

ANALYSIS OF THE ACCIDENT SCENARIO OF POWERED TWO-WHEELERS ON THE BASIS OF REAL-WORLD ACCIDENTS

Author: Dipl.-Ing. H. Liers

Verkehrsunfallforschung an der TU Dresden GmbH
Zellescher Weg 24
01217 Dresden
Email: liers@vufo.de
Tel.: +49 (351) 43898923

ABSTRACT

For the first time since 20 years the German national statistics of traffic accidents revealed an increasing number of fatalities and seriously injured persons in 2011. This negative development was especially caused by increasing numbers in all groups of vulnerable road users (VRU). Furthermore, the comparison of fatality reduction rates between several categories of road users shows that persons on motorcycles show the worst performance over years. Although every second fatality in German traffic accidents is still a car occupant, users of PTW make up more than 20% in the meantime. Assuming further improvements in the field of occupant protection this trend will continue.

For that reason, a study on the basis of real-world accidents was conducted to describe the accident scenario involving motorcycles and to identify the reasons of the above-described fact. Approximately 1.800 motorcycle accidents out of GIDAS database were used for the analyses.

The first part of the study deals with the question how representative the GIDAS database is for the German motorcycle accident scenario. Afterwards, detailed descriptive statistics on motorcycle accidents were presented considering numerous parameters about the accident scene, environmental influences, vehicle information, individual characteristics, interview data, injury severity and injury causation. One important point is the identification of the most frequent critical situations that are typical for motorcycle accidents. Furthermore, a special focus was on accident causation. Finally, conspicuous facts out of the analysis are emphasized.

All in all, the study gives a comprehensive overview about the German motorcycle accident scenario. On the one hand, the use of weighted GIDAS data allows representative and robust statements on the basis of large case numbers; on the other hand highly detailed conclusions can be drawn. The results of the study help to understand the particularities of motorcycle accidents and provide approaches for further improvements in the field of PTW safety.

MOTIVATION

In 2011 the positive trend of decreasing road fatalities in Germany was stopped for the first time since twenty years. Following the figures (Table 1), this negative development was especially caused by increasing numbers of fatally injured pedestrians, car occupants, pedestrians and users of powered two-wheelers (PTW).

Table 1: Type of fatally injured road users (Germany, 2010-2011, DESTATIS)

	Rank 2011	Fatalities 2010	Fatalities 2011	Change (absolute)	Change (relative)
Car occupants	1	1.840	1.986	+ 146	+ 7,9%
PTW users	2	709	778	+ 69	+ 9,7%
Pedestrians	3	476	614	+ 138	+ 29,0%
Cyclists	4	381	399	+ 18	+ 4,7%
Truck occupants	5	162	174	+ 12	+ 7,4%
(Others)		(80)	(58)	(- 22)	(- 27,5%)
TOTAL		3.648	4.009	(+ 361)	(+ 9,9%)

Furthermore, motorcyclists showed the second highest increase rate of fatalities in 2011 (+9,7%). On average, every day 2,1 motorcyclists are killed in a traffic accident.

Taking all fatalities and seriously injured persons into account, users of PTW represent the second largest group of road users in the German traffic accident scenario. Although every second fatality in German traffic accidents is still a car occupant, users of PTW make up about 20% in the meantime. Assuming further improvements in the field of occupant protection this trend will continue and the proportion of motorcyclists will further increase (Figure 1).

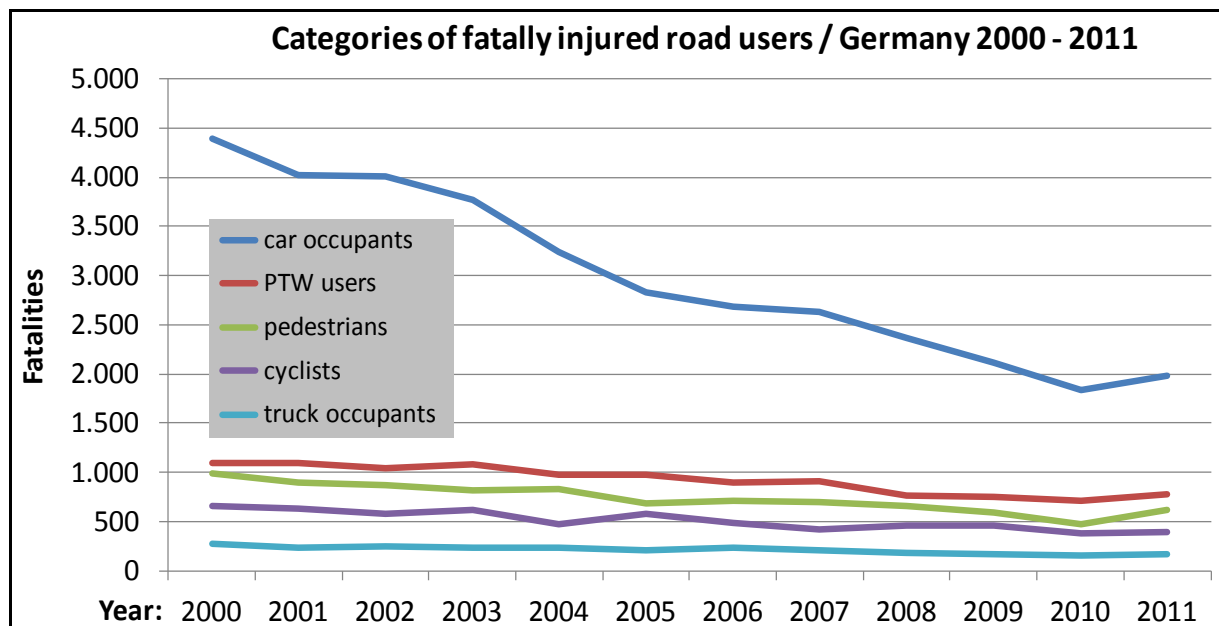


Figure 1: Type of fatally injured road users (Germany, 2000-2011)

The comparison of the fatality reduction rates between several categories of road users shows that motorcyclists show the worst performance over years (Figure 2).

