Evaluation of the Effectiveness of Vehicle Knee Airbags using Police Reported Crash Data linked to Injury Compensation Claims Data

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I. INTRODUCTION

Knee Airbags (KABs) deploy from a vehicle's lower dashboard and are designed to distribute impact forces on an occupant's legs in the case of an accident, thereby reducing leg injuries. They may also control movement of the lower body, which could reduce impact forces on the abdomen and chest [1]. To date, the few studies that have examined the performance of KABs have shown mixed results.

Some studies [2-5] have examined in-depth medical and crash investigation data from the Crash Injury Research Engineering Network (CIREN) database. A 2013 study [2] found statistically significant increases in tibia/fibula and foot/ankle fractures and a statistically significant reduction in femur fractures. Non-significant reductions were found in pelvic fractures and head injuries, which may suggest that KABs reduce forward occupant excursion. Another 2013 study [3], that also included data from the US National Automotive Sampling System (NASS), found no association between KAB deployment and risk of lower extremity fracture however did report a pattern of fracture risk, including decreased risk of hip and thigh fracture and an increased risk of tibia/fibula and foot fracture, however, these results were not statistically significant. An updated 2020 analysis using NASS and CIREN data [4] concluded that KABs may be protective for knee to hip injuries and above waist injuries, however also found an increased risk of below knee injuries. A 2021 study [5] using the CIREN database supplemented with select cases from the International Center for Automotive Medicine (ICAM) database found that KABs were associated with reduced rates of knee/thigh/hip injury and had no measurable effect on below knee injury for drivers in frontal crashes in either dataset. A study that did not utilise CIREN by the US Insurance Institute of Highway Safety (IIHS) [6], analysed both frontal crash tests and police-reported crash data from 14 US states. It found that for the frontal crash tests, KABs were associated with elevated injury risk for the upper and lower tibia and right femur, with the femur finding in contrast to another study [2], and reduced injury risk for the head. The study did not find a statistically significant reduction in overall injury risk associated with KABs. The authors concluded that KABs do not confer a substantial safety benefit onto drivers overall and the manufacturers should consider the limited safety benefit of KABs before expanding their fitment in the fleet.

It appears that whilst KABs were designed with the intention of reducing leg injuries in the event of a crash, they are potentially associated with an increase in lower limb injury. On the other hand, they may reduce knee to waist injury (although one study suggested that there was an elevated femur injury risk), and above waist injury through reducing forward excursion of the vehicle occupant. In Victoria, Australia, the availability of police reported crash data linked to injury compensation claims data with high-level injury outcome information, has been successfully utilised by the authors to evaluate the effectiveness of vehicle side airbags [7] and whiplash-reducing head restraint systems [8]. The current study aimed to utilise the same database to evaluate the effectiveness of KABs to reduce driver injury in real-world crashes by specific regions of the body.

II. METHODS

The preliminary analysis utilised police-reported crash data for the period 2010–2017 in Victoria, Australia, linked to insurance injury compensation claims data. The data included drivers only and was limited to frontal impact crashes and vehicles that were manufactured from 2003 onwards, as this was the point that KABs first appeared in the selected crash data. The analysis file consisted of 57,651 cases. It was enhanced with vehicle registration data obtained separately from the Victorian vehicle register including Vehicle Identification Number (VIN) from which vehicle details such as make and model and KAB fitment were able to be determined. Insurance injury compensation claims data contains International Classification of Diseases (ICD) injury diagnosis codes utilised for claims management. The preliminary analysis examined driver fractures by specific regions of the body, namely fractures of the lower limb (neck of femur to foot); femur (neck of femur and femur); tibia and fibula; patella; skull; pelvis; ankle to foot; and ribs and sternum. A logistic regression model adjusted for gender, age group, speed zone and year of crash (to adjust as far as possible for general trends including improvements

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to the safety of the vehicle fleet) was run to determine the association between KAB fitment and driver injury risk to various body regions in frontal crashes. Driver gender and age group was 44.5% female, 55.5% male, 21.7% aged ≤25, 63.4% aged 26 to 59 and 14.9% aged ≥60.

III. INITIAL FINDINGS

Estimated changes in the odds of injury to various body regions of a vehicle driver in a frontal crash associated with KAB fitment are shown in Table I. The initial findings show that fitment of KABs were associated with statistically significant reductions in driver injury to the patella and pelvis of 43% and 63% respectively. There were indications of possible reduced injury risk to the lower limb, femur and skull but these results were not statistically significant and warrant further investigation.

TABLE I
ESTIMATED CHANGE IN THE ODDS OF INJURY ASSOCIATED WITH KAB FITMENT BY BODY REGION

Body region	Odds ratio	*p-value*
Lower limb (neck of femur to foot)	0.85	*0.229*
Femur (neck of femur and femur)	0.88	*0.657*
Tibia and Fibula	1.04	*0.922*
Patella	0.57	*0.038*
Skull	0.79	*0.604*
Pelvis	0.37	*0.0496*
Ankle to Foot	0.96	*0.790*
Ribs and Sternum	0.99	*0.975*

IV. DISCUSSION

The use of real-world crash data linked to high-level injury outcome information in this study has provided the opportunity to undertake a more specific analysis of the benefit of vehicle KABs in reducing driver injury risk. The initial analysis presented here found evidence of decreases in the odds of patella and pelvis injury by a statistically significant 43% and 63% respectively. These results are consistent with reduced forward occupant excursion as suggested by another study [2]. In addition, there were suggestions of potential injury reductions to the lower limb, femur and skull which require further investigation. Importantly, there were no results no suggestion of any increases in injury risk to specific body regions. Overall the analysis would benefit from an increase in statistical power. Whilst the patella and pelvis injury models had a statistical power above 80%, the other models by body region only had a power of 35% or lower. An expansion of the preliminary analysis presented here to include more recent data should achieve an increase in power by capturing a much larger number of vehicles fitted with KABs. Further, the additional years of data and availability and application of the Abbreviated Injury Scale (AIS) by body region will enable injury severity by body region to be considered in addition to injury risk. Whilst previous studies have indicated a level of uncertainty on how effective KABs are at reducing injury risk and raised questions on whether this vehicle safety technology should continue to be fitted across the fleet, results of this study point to the technology being effective in reducing driver injury risk in a crash hence supporting its continued fitment. Further research would provide more robust estimates of the magnitude and specific nature of these benefits.

V. REFERENCES

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