

Injury Rates for Older and Younger Belted Drivers in Traffic Accidents

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ABSTRACT

This paper describes the correlation of a person's age to the risk of injury occurrence and the corresponding injury severity in traffic accidents. A representative sample of belted drivers was analyzed by using data from the German In-Depth-Accident Study (GIDAS) to investigate the influence of age on injury severity and special injuries to different body regions. The study focused on two age groups: 17-30 year old (younger drivers) and older drivers 50 year old and older (50+). The injury risk was described as a function of delta-v and injury risk curves based on Abbreviated Injury Scale (AIS). Furthermore, individual parameters like age and body mass index (BMI) as well as age and mass of the vehicle were considered. The statistical analysis was carried out using descriptive and multivariate statistics. This paper presents an overview of injury patterns of belted drivers and the probability of these drivers being injured in different accident scenarios. The age-related probability for special injury patterns to different body regions was shown for younger versus older drivers. A risk score to predict the injury severity expressed in relation with AIS for different body regions was developed from the resulting statistical analysis.

CITATION: Otte, D. and Wiese, B., "Injury Rates for Older and Younger Belted Drivers in Traffic Accidents," *SAE Int. J. Passeng. Cars - Mech. Syst.* 5(1):2012, doi:10.4271/2012-01-0573.

INTRODUCTION

The changes in demographic of the population of a country over time cause technical changes in the area of traffic and vehicle design. As a result, these changes resulted in different injury outcomes over the past decades. Different kinds of injuries occurred for different age groups due to different accident involvement and different kinds of accidents. Thus, one can conclude that the causes of injuries are affected by age. For younger persons a high degree of dynamics, flexibility, and great elasticity of their human body are the specific determining parameters. Whereas, for older persons lower load limit due to low bone fracture strengths and low biomechanical strength arise as principal criteria next to delayed reactions. These factors were described in literature [1,3,5]. People 65 years old and older (65+) constitute 20% of the population in Germany, but makes up 27% of all traffic fatalities [1]. A study by the German consumer association showed an injury risk that is 14% higher for the age group 55+ in comparison to the age group from 18 to 35 years [2]. The influence of age on the genesis of injuries was considered in the course of in-depth investigations in the 1970s by many researchers all over the world [4, 5]. Studies showed a higher mortality and duration of treatment for older persons [6, 7, 8]. Older occupants are

more exposed to injuries and those injuries have higher level of severity. Also, it was reported that at the same crash severity, more severe injury levels occur for different body regions, thoracic injuries in particular [9]. On the other hand, for older persons the stress limit is lower for some injuries. According to Kent this is due to the fact that older people are more fragile than younger people and they are also frailer resulting in an offset in the Delta-v distribution for fatal head-on collisions [10]. Certain age-specific parameters can be established such as belt-wearing rate and types of accident which differ between younger and older occupants. Besides the biomechanical reasons such as lower bone and tissue strengths, for older persons there is also the influence of different accident situations in which the different age groups become involved. They result in different collision conditions occurring as a function of age such as head-on or side collisions and chosen driving speeds. Moreover, the type and age of the vehicle also correlates with the age of its driver. However, modern vehicles tend to be safer and are frequently better attuned to the requirements of older persons as well as to their specific characteristics and found to be used more frequently by older drivers [11]. Based on these findings, answer to the following question will be provided: how can the current road traffic handle the increase in older age

group? It is estimated that by 2050 one quarter or more of the whole population of the OECD countries will be 65 year old and older [12].

The objective of this study was to statistically analyze the influence of the drivers' age on the distribution of the resulting injury severity in Germany by comparing two age groups younger and older drivers. The injury risk was described on injury risk curves based on AIS [13] as function of Delta-v to predict the threshold for moderate injuries. Moreover, the study focused on injury-related accident situations and special injury patterns of different body regions.

The study was based on accident documentations from surveys at the accident sites performed by the German In-Depth Accident Study (GIDAS). These data were collected since 1999 by order of the Bundesanstalt für Straßenwesen (BAST) in cooperation with the Deutsche Forschungsvereinigung Automobiltechnik (FAT) in Hannover and Dresden regions in Germany [14, 15]. Those surveys were based on a statistically representative sample of approximately 2,000 traffic accidents annually [16], the analyzed results for the individual age groups can be called representative.

