Motorcycle Crashes in Austria: Analysis of Causes and Contributing Factors Based on In-Depth Data

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Abstract

From CEDATU, the in-depth accident database run by the Vehicle Safety Institute at Graz University of Technology, a representative sample of 101 crashes involving at least one motorcycle was selected. The analysis focused on causes for crashes as well as on contributing factors, but also included parameters of road, riders and vehicles. Own riding speed and "unexpectable action by another road user" were the most frequent causes for accidents. Inappropriate safety distance or delayed reaction were frequent, both as causation factors and as contributing factors. Infrastructure issues never cause an accident, but they are very frequent as contributing factors; road geometry and road guidance are by far most frequent among these. This paper also discusses accidents by type and other parameters (e.g. injury severity by body region, collision speed, age and others), and compares accident causes to previous studies as well as the police reported accident statistics.

INTRODUCTION

Motorcycle safety is quite a peculiar field within road safety for several reasons, e.g.

- Motorcyclists are by far the fastest-moving among vulnerable road users
- Motorcycling most likely is the only kind of mobility, which is predominantly practiced just for the sake (or fun) of it. An opinion poll among 1038 riders in Austria in 2012 found 45% mainly riding on weekends and 75% predominantly riding as a spare time activity.
- Most likely, no other kind of mobility is more limited to a couple of months of the year, at least in countries with highly seasonal climate. In the same opinion poll, only 9% of the riders indicated riding the whole year.
- Reading the market-leading motorcycle newspaper in Austria gives the impression that the journalists achieve a sort of "heroic status" if (or better "every time") they crash one of the press motorcycles - even if they were injured.

Since 1990, the number of registered motorcycles tremendously increased by about 400%; by the end of 2015, more than half a million motorcycles were registered in Austria. Nevertheless, fatalities did not show any durable trend for two decades until they finally started to decrease slightly by 2010. Injuries went up by about 25% within this period, which is still a tiny increase compared to the number of registered vehicles. The decrease of crashes, in particular for passenger cars, raised the share of motorcycle crashes in the whole crash record dramatically. Currently, almost 20% of fatalities in road traffic are motorcycle riders, in Austria as well as in the whole of Europe. As for Austria, this is even more serious, considering that motorcycling is a very seasonal phenomenon.