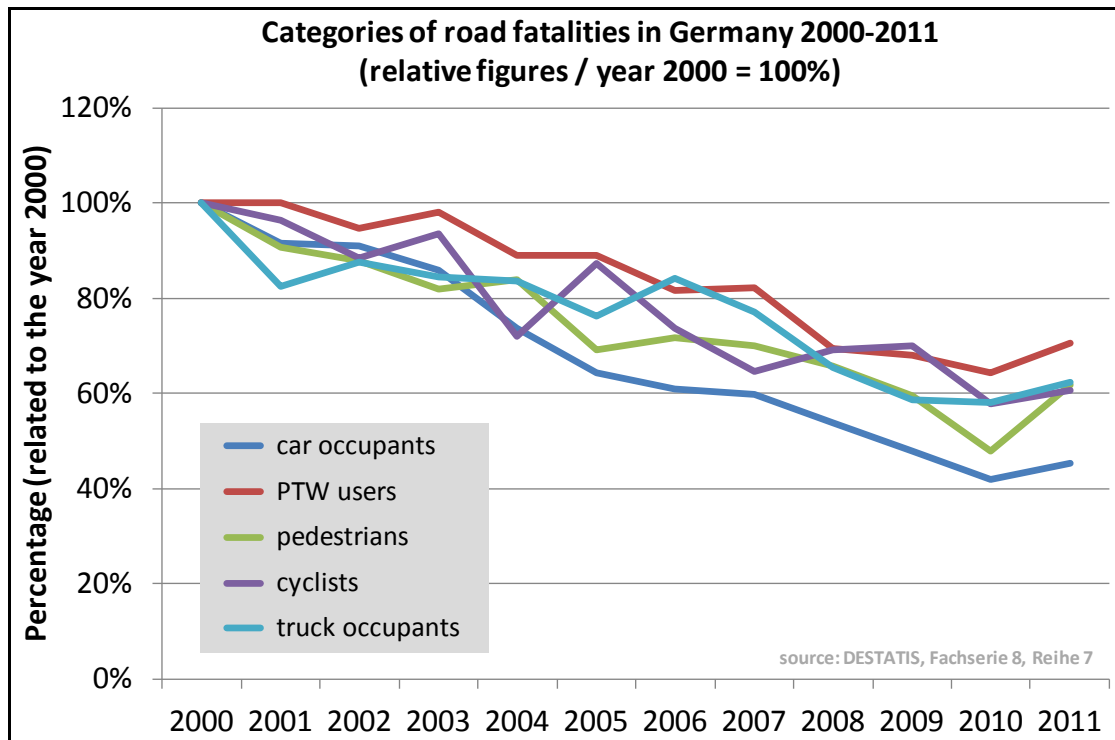


Figure 2: Development of road fatalities in Germany (relative)

Considering that the numbers of motorcycles is increasing over years it can be assumed that the relevance of accidents involving PTW will also increase in future. In addition PTW users and the related accident scenario have some particularities that differ from other groups of road users.

This study was performed to learn more about the accident scenario of motorcycles and to understand the particularities of their accidents. A detailed descriptive statistics on the accidents and the involved vehicles and persons is done, followed by the generation of typical accident scenes.

DATASET

The entire study is based on real accident data out of the GIDAS project (German In-Depth Accident Study). GIDAS is the largest in-depth accident study in Germany and the collected data is very extensive. Due to a well defined sampling plan, representativeness with respect to the federal statistics is also guaranteed. Since mid 1999, the GIDAS project has collected more than 20.000 on-scene accident cases in the areas of Hanover and Dresden. GIDAS collects data from accidents of all kinds. Due to the on-scene investigation and the full reconstruction of each accident, it gives a comprehensive view on the individual accident sequences and the accident causation. The project is funded by the Federal Highway Research Institute (BAST) and the German Research Association for Automotive Technology (FAT), a department of the VDA (German Association of the Automotive Industry).

The used version of the GIDAS database contains nearly 20.000 reconstructed accidents.

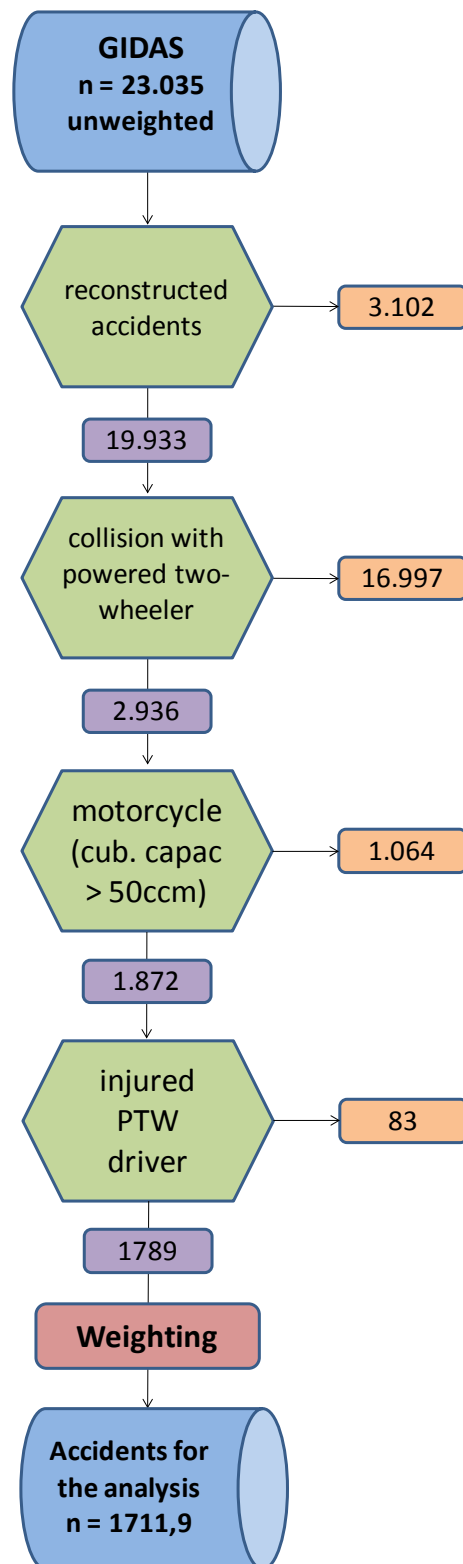
In about 3.000 of them a PTW was involved and had a collision (causers of accidents without collision were excluded from the study).

