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Injury protection and accident causation parameters for vulnerable road users based on German In-Depth Accident Study GIDAS

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ABSTRACT

Within a study of accident data from GIDAS (German In-Depth Accident Study), vulnerable road users are investigated regarding injury risk in traffic accidents. GIDAS is the largest in-depth accident study in Germany. Due to a well-defined sampling plan, representativeness with respect to the federal statistics is also guaranteed. A hierarchical system ACASS (Accident Causation Analysis with Seven Steps) was developed in GIDAS, describing the human causation factors in a chronological sequence. The accordingly classified causation factors – derived from the systematic of the analysis of human accident causes ("7 steps") – can be used to describe the influence of accident causes on the injury outcome. The bases of the study are accident documentations over ten years from 1999 to 2008 with 8204 vulnerable road users (VRU), of which 3 different groups were selected as pedestrians $n = 2041$, motorcyclists $n = 2199$ and bicyclists $n = 3964$, and analyzed on collisions with cars and trucks as well as vulnerable road users alone. The paper will give a description of the injury pattern and injury mechanisms of accidents. The injury frequencies and severities are pointed out considering different types of VRU and protective measures of helmet and clothes of the human body. The impact points are demonstrated on the car, following to conclusion of protective measures on the vehicle. Existing standards of protection devices as well as interdisciplinary research, including accident and injury statistics, are described. With this paper, a summarization of the existing possibilities on protective measures for pedestrians, bicyclists and motorcyclists is given and discussed by comparison of all three groups of vulnerable road users. Also the relevance of special impact situations and accident causes mainly responsible for severe injuries are pointed out, given the new orientation of research for the avoidance and reduction of accident patterns.

1. Introduction

Traffic participants without outer protective cells are called "vulnerable road users (VRU)". This encompasses pedestrians, bicyclists and motorcyclists. These different types of VRU have different protection options. Thus, motorcyclists have a crash helmet, which protects the whole head in case of an impact and frequently even wear protective clothing with special protectors, which are aimed at protecting the body from impact injuries. Compared to this, bicyclists frequently wear special bicycle helmets and using no special protection clothes, while pedestrians number amongst the road users the lowest grade of protection.

The number and incidence of the different groups of road users in the individual countries characterize the economic accident consequences due to the general traffic accident events and the number of casualties and fatalities recorded in doing so. Understandably bicycles and motorized two-wheelers are very frequent in Asian countries, and their numbers cannot be compared to accident events in Europe or the US. In the so-called "low and middle income countries" the behavior of mixed traffic and the velocity behavior of the individual road user can be called particularly conflict-fraught (WHO, 2009). Vehicle factors, such as insufficient brakes and frequently inadequate driving abilities of the drivers as well as poor design and layout of roads, frequently render traffic in a country unsafe and influence the accident events. In China nearly 1/10 of all traffic fatalities are bicyclists, in India approximately 4%. In India 69% of all motorized vehicles are motorized two-wheelers and 27% of all fatalities number amongst the group of users of motorized two-wheelers. In the European Union approximately 40,000 persons die in traffic annually (ETSC, 2008) of which 8000 are unprotected road users, such as pedestrians and riders of two-wheelers. Riders of motorized-two wheelers represent 16% of all road deaths, whereas they only account for 2% the total mileage/kilometers traveled.

As technical causes for accidents have become infrequent due to technically high quality automotive engineering and road design,

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and vehicles are continuously being optimized in terms of safety, human causes can be named as the main source of accidents as can be seen for one major industrial country of Europe on the example of Germany (Jänsch et al., 2009). In the "low and middle income countries", however, bad roads, insufficient traffic routing as well as the lack of training of the road users are still account for a large number and other kinds of accident causes.

For the present study the data of the accident database GIDAS (German In-Depth Accident Study) was analyzed. In the frame of GIDAS, teams in Hannover and Dresden annually document approximately 2000 traffic accidents with personal injury using scientific means and collecting large amounts of information, reconstructing the driving and collision speeds and documenting the injuries (Otte et al., 2003; Brühning et al., 2005). The Use of a new type of encoding of accident causation factors makes it possible to define relevant accident situations and subsequently preventive measures can be determined (Otte et al., 2009a,b).

Based on the documentation of the traffic accidents in accordance with statistically representative sampling and revision of the data set conducted annually, the accident data can be regarded as representative for Germany (Pfeiffer and Schmidt, 2006). This study is based on continuous documentation of traffic accidents from 1999 to 2008. For this purpose a total of 8204 vulnerable road users have been documented, consisting of 2041 pedestrians, 3964 bicyclists and 2199 riders of motorcycles. The injuries had been recorded on the basis of AIS (Abbreviated Injury Scale, 1998) and the injury severity degree in accordance with the definitions of MAIS (maximum single AIS of all injuries registered at the body) was compared to the technical conditions. For determining the collision and driving speeds, the traces at the site of the accident are documented using 3-dimensional laser technology in a sketch that is true to scale and a collision analysis is conducted using the simulation software PC-Crash (Otte, 2005). These 3 different groups of vulnerable road users were then subdivided into collisions with cars (1062 motorcycles/2482 bicyclists/1465 pedestrians), with trucks (80 motorcycles/260 bicyclists/230 pedestrians) and solitary, without involvement of another party ($n = 456$).