DATA AND CRITERIA OF SELECTION

The analysis of the effects of age on the injury severity of accidents is challenging as many parameters are involved. This resulted in a complex structure of correlations. It was scientifically proven that in addition to the accident severity represented by Delta-v, mass, age, and the production standard of the vehicle affect the resulting injuries [17]. Moreover, different genders entail different injury probabilities in conjunction with body height and size. Delta-v is the change of speed due to the collision which is in close relation to the vehicle's deceleration. Delta-v correlated with the injury severity [18, 19]. It has been documented in literature that women have a higher risk of sustaining rib fracture [20]. This was attributed to the size and the position, as women tend to sit closer to the steering wheel and use smaller vehicles. Few studies investigated the influence of physiological and anatomical stature of the human body related to injury risk. Studies showed that BMI is associated with increase in mortality and risk of severe injuries as reported for car crashes in the US [21]. Thus, lower BMI resulted in more frequent rib fractures, pulmonary contusions, pelvic and extremity fractures and less likely in head trauma and liver injuries [22]. Jakobsson and Lindman [23] concluded that for European countries the risk of AIS 2+ for thoracic injuries was related to high BMI for belted occupants.

For accident reconstruction purposes, a direct correlation between injury severity and vehicle deformation is frequently assumed. Taking the different rigidities of the vehicles into account is not always suitable as Robbins [24] proved. Still, a

certain relation between the degree of deformation and the converted energy as well as the injury severity was expected. To this end, it can be assumed that the age of the vehicle has an influence, too. For instance, newer vehicles with improved safety design and additional regulatory requirements have been optimized to lower injury severities in comparison to older models. The increase of vehicle rigidity resulted in higher accelerations in vehicle-to-vehicle collisions, thus, possibly increases the risk of injuries in certain types of collisions. Hence, accidents involving heavy commercial vehicles, rollovers and collisions involving trucks, busses, pedestrians, and two-wheelers were excluded from this study to disregard the influence of mass of impacted vehicles on the injury severity. The study included only belted drivers of cars in collision with another car or object.

In accordance with the expected influences on the resulting injury severities, the following parameters were selected in order to perform the statistical analysis:

- age of car in years
- size of driver in cm
- age of driver in years
- weight of driver in kg
- mass of the car as crash weight in kg
- BMI (Body Mass Index)
- place of impact at the car (CDC 2) (CDC, 1985)
- Delta-v in km/h
- deformation extent in percent of whole geometry (CDC 7)
- AIS body region (degrees of severity 0 to 6)
- gender of driver
- MAIS (degrees of severity 0 to 6)

For this purpose, the injury severity of a person was observed based on MAIS which is subdivided in 6 degrees of severity in accordance with AIS [13]. To characterize the injury severity of the different body regions, the principle of AIS classification was used with estimated maximum AIS of all injuries on one body part. Correctly To distinguish between minor and severe injury situation the injury severity grades AIS 2 and higher are combined as AIS 2+ as moderate to fatal injuries.

Delta-v was calculated within a comprehensive reconstruction process based on skid and brake marks during the pre-crash, crash and post-crash phases in addition to a physical and mechanical analysis of momentum vectors. The deformation patterns were based on the principle of energy equivalent speed. The software systems PC-Crash and Analyzer Pro were used to perform the analysis.

This study dealt with traffic accidents resulting in personal injury from 1999 to 2009. Figure 1 shows the

sampling frame used for the selection of the accidents for the study's objectives.

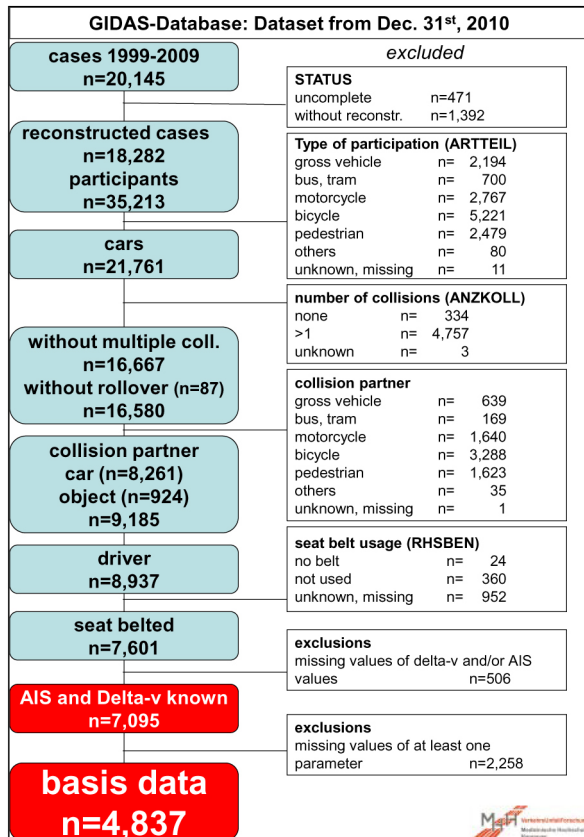


Figure 1. Sampling frame of the study.

