

## Injury patterns of seniors in traffic accidents: A technical and medical analysis

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**RESULTS:** A total of 4430 injured seniors in traffic accidents were evaluated. The incidence of sustaining severe injuries to extremities, head and maxillofacial region was significantly higher in the group of elderly people compared to a younger age ( $P < 0.05$ ). The number of accident-related injuries was higher in the group of seniors compared to other groups.

**CONCLUSION:** Seniors are more likely to be involved in traffic injuries and to sustain serious to severe injuries compared to other groups.

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**Key words:** Traffic accidents; Seniors; Head injury; Injury severity score; Abbreviated injury scale

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### Abstract

**AIM:** To investigate the actual injury situation of seniors in traffic accidents and to evaluate the different injury patterns.

**METHODS:** Injury data, environmental circumstances and crash circumstances of accidents were collected shortly after the accident event at the scene. With these data, a technical and medical analysis was performed, including Injury Severity Score, Abbreviated Injury Scale and Maximum Abbreviated Injury Scale. The method of data collection is named the German In-Depth Accident Study and can be seen as representative.

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### INTRODUCTION

Due to the rising mean age of the German population, traffic accidents involving older people are observed more and more often. Furthermore, previous investigations have shown that geriatric trauma patients are more often associated with a higher level of mortality, morbid-

ity and frequency of more severe injuries<sup>[1-4]</sup>. There is not only an increase in age, but also in motorization in our society. A growing number of elderly people are taking part daily in traffic scenes, so the number and the severity of accidents involving older pedestrians<sup>[1,5,6]</sup>, bicyclists or older people using motorized vehicles is increasing<sup>[2,6-9]</sup>. Furthermore, older people are less resistant to trauma due to co morbidities, e.g., osteoporosis<sup>[4]</sup>. Additionally, with the increasing mean age comes a decline in capabilities which impairs cognitive, sensory and psychomotor skills that are needed to avoid traffic accidents<sup>[4,7,10,11]</sup>. Also, older people are responsible for increasing costs in public health care programs due to prolonged post traumatic hospital stays<sup>[12]</sup>.

In our retrospective study based on the accident data from the German In-Depth Accident Study (GIDAS), we hypothesized that older people are involved in traffic accidents by a higher rate<sup>[13]</sup>, sustain more severe injuries by lower velocity trauma than younger patients<sup>[14]</sup>, sustain more severe injuries, especially to the head and extremities<sup>[15]</sup>, and even cause more accidents than other groups<sup>[7]</sup>. GIDAS is the largest in-depth accident study in Germany. The data collected in the GIDAS project is extensive. We used technical in-depth crash investigations in combination with medical data analysis to evaluate the injury situation of the elderly in traffic accidents.

## MATERIALS AND METHODS

Technical in-depth crash investigations in combination with medical data analysis were performed by specially trained documentation personnel from our local in-depth accident research unit as a part of the trauma department of the Medical School, Hannover. This documentation crew is notified by police dispatchers immediately after an accident and arrives on the scene, often simultaneously with the rescue personnel. Investigation of the crash and clinical injury documentation is then performed on site. This case report is then completed at the hospital, where all of the injured victims are taken, with proper documentation of X-ray examination, injury type and severity. The monitoring includes demographic data, the area of collision, environmental circumstances and injury patterns. Furthermore, it includes specific outcome and severity scores, such as Abbreviated Injury Scale (AIS), Injury Severity Score (ISS) and Maximum Abbreviated Injury Scale (MAIS)<sup>[16]</sup>, incidence of serious or severe multiple injuries (polytrauma, AIS 3+ in two different body regions of the patient admitted to the hospital), incidence of serious (MAIS, 2-4) or severe injuries (MAIS, 5-6), and mortality.

ISS is a well-known medical score to assess trauma severity. AIS is a severity scoring system that classifies injuries in each body region. Classification ranges from minor to maximum (1-6), indicating the relative severity of each body region. MAIS indicates the maximum AI-Scale of a trauma victim. Different technical measurement

techniques are performed to document the exact crash constellation at the scene. Reconstructions of the crash and vehicle site, as well as vehicle movements and human behaviors, are then performed for later technical analysis options. Slide and skid marks of objects and victims and any kind of deformation of involved vehicles or objects are also measured and these data are included in the crash analysis. The amount of injuries is directly related to the travelling speed at the time of the accident. Collisions between pedestrians or bicyclists with cars are measured by the collision speed of the car.

For this retrospective study, cases from 1999-2011 from the local traffic research unit were analyzed for the involvement of injured seniors and followed by demographic data, injury scores, incidence of death, collision speed and collision type. For this study, prevalence from the preselected patient population was investigated.

