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**Katarzyna SICIŃSKA\*, Agnieszka KRUPIŃSKA**

Motor Transport Institute

Jagiellonska 80, 03-301 Warsaw, Poland

\*Corresponding author. E-mail: [katarzyna.sicinska@its.waw.pl](mailto:katarzyna.sicinska@its.waw.pl)

## **SAFERWHEELS PROJECT: STUDY ON SCENE OF ACCIDENT WITH POWERED TWO-WHEELER AND BICYCLE**

**Summary.** The article presents results and the way of providing research project on in-depth crash study on scene of accidents of 385 Powered Two-Wheelers (motorcyclists, motorists) and 116 bicycles in the European Union in 2014-2017. The main concern of an in-depth crash study at the site of a traffic accident is to collect data on vehicles, roads, and drivers, including interviews with participants. Data descriptive statistics have been used to underline the dominant factors that appear most frequently in accident scenarios with bicycles and PTW, with a special focus on causation by Driving Reliability and Error Analysis Method and injuries coded by the Abbreviated Injury Scale, conducted for these road users across Europe for the first time. Medical data, police records, and jurisdiction files about crashes of PTW and cyclist were collected and analyzed in EU to define the most common accident scenarios and other threats to this group of unprotected road users. The articles present recommendations for making safer driving of motorcyclists and bicyclists.

### **1. INTRODUCTION**

The increasing popularity of motorcycles, mopeds, and bicycles, which are being used more over the past few years as an additional means of transportation than for fun and pleasure, has led to a higher risk of deaths and serious injuries among their users. Lack of protection of car body, airbags, and seat belts caused that drivers and passengers of powered two-wheelers and bicycles as a vulnerable road users (VRU) are often injured when involved in a crash. Accidents involving VRUs comprised approximately 48% of all fatalities in the European Union in 2014, with Power-Two-Wheelers (PTW) comprising 18% and bicyclists comprising 8% of the total number of fatalities.

According to the statistics, there were 1 082 918 road accidents in the European Union (EU) in 2017, with 25 261 deaths and 1 415 559 injuries, including 240 000 seriously injured individuals. Among those killed, there were 6 569 Power Two Wheelers users: 3 885 motorcyclists (3,695 drivers and 190 passengers), 635 mopeds (598 drivers and 37 passengers), and 2 049 cyclists (2,043 cyclists and 6 passengers). Data indicated a 3% increase of a number of fatalities of PTW and bicycles (171 more killed) compared to 2016. The number of killed users of motorcyclists and mopeds increased by 4.4% (189 more killed) and the number of killed cyclists dropped by 0.8% (less by 36 people) [1].

The risk indicator (number of deaths per 1 million inhabitants) in the EU in 2017 for motorcyclists was 7.6 and 1,2 for cyclists 4. The risk indicators in Poland for motorcyclists were higher compared to the EU, fell but was 6. The risk of death for users of mopeds was higher and estimated at 1,4 and that for cyclists also higher than in the EU, estimated at 5.8 deaths.

In Poland, in 2017, there were 32 760 road accidents; 2 831 people died and 39 466 people were injured, including 11 103 seriously. Compared to 2016, the number of killed motorcyclists dropped by 6%, and the number of users of mopeds killed decreased by 19%. Motorcyclists participated in 2 240

road accidents in which 218 drivers were killed and 13 their passengers. There were 1 334 moped accidents in which 51 drivers were killed and their 4 passengers. Cyclists were involved in 4 212 road accidents in which 220 cyclists were killed and 3 824 were injured (3 800 bicycles and 24 passengers). The number of fatalities of this group of Vulnerable Road Users, compared to 2016, decreased by 19% and the number of accidents involving cyclists decreased by 11% [2].

This group of Vulnerable Road Users, who are at risk of death and injuries, represents a real challenge for researches working on accident prevention. According to the Policy Orientation on Road Safety for 2010-2020, the European Commission defined the strategic objective of safety improvement of PTW and bicycles by investigation of the causes of accidents [3]. This was the reason why a project named SaferWheels was set up, which was implemented in 2014 to 2017 by a consortium of partners from Great Britain, France, Netherlands, Poland, Italy and Greece. Sampling represented six regions in Europe to give a representative view of such accidents, wherein 2014, 46% of bikes - and 58% of PTW fatalities were.

Purpose to better understand the causes of accidents involving powered two-wheelers and bicycles for better prevention in the future, was collecting data from the in-depth crash study in SaferWheels project. This was the first analysis of the crash from diverse sources: medical data, police records, and jurisdiction files. This kind of data from an in-depth crash study enabled a causation-orientated analysis of 500 accidents (385 with PTW and 116 bicycles). Data of each accident were collected at the scene (within minutes to hours of a crash occurrence) or retrospectively (within a few days), stored in the database, described according to the main accident typologies and factors causing the accidents and used for statistical analysis.

