A Paired Comparison of the Head Injury Severity Between Drivers and Passengers in Frontal Collisions

Shannon G. Kroeker, Gunter P. Siegmund

I. INTRODUCTION

The injury outcomes for drivers and passengers involved in the same collision depend on many factors, yet it is sometimes assumed that the injury outcome of one occupant can be used to infer the probable injury outcome of the other occupant with the same restraint and airbag use in the same collision. Our goal was to determine if this assumption is valid with respect to head injuries. To achieve our goal, we analyzed the head injury severity of outboard front-seat occupants in frontal impacts using paired data from the National Automotive Sampling System - Crashworthiness Data System (NASS-CDS) database of real-world collisions.

II. METHODS

We extracted frontal collisions with a principal direction of force of 12 o'clock (GAD1 = F, DOF1 = 12, 32, 52, 72, 92, ROLLOVER = 0) from the 1993–2015 NASS-CDS database. All collisions were single events (EVENTS = 1) with a known collision severity (DVTOTAL > 0) and with two outboard front-seat occupants (SEATPOS = 11 and 13) who were at least 13 years old (AGE ≥ 13). All occupants had a known seatbelt status (MANUSE = 0, 4) and airbag status (BAGDEPLY = 0, 1, 4 (years 1993–1994), 7 (years 1995+)), were not ejected (EJECTION = 0) and at least one of the two occupants had a head injury (REGION90 = 1 based on the 1998 Abbreviated Injury Scale, AIS). Drivers were identified using ROLE = 1 and passengers with ROLE = 2. Cases with missing entries for height or weight were not excluded, although 10 cases were excluded where occupant weights were 8 and 23 kg and heights were 56 cm to 83 cm. An additional 298 cases were excluded because there was an unbelted occupant seated in the second row. The final data set was limited to the unweighted data for occupant pairs who had identical seatbelt and airbag status. When multiple head injuries were present for a single occupant, the maximum head AIS score was used.

To determine if the injury severity of one occupant can be used to infer the injury severity of the other, a difference in AIS scores was calculated for each pair of occupants in the same collision. The absolute value of this difference was used to determine the minimum AIS difference for more than 50% of the pairs. To determine whether the driver or passenger was more severely injured, we ran a bootstrap analysis wherein we randomly resampled (with replication) the original data set 10,000 times to estimate the distribution of the proportion of more severely injured drivers (excluding cases where the AIS scores were identical and thus the difference was zero). A difference between drivers and passengers was deemed significant if the 95th% confidence interval (CI) did not include 50% (no difference between drivers and passengers).

III. INITIAL FINDINGS

There were 13,592 collisions in the NASS-CDS database that matched the collision criteria, 2,272 vehicles that matched the additional occupant criteria and 388 vehicles in which at least one occupant had a head injury. These 388 cases formed the data set for our head injury analysis. The mean collision severity was 36 ± 18 km/h (range 9 to 100 km/h) and the mean occupant age was 34 ± 19 years old (13 to 86 yrs). In 174 vehicles, the occupants were unbelted and did not have an airbag deploy (45%) and in 184 (47%) of the vehicles the drivers and passengers were both belted (Fig. 1e).

For all occupants with a head injury, the median injury severity was AIS2, with an average of 1.8 ± 1.1. There was a minimum AIS difference of one for more than 50% of the pairs (Fig. 1c). Only 7% of drivers and passengers in the same collision had the same AIS score. An additional 50% had an AIS difference of one and another 27% had an AIS difference of two. The median absolute difference of AIS scores for drivers and passengers in the same collision was AIS1, with an average of 1.6 ± 1.1. The bootstrap analysis indicated that passengers were more severely injured than drivers in 57% of collisions (CI: 51.8 to 62.0%), which was significantly more often than drivers.

S. G. Kroeker is a Biomechanical Engineer and G. P. Siegmund (e-mail: gunter.siegmund@meaforensic.com; tel: +1 604 277 3040) is a Senior Engineer and Director of Research at MEA Forensic Engineers & Scientists in Richmond, BC, Canada.