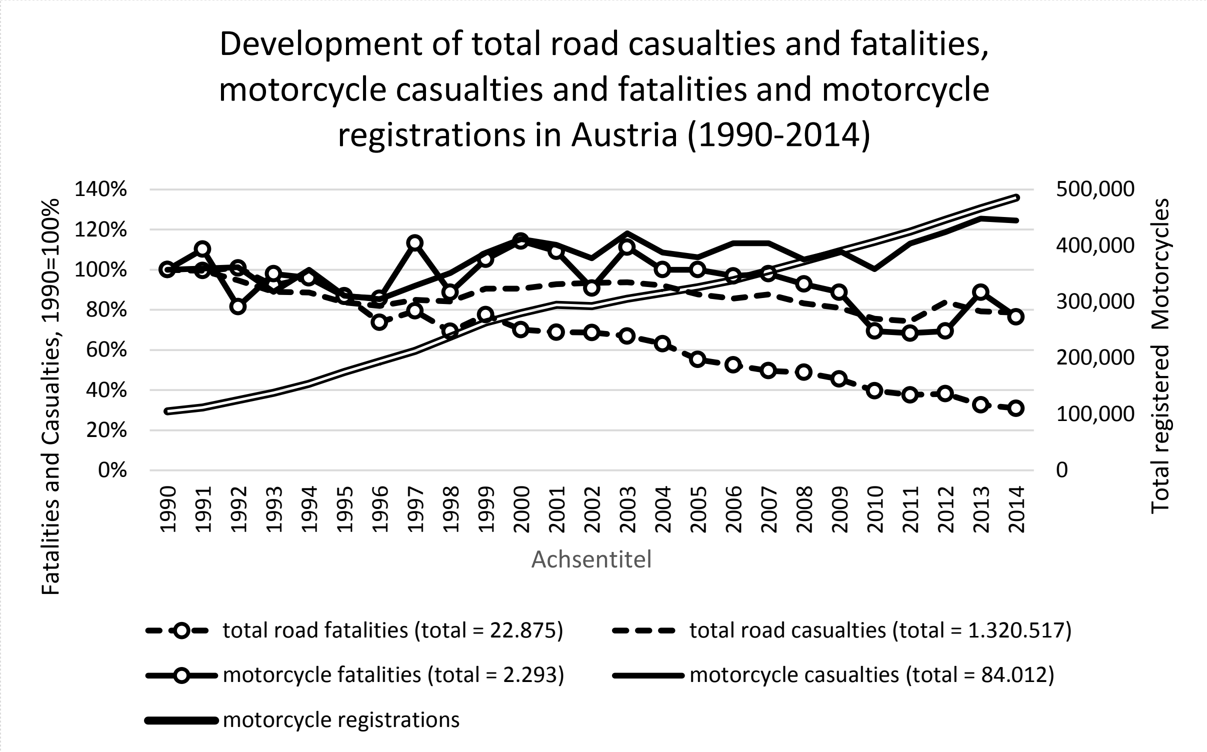

Figure 1. Total registered motorcycles & casualties and fatalities, total and motorcycle, Austria, 1991-2014

There are some in-depth studies on motorcycle crashes, most prominent the "Hurt-Study" [1] and MAIDS [2]. The KFV-study In-Depth Analysis of Fatalities [3] (2004 and 2005 data) devoted some chapters to motorcycle crashes. Recent research in Austria discovered a lot of information about exposure [4] and naturalistic studies [5] found indications about some causes for crashes. Hence, using in-depth data for improving knowledge on crash causes and contributing factors was a logical consequence.

METHODOLOGY

For the study, the in-depth accident database CEDATU - Central Database for in-depth analysis of road accidents was used, which is run by the Vehicle Safety Institute at Graz University of Technology. Currently, CEDATU contains about 3.300 cases based on variables of the STAIRS protocol [6]. More variables were incorporated using results of the co-operative European research projects PENDANT (Pan-European Coordinated Accident and Injury Databases) [7], RISER (Roadside Infrastructure for Safer European Roads) [8] and ROLLOVER (Improvement of rollover safety for passenger vehicles) [9]. Finally, the database also has information with respect to the official Austrian (police-recorded) accident database [10].

Each single accident is carefully reconstructed before it enters the database. Input parameters are final position of all involved vehicles, deformation of vehicles, skid marks, eye witness reports, biomechanical evidence from medical reports and any other evidence that can be derived from the court files. Accident reconstruction using PC-Crash provides impact speed, initial speed, reaction time, etc. of all parties involved. The results of the

reconstruction facilitate conclusions on the primary and other causes of the crash and factors, which have contributed to occurrence and/or severity of a crash.
KFV has commissioned TU Graz a study [11] on accident causation of motorcycle accidents. Mopeds were excluded. From the Austrian accident database, it is well know that moped accidents have different patterns in terms of e.g. severity and location. Hence, moped accidents could not support an extension of the sample.

SAMPLE, BASIC ANALYSIS

From CEDATU, a sample of 101 crashes involving a motorcycle was selected. The sample was composed as to have the same distribution of accident types as the official Austrian accident database. Single vehicle accidents (36%), crashes with an oncoming vehicle (31%) and crashes at intersections (23%) were the most frequent accident types. Most victims (motorcycle users) were male (92%): among 104 riders, there were only two women. Most of the injuries were fatal (86% of riders, 44% of pillion passengers) only 2 % remained uninjured. Victims were categorised in groups of five years. 20 to 24, 35 to 39 and40 to 44 included about 20% of the victims. The 101 crashes involved 170 road users. Most frequent crash partners were cars (76%). Truck (14%), vulnerable road users, busses and others (about 3% each) make up the rest of the collision partners.

16% of the riders, whose initial speed could be determined (n=77) were travelling above the speed limit. From those accidents, which occurred at 100 km/h speed limit, the average speed was 83 km/h, the median speed was 85.5 km/h, the maximum 140 km/h. The median collision speed was 69 km/h.