SaferWheels updated the database of the crashes of PTW and bicycles in the EU with wide causation analysis of reaction between: driver-infrastructure-vehicle. Medical injuries, factors contributing to the accident (alcohol consumption, very high speed for prevailing traffic, type of environmental road/conditions and infrastructure, mechanical defects of a vehicle, fatigue, use of protective clothing by drivers, their gender, type of the day of an accident occurring) as well as accident scenarios for fatality/serious injuries and slight PTW riders and bicycles were reported in the SaferWheels final report. The outcome was a proposal of the most cost-effective measures to prevent PTW and bicycle accidents.

## 2. SAFERWHEELS METHODOLOGY

SaferWheels project's methodology for an in-depth crash study at the scene of the accident was based on the DaCoTA project. The project consisted of collecting, transferring, and analyzing data on road safety and was carried out in 2010-2013 by a European consortium of several research institutes, including the Motor Transport Institute (MTI). DaCoTA continued the work started under the SafetyNet project, which involved the extension and improvement of the European Road Safety Observatory (ERSO). The ERSO platform has created a basis for unified standards, scope and method of data collection on road safety in all EU countries. The DaCoTA project developed a method for data collection at the site of a traffic accident. The construction of the database for accidents at the scene of the event was based on the experience of the German In-Depth Accident Study (GIDAS) and Chalmers University from Sweden.

The updated database was used to analyze the causes of accidents involving PTWs and bicycles. This was considered necessary since no comprehensive analysis exists on the causes of accidents within the EU. The most crucial in this study was that in-depth motorcycle, moped and bicycle accident data were collected at the scene of the accident from sampling areas with high numbers of fatalities in six European countries. As requested by the European Commission, the accident analysis was based on the in-depth road accident investigation methodology defined in the DaCoTA project [4]. The in-depth accident studies were divided into two main groups:

- In-depth accident study conducted at the scene of the accidents (within minutes to hours of crash occurrence).

- In-depth accident study conducted retrospectively (within a few days of the occurrence of the accident, from other sources: prosecutors' office, police records, hospital data).

PTW and bicycle accident data from in-depth crash studies were collected by trained teams (independent by police investigation) on the scene of an accident, supplemented by additional information: drivers' medical data of injuries to determine the causes of crashes. The intended outcomes were as follows[5]:

- Data analysis of 500 accidents collected by partners from six EU countries of 385 Powered Two-Wheelers, 116 bicycles, and 14 E-bike,
- DaCoTA in-depth investigations and reporting for each of the accidents on the basis of the data collected, and
- Description of the main accident typologies and accident factors - Accident Causation Analysis - DREAM [6].

Representative of data in the SaferWheels project meant the proportional amount of accident gathered for exact identified condition according to the distribution of incidents in the sampling region. Accidents fell within the scope of the study when a PTW and/or a bicycle were involved in an accident with another vehicle or a pedestrian, provided that at least one motor vehicle was involved. All partners who participated in the project had experienced in road safety, particularly in accident causation and accident prevention measures, in-depth road accident investigation as well vehicle technology from powered two-wheelers. As MTI had participated in the DaCoTA project in 2012, they had some experience and were familiar with the approach to this kind of investigation. The scope of collected data was strictly determined by numerous categories like accidents, road, road user, vehicle (PTW, bicycle, car/bus/truck), photo, DREAM analysis, injuries, and interviews with participants (road users and witnesses).

Case selection was random (but within the scope of the study); however, practical restrictions (traffic jam, team availability, presence of the vehicles, victims on the scene) restricted the ideal selection to put into the database.

After entering all the data collected from the accident, the next step was to analyze the causes of the accident using the DREAM analysis. The SaferWheels project used the assumptions of the DREAM analysis developed within the SafetyNet and DaCoTA projects based on:

- the reliability of the coding system,
- the possibility of creating case-by-case analyses and automatic synthetic analyses,
- clear descriptions of the factors /causes of the accident,
- easy data entry into the database,
- easy describing the behavior of all participants taking part in the accident,
- taking into account the order of events on the timeline.

In the DREAM model, factors describing the accident (phenotypes and genotypes) and the links between them are used to determine the causes of the accident. The phenotype is a factor describing human action, the so-called observed accident effect. In the model, one of the six major phenotypes (timing, speed, distance, direction, force, object) is associated with one or more specific genotypes. Genotypes are factors that cannot be observed, but play a dominant role in the occurrence of an accident. Genotypes are divided into four main categories: driver, vehicle, road conditions, and organization and each of them had separate subcategories, altogether 51. The subcategories of genotype describe the decisive factor contributing toward accidents. The driver category includes such subcategories as observation, interpretation, planning, temporary factors (e.g. lack of sleep), and permanent (e.g. poor vision). The vehicle category describes temporary or permanent problems of human-vehicle interactions (Human-Machine Interaction, HMI) and vehicle equipment failure. The traffic environment includes weather conditions, visual road restrictions due to objects (e.g. parked vehicle), and road condition. The organization category includes maintenance, vehicle design, and road design (Fig. 1).

