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Real-world evaluation of the effectiveness of reversing camera and parking sensor technologies in preventing backover pedestrian injuries

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ABSTRACT

Backover injuries to pedestrians are a significant road safety issue, but their prevalence is underestimated as the majority of such injuries are often outside the scope of official road injury recording systems, which just focus on public roads. Based on experimental evidence, reversing cameras have been found to be effective in reducing the rate of collisions when reversing; the evidence for the effectiveness of reverse parking sensors has been mixed. The wide availability of these technologies in recent model vehicles provides impetus for real-world evaluations using crash data. A logistic model was fitted to data from crashes that occurred on public roads constituting 3172 pedestrian injuries in New Zealand and four Australian States to estimate the odds of backover injury (compared to other sorts of pedestrian injury crashes) for the different technology combinations fitted as standard equipment (both reversing cameras and sensors; just reversing cameras; just sensors; neither cameras nor sensors) controlling for vehicle type, jurisdiction, speed limit area and year of manufacture restricted to the range 2007–2013. Compared to vehicles without any of these technologies, reduced odds of backover injury were estimated for all three of these technology configurations: 0.59 (95% CI 0.39–0.88) for reversing cameras by themselves; 0.70 (95% CI 0.49–1.01) for both reversing cameras and sensors; 0.69 (95% CI 0.47–1.03) for reverse parking sensors by themselves. These findings are important as they are the first to our knowledge to present an assessment of real-world safety effectiveness of these technologies.

1. Introduction

The National Highway Traffic Safety Administration describe a backover crash as a “specifically-defined type of incident, in which a non-occupant of a vehicle (i.e., a pedestrian or cyclist) is struck by a vehicle moving in reverse” (NHTSA, 2010). In the US, Austin (2008) reported an estimated 292 total annual backover fatalities. This comprised 71 deaths on-road (from official statistics) and a further 221 deaths off-road from the newly created Not-in-Traffic Surveillance (NiTS) database. Austin further estimated that the annual backover injuries in the US totalled approximately 18,000 (4000 on-road, and 14,000 off-road). Many road injury databases internationally record only crashes on public roads, excluding a significant proportion of backover crashes that occur in driveways and parking lots. Fildes et al. (2014) reported 2324 backover injuries to pedestrians in the Australian State of Victoria, as recorded by the Traffic Accident Commission, the state-wide injury compensation database, which encompasses all settings, both on-road and off-road. Despite the limited coverage of off-road injuries, other countries have also identified backover injuries as important. In Canada, Glazduri (2005) reported that there were approximately 900 pedestrians struck and injured by reversing vehicles each year. In the US, Mortimer (2006) reported that a minimum of 93 children killed in the US in 2003 were by backing vehicles. Most of these accidents involved children less than five years old in residential driveways impacted by an SUV, light truck or a van driven by a parent or relative.

In terms of causal factors identified in the crash, Fildes et al. (2014) noted that the most frequent cause of the collision involved either the driver or the pedestrian not looking properly during a reversing manoeuvre. A number of common pre-crash manoeuvers were further identified from in-depth crash data including

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manoeuvres such as backing out of a parking space, reversing into a lane or off-road, and circumstances where a driver is distracted while reversing.

The US National Highway Traffic Safety Administration (2009) and others have identified an obvious countermeasure for backover injuries: reversing cameras and associated on-board equipment. If used appropriately, such technology can assist the driver to avoid pedestrians and cyclists to the rear of the vehicle. In an experiment where reversing drivers encountered an unexpected stationary or moving object, Kidd et al. (2015) found significant benefits in terms of collision avoidance for vehicles equipped with a reversing camera compared with vehicles without any relevant technology, but the benefit was greatly reduced when a stationary object was partially or completely in shade. Parking sensors are proximity sensors for road vehicles designed to alert the driver to obstacles while parking. These systems, which use either electromagnetic or ultrasonic sensors, provide an audible warning when an object is detected. Llaneras et al. (2011) studied reverse parking sensors that provided four types of audible warnings from a sensor system for preventing, but found them relatively ineffective in avoiding collisions with unexpected moving objects. Consistent with these results, Kidd et al. (2015) found no apparent benefit for vehicles equipped with reversing sensors. Both studies found the effectiveness of the technologies varied considerably for different collision configurations.