The next filter criterion for the creation of the master-dataset was the cubic capacity. For the study, only PTW were considered that are liable to registration. Thus, only motorcycles with a cubic capacity with more than 50 ccm have been chosen for the study. Mopeds have been excluded because it is assumed that these vehicles have a different accident scenario.

A total of 1.872 accidents could be identified that meet the filter criteria. At the end, only accidents with injured PTW drivers were considered. Due to the fact that nearly every collision or fall of a PTW leads to injuries the dataset I only reduced by some accidents.

Finally, 1.789 accidents out of the GIDAS database are considered for the study. To ensure representative results for the German accident scenario every accident is weighted to the German traffic accident statistics (DESTATIS, 2010). This process may lead to real numbers (1711,9 accidents).

Due to the fact that in some accidents more than one motorcycle is involved and more than one PTW driver is injured there are finally 1.734 persons resp. vehicles in the dataset.



DESCRIPTIVE STATISTICS

The use of the GIDAS database and its large variety of encoded parameters enforces researches to do numerous analyses concerning the accident scenario of motorcycles. For the present study, a selection of important parameters was chosen to describe some particularities of motorcycle accidents in Germany.

First of all, the time of motorcycle accidents is analyzed. As expected, the majority of PTW drivers are involved in accidents in summer, spring and autumn (Figure 3). One main reason for this particularity is the weather (low temperatures, snow, and precipitation) during the winter period and the resulting poor road conditions. In Germany, many PTW only have seasonal license numbers.

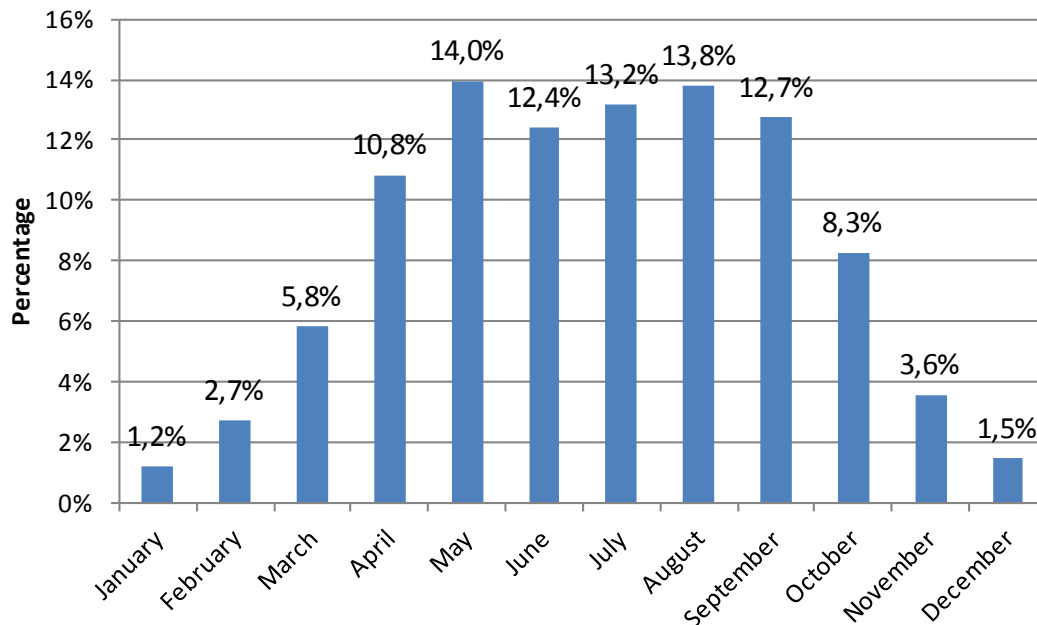


Figure 3: Accident time – Month

Besides some smaller proportions on Saturday (12,3%) and Sunday (12,8%), there are no substantial differences between the days of the week when the accident occurs (maximum on Thursday with 17,0%).

Four out of five accidents with injured motorcyclists occur during daytime (80,6%). Only 7,6% of the considered accidents occur during night.

Looking on the accident scene it can be stated that more than two thirds (68,6%) of motorcycle accidents with injured drivers occur on urban roads.

The kind of accident (Figure 4) shows that nearly one third of the considered accidents are collisions between vehicles that are turning into or crossing a road which is a typical urban situation. The second most frequent kind of accident are accidents of another kind which are mostly single falls on the road without leaving the carriageway.

Collisions with vehicles that are waiting / moving ahead or moving in the same direction are typical scenarios in longitudinal traffic and occur relatively frequent.