## Statistical analysis

For statistical analysis of the correlation between crash circumstances with injury severity (AIS/MAIS/ISS), a student's *t*-test or linear-trend test as well as descriptive statistics were performed using SPSS for Windows;  $P \leq 0.05$  was determined as the level of significance. Seniors are defined as aged 65 years or older in our study design. The control group to which the results of the senior group were compared was defined as younger than 65 years of age.

## RESULTS

From 1999 to 2011, we collected 4430 people aged 65 years or older involved in traffic accidents from a total of 46 490 traffic accident victims.

## Demographic data

A total of 2454 were male seniors (55.4%). There were 1928 car drivers, 896 car riders and 46 truck drivers. 828 drove two-wheel motorized vehicles or bicycles and 638 seniors were involved in traffic accidents as pedestrians. A total of 2482 seniors were found guilty of being responsible for the accident (56.4%). In the group of people younger than 65 years of age, 50.7% were found guilty of being responsible for the accident.

## Medical analysis

The maximum abbreviated injury scale<sup>[16]</sup> in our group was 6 with 28 seniors, 34 with a MAIS 5, 51 with a MAIS 4, and 4133 with a MAIS 3 or lower (93.2%). Some 119 seniors sustained injuries to the head with at least MAIS 3 or higher (2.7%). Overall, 12 seniors sustained lethal injuries to the head with an AIS 6, 23 seniors an AIS 5, and 4245 an AIS 4 or lower (95.8%). Injuries to the neck and maxillofacial region occurred in 531 victims in our group (12%), AIS 3 or lower in 390, and AIS 4 or higher in 141 cases. With an AIS 4 or higher, 57 seniors in our group sustained severe injuries to the chest, 934 sustained

injuries with an AIS 3 or lower (21%). Moderate to mild abdominal trauma was observed in 138 victims of our group. Severe trauma with a MAIS higher than 3 to the abdominal region was seen in 25 elderly trauma patients.

Pelvic trauma with higher MAIS scores was a rare but observed injury, with 25 patients with an AIS higher than 3. Besides injuries to the head and maxillofacial region, injuries to upper and lower extremities were often observed. Severe injuries to lower extremities with a MAIS 3 or higher were sustained by 131 of the elderly, with comparable injuries to the upper extremities by 30 accident victims. Compared to other groups involved in daily traffic scenes, the prevalence and severity of injuries to head, maxillofacial region and upper or lower extremities were significantly more frequent ( $P = 0.002$ , students-t-test for independent variables). Secondly, the overall percentage of accident-related injuries was higher in the group of older people (60% *vs* 52% younger than 65 years of age). There were no gender-related differences observed in accident-related injury patterns in the elderly.

### Technical crash analysis

Technical in-depth crash investigation was performed in all observed traffic accidents. At a travelling speed of 2-40 km/h, 8.8% of all car passengers sustained moderate to severe injuries (MAIS 2+). With an increase of the travelling speed above 40 km/h, the number of injured passengers sustaining moderate to severe injuries increased to 41.2%. Only 8.1% of all passengers were not injured at this collision speed. There were no substantial differences within the groups of younger or older people.

Different from car passengers, motor bicyclists were injured more severely and more frequently throughout the whole speed range. With closing speeds of up to 20 km/h, 27.3% of all older motor bicyclists sustained severe injuries (19.5% in the group of younger motor bicyclists). With an increase in travelling speed, the proportion of severely injured motor bicyclists increased to 55.6% in the group of older people (27.3% in the younger riders). Comparable trends were observed with bicyclists colliding with cars.

At a collision speed of 21-40 km/h, 46.9% of older bicyclists sustained serious to severe injuries, whereas in the group of younger people, only 30.9% of bicyclists were seriously injured. Within the group of pedestrians, 79.8% of older people sustained severe to serious injuries when colliding with a car travelling at a speed of 21-40 km/h (43.4% younger people). Additionally, 14.3% of injured older pedestrians suffered severe to fatal injuries. Overall analyses of the accident situation showed that seniors are more likely to sustain severe injuries, especially as so-called external or vulnerable road users. The reasons for this can be direct transfer of impact energy and, with this, a disproportionally frequent inclusion of head and thoracic areas due to the impact kinematics.

## DISCUSSION

The mean age of the German population is still increasing and so does the number of people aged 65 years or older taking part in daily traffic and maintaining their continuous level of motorization as a part of their independence. So, the number of seniors involved in traffic accidents has grown over the last years (Federal Statistical Office Germany, Report 2010).

The objective of our retrospective study was to analyze the actual traffic injury situation of older people, including MAIS and AIS/ISS, and special injury patterns compared to younger people. The main findings in our analysis were: firstly, a higher prevalence and severity of injuries to head, maxillofacial region and extremities in older people; secondly, older people are overall more likely to sustain injuries in road traffic accidents; and thirdly, there is a higher percentage of the elderly population responsible for road traffic accidents.

