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Sleep-related vehicle crashes on low speed roads

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ABSTRACT

Background: Very little is known about the characteristics of sleep related (SR) crashes occurring on low speed roads compared with current understanding of the role of sleep in crashes occurring on high speed roads e.g. motorways. To address this gap, analyses were undertaken to identify the differences and similarities between (1) SR crashes occurring on roads with low (≤60 km/h) and high (≥100 km/h) speed limits, and (2) SR crashes and not-SR crashes occurring on roads with low speed limits.

Method: Police reports of all crashes occurring on low and high speed roads over a ten year period between 2000 and 2009 were examined for Queensland, Australia. Attending police officers identified all crash attributes, including 'fatigue/fell asleep', which indicates that the police believe the crash to have a causal factor relating to falling asleep, sleepiness due to sleep loss, time of day, or fatigue. Driver or rider involvement in crashes was classified as SR or not-SR. All crash-associated variables were compared using Chi-square tests (Cramer's V = effect size). A series of logistic regression was performed, with driver and crash characteristics as predictors of crash category. A conservative alpha level of 0.001 determined statistical significance.

Results: There were 440,855 drivers or riders involved in a crash during this time; 6923 (1.6%) were attributed as SR. SR crashes on low speed roads have similar characteristics to those on high speed roads with young (16–24y) males consistently over represented. SR crashes on low speed roads are noticeably different to not-SR crashes in the same speed zone in that male and young novice drivers are over represented and outcomes are more severe. Of all the SR crashes identified, 41% occurred on low speed roads.

Conclusion: SR crashes are not confined to high speed roads. Low speed SR crashes warrant specific investigation because they occur in densely populated areas, exposing a greater number of people to risk and have more severe outcomes than not-SR crashes on the same low speed roads.

1. Introduction

Sleep-related (SR) crashes are a road safety problem the world over (Åkerstedt, 2000). Drivers who are sleepy are at an almost six fold increase in the odds of having an injury involved crash (Herman et al., 2014). It has been demonstrated that SR crashes are prevalent on high speed motorways (e.g. Connor et al., 2002; Philip et al., 2014). Reflecting this, the majority of driver sleepiness research has been targeted at understanding and mitigating SR incidents during motorway driving (e.g. Philip et al., 2005; Filtness et al., 2012; Hallvig et al., 2013). However, self-reported experience by drivers of SR driving incidents suggest that approximately 25% of SR incidents occur on roads with a speed limit of ≤50 km/h (31 mph), with a further 30% occurring on roads with speed limits between 50 and 80 km/h (31–50 mph) (Armstrong et al., 2013). To date, little attempt has been made to specifically investigate these low speed SR crashes therefore it is unknown how these differ from either not-SR crashes of a similar speed or high speed SR crashes.

Driver sleepiness is common, with 9% of French drivers (n = 35,000) reporting being so sleepy that they have to stop driving at least once per month (Philip et al., 2010), and 8% of Norwegian drivers reporting having fallen asleep while driving in the past month (Sagberg, 1999). Experimental investigations using driving simulators and on-road driving protocols have demonstrated that sleepy drivers have impaired driving performance in terms of increased number of out of lane events (e.g. Horne and Reyner, 1996), variability in lane positioning (e.g. Anund et al., 2008; Forsman et al., 2013) and variability in speed control (e.g. Matthews et al., 2012). These investigations (and many others) have

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provided important insight into driver sleepiness, but in each case the influence of sleepiness on driving performance was examined in high speed zone motorways or high speed zone scenarios meaning that it is unknown whether findings can be inferred to low speed driving conditions or not. Furthermore, education and awareness campaigns have sought to highlight the dangers of sleepiness associated with long distance driving, with many strategies targeted towards motorway driving e.g. road signs advising drivers to take a break, while driver sleepiness in low speed zones is largely overlooked.

The focus of research attention towards high speed zones is arguably warranted as analyses of crash data demonstrate SR crashes to be most common in high speed zones, with driving on a highway a leading predictor of SR crash (Philip et al., 2014). However, using such a focused approach to both education and awareness campaigns and targeted maximum driving hours requirements for heavy vehicles, could result in drivers believing that driver sleepiness is a problem isolated to high speed motorways. Therefore, it is possible that drivers may ignore or overlook the danger during city driving. Similarly, targeted interventions may be missing some important aspects related to driver sleepiness on low speed roads.