CRASH CAUSES AND CONTRIBUTING FACTORS

Contributing factors in general

Contributing factors are determined for all parties involved in the sample of 101 crashes. For all parties involved (n=169), there is an average of 3.7 contributing factors per crash (median: 3.0). For the cars only, the average is 3.3 (n=49), for other parties it is 3.0 (n=16). For the motorcycles themselves, the average is 3.9 contributing factors per crash, the median is 4.0 (n=104). This may lead to the conclusion that riders are better than other road user groups in terms of defensive strategies. In other words, for a motorcycle it takes more adverse conditions driving a rider into trouble.

Split by accident type for all the crashes (not for the parties), the average is 5.2 contributing factors, head on-collisions (n=31) have an average of seven, single vehicle crashes (n=36) and crashes at intersections (n=24) have an average of about 4.5 contributing factors. Luckily, since these are also the accidents with the most severe consequences, it takes more adverse conditions triggering a head-on collision.

“Speed” and “unexpectable behaviour of other road users” are, by far, the most frequent causes for crashes (Figure 2). Three more causes were counted in considerable numbers (rider failure, overtaking and time headway / delayed reaction). Road alignment is, by far, the most frequent contributing factor and applied to almost all the crashes. Only “speed”, “rider failure” and “time headway / delayed reaction” show considerable appearance as both causal and contributing factors.