Accidents involving older pedestrians, car drivers or riders account for more than two-third of all involved seniors. Injury analysis in our study shows similar results compared to earlier investigations, as seniors seem to be more likely to be involved in road traffic accidents and sustain more severe injuries with minor trauma<sup>[1-3,8]</sup>. Allard described the specific needs of accident prevention of the elderly living in an inner city. McCoy showed similar results with an increase in morbidity and mortality in the elderly compared to younger traffic participants. However, a quantitative comparison to previous reports was not part of this study. Our results can be seen as a consequence of the physiological changes with increased age, such as decrease in balance, vision, hearing and reaction time. For further improvement and a reduction of severe accidents caused by seniors in traffic accidents, it is important to realize the special environment of older people<sup>[7]</sup>. Caused by physiological changes as described earlier, the reaction time and the time needed for analyzing recognized situations is often extended. In addition, seniors seemed to be overwhelmed by the amount of information given nowadays in regular traffic situations<sup>[5]</sup>. The accident causations could not be analyzed within this study and future studies should give special focus to this.

There are already several injury scores and injury observations focusing on older people, particularly considering the different and special circumstances in which older people take part in daily traffic scenes<sup>[3,17,18]</sup>. Here, we used the AIS scale. This scale is limited to the moment of the accident event and does not include age-related long term effects. Special focus should be given in future studies on better injury scaling related to age.

Prevention as a method of choice<sup>[17]</sup> with educational programs is a necessary tool in combination with an overall improvement in street safety to decrease the number of seniors in road traffic accidents<sup>[19]</sup>. Here, only

detailed in-depth studies can show special age-related results, *i.e.* crossing points for the elderly, special accident types and influences on the accident kinematics. Within the presented study, only an overview of the age related casualties should be given. In future studies, physicians should be integrated to ensure the coordination between physiological changes on one hand<sup>[20,21]</sup>, and changes in environmental circumstances and the special needs of seniors<sup>[19,22]</sup>. Engineers should work out how safety features like warning signals, speed limiters, road stabilizers and infrastructure can be linked together to avoid accidents in the elderly. Medical doctors should work on precision of injury pattern and long term related injury outcomes. Only in an interdisciplinary coordinated study can the most efficient reduction of injury severity be approached.

In conclusion, seniors are more likely to be involved in traffic injuries and to sustain serious to severe injuries compared to other groups. To improve the safety of all road users, special focus should be given to improved car and street designs for more safety and visibility. In addition, educational programs should improve the active safety of older people in traffic.

## ACKNOWLEDGMENTS

For the present study, accident data from GIDAS have been used. Use of the data is restricted to the participants of the project. However, to allow interested parties the direct use of the GIDAS data, several models of participation exist.

## COMMENTS

### Background

Due to the rising mean age of the German population, traffic accidents involving older people are observed more and more often. Furthermore, previous investigations have shown that geriatric trauma patients are more often associated with a higher level of mortality, morbidity and frequency of more severe injuries. The background of this study was to evaluate actual injury patterns in older patients caused by traffic accidents. The study design was retrospective; data were used from the German In-Depth Accident Study (GIDAS). The results were then compared to injury patterns of people younger than 65 years of age.

### Research frontiers

Limitations and research frontiers of the presented study are the retrospective design of the study by analyses of accident data, crash analysis at the scene performed by different examiners and the presented results in a global overview manner.

### Innovations and breakthroughs

Seniors are more likely to be involved in traffic injuries and to sustain serious to severe injuries compared to other groups. To improve the safety of all road users, special focus should be given to improved car and street designs for more safety and visibility. In addition, educational programs should improve the active safety of older people in traffic.

### Applications

The results of this study can lead to improvements in safety features in cars, bikes and on road crossings. Future urban designs should pay attention to the special needs of older people. Additionally, educational programs should improve road safety for all road users.

### Terminology

GIDAS is the largest in-depth accident study in Germany. The data collected in the GIDAS project is extensive and serves as a basis of knowledge for different groups of interest. Since mid 1999, the GIDAS project has collected on-scene

accident cases in the areas of Hannover and Dresden. GIDAS collects data from accidents of all kinds and, due to the on-scene investigation and the full reconstruction of each accident, gives a comprehensive view on the individual accident sequences and their causes; ISS is a well-known medical score to assess trauma severity; AIS is a severity scoring system classifying injuries in each body region. Classification ranges from minor to maximum (1-6), indicating the relative severity of each body region. MAIS indicates the maximum AIS of a trauma victim.

### Peer review

The purpose of this article was "to evaluate the overall outcome of older people involved in traffic accidents as a retrospective study from the Hannover in-depth accident research unit. Points of interest were morbidity, mortality and special injury patterns in seniors (65 years+) compared to younger people". This is a well-written paper.

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