1 **Title page**

2 Title: Contributory factors to sleepiness amongst London bus drivers

3 Authors: Karl A. Miller ^{a,1}, Ashleigh J. Filtness ^a, Anna Anund ^b, Sally E. Maynard ^a, Fran Pilkington-
4 Cheney ^a

5 ^a Loughborough University, Loughborough, Leicestershire, LE11 3TU, UK, United Kingdom

6 ^b Swedish National Road and Transport Research Institute (VTI), Linköping, Sweden

7 ¹Present address: School of Psychology, University of Nottingham, Nottingham, NG7 2RD, United
8 Kingdom

9 Corresponding author:

10 Karl A. Miller

11 School of Psychology, University of Nottingham, Nottingham, NG7 2RD, United Kingdom

12 Email: karl.miller@nottingham.ac.uk

13

14 Funding: This work was supported by Transport for London [grant number 94050].

15 Declarations of interest: none.

Abstract

Driver sleepiness contributes to a substantial proportion of all road crashes. Despite all that is known about driver sleepiness, bus drivers are often overlooked. What is certain is that bus drivers have the potential to suffer from sleepiness as they are shift workers. The current research used a large online survey to investigate sleepiness amongst London bus drivers. There were two aims; to quantify the prevalence of sleepiness amongst London bus drivers, and to determine the factors which contributed to sleepiness. Overall, 20.8% of respondents indicated that they had to fight sleepiness at least 2-3 times a week, and 36.6% of respondents stated that they had experienced a close call due to sleepiness in the past year. There were several potential causes of sleepiness including work, sleep, and personal factors such as obtaining less than 11 h rest between shifts, working 6 or more days without a rest day, and poor self-reported health. These findings show that sleepiness is common amongst London bus drivers and is caused by a combination of factors. The combination of contributory factors suggests that a multifaceted approach should be taken to reduce bus driver sleepiness.

Keywords: Bus driver; sleepiness; fatigue; driver sleepiness

1. Introduction

Driver sleepiness is one of the leading contributors to road crashes, accounting for an estimated 15-30% of all road traffic crashes globally (Åkerstedt, 2000; Bioulac et al., 2017; Connor et al., 2002).

Sleepiness causes performance decrements in both simple and complex tasks, impaired attention, and slower reaction times (Williamson et al., 2011). Sleepiness related crashes are particularly prevalent on high speed motorways, and rural roads (Connor et al., 2002; Filtner, Armstrong, Watson, & Smith., 2017; Phillip et al., 2014), with most of the research into driver sleepiness focusing on passenger car drivers, or truck drivers, during long monotonous drives (Bioulac et al., 2017; Connor et al., 2002). Shift workers and professional drivers are susceptible to sleepiness due to a combination of work and non-work related factors such as long working hours, working during points of circadian lows, and irregular starting times (Gander et al., 2011). Bus drivers are at risk of these shift work related factors, however bus driver sleepiness is potentially overlooked as these drivers do not fit the classic motorway type sleep crash.

In addition to the usual pressures of shift working and long driving hours affecting sleep (Gander et al., 2011) drivers can suffer from fatigue as a result of task related factors. May and Baldwin's (2009) model of driver fatigue shows how sleep related factors such as sleep deprivation and restriction can interact with task related underload or overload. Bus drivers will encounter mental overload and fatigue from driving in complex city environments (Makowiec-Dabrowska et al., 2015). Despite the fact that most research focuses on incidents on high speed monotonous roads, which may lead to mental underload, (Anderson & Horne, 2013; Horne & Reyner, 1995; Tse, Flin, & Mearns, 2007), there is evidence that mental overload from complex city environments is fatiguing, and that driver sleepiness is not mitigated by driving on urban roads (Ahlström, Anund, Fors, & Åkerstedt, 2018). As such, more research is needed to understand sleepiness and fatigue whilst driving on urban roads.