Determining the main factor influencing accidents was not an easy task. For a better understanding of the mechanism of the accident to conduct an in-depth analysis according to the DREAM model, interviews with drivers and photos taken on the spot were helpful together with the other collected

information. There were quality and assurance controls with several cross-checks of coded data between consortium partners. The quality control containing causation of the crash, DREAM analysis. The injuries of individuals involved in road accidents were coded and unified by the medical scale of AIS (Abbreviated Injury Scale). Each research team received from 8 to 10 examples of the coded accident to check. It was crucial to verify the coding method and use homogenous codes for unification data. Dream analysis provided by all causes of accidents was carried out for each participant separately. Information prepared in a descriptive form was also used.

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

Fig. 1. Genotypes and phenotypes according to the DREAM 3.0. methodology [4]

The SaferWheels database used the DaCoTA database with a rich user interface, supported modification and deleting some data (text, images, documents through an Adobe Flash application). Application was managed and hosted by one of the consortium’s partners, the CTL in Rome, Italy. Online data entry, after secure login to the application, was performed at a web address from home countries (Fig. 2).

Once data were finalized, all 500 cases were exported from the database as CSV files for statistical analysis. A glossary for the database and variables in SaferWheels used a modified version of the original DaCoTA under the address: <http://rs.ctl.uniroma1.it:8081/saferwheels/pmwiki.php>.

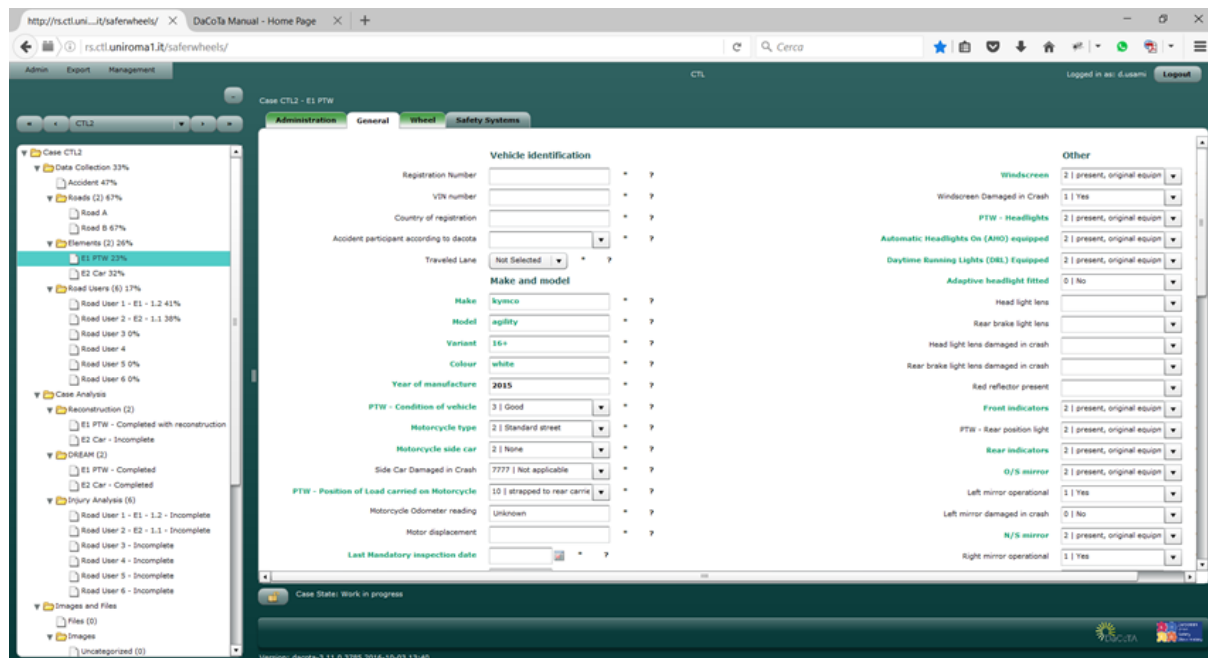


Fig. 2. SaferWheels’ application homepage for data entry [5]

Data descriptive statistics as a primary analysis were used to underline the dominant factors that appear most frequently in accident scenarios with bicycles and PTW. The graphical presentation of the findings contained 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.

