

The role of driver sleepiness in motor vehicle crash injuries in Fiji

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Abstract

Background: Despite its acknowledged relevance as a risk factor for road traffic injuries, few studies have quantified the prevalence of driver sleepiness in low and middle-income countries.

Objective: To estimate the contribution of driver sleepiness to four-wheeled motor vehicle crashes in Fiji.

Method: A population-based case control study conducted in Viti Levu, Fiji, between July 2005 and December 2006, identified motor vehicles involved in crashes where at least one person died or was hospitalised (cases) and motor vehicles sampled from roadside surveys (controls). A structured interviewer-administered questionnaire sought information from drivers on driver and vehicle characteristics including sleep related measures.

Results: The driving population (131 cases, 752 controls) comprised mostly drivers who were male (93%), of Indian ethnicity (70%), and aged 25 to 44 years (61%). The motor vehicles driven by the driving population were cars (67%), vans/utility vehicles (30%), and trucks (3%). Shift work and working for more than 60 hours per week was reported in 15% and 6% of the driving population respectively. There was a six-fold increase in the odds of injury-related crashes among drivers reporting they were not fully alert, had difficulty staying awake, or were sleepy (OR 5.7, CI 2.7, 12.3). At least one third (34%) of injury crashes were attributed to driving while sleepy or less alert (CI 30.0, 37.4).

Discussion and conclusions: Acute driver sleepiness is an important contributor to the burden of four-wheeled motor vehicle crashes in Fiji. The research highlights the need to design evidence-based strategies which reduce driver sleepiness-associated road crashes in less resourced settings. Interventions could include measures to limit work and driving (night) hours. This requires a collaborative approach by road safety stakeholders, ensuring road safety initiatives are integrated with the relevant legislature and wider social, occupational, and economic policy.

Key words:

high-risk drivers

driver sleepiness

Pacific island nations

1. Introduction

Driver sleepiness is an important contributor to the global burden of road traffic injuries (RTI), (Lyznicki et al., 1998, Cummings et al., 2001, Peden et al., 2004) estimated to increase crash risk at least six-fold (Philip et al., 2010, Ellen et al., 2006, Teran-Santos et al., 1999) and attributed to as much as 22% of crash injuries. (Horne and Reyner, 1995, Maycock, 1997, Philip et al., 2001, Connor et al., 2002, Nabi et al., 2006, Connor, 2010)

While 90% of RTI-related injuries and deaths occur in low and middle-income countries, (World Health Organization, 2009a) only a small number of epidemiological studies have investigated the role of driver sleepiness to crashes in these less resourced settings. However most studies focussed on long haul truck drivers with no driver sleep related studies conducted in Pacific island countries and territories. Routinely collected statistics suggest that three quarters of road crash fatalities in Fiji involve four-wheel motor vehicle occupants (drivers 26%, passengers 49%). (World Health Organization, 2009b)

As part of the Traffic Related Injury in the Pacific (TRIP) research project, we investigated the prevalence and role of driver sleepiness to the risk of injury-producing crashes involving four-wheeled motor vehicles in Fiji.

2. Method

We undertook a population-based case control study of motor vehicles driving on public roads in Viti Levu, from July 2005 to December 2006. Eligible vehicles included motorised four-wheeled vehicles such as; private cars, taxis, van/minibus, pick up (open "ute" with tray)/utility vehicles, and trucks. Buses, two or three-wheeler vehicles (motorcycles) and emergency response vehicles were excluded.

Viti Levu is the largest island of Fiji and home to 650,000 people, with two main ethnic groups Indigenous Fijian (54%) and Indian (40%). Of the estimated 4000 kilometres (km) of major public roads, only 800 km are sealed, being limited to the two main cities, Suva (Fiji capital) and Lautoka, as well as major highways. The vehicle fleet comprises mostly cars (60%), and light and heavy goods vehicles (26%). Two wheeler motorcycles comprise 3% and buses 1%.

Selection of Controls

We used a prospective two-stage cluster sampling design to identify public roads drawing from police, public works, and city council databases. Eligible roads included those classified as main, secondary, country or residential, measuring more than 400 meters in length and with daily traffic counts of 200 or more. To ensure the roads were representative of the public roads in Viti Levu, three clusters were identified one each for the two main cities, and the third for roads beyond city boundaries (rural). A total of 50 roadside sites were randomly selected, with 10 sites assigned for each of the city clusters, and 30 for the rural cluster. The sites were further randomised by day of week, time of day, and travel direction. To improve study efficiency, roadside surveys were not undertaken between 2am and 5am, as Fiji transport data suggested road crashes were uncommon during this period.

Recruitment of control vehicle drivers required collaboration with Fiji traffic police, who were present at all survey sites. We used fluorescent road signs and cones to alert oncoming drivers and traffic police assisted in safely guiding them to the curb. Research members then approached the driver informing them of the study, providing a brochure and invitation to participate in the study.

We collected traffic counts at all survey sites, for all vehicles travelling in the same direction as those selected for the study.