There is some evidence that sleepiness is a problem for city bus drivers. A previous Swedish survey found that 45% of drivers had to fight sleepiness at least 2-4 times a month, and 19% had to fight

sleepiness at least 2-3 times a week. Additionally, 19% of drivers had experienced a sleep related driving incident over the past 10 years (Anund, Ihlström, Fors, Kecklund, & Filtner, 2016). In a Swedish on-road investigation, 12 out of 18 bus drivers reported having to regularly fight to stay awake whilst driving, whilst 5 drivers reported high Karolinska Sleepiness Scale (KSS) levels whilst driving during a split shift (Anund, Fors, Ihlström, & Kecklund, 2018). Similar results have been reported in the UK (Edinburgh), where a survey found that 12% of sampled bus drivers had fallen asleep whilst driving the bus, as well as 20% of drivers scoring highly on the Epworth Sleepiness Scale (ESS) indicating that they suffered from excessive daytime sleepiness (Vennelle, Engleman, & Douglas, 2010). In Peru 16% of drivers reported excessive daytime sleepiness (as indicated by an ESS score above 10) whilst 70% indicated that they experienced sleepiness whilst driving (Liendo, Castro, & de Castro, 2010). A further Peruvian study found that 74% of drivers experienced sleepiness whilst driving the bus. Overall, 29% of respondents had an accident or near miss whilst driving, whilst 36% admitted falling asleep whilst driving the bus (Deza-Becerra et al., 2017). Self-report data in Korea also showed excessive daytime sleepiness, with 13% of bus drivers scoring highly on the ESS (Kim et al., 2017). Taken together, these findings suggest that between 16-74% of drivers are likely to experience some form of sleepiness. The variability in prevalence suggests that a wide range of contributing factors such as those related to shift work (Åkerstedt & Wright, 2009), the work demands of being a bus driver (Anund et al., 2016), and sleep management (Anund et al., 2016; Liendo et al., 2010) may be at play.

As shift workers, bus drivers are likely prone to experiencing sleepiness at work. Various aspects of shift work are known to contribute to sleepiness, these include irregular working hours, having less than 11 h rest between shifts, night shifts, extended shift duration, split shifts, and early morning shifts (Åkerstedt & Wright, 2009; Caldwell, Caldwell, Thompson, & Lieberman, 2019). Specifically amongst bus drivers, shift schedules have been found to directly impact crash risk (Abdullah & Von, 2011; Lee, Kim, Byun, & Jang, 2017; Wang & Wu, 2019). Bus drivers have self-reported that some of the main contributing factors to bus driver sleepiness are unrealistic scheduling, tight route

schedules, turn-around and shift irregularity, and extended shift cycles (Biggs, Dingsdag & Stenson, 2006, 2009). Additionally, questionnaire data has revealed that sleepiness is a particular problem for those working night shifts or rotating shifts (Chaiard, Deeluea, Suksatit, & Songkham, 2019) and those working split shifts (Ihlström, Kecklund & Anund, 2017; Sando, Mtoi, & Moses, 2010).

A major cause of driver sleepiness is not obtaining enough sleep prior to driving, with one survey showing that only 50% of bus drivers obtained the recommended 7 h of sleep prior to a shift (Liendo et al., 2010). Sleep related factors were also significant predictors of sleepiness in the survey of Swedish bus drivers by Anund et al., (2016) who found that higher scores on five sleep indexes, from the Karolinska Sleep Questionnaire, significantly predicted having to fight sleepiness whilst driving.

Driver health has been seen as a contributory factor to sleepiness, with obstructive sleep apnoea (OSA) being associated with daytime sleepiness (Kim et al., 2017) amongst bus drivers. Additionally, driver health has been found to be a predictor of whether or not drivers have to regularly fight sleepiness (Anund et al., 2016), with professional drivers being more likely to suffer from cardiovascular and metabolic disease than non-professional drivers (Hege, Lemke, Apostolopoulos, & Sönmez, 2018). It has also been shown that bus drivers who continue to drive the bus despite feeling sick are more likely to be involved in an accident or near miss incident (Miyama, Fukumoto, Kamegaya, & Hitosugi, 2020).

The London bus network is one of the most extensive in the world. Over 9000 buses operate on approximately 700 different routes. Annually, the network carries around 2.5 billion passengers. In total, Transport for London employs approximately 25,000 bus drivers (8% females) (TfL, n.d.). The size and complexity of this network makes it an excellent case study for examining bus driver sleepiness. As such, the current research investigates London bus driver sleepiness using a large online survey. There were two main aims: firstly, to quantify the prevalence of sleepiness amongst London bus drivers and secondly, to determine which factors significantly contributed to driver

sleepiness. It is hypothesised that London bus drivers will suffer from sleepiness whilst driving, which will be due to a combination of sleep, health, and work-related factors.