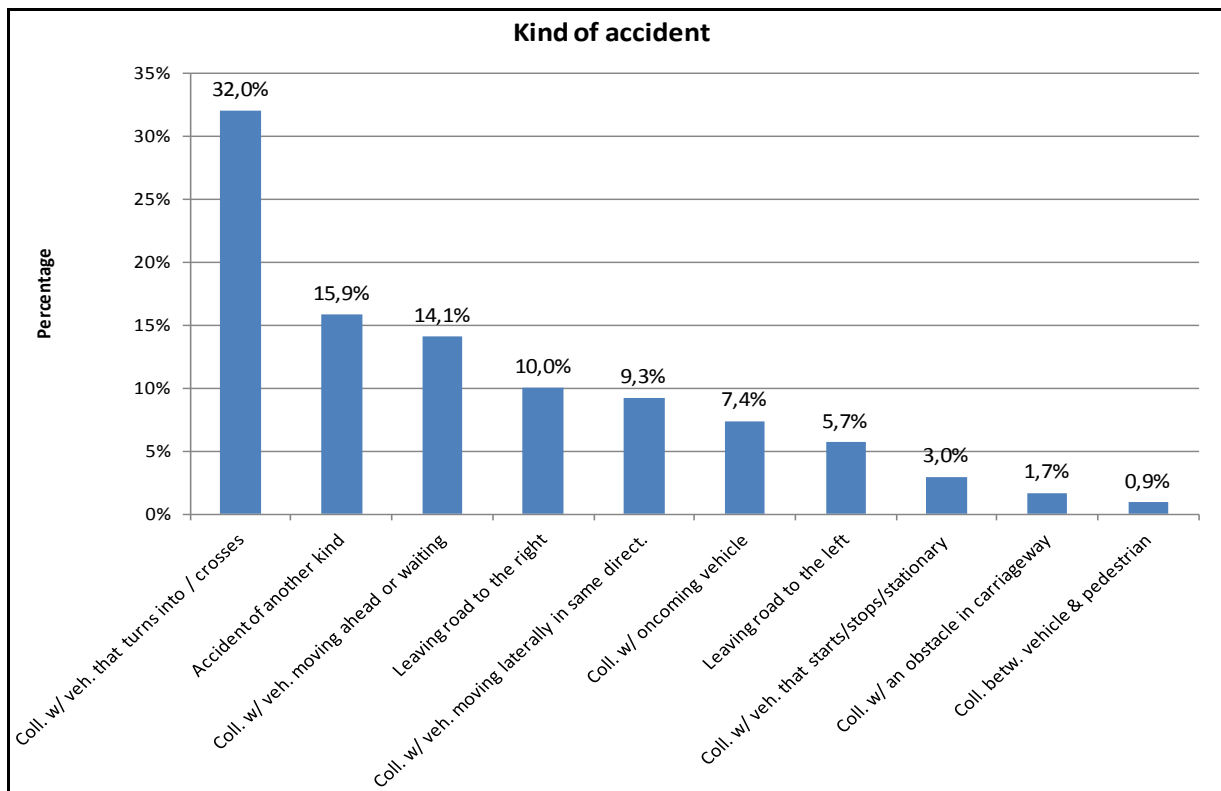


Figure 4: Kind of accident

It can also be seen that leaving the road to the right (10,0%) occurs nearly twice as often as leaving the road to the left side (5,7%). On the one hand the distance between the driving line and the edge of the road is smaller on the right (less space to correct mistakes) and on the other hand a collision with an oncoming vehicle is possible when leaving the own lane to the left (other kind of accident).

Nearly two thirds of the considered cases (64,5%) are accidents between the motorcycle and another participant (passenger car, truck, bus, tram, PTW, bicycle or pedestrian) which correlates with the above shown kind of accident. However, 29% of the cases are single accidents which are mostly loss of control situations.

Accidents with more than two participants are rather seldom (6,9%).

Together with the kind of accident the accident type is of special interest for the characterization of the accident scenario of PTW. The accident type describes the critical situation that caused the accident. Figure 5 shows the seven main categories of accident type for the 1712 analyzed accidents. It can be seen that every fourth accident of a PTW is a driving accident where loss of control played an important role. Turning into/crossing situations and conflicts in the longitudinal traffic each account for 21%. About 18% of the accidents occur during turning off the road.

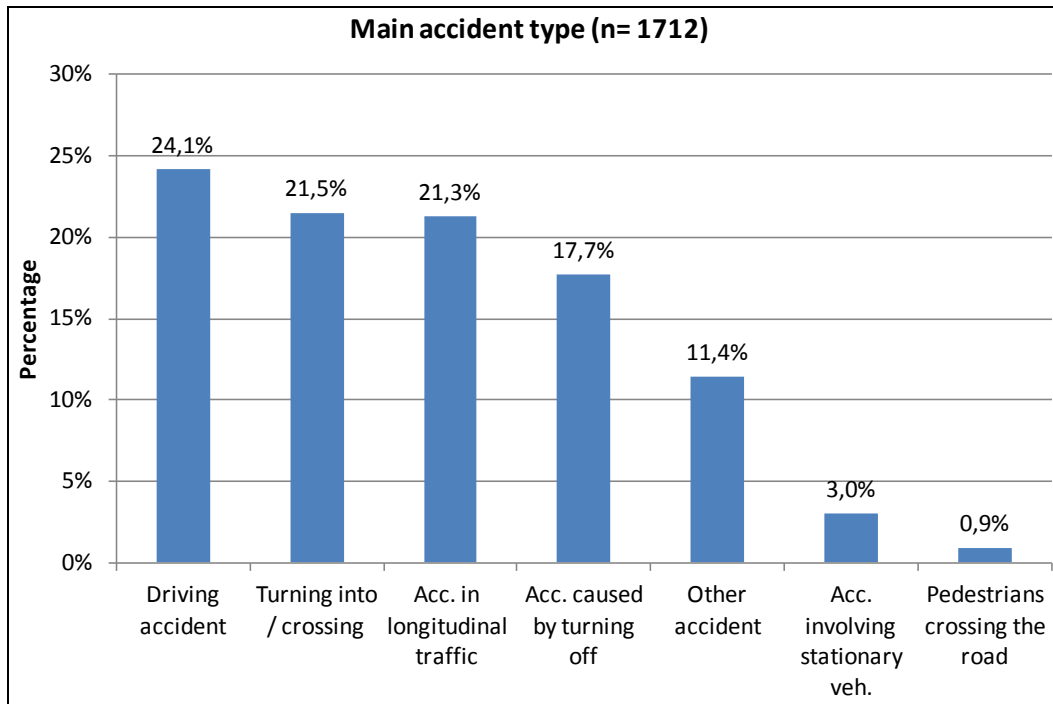


Figure 5: Accident type

To get a better understanding of typical conflicts between PTW and other road users the 10 most frequent single accident types and the role of the motorcycle (participant A = causer / participant B = non-causer / W = give right of way) is shown in Figure 6.