Selection of Cases

Eligible cases were defined as drivers of motor vehicles involved in a crash in Viti Levu, where a road user (driver, passenger or pedestrian) died or was hospitalised for 12 hours or more, during the study period. Cases were prospectively identified from the Fiji Injury Surveillance in Hospitals database, drawing from accident and emergency registers, admission records, and mortuary registers. (Wainiqolo et al., 2011) With the assistance of Fiji police, nurses and medical student interns, all efforts were made to ensure all eligible cases were identified, and information accurate and complete. For those drivers who had died or were unable to complete an interview due to severe injuries, an appropriate proxy was identified.

Data Collection

Following informed consent, interviews for controls were conducted at the roadside survey site or at a later time and place appropriate to the study participant, whereas for cases, interviews were conducted in the hospital or home setting.

Structured questionnaires standardised for controls and cases were administered by trained interviewers. The questionnaires (72 questions) sought self-report information on driver and vehicle characteristics, including sleep and sleep related measures. Additional information relating to drivers included shift work, and number of work hours.

Sleep measures

Two validated self-rating tools for measuring acute and chronic or average daytime sleepiness respectively are the Stanford sleepiness scale (SSS) and Epworth Sleepiness Scale (ESS). (Cluydts et al., 2002, Expert panel on Driver fatigue and sleepiness, 1997) During the pilot phase of the study, participants experienced difficulties interpreting the scales, and as a result, we withdrew the ESS and developed a sleepiness scale specific to the TRIP study, drawing conceptually from the SSS (Table 1). Additional sleep measures included driver-reported sleep prior to the survey/crash to measure sleep deprivation; and information on participants experiencing the triad of sleep apnoea syndrome symptoms (regular loud snoring, breathing pauses, choking).

Table 1: Definition for sleep and sleep-related factors

| Sleep-related factors | Definition |
|------------------------------|--|
| TRIP sleepiness scale | |
| Level 1 | Felt active, wide awake |
| Level 2 | Relaxed and awake but not fully alert |
| Level 3 | Difficulty staying awake, was beginning to lose track |
| Level 4 | Felt sleepy, would have preferred to lie down |
| Sleep deprivation | |
| Acute sleep deprivation | < 6 hours sleep in previous 24 hours |
| Chronic sleep deprivation | No adequate nights of sleep in the previous week |
| Sleep apnoea syndrome | |
| Triad of symptoms | Witnessed reports of regular loud snoring, breathing pauses, choking |
| Regularly snore loudly | Witnessed reports of regular loud snoring |
| ≥ 2 symptoms | Witnessed reports of two or more sleep apnoea symptoms |

Confounding variables

Potential confounders were considered in analyses included age, sex, ethnicity, income, occupation, work hours, vehicle type, time and day of survey/crash, vehicle speed, and use of alcohol and psychotropic/soporific agents such as marijuana, recreation drugs, sleeping tablets, regular medication for depression or anxiety and kava (a drink with sedative properties consumed in Fiji).

Analysis

Analysis was undertaken using STATA 12 statistical software taking into consideration the cluster sampling design, with weighting applied for each of the 50 recruitment sites, using the inverse proportion of control vehicles selected and traffic flow. We used unconditional logistic regression to calculate the odds ratio. We developed models selecting potential confounders, based on the change-in-estimate (10%) method.(Greenland, 1989) We selected income rather than education or occupation, as the measure for socioeconomic status as it was the most reliably reported measure. Population attributable risks were calculated using established methods.(Greenland, 1987, Coughlin et al., 1994)

This study was approved by the Fiji National Research Ethics Review Committee with approval to undertake the roadside survey granted by the Fiji Police Force and Land Transport Authority.

3. Results

The traffic count for the 50 survey sites was 17,217, and of the 892 motor vehicle control drivers invited to participate in the study, 820 consented, with 752 completing the interview process (84% response rate). While 142 cases were eligible for inclusion in the study, 4% declined to participate. Interviews for cases were largely face to face (85%) whereas for controls it was equally distributed.

In general, the distribution of the demographic, vehicle and work characteristics of cases and controls were similar. Most driving was undertaken by males (93%), drivers of Indian ethnicity (70%), and drivers aged 25 to 44 years (61%), with the average age of study participants 38 years (range 17 to 75 years). The majority of motor vehicles used by the driving population were cars (67%) and vans/utility vehicles (30%), with trucks comprising 3%. At least a quarter of driving was undertaken by those reporting their main occupation as *driving* (cases 24%, controls 26%), and of these 1% drove trucks. Shift work and working for more than 60 hours per week was reported in 15% and 6% of the driving population respectively.

After controlling for confounders, we found a six-fold increase in odds of injury crash (OR 5.7, CI 2.7, 12.3) among drivers who reported being less alert, having difficulty staying awake, or feeling sleepy compared with those who felt active and fully awake (Sleepiness scale: 2 to 4 versus 1). (Table 2) The odds of a crash among drivers reporting acute sleep deprivation and those reporting two or more symptoms suggestive of obstructive sleep apnoea (regular loud snoring, breathing pauses, and choking).

The population attributable risk (PAR) for crashes associated with driving while less alert or sleepy was 34% (CI 30.0, 37.4).