2. Method

2.1. Participants

The survey was open to all bus drivers working for any of the 10 operators in London, regardless of how long they had been working as a bus driver, or whether they worked as a bus driver full time or part time. Across each of the 10 operators, all offer mixed shifts, with 9 also offering fixed shift patterns (such as working early shifts only). 8 of the 10 operators run 24 h a day.

A total of 1400 London bus drivers initially responded to the survey. Data from 40 respondents were excluded as they completed the survey in under 5 min (indicating that they were unable to fully read and complete the survey). In order to minimise bias and ensure sufficient representation of work related factors from any particular operator, operators with less than 50 respondents were excluded from the analysis, leading to the removal of a further 25 respondents. This left a final sample of 1335 (86% male) consisting of drivers from 7 out of 10 operators. All respondents were eligible to be entered into a prize draw to win 1 of 20 £20 vouchers.

This research received full ethical approval from Loughborough University (HSPC Reference Number: C16-62).

2.2. The survey

The survey contained 54 questions. The core questions were translated from a previous survey of Swedish bus drivers (Anund et al., 2016). Most questions were multiple choice, or required a response on a Likert scale.

The survey was split into five sections: Section 1 contained questions relating to respondents' work as a bus driver, including length of service, working hours and shift patterns. Section 2 focused on drivers' sleep, with questions relating to sleep quality, sleep disorders, and the amount of sleep

obtained before shifts. Within section 2, drivers were also presented with 20 statements related to sleep and were asked to “indicate the degree to which the following have happened to you during the last 3 months”. Drivers responded to each statement with one of six options ranging from “never” to “always (5 or more times a week)”. Responses to these statements were used to create five sleep indexes. All indexes (apart from the fatigue index) were part of the Karolinska Sleep Questionnaire (KSQ) and were previously used by Anund et al. (2016). The indexes consisted of the following items:

- **Sleep quality index:** difficulty falling sleep, repeated waking, waking up too early, disturbed or worried sleep
- **Sleepiness index:** feeling sleepy at work, feeling sleepy during leisure time, fighting to stay awake throughout the day, involuntary falling asleep at work, involuntary falling asleep during leisure time
- **Fatigue index:** physical fatigue, mental fatigue
- **Impaired waking index:** difficulty in waking up, not feeling alert on waking up
- **Suspected sleep apnoea index:** snoring, difficulty catching your breath whilst sleeping, interrupted breathing during sleep

Questions in section 3 related to drivers’ health and concerned general health, smoking, exercise and stress. Section 4 contained questions relating to the respondent as a bus driver, and included several questions regarding the prevalence of driver sleepiness. There were five questions which asked about the occurrence of sleep related incidents (stopping the bus, falling asleep, road crashes etc.) in the past 12 months. The final section contained basic demographic questions. Response times showed that the survey took an average of 40 min to complete.

2.3. Procedure

The survey was distributed to drivers through each of the 10 individual operating companies and union representatives within each company who were asked if they could promote the survey to

drivers within their company. They were provided with a number of resources to do so. These resources included the survey URL to be shared with drivers, posters and cards containing a QR code linking to the online survey, and letters sent by operators directly to drivers containing the online survey URL. A self-selection sampling method was used in which all London bus drivers were eligible to participate and could choose to do so through the various promotional methods.

The majority of respondents completed the survey online, however paper copies were available upon request. Although, the survey was promoted at all operators, there was variability in uptake between drivers employed by different operators.

2.4. Analysis

Descriptive statistics were used to examine background factors, as well as the occurrence of sleep related incidents (such as crashes and close calls) amongst London bus drivers. In order to examine which factors contributed to driver sleepiness two outcome variables were used, both of which involved the respondents being split into one of two groups. Firstly, respondents were split into those who had to fight sleepiness at least 2-3 times a week ($n = 277$) and those who did not ($n = 1056$). Secondly, those who had experienced at least one close call due to sleepiness in the past 12 months ($n = 489$) and those who had not ($n = 844$). Following this, a two stage regression method was used. For the first stage, a series of univariate logistic regressions were used to determine which individual factors best predicted whether or not respondents had to fight sleepiness often, and whether or not they had encountered a close call. These factors were related to sleep, work, health, or demographic information. For the second stage, any univariate predictors with a significant odds ratio ($p < .05$) were entered as predictors into a multivariate logistic regression using the stepwise method.