Understanding whether low speed SR crashes differ from high speed SR crashes is necessary in determining whether those road safety countermeasures applied in high speed environments (e.g. driver sleepiness advise warning signs) may also be relevant for low speed environments. This is particularly important as many drivers report having experienced a SR incident on a low speed road and any SR incidents (regardless of speed zone) are most common when commuting to and from work (Armstrong et al., 2013). Highly dynamic urban driving requires quick responses and quick decision making in a complex and often shared road environment. Both reaction time (Belenky et al., 2003) and flexibility of decision making in cognitive tasks (Harrison and Horne, 2000) are known to be impaired by sleepiness, suggesting that sleepy drivers may have impaired responses to safety critical events. Low speed roads are predominantly located in highly populated areas exposing a greater number of people to risk from a sleepy driver than the equivalent driver on a high speed road. However, there is a dearth of literature exploring sleep related impairment in an urban driving context. A first step in understanding the impact of sleepiness on low speed driving performance is to examine its consequence through analysis of crash data from low speed zones.

The objective of the current work was to quantify the characteristics of SR crashes occurring on low (≤60 km/h; approximately ≤37 mph) speed roads in comparison to both high (≥100 km/h; approximately ≥62 mph) speed road SR crashes and to not-SR crashes on the same low speed areas. Both vehicle operator and crash characteristics from police crash report data were considered. Statistical analysis sought to identify similarities between high and low speed sleep crashes and differences between SR and not-SR crashes on low speed roads.

2. Methods

2.1. Crash data

Queensland (Australia) police reports for crashes occurring on low (≤60 km/h) and high (≥100 km/h) speed roads between 1st January 2000 and 31st December 2009 were examined. Ten years of crash data provided sufficient scope for identifying general trends and permitted meaningful comparisons between SR and not-SR crashes. Police crash reports detail those crashes which occur on a public road, and where: a person was killed or injured, a vehicle towed, or greater than $2500 of damage to property other than vehicles was incurred. Crashes resulting from medical conditions and deliberate acts were excluded. Police crash reports detail vehicle operator characteristics and crash characteristics as well as crash causal factors (multiple causal factors may be identified for each crash); these are all identified by the reporting Queensland Police Services (QPS) officer. Serious crashes (fatal or serious injury) are attended by the Forensic Crash Investigation unit, where specially trained officers will seek detailed information about the circumstances during and prior to the crash which can include the extent of prior sleep. All non-serious crashes are attended by regular enforcement officers.

All crash reports where the contributory factor "fatigue/fell asleep" was noted were classified as SR. In assigning this contributory factor the crash database does not distinguish between crashes due to falling asleep while driving, sleepiness due to sleep loss, time of day, duration of driving or fatigue etc., although these may have been considered by the attending officer.

In order to include driver characteristics as variables of interest the main unit of analysis was the drivers or riders involved in crashes during the period, rather than crashes per se. Crash reports were grouped into four crash categories:

1. Sleep-related on ≥100 km/h speed roads (SR-H)
2. Not sleep-related on ≥100 km/h speed roads (Not SR-H)
3. Sleep-related on ≤60 km/h speed roads (SR-L)
4. Not sleep-related on ≤60 km/h speed roads (Not SR-L)

This work extends a previous investigations which used subsets of this sleep-related crash data (Armstrong et al., 2008; Filtness et al. in press). Within Queensland, local government authorities retrospectively apply a proxy definition to police crash data in order to identify sleep-related crashes which were potentially missed by the police. This is a desk based exercise applied externally from police investigations and is not considered in the current work. All presented analysis is for crash data as recorded by the police.

2.2. Statistical analysis

For each variable, comparison was made between category 1 and 3 and category 3 and 4. Categorical data were analysed using Chi-square ($\chi 2$) tests with Cramer's V (φc) as an estimate of effect size. Post-hoc analyses were undertaken within each variable using the adjusted standardised residual statistic ($\hat{e}$).

A multivariate analysis consisting of a series of logistic regressions were performed, with driver/crash characteristics as predictors of crash category. The crash characteristics are defined by the Queensland Department of Transport and Main Roads (2014). In the interests of parsimony, only statistically significant predictors at the bivariate level were included in the model. A significance level (α) of 0.001 was used to control for the effects of large sample size. Accordingly, standard residuals outside ±3.29 were considered statistically significant. All statistical analyses were conducted using IBM SPSS 19.0 statistical software.

3. Results

Overall, there were 440,855 vehicle operators (drivers and riders) involved in crashes on Queensland roads with speed zones of interest during the time period. Of these crashes 6923 (1.6%) were considered by the police to be sleep-related, with 41.1% of these occurring in low speed zones (see Table 1 for breakdown by speed zone).