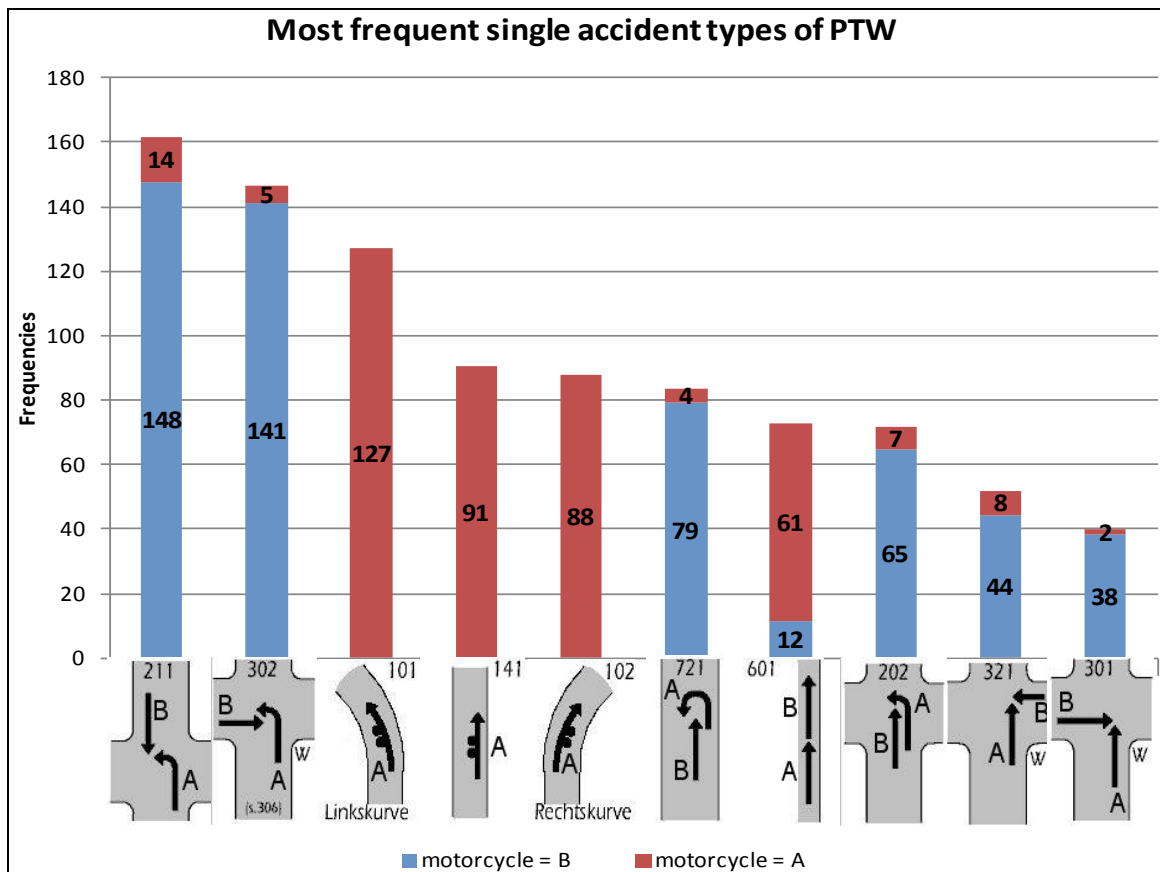


Figure 6: TOP10 single accident types and kind of PTW involvement

It can be seen that the accident type 211 is the most frequent initial situation in motorcycle accidents with injured drivers. It is very interesting that the PTW is nearly always the non-causing vehicle and is obviously overseen by another road user. The same fact can be derived from the accident types 302, 321, and 301 that represent 238 of the 1712 considered accidents (14%). In 94% of these situations there was a violation against the right of way of the PTW. Number 3, 4, and 5 of the ten most frequent accident types are loss of control accidents; the vast majority of these accidents are single accidents without involvement of other road users. Number 6 (721) and 8 (202) of the most frequent accident types are situations where the motorcycle is overtaking and another vehicle is turning on the road or turning into another road. These are particular situations that are often caused due to the fact that the PTW is overseen. Finally there is one frequent accident type in longitudinal traffic (601) where the vast majority is caused by the motorcycle due to appropriate safety distance.

In the next step the vehicle was analysed. Numerous variables have been considered within the study. Some chosen results are given here:

- Nearly half of all considered PTW (47%) are younger than 5 years.
- Vehicles aged 20 years or more make up 3% in the dataset.
- Concerning engine power there are two obvious peaks within the distribution. The first one is the group up to 10kW (19%) and the second one is between 71 and 80 kW (16%). PTW with more than 100kW make up 6,5%.
- One third of the motorcycles have a cubic capacity between 501 and 750 ccm. Another 30% have more than 750 ccm and about one quarter (23,3%) have a cubic capacity between 81 and 125 ccm.
- The mileage of the most vehicles is below 20.000km (50%). PTW with a mileage of more than 50.000 make up 13% of the dataset.
- Only 5% of the vehicles in the dataset were equipped with ABS. One reason is the GIDAS dataset that contains accidents from 1999 to 2011 and thus, some older vehicles. However, even for newer motorcycles (registered in 2005 or later) the rate is only 17%.
- On 6,5% of the considered motorcycles a second person was on the vehicle.

Furthermore, some facts concerning the accident sequences, the driver behavior and the circumstances are presented:

- About three quarter (77,4%) of the vehicles had one collision and 19% collided two times. There are hardly three or more collisions.
- Every sixth motorcycle was skidding prior to the accident.
- In 84% of the accidents the road was dry. Accidents on damp or wet roads make up 9% resp. 7%. There was hardly any accident on snow/ice (0,2%).

Figure 7 shows the most frequent collision partners of motorcycles. As expected the most frequent collision partners are other vehicles and especially passenger cars which is correlating with the high proportion of accidents in urban areas. The road surface makes up about 30%. This group mostly contains single falls of the motorcyclists in loss of control accidents or accidents where the PTW rider braked too strong as reaction to a critical situation or another vehicle and fell on the road.