All statistical analyses were conducted using IBM SPSS 23.0 statistical software. The alpha criterion was set to 0.05.

3. Results

3.1. Sample

Respondents (86% male) were aged between 20 and 73 years ($M = 45.09$, $SD = 10.85$). The small proportion of female drivers (14%) was similar to the proportion of all female bus drivers in London (8%) ($\chi^2(1) = 1.84$, $p = .16$) and the UK as a whole (7%, Department for Transport, 2019) ($\chi^2(1) = 2.61$, $p = .12$). Uptake within operating companies ranged from 1.63-10.32% ($M = 5.25$, $SD = 3.35$).

Participants had been working as a bus driver between 2 months, and 43 years ($M = 10.54$ years, $SD = 8.46$). The majority of the drivers (96%) worked full time as bus drivers and said that bus driving was their only occupation (97%). Full time drivers worked between 35 and 75 h a week, with an average working week of 45.15 h ($SD = 6.93$). Part time drivers worked between 12 and 35 h a week, with an average working week of 25.34 h ($SD = 6.58$). 46% of respondents were on fixed rosters where they only worked a certain type of shift (such as nights or early mornings), whilst 54% were on a rotating roster where they worked a mixture of different shift times.

46% of the sample indicated that they had poor sleep, whilst only 18% indicated that they had good sleep. When asked to report the amount of sleep needed to feel rested before a shift, and the amount of sleep actually obtained between shifts, 70% of the sample had a discrepancy indicating that they did not get enough sleep. Of those who did not get enough sleep, the average difference between obtained and needed sleep was two hours (range 15 min – 7 h, $SD = 68.76$ min).

In relation to health, 60% of respondents believed they had good general health, whilst 10% indicated they had poor health (the remaining 30% had neither good nor bad health). Respondents' BMI ranged from 14.79 to 61.68 with an average BMI of 27.72 ($SD = 5.22$) (similar to the average BMI of UK citizens which is 27.7 (NHS Digital, 2017), 65% of the sample were classified as overweight or obese ($BMI > 25$)).

3.2. The prevalence of sleepiness amongst London bus drivers

36.3% of drivers reported that they have to fight sleepiness while driving the bus at least 2-4 times a month, whilst 20.8% of drivers responded that they have to fight sleepiness at least 2-3 times a week. Furthermore, drivers self-reported experiencing signs of sleepiness whilst driving in the past 12 months such as yawning, difficulty concentrating, and others (see Table 1).

Table 1: The number of respondents who had experienced symptoms of sleepiness in the past 12 months

In the past 12 months when driving the bus, have you experienced any of these symptoms?	Frequency	% of total responses
Yawning	1188	89.0
Difficulty concentrating on driving	728	54.5
Needing to change position	706	52.9
Frequent eye blinks	596	44.6
Difficulty keeping eyes open	542	40.6
Head nodding	476	35.7
Dreamlike state of consciousness	444	33.3
Increased variation in speed	303	22.7
Slower reactions to traffic events	210	15.7

As well as experiencing signs of sleepiness, drivers reported being involved in different sleep related incidents (as seen in Table 2). Of the 73 drivers who had a road crash due to sleepiness, 78% reported that their employer would not know this was due to sleepiness. Similarly, for the 489 drivers who had a close call due to sleepiness, 88% reported that their employer would not know sleepiness was a factor.

215 *Table 2: The number of respondents who reported having a variety of sleep related driving incidents*

<i>Sleep related incidents</i>	Once		More than once	
	Frequency	% of total responses	Frequency	% of total responses
Had to stop the bus due to sleepiness in the past 12 months	120	9.0	183	13.6
Wanted to stop the bus due to sleepiness in the past 12 months	166	12.4	572	42.9
Fallen asleep whilst driving the bus in the past 12 months	78	5.8	143	10.7
Had a close call whilst driving the bus due to sleepiness in the past 12 months	209	15.7	280	20.9
Had a road crash whilst driving the bus due to sleepiness in the past 12 months	61	4.6	12	0.9
Had an incident or crash where sleepiness was solely or party to blame whilst driving any vehicle in the past 10 years	175	13.1	50	3.7

216

217 3.3. Contributing factors to sleepiness

218 A number of factors were found to significantly predict whether or not drivers had to fight

219 sleepiness at least 2-3 times a week (see Table 3). These factors were related to the driver's

220 background, sleep, health, or work. The one background factor which was found to be a significant

predictor was being a younger driver. The significant sleep related factors included higher scores on all five sleep indexes, having a sleep disorder (with 35% of those with sleep disorders reporting having sleep apnoea), poor self-reported sleep, not obtaining enough sleep, and snoring. Two health related factors were also found to be significant predictors, there were smoking, and having poor self-reported health.

