SHORT COMMUNICATION: STAPP CAR CRASH CONFERENCE



# Comparison of Chinese and German in-depth accident data of pedestrian thorax and head injuries

Holger Staack, Volker Labenski, Giacomo Marini
AUDI AG
Yunshi Liang
VW China CSA

**ABSTRACT** – Outcomes from car to pedestrian accidents as recorded in 2022 German (GIDAS) and Chinese (CIDAS) in-depth accident databases are compared for moderate to severe (AIS2+) thorax and head injuries. Both databases are independently analyzed with respect to different injury types, e.g. thorax and head injuries. In general, accidents with AIS2+ thorax injuries are characterized by higher pedestrian ages and higher collision velocities and show more polytraumatic outcomes compared to other AIS2+ injuries. The last two aspects are especially higher in CIDAS. Besides infrastructure effects (higher collision velocities) and fewer cars with pedestrian protection measures, differences in accident documentation are identified as possible reasons for the higher occurrence of head and thorax injuries in CIDAS. Further investigations are recommended in order to validate these findings.

## INTRODUCTION

Automotive pedestrian protection can play a relevant role in reducing the number of fatal and serious injuries in vulnerable road user (VRU) accidents worldwide. To enable comparability of accidents and injury mechanisms globally, in-depth comparisons of different international accident databases are necessary [Staack 2022]. Different vehicle types, infrastructure, traffic rules, driver behavior and population characteristics can lead to different accident configurations and injuries. In order to address this properly using passive pedestrian protection measures it is necessary to understand the accident parameters affecting the injury outcome. Previous studies compared Chinese and German VRU accident data based on human body model simulations [Leo 2021]. Although external conditions (e.g. impact velocity) seemed to be different, the resulting head impact parameters showed similar trends for both countries. An in-depth analysis of thorax injuries in pedestrian accidents from the German in-depth accident database (GIDAS) has already been published by the authors [Staack 2022].

The present study updates the used dataset from GIDAS and analyzes similar pedestrian accidents from the Chinese in-depth accident database (CIDAS) [Pei 2023]. Taking the differences of the countries and databases into account, a comparison of statistics on injury outcomes is provided with focus on moderate to critical (AIS2+) head and thorax injuries.

Dr.-Ing. Holger Staack, AUDI AG, Auto-Union-Str. 1, 85057 Ingolstadt, Germany. Email: holger.staack@audi.de

## METHODS

The dataset for frontal car vs. pedestrian accidents from the previous study [Staack 2022] is updated with GIDAS (12/2022) data. Abbreviations and injury clustering are carried over from the previous study [Staack 2022]. The data are divided with respect to 45 kph collision velocity ($v_c$). This considers the current 40 kph testing requirement for pedestrian protection (GTR 9 and EuroNCAP Pedestrian Testing Protocol) and an average 5 kph reconstruction tolerance. Analogously, a corresponding study is performed with the CIDAS database. At the time of the analysis, GIDAS was based on the 2015 version of the Abbreviated Injury Scale (AIS) codebook whereas CIDAS used the 2005 version. The Injury Severity Score (ISS) is calculated and used to define polytrauma (ISS > 15). Furthermore, the data are analyzed with respect to boundary conditions, case numbers, injury numbers, AIS2+ thorax and head injuries and their relation to polytrauma, velocity and pedestrian age. Country specific differences in data acquisition, fleet safety level, etc. are considered in the discussion.

## RESULTS

Figure 1 reports the data from GIDAS (left) and from CIDAS (right) database. The first column lists the number of cases/injuries falling into the ≤ 45 kph $v_c$ range and the second displays all crashes with a known $v_c$ in the sample. The row All AIS (injuries) refers to the number of injuries assigned an AIS code in each data set. All MBAIS (persons) refers to the number of injured people in the two data sets while taking the highest known AIS code as the basis.

| GIDAS 12/22 Car vs. Pedestrian | ≤45 kph | all $v_c$ |
|---|---|---|
| All AIS (injuries) | 3095 | 3923 |
| All MBAIS (persons) | 827 | 924 |
| AIS2+ | 1645 | 2371 |
| MBAIS2+ | 307 | 371 |
| AISTHO2+ | 42 | 121 |
| MAISTHO2+ | 24 | 52 |
| AISHEAD2+ | 223 | 339 |
| MAISHEAD2+ | 173 | 219 |

| CIDAS 06/22 Car vs. Pedestrian | ≤45 kph | all $v_c$ |
|---|---|---|
| All AIS (injuries) | 1065 | 2311 |
| All MBAIS (persons) | 279 | 457 |
| AIS2+ | 478 | 1067 |
| MBAIS2+ | 170 | 336 |
| AISTHO2+ | 60 | 165 |
| MAISTHO2+ | 40 | 120 |
| AISHEAD2+ | 209 | 438 |
| MAISHEAD2+ | 98 | 237 |