Statistical analysis first included a cluster analysis of the accident-level variables. The selected type of clustering method was the Two-Step Cluster Analysis to produce solutions based on both continuous and categorical variables. The clustering algorithm was based on a distance measure. The first step of the two-step procedure was the creation of pre-clusters. The goal of pre-clustering was 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 was applied on the pre-clusters. The two-step cluster algorithm required that all continuous variables be standardized. In terms of the distance measure, the log-likelihood method was selected 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 a better clustering outcome. Also, a satisfactory solution should have a large ratio of BIC Changes and a large ratio of distance measures [5].

As a second part of the more in-depth statistical analysis, it was aimed to gain insight into the parameters affecting the severity of the injury of occupants (dead against no-dead). For this reason, the Random Forests analysis was chosen to rank the explanatory variables according to their relative importance. A random forest is a classifier including a collection of tree-structured classifiers [7, 8].

### **3. SAFERWHEELS, IN-DEPTH CRASH STUDY ON SCENE WITH PTW IN POLAND**

The SaferWheels project was conducted by the Road Traffic Safety Centre at the Motor Transport Institute in Warsaw, Poland. The project was accomplished thanks to cooperation with the Warsaw Police Headquarters and the Provincial Police Headquarters in Radom. Data were collected from the Prosecutor's Office in Warsaw, the District Prosecutor's Office in Radom, prosecutors and district courts of law in Warsaw and Mazovian region, and the Department of Health of Provincial Office. The research was carried out in the city of Warsaw and outside, in the Mazovian Province. Mazovian voivodship was recognized as the most representative for Poland to gather and collect data from accidents with Powered Two-Wheeler drivers and bicyclists based on the criteria adopted in the SaferWheels program for statistical analysis [5].

An in-depth study of the scene of an accident in Poland required, after obtaining access to the crash site by the Police, insight into the case file from prosecutors and district courts of law and hospital data. The procedures were as follows:

- Setting up of investigation teams to visit the scene of the accident,
- Assessment and description of vehicle damage,
- Taking of photographs of the place of the event, vehicles, roads,
- Interview of each participant of the incident (relative, witness),
- Collection of medical information about the injuries of the victims from hospitals and coding according to the Abbreviated Injury Scale,
- Collection of other required data according to the projects' protocol (14 different sheets of information),
- Translation into English and entry/coding of data into the database,
- Coding of data by using DREAM, a method for determining the causes of accident and injuries by AIS.

The research team of the Motor Transport Institute was notified by phone about an accident that took place in Warsaw. Information was provided by the Road Traffic Services Section, Traffic Department of the Warsaw Metropolitan Police Headquarters. Within 15 minutes of receiving the notification, the team was ready to depart from MTI. Due to the distance and traffic, the team was at the scene of the incident usually about an hour after the occurrence of the incident. The vehicles participating in the accident were (most often) already pushed on the roadside, sometimes some of the tracks on the road were not visible any more. After reaching the place of the traffic accident, the MTI research team collected basic data about the accident, conducted interviews with the accident's

participants, and inspected the road and vehicles. On the scene of the accident, photographic documentation of vehicles involved in the accident was carried out, along with assessment of damage and vehicle' deformation. Traces were recorded on the road and on the roadside along with the location of damaged parts of vehicles. For the research team, an important and challenging element of the work was to collect information about the vehicles participating in the accident, the technical condition, damage, equipment of motorcycles with security systems and additional modifications, protective clothing worn, and type of helmet worn.

Members of the MTI team conducted interviews with the victims and witnesses of the accident present at the spot. This was one of the crucial and demanding tasks for the team members, as people were nervous about what happened and gave answer being under stress. Their statements were sometimes verified by police documentation and other information. This meant that the participants had to stay longer on the scene of the incident because of SaferWheels procedures. Usually, the site of an accident on the street is obstructed by vehicles involved in the incident, traffic is not regular, and sometimes when there are victims, traffic is closed. Motorcycle drivers and cyclists, after the arrival of the MTI team, were often not present at the scene. The most exposed to injuries during the accident, were the ones fastest transported to hospitals. After obtaining the phone numbers from their relatives who were called at the scene of the accident (they picked up damaged two-wheelers), MTI employees called them within a few days of the accident. Sometimes, our employees visited victims in the hospital. Due to the protection of personal data, it was difficult to reach this group and took extra time.

Data from the accident scene were supplemented with information that was obtained directly from the police, prosecutors' offices, and courts, which provided more detailed information about the incident and its participants. MTI teams did not determine the cause of the accident at the scene. Collected data were important for determining the cause of the accident according to the DREAM method analysis. Detailed data collected for each case presented below case, with detailed information on area, drivers, vehicles (damages), road, course of accident, opinion of expert witness due to the reconstruction and medical data. All collected data were anonymous.