In relation to work and working environment, 11 univariate factors were identified as significant predictors. These were: having less than 11 h rest between shifts, working 6 or more days without a rest day, short notice of shifts, variability in shift start times, enjoyment from bus driving (with driver who reported higher levels of enjoyment being less likely to experience sleepiness), stress whilst driving, having a longer commute time, having nowhere to sit during breaks, having no indoor rest area, and having insufficient time to eat and rest during breaks.

Similar results were observed for the factors predicting whether or not respondents had a close call in the past 12 months, with five additional work related factors emerging as significant predictors. These were: working hours per week (with those working more hours being more likely to have had a close call), working a morning shift, having a rota which includes both daytime and evening shifts, the over running of bus routes, and buses running late.

Table 3: Univariate logistic regressions for having to fight to stay awake, and experiencing a close call due to sleepiness. OR = odds ratio, CI = confidence intervals, p = significance. Significant values are presented in bold.

Univariate variables	Have to fight sleepiness			Having a close call in the last 12 months		
	OR	CI	Sig	OR	CI	Sig
Background						
Age: 20-29 (ref)						
30-39	0.76	0.47-1.23	0.269	0.45	0.29-0.71	0.001
40-49	0.52	0.32-0.86	0.011	0.39	0.25-0.62	<0.001
50-59	0.45	0.28-0.74	0.002	0.36	0.23-0.56	<0.001

60-73	0.39	0.20-0.75	0.005	0.45	0.26-0.77	0.003
Gender: male vs female (ref)	1.00	0.65-1.53	0.995	0.89	0.62-1.28	0.536

Sleep

Sleep condition	3.16	1.84-5.42	<0.001	2.21	1.30-3.75	0.003
Sleep quality index	2.07	1.84-2.33	<0.001	1.70	1.55-1.87	<0.001
Sleepiness index	3.05	2.66-3.50	<0.001	2.21	1.99-2.46	<0.001
Fatigue index	2.35	2.09-2.64	<0.001	1.66	1.53-1.80	<0.001
Impaired waking index	2.37	2.11-2.68	<0.001	1.75	1.60-1.91	<0.001
Sleep apnoea index	1.48	1.33-1.64	<0.001	1.47	1.33-1.62	<0.001
Self-reported sleep quality: good (ref)						
Neutral	1.76	0.95-3.28	0.073	1.75	1.19-2.57	0.005
Bad	8.77	4.99-15.43	<0.001	4.80	3.33-6.92	<0.001
Under sleeping: no (ref) vs yes	3.04	2.06-4.48	<0.001	3.06	2.27-4.12	<0.001
Snoring: no (ref) vs yes	1.19	1.11-1.28	<0.001	1.18	1.11-1.26	<0.001

Health

Self-reported health: Good (ref)						
Neutral	1.82	1.35-2.44	<0.001	1.95	1.52-2.50	<0.001
Bad	3.40	2.28-5.06	<0.001	2.96	2.03-4.30	<0.001
Stress in the last 3 months	1.29	1.22-1.36	<0.001	1.21	1.16-1.27	<0.001
Smoker status: non-smoker (ref) vs smoker	1.48	1.09-2.01	0.012	1.42	1.09-1.85	0.010
Exercise: no (ref)						
No vs Low	0.91	0.65-1.26	0.552	1.01	0.77-1.34	0.922
No vs Regular	0.85	0.58-1.22	0.372	1.09	0.80-1.47	0.587
No vs Competitive	1.41	0.92-2.17	0.112	1.05	0.71-1.54	0.811
BMI	1.00	0.97-1.03	0.988	0.99	0.97-1.01	0.516