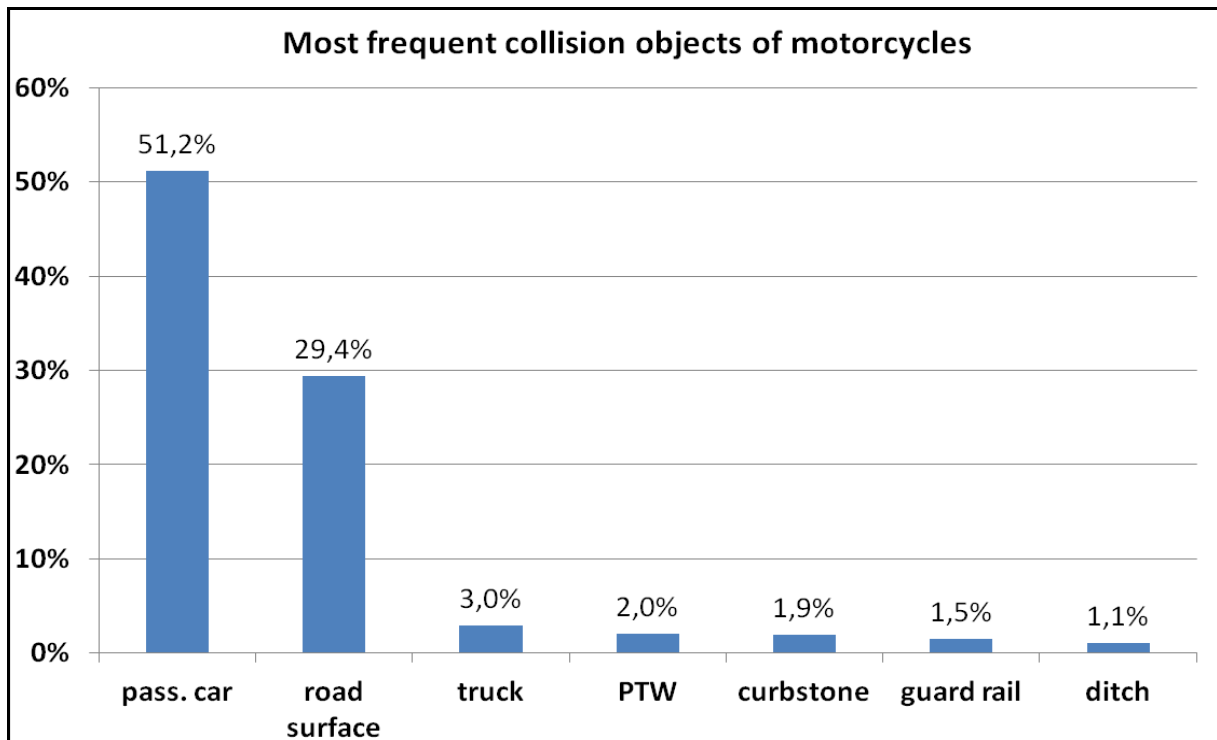


Figure 7: Most frequent collision objects of motorcycles

An important point in PTW accidents is the braking behaviour. In general, the majority (72,8%) of motorcyclists is braking prior to the collision. About 40% are braking with more than 5 m/s² and less than 7,5 m/s² as reaction to the critical situation. Only 5% achieve a braking deceleration above 7,5 m/s².

Taking into account the maximum possible deceleration at the accident scene which is mostly determined by the type and condition of the road surface and the tire, the following distribution can be derived from the reconstruction data (Figure 8). It can be seen that only 30% of the drivers brake with more than 80% of the maximum possible deceleration. There seems to be a need of supporting the driver in braking situations. Possible measures for increased braking decelerations may be technical solutions (e.g. ABS) or training of the driver.

By analyzing the interview data of involved motorcyclists it could be stated that motorcyclists that already had a safety training showed slightly higher braking decelerations than riders without any training.

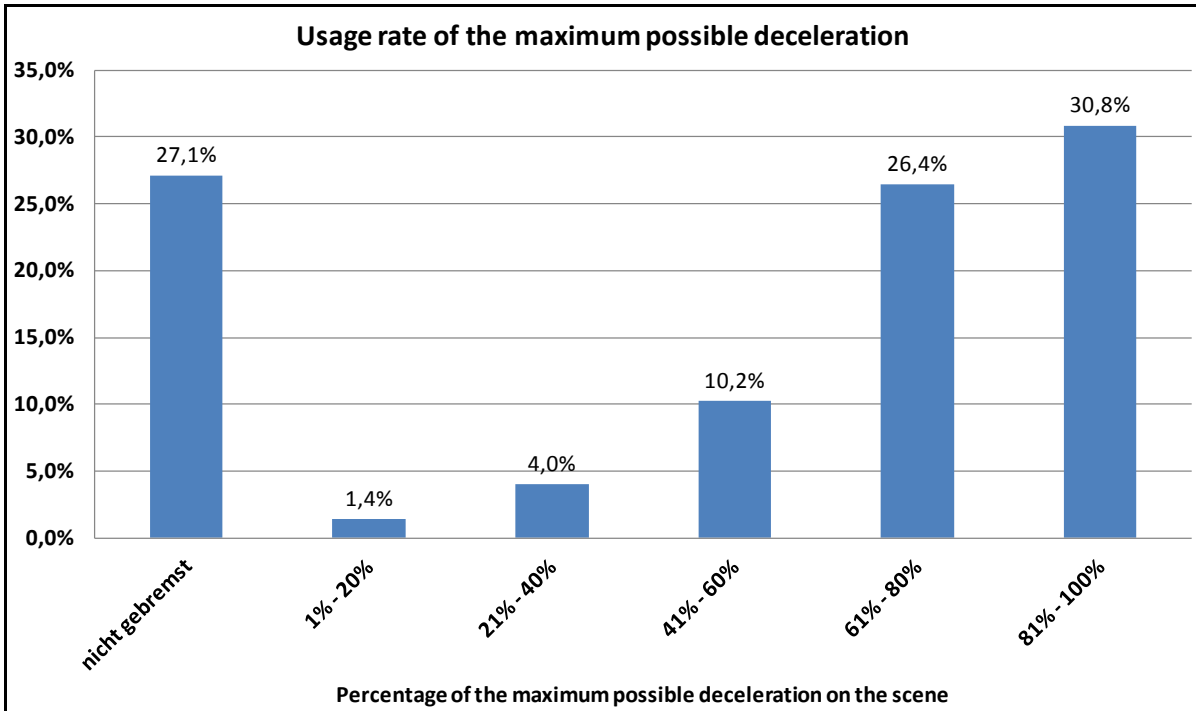


Figure 8: Mean braking deceleration of the motorcycle in PTW accidents

In the dataset the equipment rate of ABS is only 5% which is a result of the dataset (accidents from 1999 to 2011). In general, increasing numbers of vehicles with ABS can be found in GIDAS (although there may be a bias between the actual ABS equipment rate in the entire fleet and the ABS rate in accidents due to already avoided accidents by ABS). Figure 9 shows the ABS equipment rates per year of first registration in GIDAS. About 40% of modern motorcycles (registered since 2008 or later) are already equipped with ABS.