### 3.1. Case study

Accident with PTW and passengers car took place on 1 September 2015 (Tuesday) at 11:59 am in Warsaw on one of the main streets in the city center. The MTI team was notified at 12:40 pm and they arrived at the scene at 1.05 pm. They finished the on-scene investigation at 3.00 pm.

Information obtained from the Health Office of the Mazovian Governor's Office showed that one ambulance, notified at 12:00 am, arrived at the scene at 12:05 pm, patient was handover at 12:30 am to the one of the main hospital in Warsaw, about 10 km distance from the accident. Rescue procedures undertaken by the Emergency Medical Team were in accordance with ICD9 (International Code of Disease):- 89.71, 89.79, 89.13, 99.99904, 99.18, 89.61, 89.602, 93.5001, 93.521, and 93.5.017. The ICD code then had to be changed and coded into the database according to the Abbreviated Injury Scale.

The driver of the motorcycle DUCATI, a man, born in 1976, had driving license category A (since 2005), B, C, and E. The driver was wearing a full-face helmet with Hinged Front AIROH (model Dragon) that can be worn with sunglasses and prescription glasses.

Motorcycle DUCATI, B1, HYPERMOTARD 1100 S, red, year of manufacture: 2007 had its number of approval 'certificate. Kerb weight: 200 kg, gross vehicle mass: 390 kg, capacity: 1079 ccm, engine power: 62 kW. Fuel: petrol. Category L3E. Mileage: could not be read. The last recorded mileage (at technical check-up on 26 June 2015) was 2 088 km. Provisional registration was issued on 18 August 2015, which was valid until 17 September 2015. The date of first registration was 7 October 2009. The most recent technical check-up was on 26 June 2015 and was next due on 26 June 2016. Change of vehicle ownership occurred on 8 July 2015.

Tyres: (front) PIRELLI Diablo Corsa III 120/70 ZR 17, M/C (58W); tread depth above 1,5 mm, pressure correct; (back) PIRELLI Diablo Corsa III 180/55 ZR 17, M/C (73W); no information.

Car driver of FORD Fiesta, woman, born in 1980 had driving license category B (since 2006). The passenger car two-door Ford FIESTA, white color, was manufactured in 2014, capacity: 1499 ccm,

engine power 55 kW. Mileage: 19 407 km. Most recent technical check-up: 5.12. 2014, next due on 7.11. 2017.

Tyres: (front and back) HANKOOK VENTUS S-1 EVO K107 195/50 R15 82H; tread depth above 1,5 mm, pressure correct.

The scene of the accident was an urban area, straight section, single carriageway. Roadway width: 9.4 m; 2 lanes of traffic, tarmac, condition of the roadway: dry and clean, uneven, potholes. Left side roadway width: 1.7 m, asphalt. Right side roadway width: 1,2 m, unpaved, dry, height relative to the roadway above 10 cm. No traffic lights, horizontal markings correct, speed limit 50 km/h. Little traffic. Day time. Weather good, the temperature 34°C, sunny, wind 7 km/h, 22% humidity.

Course of an accident showed that the female driver of the FORD Fiesta was making a U-turn as she was driving out of a car park space (2) (Fig. 3). The motorcyclist was coming from the opposite direction. The driver of the Ford FIESTA drove onto the right (opposite) lane, blocking the motorcyclist's way. When the PTW driver (1) saw the car, he started to brake abruptly and laid the motorcycle down. As a result, first the motorcycle and then the motorcyclist himself hit the front end of the car from the right side. The force of the impact threw the motorcyclist onto the tram tracks along the street, on the same side. His motorcycle continued ride for fifty meters forwards, leaving behind marks on the asphalt. From FORD Fiesta's dashboard camera was on to record the course of crash. Photos showed views from the PTW driver's and car driver's side, as well as road and vehicle damages.

Interviews with both participants were conducted. The female driver of the passenger car stated that she did not see the motorcycle, her U maneuver was correct, and her speed was minor. She worked as a sales representative, had no problem with her eye sight, and had not been dazzled by the sun. She didn't have any trouble, slept well overnight and didn't take any medicine.

The motorcyclist did not recall his speed, but in his opinion, he was within the limit of 50 km/h. He was shocked seeing a car on his lane. He started to stop abruptly. During the accident, he was wearing sunglasses with an anti-reflecting coating, special riding glasses.

Information obtained from the hospital about the PTW driver revealed that he stayed at the hospital for eleven days because of multiple injuries. He had trauma to the head, rib, and the hip joint and both branches of the pubic bone and sciatic bone.