Work

Roster type: fixed (ref) vs rotating	1.13	0.87-1.48	0.357	1.13	0.90-1.42	0.274
Working hours per week	1.01	0.99-1.03	0.241	1.02	1.00-1.03	0.012
Working over 45 h per week	1.01	0.99-1.03	0.241	1.16	0.93-1.45	0.191
Morning shift	1.29	0.86-1.94	0.219	1.54	1.09-2.17	0.015
Daytime shift	1.17	0.76-1.78	0.477	1.24	0.87-1.77	0.243
Evening shift	1.10	0.79-1.53	0.586	1.22	0.92-1.62	0.160
Night shift	0.90	0.64-1.28	0.563	1.01	0.75-1.35	0.959
Rota with day and evening shifts	1.26	0.92-1.73	0.147	1.33	1.02-1.74	0.034
Spreadover	1.16	0.85-1.58	0.345	1.15	0.89-1.49	0.286

Less than 11 h break	1.46	1.10-1.94	0.010	1.29	1.01-1.63	0.040
6 or more days without rest	1.89	1.20-2.98	0.006	1.40	1.00-1.97	0.052
More than 10 h overtime	1.13	0.85-1.49	0.404	1.17	0.92-1.48	0.209
Short notice of shifts	1.63	1.23-2.16	0.001	1.41	1.11-1.80	0.005
Variability in start times	1.75	1.22-2.51	0.002	1.37	1.03-1.82	0.028
Over running of routes	1.17	0.72-1.88	0.527	1.55	1.03-2.34	0.035
Enjoyment from bus driving	0.83	0.79-0.87	0.000	0.91	0.87-0.94	<0.001
Stress from bus driving	1.27	1.21-1.34	0.000	1.21	1.16-1.26	<0.001
Commute time	1.01	1.00-1.01	0.017	1.01	1.00-1.01	0.002
Nowhere to sit during breaks	1.64	1.25-2.16	<0.001	1.55	1.22-1.96	<0.001
Insufficient time to eat during breaks	1.97	1.45-2.69	<0.001	1.72	1.34-2.20	<0.001
Insufficient time to rest during breaks	2.68	1.85-3.88	<0.001	2.06	1.56-2.72	<0.001
Late running of buses	1.44	0.88-2.37	0.150	1.87	1.23-2.86	0.004
No indoor rest area	1.37	1.04-1.80	0.025	1.34	1.06-1.69	0.014

240

241 The multivariate logistic regression for the outcome of having to fight sleepiness produced a
242 significant model ($\chi^2(3) = 287.26, p < .001$) containing three predictor variables, with an overall
243 classification rate of 82.6%. The regression for the outcome of experiencing a close call due to
244 sleepiness in the past 12 months produced a significant model ($\chi^2(4) = 216.59, p < .001$) which
245 contained four predictor variables, with an overall classification rate of 71.7%. The variables included
246 in both models can be seen in Table 4. Results show that having to fight sleepiness is predicted by
247 higher scores on the sleepiness and impaired waking indexes, and enjoyment from bus driving (with
248 participants who enjoy driving being less likely to have to fight sleepiness), whilst having a close call
249 is predicted by high scores on the sleepiness and impaired waking indexes, not obtaining enough
250 sleep, and having nowhere to sit during breaks.

Table 4: Final multivariate logistic regression models for having to fight to stay awake, and experiencing a close call due to sleepiness. B = regression coefficient, SE = standard error of coefficient, OR = odds ratio, CI = confidence intervals, p = significance.

	<i>B</i>	<i>SE</i>	<i>OR</i>	<i>CI</i>	<i>p</i>
<u>Have to fight sleepiness</u>					
Sleepiness index	0.913	0.097	2.491	2.06-3.01	<.001
Impaired waking index	0.312	0.090	1.366	1.14-1.63	0.001
Enjoyment from bus driving	-0.088	0.035	0.916	0.85-0.98	0.012
<u>Having a close call in the past 12 months due to sleepiness</u>					
Sleepiness index	0.634	0.083	1.886	1.60-2.22	<.001
Impaired waking index	0.202	0.074	1.224	1.05-1.41	0.006
Under sleeping	0.499	0.213	1.648	1.08-2.50	0.019
Nowhere to sit during breaks	0.437	0.162	1.548	1.12-2.12	0.007

Note: R² for having to fight sleepiness = .27 (Cox & Snell), .41 (Nagelkerke). R² for having a close call = .22 (Cox & Snell), .30 (Nagelkerke).