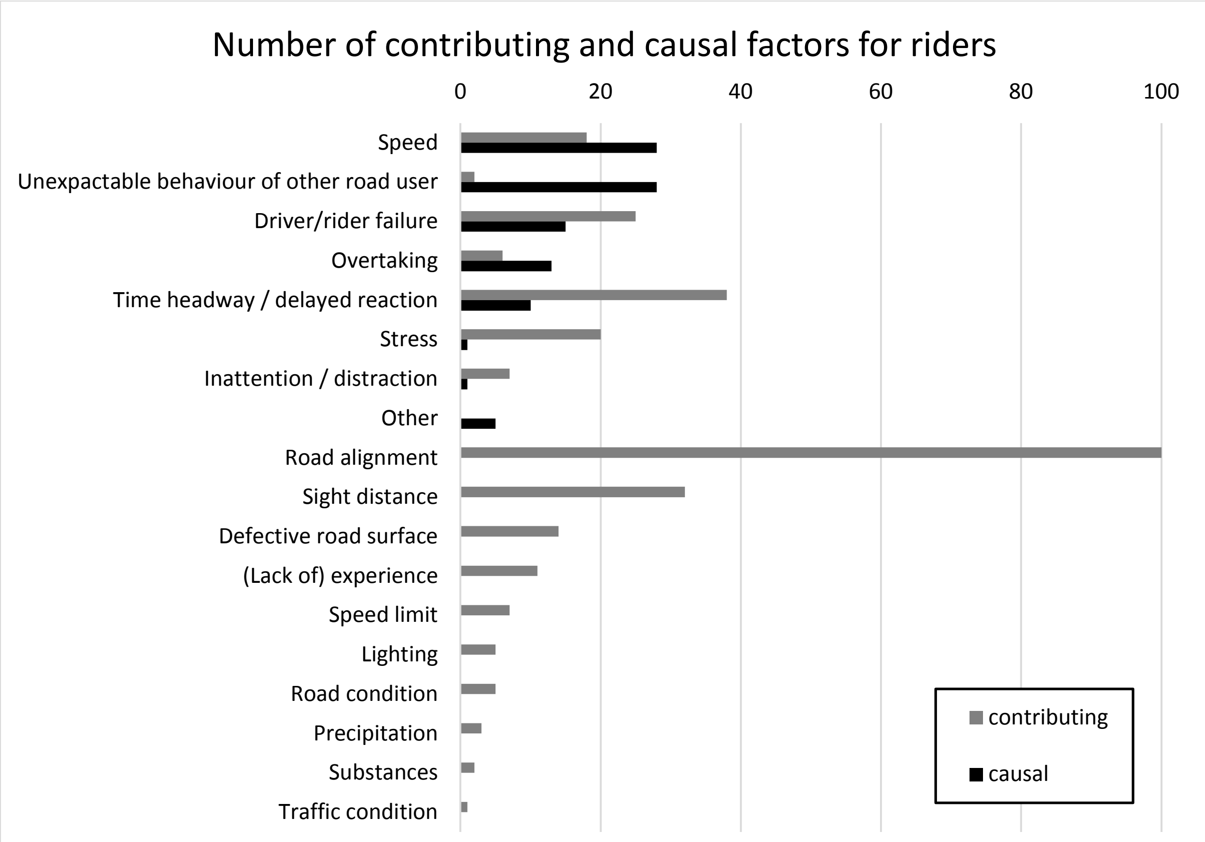

Figure 2. Number of Contributing and causal factors for motorcycles

“Substances” take a particular role in Austrian statistics. Although alcohol might be less of a problem with riders compared to drivers due to riders’ attitudes and behaviours with respect to impaired driving [12] the truth seems different. The Hurt Study [1] found about 40% of fatally injured motorcycle riders under influence of alcohol. The MAIDS [2] found 3.9% of riders under influence of alcohol and 2.3% of the drivers of their crash partners. Other literature reports about 20 to 30% of the fatally injured riders having ridden under influence of alcohol. Austria is third in Europe in terms of beer consumption [13] and not considerably different from most of the other central and western European countries [14]. However, fatally injured persons must not be examined for alcohol (or other) intoxication except for the case, the state attorney explicitly orders a test.

Riding Speed

“Being too fast” means either exceeding the legal limit (excessive speed) or the physical limit (inappropriate speed). Inappropriate speed may also include cases where an organisational limit is exceeded, e.g. travelling at high speeds between the lanes on a congested multi-lane road. Excessive speed per se can never cause an accident, more precisely it should probably be called “inappropriate speed above the local speed limit”. Data in Table 1 suggests that inappropriate speed is even more dangerous below the speed limit. In other words, always riding according to the speed limit does not protect a rider from being too fast.

Table 1. Speed as contributing and causal factor

Speed (number of appearances)	contributing	causal
excessive	8	8
inappropriate	10	20

Unexpectable behaviour by other road users

Of course, it is difficult to assess, what is “expectable”. A very experienced rider may develop better skills in risk assessment over time. In general, safe driving or riding is strongly influenced by a road user’s ability to correctly predict other road users’ behaviour continuously.

Table 2. Unexpectable behaviour by other road user as contributing and causal factor

Unexpectable behaviour by other road users	contributing	causal
pedestrian crosses unexpectedly	0	1
no reaction	1	1
other road user moves into rider’s lane	1	22
other road user overtakes unexpectedly	0	1
other road user skids into rider’s lane	0	2
harsh braking without predictable reason	0	1

Probably “expecting the unexpectable” is the most important task of being a safe rider. Unfortunately, the analysis of prevalence of this factor by rider age does not suggest that riders learn to deal with unexpected behaviour of other road users during their years of riding. On the contrary, there are even slightly more events of this kind registered for elder riders (Figure 3). It was not investigated to more detail, from where other road users entered the path of the riders, although this is by far the most frequent factor. 22 cases would not have been sufficient; furthermore, literature provides good evidence about the most common accident types of “SMYDSY”-crashes („Sorry mate, I didn’t see you“).