Damage to the motorcycle included many damages and scratches to the whole body of the PTW (side scratches on the left surface of the front wheel, front right indicator bent on the motorcycle's longitudinal axis, both mirrors folded, both additional mirrors broken off, front left indicator broken, fuel tank shell cracked on the left side with paint damage and vertical scratches, gear shifter bent with scratches, other paint damage and scratches on the end of the silencer, and scratches on the left side of the rear light). The motorcyclist wore a helmet (An AIROH) of white-red color, with no visor, but the shell of the helmet had multiple scratches (Fig. 4).

There were minor damages to the car, with black marks on the right corner of the bumper, the right edge of the bumper had come off and was pushed to the front, and the front registration plate with the frame had ripped off the bumper on the right side. All systems and installation of the car were working properly before the crash (Fig. 5).

The prosecutor's file showed that an expert witness accident reconstruction was performed for this case. According to the opinion of the expert witness, the driver of the two-wheeler DUCATI had no problems with visibility and his total initial speed, including braking and the friction between the motorcycle and the surface, was 110,44 km/h. The speed limit in an urban area is 50 km/h (13,88 m/s) and his stopping distance was about 26 m (the stopping distance was three times longer). He had driven at a speed above the limit. This must have had an effect on the occurrence, course, and consequences of the crash.

Because the driver of the FORD Fiesta was making a U-turn coming out of a parking space, her speed was slow, around 5-7 km/h.

The maximum speed at which the motorcyclist could stop before the car could have approached (about 50 m distance) was 71 km/h. At this speed, the motorcyclist would have been able to stop the motorcycle before the car made a U-turn and the incident could have been avoided.

