18% of all cases and a contributing factor for the OV (other vehicle) in 4.8% of all cases.

Alcohol played a role in the occurrence of only 2% of the investigated PTW accidents. This is even lower than the number found in the MAIDS project (4%). This decrease is in line with the general reduction in alcohol related accidents over the last decade [ETSC, in press]."

Vehicle defects were less prevalent than was found in the MAIDS study. According to that study, PTW defects were present in 6% of all accidents (contributory in 0.4%). In 3.7% of all PTW accidents in MAIDS the vehicle failure related to the tyre or wheel (tyre blowout or a tyre failure), and in 1.2% it related to of brake problems. In the current in-depth study, vehicle equipment failure was found in only 4% of cases. The most common identified defects were also tyres and brakes. Both types of defects were identified in 2% of the PTW cases.

Comparability of MAIDS and SaferWheels depends on several factors, including the countries in which accidents have been collected and the distribution of vehicle types (e.g., share of motorcycles). In both SaferWheels and MAIDS, accidents have been collected in France, Italy and the Netherlands. In addition, SaferWheels accidents have been collected in UK, Poland and Greece. In MAIDS, however, additional data were collected in Germany and Spain. Different country characteristics may lead to other distributions in vehicle types. In MAIDS, 52% of PTW accidents involved a motorcycle, 45% a moped, and 3% a light moped. In SaferWheels, the share of motorcycles in the total number of PTW accidents was much larger: 77%. Moreover, distributions may have changed over time. An example is the distribution of mopeds and light mopeds in the Netherlands. Whereas light mopeds had a share of 43% in all mopeds in 2006, they had a share of 57% in 2015. Light mopeds became more popular and their number doubled in 10 years' time, whereas the number of mopeds is currently decreasing.

In the MAIDS study, a difference in speed compared to the surrounding traffic was identified as a contributing factor for PTWs in 18% of all cases and a contributing factor for the OV (other vehicle) in 4.8% of all cases.

Vehicle defects were also not prevalent. According to that study, PTW defects were present in 6% of all accidents (contributory in 0.4%). In 3.7% of all PTW accidents the vehicle failure related to the tyre or wheel (tyre blowout or a tyre failure), and in 1.2% it related to brake problems. In the current in-depth study, vehicle equipment failure was found in 4% of PTWs, the most common identified defects were also tyres and brakes. Both types of defects were identified in 2% of the PTW cases.

Annex 6 – Case Summaries

Annex 6 provides a short 1-page summary for each of the 500 collected cases.

It should be noted that these summaries are only intended to show a small selection of the data collected for each case; to give the reader an overview of the sample characteristics and accident scenarios. Further data was collected for each case but is not presented here due to data confidentiality restrictions.

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