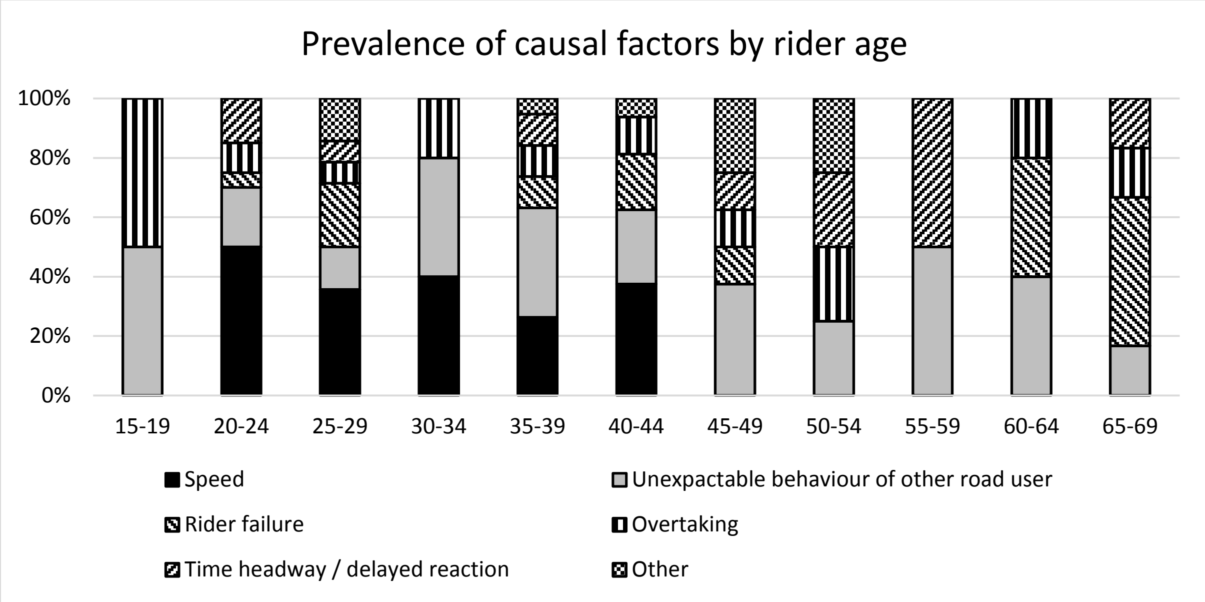

Figure 3. Prevalence of causal factors by rider age (n=101)

E.g. Kramlich [15] repeatedly investigated motorcycle crashes, including collisions with cars. The most common accident types were a car driver crossing the rider's trajectory at an intersection (45%) and a car driver turning left in front of a rider (22%). In 71% of the collisions between cars and motorcylces, the driver was at fault. The author of this paper has repeatedly compared Kramlich's findings based on German data with Austrian accident data and found similar patterns.

Causes by accident type

The results of this study could proof all previous evidence. At intersections, "unexpectable behaviour" is the most frequent crash cause (15 out of 23 cases). For single vehicle crashes, inappropriate speed caused most of the crashes (21 of 36 cases). For the other accident types, causation is more diverse.

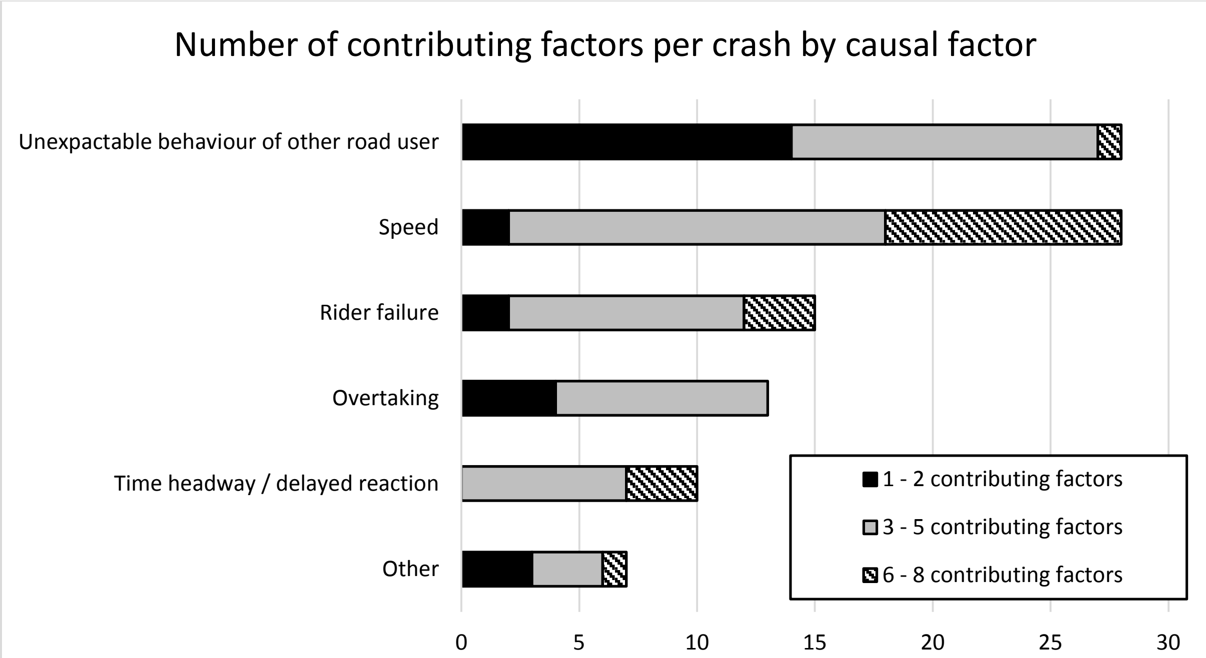

Figure 4. Number of contributing factors per crash by causal factor (n=101)