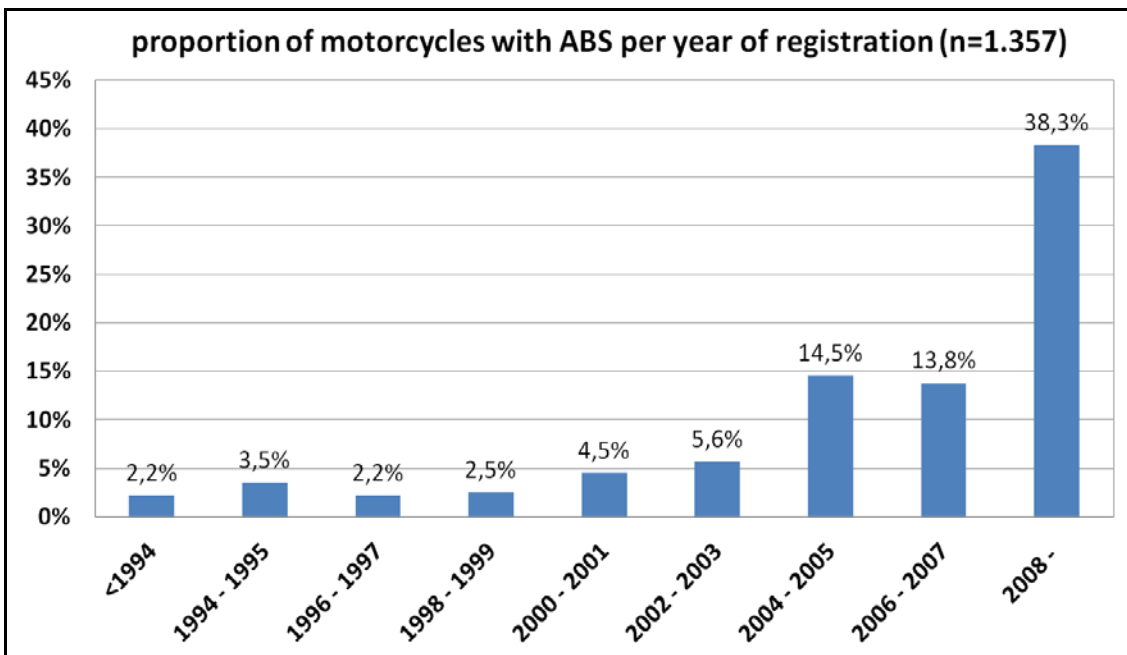


Figure 9: ABS equipment rate per year of first registration in GIDAS

The analyses on personal level showed that motorcyclists represent a very special group of road users. One particularity is the gender distribution. About 91% of the PTW riders in the dataset were male.

Looking on the age distribution it can be seen that – similar to drivers of passenger cars – especially young drivers are involved in accidents. This may correlate with a higher annual mileage of this group. Compared to passenger car drivers there are only few elderly riders involved in accidents which also may be caused by the decreased mileage or frequency of motorcycling in this age group Figure 10.

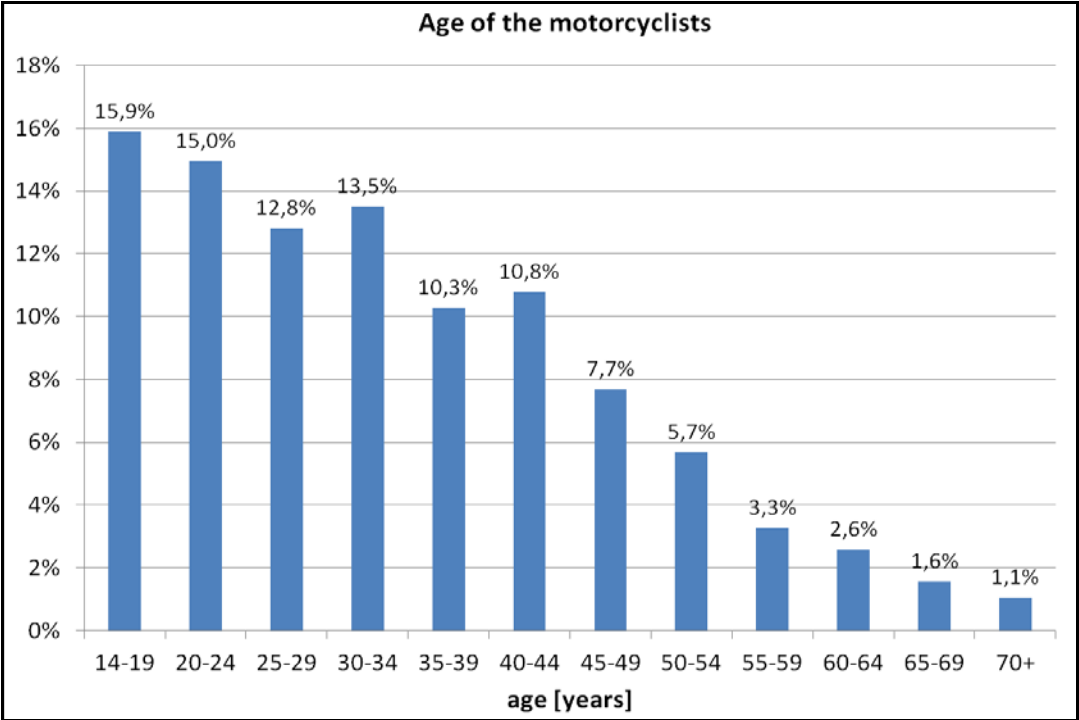


Figure 10: Age distribution of motorcyclists

Looking on the injury severity (official definition) it can be seen that more than two thirds (70,2%) of the motorcyclists were slightly injured (out-patient treatment). About 2% died in the considered accidents, 28% suffered severe injuries.