It might be expected that the reverse parking sensors would work synergistically with the reversing cameras if the audible warning from the sensors could alert the driver look for objects on the reversing camera screen. However, Mazzae et al. (2008) found that drivers of vehicles equipped with both the camera and the audible warning often did not even use the camera. When reversing, drivers of vehicles solely equipped with reverse parking sensors often ignored the audible warning; drivers of vehicles with just a reversing camera paid much greater heed to the image from a camera (Kidd et al., 2015). This may reflect a general limitation to the way that drivers are willing or able to attend to several stimuli at once. For example, Rudin-Brown et al. (2012) found that drivers in vehicles equipped with reversing cameras made little use of mirrors while reversing, instead focusing on the camera screen.

As both reversing cameras and reversing sensors are becoming more common in newer vehicles, it has become possible to analyse the safety effects of these technologies using real-world crash data. The current study aimed to evaluate the real-world benefits of these technologies using police road injury data from some Australian States and from New Zealand.

2. Methods and materials

2.1. Data

Government authorities in New Zealand and each Australian State maintain databases of road crashes reported to the police that meet common guidelines for reporting and classification (Giles, 2001; Ministry of Transport, 2015). Although these datasets theoretically cover all traffic injuries on public roads, around one third of traffic injuries requiring hospital admission are not recorded, with reporting rates likely to be lower for pedestrian injury (Alsop and Langley, 2001; Lujic et al., 2008). The crash reports from the police are then normally checked and coded to ensure that the data are consistent. The way these data are coded nevertheless varies between jurisdictions. For example, backover injuries needed to be defined according to the vehicle's direction of movement for some databases or according to the point of impact of the vehicle with the pedestrian for other databases. Data were collated for all police-reported crashes where a pedestrian was injured in New Zealand and the Australian States NSW, Victoria, Western Australia and South Australia for the years 2010–2013. Data from recent years provides more information for this sort of analysis as more recent vehicles have higher fitment rates of technologies such as reversing cameras. Data for Queensland were only available for 2010–2012, so lacked critical recent crash data, and these were not used in the analysis.

RedBook (Automated Data Services Pty Ltd, 2014) provided a spreadsheet detailing make, model, basic variant data from 1990 to identify those vehicles with Rear Parking Sensor and Rear Cameras as standard equipment. All other vehicles (including those with reversing cameras or rear parking sensors as non-standard and those never equipped at manufacturing stage with these technologies) constituted the comparison set of vehicles. The analysis was therefore conservative in the sense that some of the comparison set of vehicles would have had the relevant technology, either installed as after-market devices (in the case of reversing cameras), or installed at the time of manufacture but as non-standard equipment. Such misclassification will therefore tend to generate slight underestimates of the true effectiveness of reversing cameras. Reversing cameras are sometimes packaged with rear parking sensors, which could potentially influence the effectiveness measured for the reversing cameras. The analysis looked at the effectiveness for preventing pedestrian injury by reversing vehicles of the technologies separately and together.

As different types of vehicles (as defined by market group) may have different rates of backover crashes with pedestrians arising from different uses made of the vehicles or from characteristics of the vehicles themselves, it was desirable to identify broad vehicle types in the analysis. Only light passenger vehicles were within the scope of this study, classified as cars, SUVs and commercial vehicles (vans or utility vehicles/pickup trucks). The reversing cameras are relatively rare in older vehicles (in the data analysed, only 15% of pedestrian crash-involved vehicles identified with standard equipment reversing cameras were manufactured before 2007). As older vehicles may have different exposure patterns with respect to pedestrians, it also made sense to restrict the analysis to newer vehicles, with year of manufacture between 2007 and 2013. A total of 3172 pedestrian injury crashes were analysed, of which 305 (just under 10%) were backover crashes.

2.2. Methods

The analysis procedure was one that could be achieved within the Australasian databases. Sensitive crash types were pedestrians injured by a reversing vehicle while non-sensitive crashes were all pedestrian crashes involving a vehicle not reversing and a pedestrian. Induced exposure was the method used to control for extraneous influences as discussed in Keall and Newstead (2009). Available data were analysed using the New Zealand and quasi Australian national (police-reported) crash database described above for crashes that occurred 2010–2013.

Using a logistic regression technique, statistical models were fitted to the data to ensure that the estimates were adjusted for important factors that could confound estimates of the safety effects of reversing camera or reverse parking sensors. Quasi-induced exposure methods (Keall and Newstead, 2009) were used to estimate the risk of pedestrian backover crashes. This approach makes use of crash counts of a comparison crash type specially chosen to reflect the exposure of a given vehicle type to a particular driving situation where the crash type of interest could occur. Where a given vehicle safety feature is being evaluated, this safety feature should not affect the occurrence of the comparison crashes (Fildes et al., 2013). In the current study, counts of non-reversing