2. Accident severity of vulnerable road users

When looking at the accidents of vulnerable road users (VRU) cars are amongst the collision partners most frequently found. In particular for accidents with pedestrians, cars are involved in 72.3% of the cases, for accidents with bicyclists in 63.5% of the cases and for accidents with motorized two-wheelers in 49.7% of the cases. Therefore in this study the accident severity of VRU will be analyzed for crashes with cars.

There is however a significant difference in the resulting distributions of the injury severities for the different types of VRU (Fig. 1). Recorded as minor injured, MAIS 1 were found in 61.9% of the pedestrians, 65.1% of the users of motorized two-wheelers, but 74.0% of the bicyclists. On the other hand 8.8% of the users of motorized two-wheelers and even 11.2% of the pedestrians were severely injured (MAIS 3+), while only 3.5% of the bicyclists had such severe injuries. Thus in comparison to the other VRUs bicyclists frequently seem to be injured slightly, but less frequently suffer from severe injuries (MAIS 3+). Pedestrians however show particularly high frequencies of high injury severities.

The accident severity as well as the protective devices (e.g. helmet) is obvious factors to influence the injury outcome. For pedestrians and bicyclists the collision speed of the car/truck is a huge influence parameter for the accident severity. For motorized two-wheelers (MTW) the accident severity can be seen related to the relative velocity between the MTW and the car or truck (Otte, 2006) by vector subtracting the speed vectors of each vehicle.

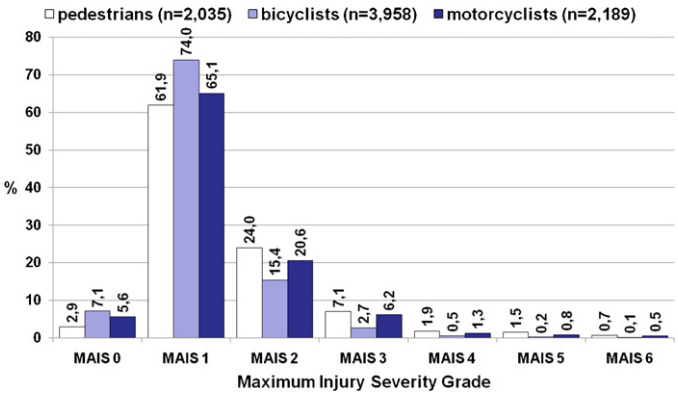

Fig. 1. Maximum degree of injury severity (MAIS) for different vulnerable road users.

The analysis in Fig. 2 shows that through all speed ranges of accident severity pedestrians have the highest frequencies of severe (MAIS 2/3) and most severe (MAIS 4+) injuries. The riders of MTW have the smallest shares of most severe (MAIS 4+) injuries and the highest shares of only minor injuries (MAIS 1) and thus can be considered as the safest group. It can be assumed here, that the advantages of MTW-riders concerning injury severity at identical accident severities can be attributed to the specific protective clothing (helmets, leather gear) used.

The fact however that the casualties of the bicyclists have the lowest amount of severe injuries comparing to the better protected riders of powered two-wheelers can be explained with the lower impact energy by analyzing the distribution of the collision speeds of the different types of VRU (Fig. 3).

The collision speeds of cars respectively the relative speed between the vehicles is varying significantly between the different types of VRU. While for bicyclists the speed of the collision partner was in 50% of the cases less than 13 km/h, half of the pedestrian collisions occurred at speeds of 23 km/h or more. Even higher accident severities can be found for the riders of MTW, where the relative speed in half of the cases exceeded 30 km/h. Thus motorcyclists due to their usually higher own speeds are subject to more serious accident severities. Here obviously the protective helmet and clothing of motorcyclists prevents this group from suffering more severe and most severe injuries.

2.1. Detailed injuries of vulnerable road users

It is remarkable, that the different types of vulnerable road users show such differences in the distribution of injured body parts

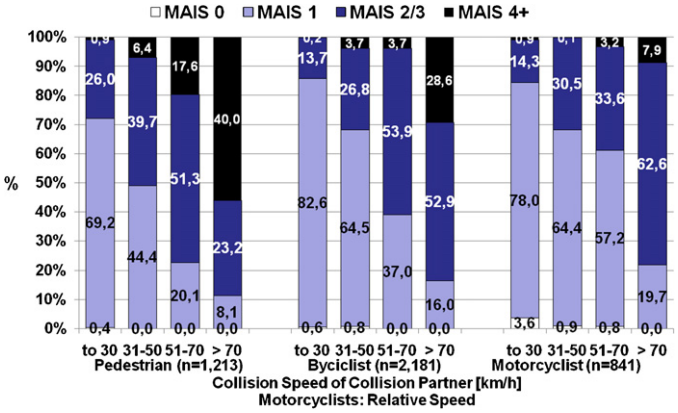

Fig. 2. Maximum degree of injury severity suffered at different accident severities, showing different types of vulnerable road users.