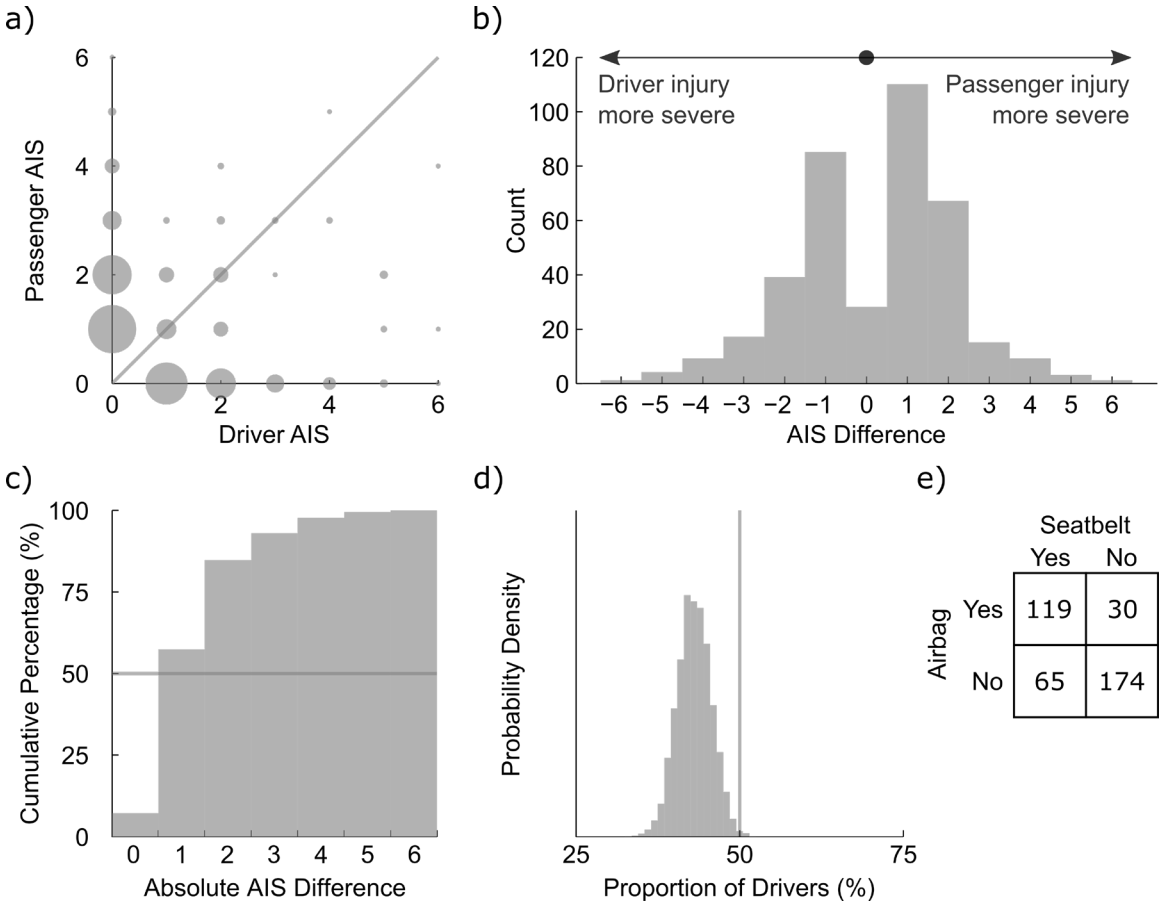

Fig. 1. Summary data for head injuries among paired drivers and passengers involved in frontal collisions: a) paired AIS scores for drivers and passengers (the circle area represents the relative number of data pairs); b) histogram describing the distribution of the difference in AIS scores (passenger - driver) for all pairs; c) cumulative percentage of the absolute value of the AIS differences; d) distribution of the proportion of drivers more severely injured than passengers; and e) summary of the number of cases grouped by seatbelt and airbag status.

IV. DISCUSSION

Our goal was to determine whether drivers and passengers exposed to the same frontal collision had similar or different head injury severities. Based on paired AIS data extracted from the NASS-CDS database, we found that the head injury severity for drivers and passengers was the same in only 7% of collisions. Within the 93% of collisions with different AIS scores, the proportion wherein the passenger AIS exceeded the driver AIS was significantly greater than 50%. Despite this greater proportion, the average magnitude of a passenger's AIS was only 0.18 ± 1.92 higher than their paired driver's AIS across all collisions. This small and variable difference precludes making reliable inferences of one occupant's AIS score from the other occupant's AIS score.

A median difference in AIS scores of only one level may appear to be small, however a preliminary analysis of specific head injuries reveals a more complicated picture. About half (47%) of occupant pairs have an AIS difference in brain haemorrhage severity of three or less, and about one-quarter (26%) of occupant pairs have an AIS difference in skull fracture severity of two or less. Further work is needed to analyze the paired differences in these and other specific injuries, and we caution against applying the findings from a broad injury category, such as head injury, to specific types of head injury.

Our analysis did not account for individual occupant characteristics, such as age, height, weight, posture or pre-existing medical conditions. Further work is needed to evaluate if these factors affect injury outcomes. Our preliminary conclusions are also limited to the cases included in the NASS-CDS database, which is a stratified sample of all police-reported crashes in the United States and requires that at least one vehicle be towed from the collision scene. Nevertheless, these data show that one should not infer that head injury risk is similar for two front-seat occupants in the same collision with similar seatbelt and airbag conditions.