Relation between contributing and causal factors

The causal factors were analysed for the number of contributing factors, which are observed for the same accident. This may be considered an indication, how severe or how dangerous these factors are, if they occur. A factor may be considered more dangerous, if there are only few contributing factors necessary allowing this factor to be a causal one. Remarkably, not a single among 101 crashes was caused by one factor exclusively (i.e. without any contributing factor). However, "unexpectable behaviour of other road user" does not require very much "support" to cause an accident. Inappropriate or excessive speed as cause of an accident predominantly appears together with a higher number of contributing factors.

DISCUSSION

Starting in 2012, Austria changed the system of recording injury accidents. Until the end of 2011, there was a paper/pencil method. The new road accident data management is part of the police file management, i.e. filling the forms is obligatory as before, but the software forces filling the statistical data. It was never officially evaluated, but as a rough estimate, the number of registered cases increased by about 8% by reducing the number of unreported cases. The new system integrated two very new questions: person with main responsibility and presumptive crash cause. The police edits this information either at the accident scene or later as a part of their office work. Their opinion may be based on all the witnesses' interviews, personal impression or photos of the accident scene and the vehicles involved, a drawing of the accident scene and other evidence. But the police does not prepare expert statements or reconstruct crashes in Austria. Hence, this may be considered an educated guess, but not a conclusion.

The distributions displayed in Table 3 look quite similar for injury accidents with and without a motorcycle involved. Nevertheless, for both injuries and fatalities, the distributions significantly (by χ^2-test at 95% level) differ between motorcycles and other road users. The biggest difference can be found in Police's assessment of speed as a causal factor. Considering that 86% of riders within this project's sample sustained fatal injuries, it is positive that there are more similarities between causal factors (sample) and primary causes (police data) for fatalities than for injuries. However, probably the most striking "difference" is that almost 50% of the causes cannot be directly matched between the two data sets.

Table 3. Presumptive crash causes, police-recorded road crashes, Austria, 2012-2014 and causal factors

Primary cause / Causal factor	causal factors (in-depth)	Fatalities (police data)		Injuries (police data)	
		Motorcylce involved	all others	Motorcylce involved	all others
Inattention / distraction	0,99%	10,97%	15,01%	9,46%	8,58%
Unappropriate speed	27,72%	38,40%	21,03%	16,39%	13,57%
Right-of-way violation, red light running		16,03%	11,11%	22,63%	22,81%
n.a.		16,03%	3,99%	7,96%	3,00%
Overtaking	12,87%	13,50%	25,28%	29,42%	32,74%
Time headway	9,90%	0,84%	2,29%	1,92%	4,06%
Pedestrian error		0,00%	4,07%	0,24%	1,59%
Substances	0,00%	0,42%	9,33%	0,77%	2,21%
Other offences		0,42%	2,88%	0,17%	0,57%
Fatigue		1,27%	0,93%	4,61%	6,41%
Obstacle		1,27%	2,46%	2,90%	2,31%
Heart attack		0,00%	0,68%	0,96%	0,75%
Technical defect		0,84%	0,93%	2,56%	1,41%
Unexpactable behaviour of other road user	27,72%				
Driver/rider failure	14,85%				
Stress	0,99%				
other	4,95%				
n (grey cells indicate significant results)	101	237	1179	12670	133939

The Austrian study “In-Depth Analysis of Fatalities” [3] found two particular model cases for accidents within a sample of 212 cases that were assessed based on court files:

a) A rider overtaking a truck in a soft right hand corner, where the rider tries to assess oncoming traffic by looking past the right side of the truck and either failing to perceive an oncoming vehicle, misjudging the necessary space for overtaking or simply failing to consider that vehicles may enter the road, where they are not able to see them.
b) A test ride scenario. Friends meet, one tests the motorcycle of another. Typically, there is little or even no protective equipment worn except a helmet. This also includes little experience of the respective rider using the respective vehicle, and third, the intention to test or even challenge the performance of the respective motorcycle.