DESCRIPTION OF THE DATA SET

The GIDAS database contains documentation of accidents collected in Hannover and Dresden based on a statistical selection plan that follows a random sample method that already constitutes a good approximation of actual accident structures [16].

Altogether 20,145 accidents occurred with at least one person being injured during the course of the accident. Only accidents for which the relevant parameters are known were selected. This also includes technical details of the collision. Thus, only accidents that have been reconstructed were included.

Subsequently, 18,282 accidents were reconstructed involving 35,213 persons. This study analyzed the influence of the driver's age on the resulting injury severity and was limited solely to drivers of motorcars to neglect the correlations between characteristics and the types of vehicles, i.e. heavy trucks and two-wheelers. Thus, 21,761 motorcars remained which were involved in accidents. Complex collision types that might influence the injury pattern were also excluded. For that reason, only motorcars with single collisions and without roll-overs were considered. Thus, only 16,580 motorcars were considered. In order to reduce the

influence of the effect of mismatch of the colliding masses and isolate the risk assessment of the driver's age, only cases with motorcars-to-motorcars or motorcar-to-object were considered.

In total 9,185 accidents remain in the dataset; 8,261 cases involve another car and 924 cases involved hitting an object. Of these 924, 248 cases the object was a stationary car (no driver).

The use of safety belt has a significant influence on the origin of injuries. Due to the high wearing-belt rate in Germany of more than 90%, the study was limited to belted drivers (7,601 drivers). Case where age, injury severity MAIS, Delta-v were unknown were excluded from the dataset. Thus, 7,095 drivers remained in the dataset of the study.

After all datasets that contained unknown values (missing values) were removed, the dataset for the multivariate analysis of the study was **n = 4,837**. For the descriptive analysis of the injury severity (AIS) to the accident severity (Delta-v) only those cases were included for which these information were known resulting in **n = 7,095**.

According to literature, a person who is 65 year old or older is considered an elderly, also in the biomechanics field, the researchers follow the convention of the World Health Organization in using the ages above 65 for being an elderly. In this study the age group 50+ was selected to define older drivers assuming that a scientific significant influence on the injury severity can be observed at 50+. Besides, this enables a categorization of age groups into three roughly equal parts. Figure 2 shows the number of cases in the Federal Republic of Germany for belted car drivers in 2009 in reference to the national age distribution. Out of 400,000 belted drivers who were injured in accidents: one third (32.1%) were in the age group up to 30 years and 11% were 65 year old and older. The percentage of the latter increased by approximately 2% over the past 3 years [25].

This shows that the percentage of younger injured drivers is relatively higher. However, with a percentage of 29.5%, older drivers (50+) constitute a group of significant size, too.

STATISTICAL ANALYSIS

The injury state of younger and older drivers was given by description of frequencies AIS and differentiated for relevant body regions. All age groups were equally included in the descriptive analysis; however for the evaluation of the results, the study focused on the comparison between younger (17 to 30 years) and older (50+) drivers.

To evaluate the influence of the different parameters on the injury severity, the principle of mixed effects logistic regression with AIS to the different body regions as response variable was applied. Because of the small number of cases in the higher AIS-scores, the analysis was categorized into groups. In the first regression analysis, the response variable was dichotomized between injured and injury levels. The second analysis was performed within the subgroup of