The multivariable models did not include the use of psychotropic and soporific agents because the main exposure variable of interest (sleepiness) is in the pathway of this potential effect on the risk of a crash. However, including the use of these agents as a covariate shifted the point estimates relatively little (OR 5.5, CI 2.4, 13.0).

Table 2: Association of variables related to sleep with risk of crash Adjusted odds ratio and 95% confidence intervals for multivariate model.

| Variables | Adjusted odds** | (95% CI) |
|---|-----------------|----------------|
| Sleepiness scale for TRIP | | |
| 1 (felt active, wide awake) most alert | 1.0 | |
| 2-4 (not fully alert, difficulty staying awake, sleepy) | 5.7 | (2.67 – 12.28) |
| Amount of sleep in the previous 24 hrs*** | | |
| ≥ 6 hours | 1.0 | |
| < 6 hours (Acute sleep deprivation) | 5.9 | (1.66 – 20.85) |
| Amount of sleep in the previous week**** | | |
| At least 1 adequate night | 1.0 | |
| No adequate night (Chronic sleep deprivation) | 1.1 | (0.18 – 7.09) |
| ≥ 2 Triad sleep apnoea symptoms***** | | |
| No | 1.0 | |
| Yes | 2.9 | (0.61 – 13.57) |

* Adjusted for sampling design

** Logistic regression analysis included age, sex, ethnicity, income, vehicle speed prior to survey/crash, day and time of survey/crash, self-reported alcohol use, vehicle type.

*** Number of hours slept

**** Number of nights with adequate sleep (mostly between 11pm and 7am for seven hours or more)

***** Witnessed reports of symptoms of sleep apnoea syndrome (regular loud snoring, breathing pauses, choking)

***** Involving paid work starting before 6am or finishing after midnight whether permanent, rotating or on call

4. Discussion

There was a strong association (six-fold odds) of driving a four-wheeled motor vehicle while less alert or sleepy and injury crash, contributing to at least one third of all crashes among the study population. The association between people reporting sleep deprivation, and symptoms indicative of obstructive sleep apnoea, were not statistically significant. While shift work and working long hours (data not shown) did not appear to influence the odds of a crash injury, overall there was a consistent effect of driver sleepiness on the risk of crash injury.

Study limitations included the introduction of selection bias due to the relatively small number of cases, which limited the statistical power of the study and compromised the precision of some estimates of interest. The absence of objective measures for alcohol use given its importance as a confounder and effect modifier potentially introduced misclassification bias. Although we used a standardised and structured interviewer-administered questionnaire to minimise information bias, the absence of validated subjective and objective measures, for sleep measures (due largely to resource constraints) may have introduced misclassification and recall bias. It follows that this study was not designed to investigate all mechanisms which could influence driver sleepiness, and therefore factors such as the circadian cycle were not examined. In our study less than 10% of crashes occurred during the 2am to 5am period. Nevertheless, we employed a modified version of the Stanford Sleepiness Scale which was adapted following pre-testing in the study population, and other sleep measures used in our previous research.(Connor et al., 2002)

Notwithstanding these limitations, this study adds to the limited evidence base in less resourced settings, highlighting the role of acute driver sleepiness to four-wheeled motor vehicle crashes. These findings contrast with those of a study from Shenyang, China, (Liu et al., 2003) which found an increased risk for chronic driver sleepiness rather than acute sleepiness. However, our findings are consistent with the much larger body of evidence from high-income countries. (Connor et al., 2002, Crummy et al., 2008, Williamson et al., 2011, Connor, 2010) This includes increased odds of crashes involving vehicles driven by people with symptoms indicative of obstructive sleep apnoea. (Expert panel on Driver fatigue and sleepiness, 1997, Ellen et al., 2006, Tregear et al., 2009)

Sleep research has evolved however, identifying the gold standard for measuring sleepiness is elusive, reflecting the multiple factors influencing the sleep wake circadian cycle. (Johns, 2010, Kryger et al., 2010, Shepard et al., 2005) While the ESS is validated in some less resourced countries, (Chen et al., 2002, Cho et al., 2010, Bertolazi et al., 2009) neither the ESS nor SSS have been validated in Pacific populations, highlighting a research gap to progress.

The World Report on Road Traffic Injury Prevention argued for better working conditions for drivers at risk of sleepiness related crashes, proposing mechanisms such as limiting work and driving (night) hours and requiring rest periods for long haul drivers. (Peden et al., 2004) The impact of driver sleepiness to crashes is significant particularly in less resourced settings. (Munala and Maina, 2010, Yusoff et al., 2010, Pradeep Kumar et al., 2003, Santos et al., 2004, Adams-Guppy and Guppy, 2003) where drivers are likely to be vulnerable to less regulated labour conditions and socioeconomic pressures to drive for prolonged periods without adequate rest. (Kapila S, 1982, Mock et al., 1999, Nantulya VM, 2001, Williamson et al., 2011) suggesting road safety policy initiatives are critical and require an integrated multi-sectoral approach. (Mohamed et al., 2012) Initiatives must also take into account country context-specific characteristics including social and economic pressures, and resources and legislative mechanisms available

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