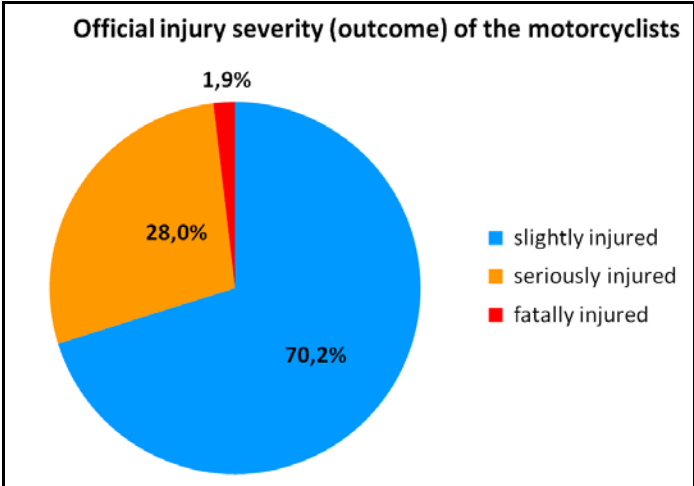


Figure 11: Injury severity according to the official definition

The analysis of the injury severity according to the MAIS gives similar results. For the study, the AIS definition of 1990 Update 1998 was used. About 60% of the riders were MAIS1 injured which correlates relatively well with the proportion of “slightly injured” persons. About 39% of the motorcyclists were MAIS2+ injured; a total of 12% suffered an MAIS3 or more. The proportion of MAIS5+ again correlates well with the fatally injured persons.

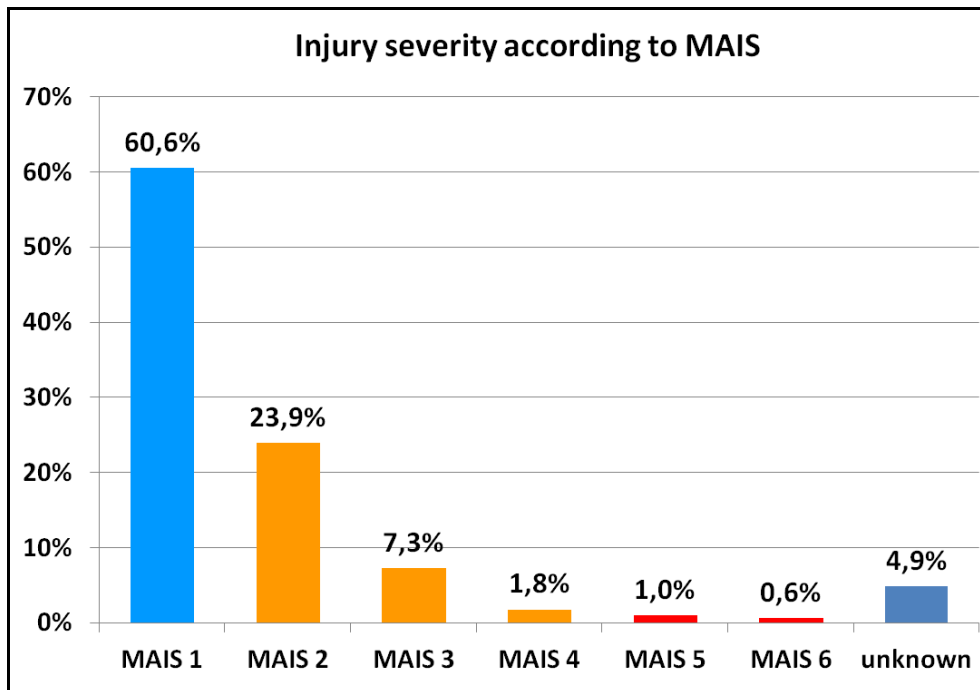


Figure 12: Injury severity according to the MAIS (AIS 1990 Update 1998)

Looking on the injured body regions of motorcyclists it can be derived from the data that most of the injuries occurred on lower and upper extremities. However, the most severe injuries occur on the head, the thorax, and the spine.

Finally the use of helmets was analysed. About 3% of the PTW riders in the dataset did not wear a helmet during the accident. This results in a very high fatality risk (Odds Ratio for sustaining fatal injuries approx. 17 times higher w/o helmet).

SUMMARY AND CONCLUSION

Accident figures of many other countries show remarkable proportions of seriously and fatally injured motorcyclists. In Germany, nearly every fifth killed person in traffic accidents is a user of a PTW. Furthermore, this group of road users shows the worst performance over years, especially in comparison to car occupants, pedestrians and bicyclists.

To characterize the accident scenario of motorcycles, the VUFO did a comprehensive study on the basis of 1.800 real accidents out of GIDAS. Numerous parameters concerning the accident, the environment, the involved vehicles and injured persons were analyzed.

One main part of the study was the identification of typical situations and critical scenarios. It was found that motorcycles often collide with other vehicles on crossings or junctions and in the majority of these cases the PTW rider was not the main causer of the accident. On the other hand side the proportion of loss of control accidents (especially in rural areas) is remarkably high.

Motorcycles as road users show many particularities. The vast majority of riders are male; they mostly ride at certain times and for particular purpose (leisure).

The detailed analysis of accident initiation, accident causation and the most relevant accident types helps to identify some main problems of PTW. These are:

- poor perception / visibility; especially at junctions/crossings, leading to the violation against the right of way of the PTW
- loss of control accidents; mostly caused by speeding or inappropriate speed, leading to single accidents and – in case of collisions with objects – often to serious/fatal injuries
- insufficient braking; either as reaction to critical situations caused by other road users or in curves)

The main goal in motorcycle safety is the reduction of the numbers of slightly, seriously and especially fatally injured motorcyclists. Therefore, further improvements in different fields have to be made. To address the above mentioned problems, several measures seem to be effective, e.g.:

- prevention (safety training, education of both motorcyclists and others)
- technical solutions (e.g. active safety systems like ABS, (curve) braking systems etc.)
- increased perception (visibility)

The majority of measures or systems seem to be effective even for other countries with a varying motorcycle fleet and accident scenario.