While the first one of these scenarios clearly fits into “overtaking” in both distributions, the other one finds no clear match in neither the causal factors nor the primary causes. IDAF [3] found 29% of the cases being caused by inappropriate speed, another 25% occurred with the motorcycle travelling above the speed limit.

A naturalistic study [5] carried out by KFV involving twelve riders that were observed using four cameras, GPS, acceleration sensors, etc. for about two years each, compared speed data with 118 car drivers from another naturalistic study [16]. It was found that riders have by far more episodes of travelling above the local speed limit, however, this does not apply to excessive speed (more than 20% over the limit). These findings suggest that riders take more care about speed, but, by choosing speeds continuously at a certain level above the limit also continuously put themselves at a higher level of risk. A study from Australia [17] found the majority of crashes was to blame to system failure and only a minority to extreme behaviours. This indicates that systematic low-level speeding by motorcycle riders puts them more at risk than preventing (a much lower number of) episodes of excessive speeding could save them. At least for Austria this would mean: It would make more sense addressing the majority of riders continuously riding at 60 instead of 50 km/h in urban areas instead of tackling the minority of excessive speeders (which is more interesting for newspapers). Unfortunately, this conclusion is based on a very small sample of riders, which probably can be strongly extended by the UDRIVE [18] project. This naturalistic study currently involves 40 motorcycle riders, which are observed over a period of 21 months using the same data acquisition system as it is used for about 100 cars and 40 trucks.

Table 4. Causal and contributing factors, MAIDS [2]

	contributing	causal
PTW rider	43,71%	37,35%
OV driver	28,61%	50,49%
PTW technical failure	1,55%	0,33%
OV technical failure	0,49%	0,00%
Environmental cause	14,57%	7,71%
Other	4,23%	4,13%
Unknown contributing factor	6,85%	0,00%
n	2059	921

The MAIDS [2], among a lot of other information, looked at "Primary accident contributing factor" and "Other accident contributing factors". This analysis distinguished more precisely which party involved was at fault than the other studies or data presented above (Table 4).

The MAIDS [2] provides information about riding speed in comparison to the surrounding traffic. For 86% of the cases, "no unusual speed or no other traffic" was found, it was indicated that the speed difference to surrounding traffic contributed to the accident in only 5% of the cases.

CONCLUSIONS

It turns out to be very difficult comparing different studies' results in terms of accident causation. None of the studies provided an overview on "who did what" with respect to causal or contributing factors and/or behaviours. The analysis of CEDATU data suggests that there are two major issues in terms of motorcycle crashes: speed and unexpectable behaviours of other road users, both causing 28% of the 101 crashes that have been investigated in this study. Even if the other studies approach the issue from different directions, riding speed and failures by other road users turn out to be the common denominators in all the studies.

Particularly in terms of behaviours of other road users, it seems to be most important distinguishing between "unexpected" and "unexpectable". In many European countries – with Austria among those – motorcycle riding is a very seasonal task. One could argue that, before car drivers really get familiar with motorcycles each summer, the riders get back into winter sleep. Hence, both riders and drivers lack experience in "expecting" potentially hazardous situations. Neither is "trial and error" a good strategy of gaining experience. There's some evidence that riders are better in spotting potential hazards than car drivers [19]. The MAIDS [2] gave evidence that car drivers also holding a motorcycle license are, as car drivers, less likely to crash powered two-wheelers. These facts dissolve the concept of "unexpected" or "unexpectable" by riders. There should be more concern on the question "who has the capability to expect what?" which finally should end up in eliminating all "unexpected" events and reduce motorcycle crashes to the really "unexpectable" ones, where finally the term "accident" would be the appropriate one. It requires more awareness from both sides: Drivers should consider that there are things that cannot be done with a car, but can be done with a motorcycle. On the other side, riders need to continuously scan for situations, where other road users might fail expecting their presence.

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