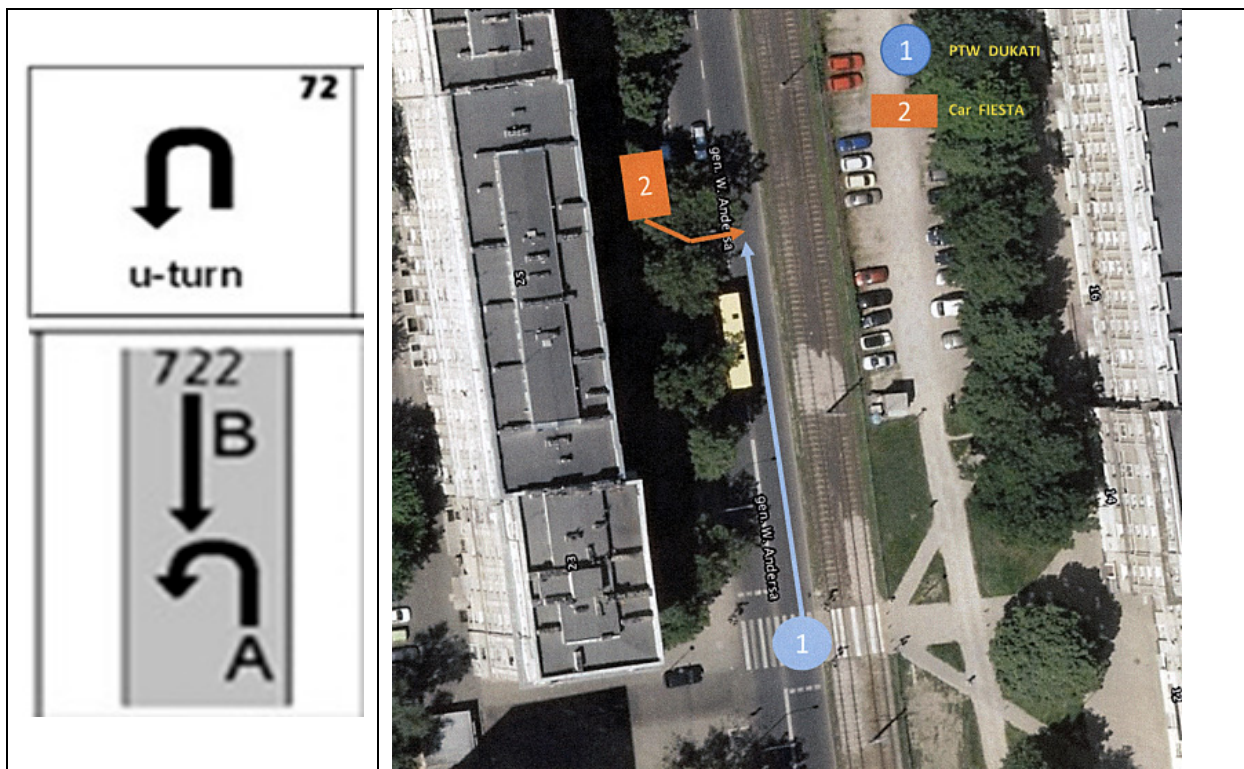


Fig. 3. Course of an accident

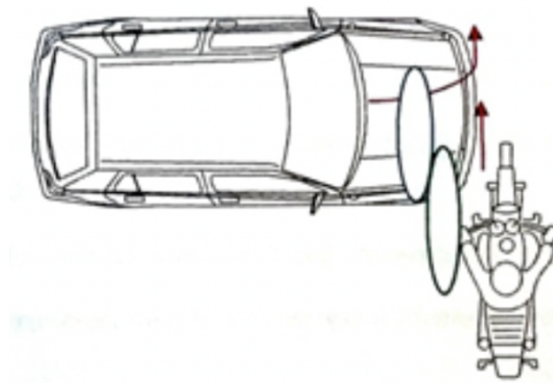


Fig. 4. Crash area, damage of the vehicle

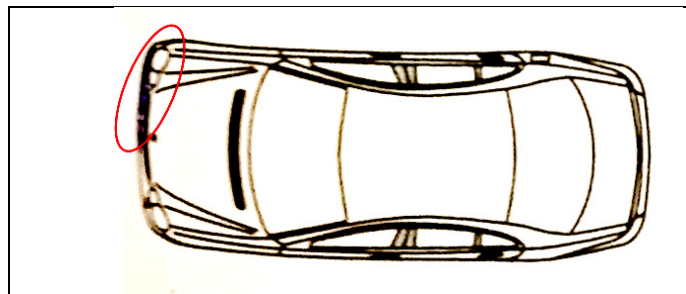


Fig. 5. Damages to the car

Each of the 87 Polish cases was described as shown above, with a lot of information not only from the scene of an accident but also from prosecutors' documentation, hospital data, and police notes, which provided a more comprehensive description of the incidents, allowing to proceed causation.



#### 4. RESULTS

As a result of the SaferWheels project, the dominant factors and the most frequent accident scenarios of crashes with bicycles and PTW were established, with a special focus on causation and injuries. Data on 500 cases were collected, of which 385 involved PTWs and 116 bicycles and 14 E-bikes (analyzed separately). Generally, most PTW or bicycle accidents involved at the most two vehicles/pedestrians. Bicycle accidents always occurred as a result of interaction with another vehicle. Killed and seriously injured were over-represented in single PTW accidents.

Aggregated data showed that 18% of PTW cases resulted in fatalities, 27% resulted in serious injuries, and the rest of the sample had slight or no injury. Scenario analysis related to the users of PTW showed that 25% of fatally and serious injured were a single PTW crash, 64% of these occurring on a curve while losing control of the vehicle. The most common maneuver resulting in a crash with serious injury to the PTW driver was when going straight and coming from the opposite direction and the opponent mostly passenger car was turning left from the opposite direction and when the PTW was perpendicular approaching from the right side of the opponent vehicle. Losing control of a motorcycle and crashing into an opponent vehicle belonged to this main scenarios with fatalities. The risk of death for a PTW user is 23 to 35 times higher than that for a car driver. The aggregated data results for PTW drivers showed that a few of them (13%) lacked experience. Mostly men (85%) than women drove PTW. Use of alcohol was found only in 4 % of cases and psychoactive substances in 3% of cases. Drivers of motorcycles, mopeds, and mofas mostly wore helmets (88%). Wearing specialized protected clothing as jackets was in 23%, gloves (23%), boots (15%) and reflecting cloths in 10%. The main reasons for the accident with PTW to happen was limited visibility (looked, but didn't see) of car drivers and their lack of knowledge about PTW users in traffic situation as well as their fast acceleration. According to the hospital data coded as AIS, body zones with the highest risk of injury to PTW drivers have been determined. Whenever a PTW driver or a bicyclist was involved in a traffic accident, he/she had injuries. Serious injuries happened mostly to PTW users and these occurred on the lower limbs (27%), upper limbs (21 %), thorax- 15 %, and head (10 %). Both PTW and cycle accidents occurred often on Saturdays and Sundays; the highest number of accidents occurred on Wednesdays for PTWs and on Fridays for cyclists.

Bicycle accidents characteristic indicated that among 116 cases 15 person (13% of sampling group) were dead, 69 serious injured (41%), 49 slightly injured. Female drove more bicycle (67%) than men. Bicycle riders ranged in age from 46 to 65 years; only 32 % wore a fastened helmet, 14% had it unzipped, 21 % wore reflective clothing, and 20 % had the light on the front of their bicycle. Due to the scenario of the accidents with bicyclers 38 % of them made an error in observation and made bad decision in traffic situation, causing crash. Visual obstacles (tees, parked cars, flashing light) caused 15% of accidents. 16 % bicycle riders were tired or distract. Speed was a contributing factor to the accident in only three cases (2%), mostly younger bicyclists younger than 24 years of age; 7 % lacked experience, only 6 % were under the influence of alcohol, and 2% had used psychoactive substances. Technical inspection of bicycles in 72% were estimated as a good or very good. Mainly problems were with lack of tire tread. Accidents happened mostly in commercial areas (49%) and in habitat areas (39%). 81% of the accidents occurred during the day. Half of the accidents were on local roads, 34% of collected roads, and rest occurred on main or secondary arteria, where the speed was 50 km/h or lower.