*Figure 1: Data evaluation from GIDAS (left/blue) and CIDAS (right/red) for collision velocities ($v_c$) ≤ 45 kph and for all $v_c$. Comparison between AIS2+ head & thorax injuries (AIS, AISTHO, AISHEAD) and accidents/persons (MBAIS, MAISTHO, MAISHEAD) is performed.*

MBAIS2+ refers to the number of persons suffering at least one moderate to severe injury. These were further divided depending on the specific maximum injury severity (MAIS) for moderate to severe injury for the thorax (MAISTHO2+) and for the head-face-neck (MAISHEAD2+) body region. The injured people in MBAIS2+ group is further divided with respect to the injured body region and $v_c$ for the GIDAS and CIDAS (Figure 2). Figure 3 reports the cumulative distribution of pedestrian accident having MBAIS2+ MAISTHO2+ injury with respect to $v_c$. The ratio of MBAIS2+ and MAISTHO2+ pedestrians affected by polytrauma for $v_c \leq 45$ kph for GIDAS and CIDAS is shown in Figure 4.

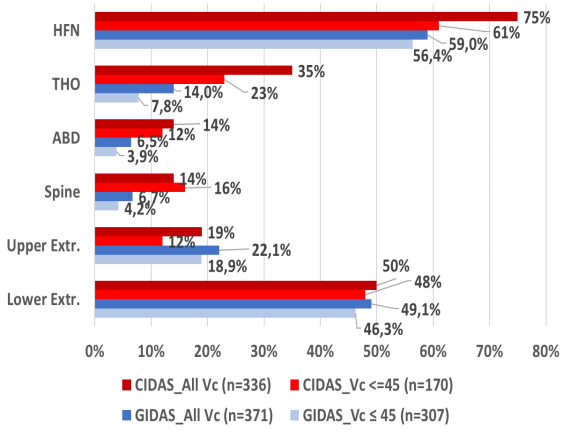


*Figure 2: Distribution of AIS2+ injury types based on MBAIS2+ injured pedestrians in GIDAS (blue) and CIDAS (red) for $v_c \leq 45$ kph and for all $v_c$. Body regions are divided in: HFN, head-face-neck; THO, thorax; ABD, abdomen; Spine and Upper and Lower Extremities.*

In GIDAS, 7 times more cases with MAIHEAD2+ injuries are found compared to MAISTHO2+ injuries for $v_c \leq 45$ kph.

Most of the recorded MBAIS2+ accidents (89.5%) occur in this velocity range (Figure 3). In particular, 34.7% of the AIS2+ thorax and 65.8% of the AIS2+ head injuries occurred for $v_c \leq 45$kph (Figure 1).

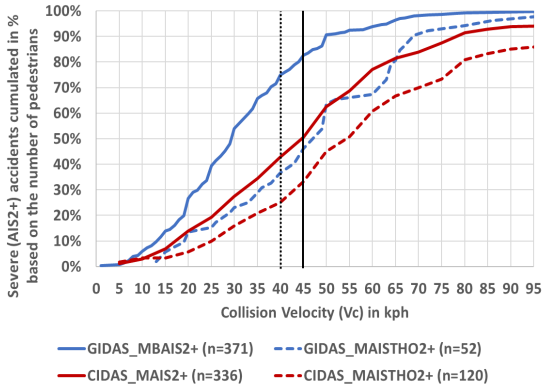


*Figure 3: Comparison of German (blue) and Chinese (red) pedestrian accidents. Cumulation in [%] of accidents with at least one moderate to severe injury (MBAIS2+) or at least one moderate to severe thorax injury (MAISTHO2+), based on $v_c$. As $v_c$ had to be adjusted for some accidents after expert review to "unknown", not all curves reach 100%.*

MAISHEAD2+ injuries are found in 56.4% of the MBAIS2+ for $v_c \leq 45$ kph, whereas MAISTHO2+ plays a minor role with 7.8% (Figure 2). In 71% of the GIDAS cases with MAISTHO2+ injuries are affected by polytraumas, while only 9% of any MBAIS2+ injured for $v_c \leq 45$ kph are polytraumas. CIDAS data shows a two times higher rate of accidents at velocities > 45 kph (55.1% of all injuries result) than GIDAS. MAISHEAD2+ injuries in Chinese data result in 61% (+4.6%) of the MBAIS2+ cases for $v_c \leq 45$ kph. MAISTHO2+ injuries were recorded in 23% of the cases with AIS2+ injuries ≤ 45 kph (Figure 1). 70% of these pedestrians suffer polytraumas, 91% show at least one other AIS2+ injury beside thorax. 42.2% of MAIS2+ ≤ 45 kph injured pedestrians can be identified as polytraumas, which means a 7x higher rate compared to GIDAS (Figure 4).