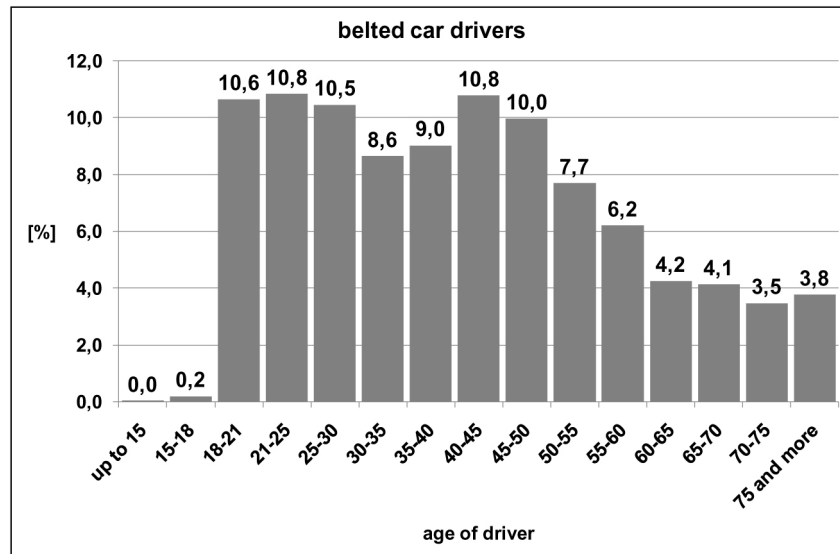


Figure 2. Age distribution of drivers in Germany (StBa [25]).

injured drivers and divided into AIS 1 and AIS 2 and greater injured (AIS1/AIS 2+) to compare minor injuries with moderate-to-fatal injuries. To adjust for possible confounders, all previously described influence parameters were included in the analysis. The accident (the case) was included as random effect to take into account the clustered structure of data, i.e. more than one driver for one accident. The analyses were performed using the software STATA, version 12.

The resulting odds ratio is the ratio of the odds of an event occurring in one group to the odds of it occurring in another group. An odds ratio greater than 1 indicates that the condition or event is more likely to occur in the first group. An odds ratio less than 1 indicates that the condition or event is less likely to occur in the first group. The p-value can be regarded as a value for the assessment of significance, the values range between 0 and 1. Values < 0.05 can be regarded as significant and those between 0.01 and 0.001 as highly significant.

DESCRIPTIVE ANALYSIS

The descriptive statistics of the demographic data, the characteristics of humans and cars as well as traffic parameters are shown in Table 1.

The one-dimensional frequency distribution of the injury severities showed only small differences between older and younger drivers (Figure 3). Younger drivers were slightly more frequently injured (50.4% vs. 43.6%) than older drivers. Older persons frequently suffered higher injury severities MAIS (MAIS 2+ 19.9% vs. 14.8%). Minor injuries (MAIS 1) occur more frequently with younger drivers at 85.2% vs. 80.1%.

Table 1. Baseline characteristics of data description and parameter variance

	MAIS 0	MAIS 1	MAIS 2+
	n (%)	n (%)	n (%)
Car Shape			
standard	2224 (87.6)	1792 (92.3)	337 (94.1)
Van/ SUV	314 (12.4)	149 (7.7)	21 (5.9)
Gender			
male	1908 (75.2)	1013 (52.2)	226 (63.1)
female	630 (24.8)	928 (47.8)	132 (36.9)
Impact Area Car			
front	1515 (59.7)	1019 (52.5)	239 (66.7)
right	256 (10.1)	134 (6.9)	36 (10.1)
rear	465 (18.3)	488 (25.1)	19 (5.3)
left	302 (11.9)	300 (15.5)	64 (17.9)
Age			
mean, $\pm$ SD	41.0 $\pm$ 16.4	38.5 $\pm$ 15.3	41.6 $\pm$ 18.1
Def. Extent(CDC 6)			
mean, $\pm$ SD	6.9 $\pm$ 7.0	11.0 $\pm$ 10.5	22.3 $\pm$ 16.7
Age of car (year of first registration)			
to 1995	1029 (40.5)	842 (43.4)	202 (56.4)
1996 – 2002	1113 (43.9)	849 (43.7)	133 (37.2)
2003+	396 (15.6)	250 (12.9)	23 (6.4)
Age of car (at the time of the accident)			
mean, $\pm$ SD	8.0 $\pm$ 4.7	8.8 $\pm$ 4.9	9.9 $\pm$ 4.7
Mass of car			
mean, $\pm$ SD	1345 $\pm$ 313	1231 $\pm$ 285	1190 $\pm$ 236
Height of driver			
mean, $\pm$ SD	175 $\pm$ 9	173 $\pm$ 9	174 $\pm$ 9
Body mass index			
mean, $\pm$ SD	25.3 $\pm$ 4.0	24.9 $\pm$ 4.4	25.0 $\pm$ 4.3
Delta-v [km/h]			
mean, $\pm$ SD	14 $\pm$ 9	21 $\pm$ 13	36 $\pm$ 18

Considering the different body regions, the parameter “age” correlated significantly with the injury outcome for the thorax and neck injured/not injured. The risk of sustaining a thoracic injury is higher in the age groups 31-49 and 50+, whereas the age group 50+ showed a lower risk of neck