The main accident scenarios for slightly injured road users involved a bicycle accident when: the cyclist was perpendicular coming from the right side of the opponent vehicle, and when the opponent vehicle was turning right and the cyclist was coming from the left side or from the opposite direction.

The most frequent accident scenarios that involved fatalities and serious injuries were two-vehicle accidents at crossroads, when vehicles were coming from perpendicular directions and the cyclist was turning right just in front of the opponent vehicle [5].

## 5. RECOMMENDATIONS

The main objective of the SaferWheels project was to identify the most common causes of road accidents involving Powered Two-Wheelers and bicycles to provide recommendations for effectively reducing the risks of this group of unprotected road users. Polish experience gathered during the work with the SaferWheels project showed that there are no appropriate legal regulations for data collection at the scene of an accident; only Police conducts this procedure. The confidentiality of the collected data should be solved (photos of the accident site, vehicles, registration numbers of vehicles, street names of the accident). For implementation of scientific projects for in-depth research on the causes of road accidents, it is reasonable to create mechanisms and legal procedures enabling the collection of information irrespective of the protection of personal data.

Collection and entry into a database of 500 cases from accidents on the spot (approx. 1500 different data for each case, according to the 14 sheets) from six EU countries seemed too much for analysis. A lot of information gathered was not used for analysis.

87 cases at the national level seem to be a very small number. However, collection of data on 500 accidents at the European level provides an idea about the main factors that cause accidents in the EU with the participation of drivers of motorcycles, mopeds, and bicycles. The project summary indicated that the most common situations in which accidents involving two-wheeled motor vehicles occurred were accidents involving a passenger car at the intersection. This was a maneuver: when the motorcyclist/PTW driver was riding straight from the opposite direction and was hit by a left-turning vehicle (right in the UK) and a maneuver when the PTW arriving from the right side was hit by another vehicle. Often, an accident happened when the motorcyclist lost control of the vehicle (on the curve, bend), single accident (spontaneous).

The recommendations for the European Commission prepared by the project consortium included motorcyclists/other PTW drivers and cyclists, vehicles, and infrastructure. To eliminate accidents caused by excessive speed (above the limit) by PTW drivers, strong and effective police control was recommended. The use of helmets and specialist clothing by motorcyclists should be promoted (which reduces the risk of injury from 33% to 50%) and during training of motorcyclist drivers, it is advisable to introduce them with the problems and expectations of other road users. Knowledge (through educational activities) should be disseminated about the negative impact of riding under the influence of alcohol, which increases the risk of an accident. Loss of control of the vehicle, including individual accidents, resulted in fatalities and serious injuries. It was recommended to equip motorcycles above 125 cm<sup>3</sup> with ABS systems (which reduces the number of fatal accidents by 31%).

Recommendations for increasing the safety of cyclists included road infrastructure solutions in which the bicycle traffic should be separated from other vehicles, traffic calming zones should be introduced (speed limit not higher than 30 km/h), and also traffic separation between PTW and bicycle. Use of helmets, which reduces head injuries by 65%, must be strictly promoted. An in-depth study of accidents involving cyclists, represented in the project to a smaller extent than PTW drivers, should be carried out in the future.

Factors related to vehicle equipment to improve safety, according to the recommendations, include use of speed-limiters, intelligent speed adjustment, and over-speed warning systems. Infrastructure recommendations include extension of the scope of Intelligent Transport Systems with information on the approach or appearance of single-track motor vehicles.

SaferWheels project, which is very time-consuming due to the need for collection of enormous amount of data, was a great opportunity to test a new method of conducting an in-depth study at the scene of an accident to understand the causes of accidents involving powered wheelers and bicycles. But research of this kind should have more limited scope. Skipping vehicle inspections due to technical conditions and concentrate on analysis of the main causes of accidents, as a main focus. Unfortunately, the very long process of completion and entry of data into the database and excessive amount of collected information did not allow examination of all aspects of risks to this group of unprotected road users. Implementation of SaferWheels' project in Poland by MTI has allowed the research team to gain knowledge and experience in conducting in-depth research on the scene of a

road accident involving powered two-wheelers and bicycles. This was EU's second research project for the MTI team, after DaCoTA, focusing on investigation of scenes of accidents. We hope that the knowledge and experience gained today will be used in other projects of this type. Project results due to the identification of dominant factors affecting risks of this group of unprotected road users will contribute toward better road traffic safety in the country and the rest of EU in the future [9].

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