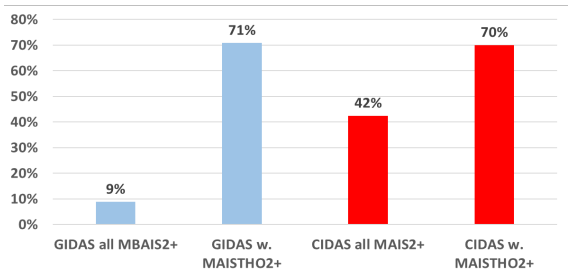


*Figure 4: Share of pedestrians with polytraumas with $v_c \leq 45$ kph in GIDAS (blue) and CIDAS (red).*

## DISCUSSION

In general, AIS2+ Chinese car vs. pedestrian accident data shows a higher $v_c$ compared to German data. The main reason can probably be found in a different traffic infrastructure and notable share of CIDAS accidents outside urban areas while GIDAS' data collection represents mainly urban areas. For both German and Chinese data, the findings of [Staack 2022] can be confirmed in general: AIS2+ thorax injuries show a clear trend to $v_c > 45$ kph where a passive pedestrian protection measure could bring the most effective solution to reduce such kind of injuries. Further, a high occurrence of polytraumas even at lower velocities (≤ 45 kph) and a higher VRU age can be observed for MAISTHO2+ cases (Figure 4). The first two effects are higher in CIDAS data than in GIDAS pedestrian accidents and may result from the low level of pedestrian protection measures in the Chinese fleet. As this difference is not physically explainable, particularly for $v_c \leq 45$ kph, differences in data acquisition and reconstruction should be investigated. CIDAS has different sampling criteria to GIDAS and not all of the identified cases in CIDAS contain reconstruction-based speed information. Furthermore, a possible influence of different body sizes should be investigated. As mentioned, the general outcome of Chinese pedestrian accidents seems to be more severe (Figure 4). Based on this, the larger amount of polytraumas for thorax injuries should be further investigated. The analysis of the single injuries and injured body regions of pedestrians with the GIDAS database was done based on the AIS2015 codebook. Within the CIDAS database the most recent data available is based on the AIS2005 codebook. Using results based on different AIS codebooks limits the comparability of injuries and injured body regions given the number of changes implemented in the AIS2015 codebook. This particularly applies to the body region head-face-neck when looking at diffuse head injuries. Therefore, it is not possible to draw conclusions based on comparisons of the results of GIDAS and CIDAS directly for this body region. In contrast, the thoracic body region has only minor changes between version 2005 and 2015. As the two databases were independently evaluated and compared, the resulting correlations have not been investigated by statistical methods regarding their significance. Thus, further evaluation on a case-by-case level and review of data gathering approaches for both databases are strongly recommended to ensure comparability of the data. As seen in [Leo 2021] for head injuries in 2-wheeler accidents, comparison of data from international accident databases is beneficial for evaluation of test procedures and safety strategies. However, findings of [Hiroshi 2023] and German thorax injury numbers/severities suggest, that head-focused pedestrian protection measures have a positive protective effect on thorax injuries.

## CONCLUSION

The current study confirmed previous analysis on two independent accident databases and highlighted the higher amount of moderate to severe thoracic injuries with high velocities and ages as well as with polytraumatic accident outcomes. The approach presents a generic way to compare injury occurrence by taking the unique features of the different accident databases into account. Thus, it becomes feasible to harmonize safety strategies in different regions of the world.

The occurrence of thorax injuries seems to be dependent on the overall safety level of the individual fleet and traffic infrastructure. Introduction of commonly known pedestrian protection measures in legislation and consumer ratings seems to have a clear effect on accident numbers and severities, also for those body regions not directly addressed in the assessment schemes (e.g. head vs. thorax in GIDAS). Interactions between head and thorax injury kinematics will be investigated in further studies as well as the injury outcomes for car vs. 2-wheeler or bicycle accidents. A deeper understanding of (thorax) injury mechanism and kinematics is needed to find effective strategies for accident avoidance or injury mitigation [Jani 2023].

## REFERENCES

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