4. Discussion

4.1. The prevalence of sleepiness amongst London bus drivers

Sleepiness is a problem amongst London bus drivers, with 20.8% of respondents having to fight sleepiness at least 2-3 times a week, and almost all respondents declaring that they had experienced some signs of sleepiness whilst driving the bus. Particularly concerning is that 5.5% had a road crash whilst driving the bus in the past 12 months in which sleepiness was a contributing factor. In particular, higher scores on a sleepiness index proved to be one of the strongest predictors.

The proportion of London bus drivers who are regularly fighting sleepiness while driving is similar to those of previous research including Anund et al. (2016) who found that 19% of bus drivers in a

Swedish survey had to fight sleepiness at least 2-3 times a week. The prevalence of sleepiness in the current sample is also similar to the results obtained from studies outside of Europe (Deza-Becerra et al., 2017; Kim et al., 2017; Liendo et al., 2010) further demonstrating that bus driver sleepiness is a global issue.

There are obvious safety implications of drivers falling asleep whilst driving the bus. In the current sample 16.5% of participants had fallen asleep while driving the bus, 5.5% had crashed the bus and 36.6% had had a close call due to sleepiness in the past year. Bus crashes are particularly dangerous due to the large vehicle size, and the number of passengers on board. Between 2006 and 2015 there were just under 25,000 casualties in London in which a bus or a coach was involved. In 188 of these cases, an individual was fatally injured (Edwards et al., 2018). The degree to which sleepiness was a contributory factor in these incidents is not known.

Within the existing literature, there is evidence which shows that driving whilst sleepy can lead to performance decrements in both simple and complex tasks, including impaired attention, and slower reaction time (Williamson et al., 2011). Sleepiness has also been found to lead to increased lane crossings (Filtiness, Reyner, & Horne, 2012; Hallvig et al., 2013), reductions in hazard perception (Smith, Horswill, Chambers, & Wetton, 2009), and slower braking reaction times (Miyata et al., 2010; Vakulin et al., 2007). Performance decrements may also be present when a driver is seemingly awake (with their eyes open) as a result of localised sleep-like states in specific regions of the brain such as those related to motor functions (Ahlström, Jansson, & Anund, 2017; Krueger, Nguyen, Dykstra-Aiello, & Taishi, 2019; Van Dongen, Belenky, & Krueger 2011). Sleepiness has also been associated with an increased risk of cardiovascular and metabolic disease amongst professional drivers (Hege et al., 2018), and an increase in risky driving behaviours (Useche, Gómez, Cendales, & Alonso, 2018; Watling, Armstrong, & Smith, 2013). Amongst bus drivers, it has been shown that psychosocial work related factors such as job strain can predict risky driving behaviours, with this

relationship being mediated by driver fatigue such that job strain combined with fatigue leads to an increase in risky driving behaviours (Useche, Ortiz, & Cendales, 2017).

Less is known about the subtler performance decrements which occur as a result of sleepiness. With 36.6% of respondents experiencing a close call due to sleepiness, this could be caused by decrements such as increased reaction times or variability in speed (Anund et al., 2008; Gillberg, Kecklund, & Åkerstedt, 1996). Performance decrements due to sleepiness are dangerous in all circumstances, however they will be particularly dangerous for bus drivers as they not only have to consider their own safety, but the safety of the passengers on the bus and vulnerable road users outside the bus such as pedestrians and cyclists.

The prevalence of close calls in the current study is higher than that of previous research, with Vennelle et al. (2010) reporting 7% of respondents having a crash, and 18% having a close call due to sleepiness. This suggests that little progress has been made in addressing the issue of bus driver sleepiness over the past 10 years. An additional finding in the current study is that over half of all respondents indicated that they had wanted to stop the bus due to sleepiness, but were unable to. As crash rates in other countries are similar to those in the current survey, it might be expected that a similar proportion of drivers in other countries want to stop the bus due to sleepiness but feel unable to do so.

There was some evidence that drivers are aware of the potential dangers of driver sleepiness due to the proportion of drivers wanting to stop the bus due to sleepiness. Only 22.6% reported actually stopping the bus suggesting that there are barriers in place to drivers acting on their desire to stop. These barriers are also evident in the reporting of sleepiness as the majority of drivers who have experienced an incident due to sleepiness believe that their employer would not know that sleepiness was a contributory factor. If drivers are unwilling to report to their employer that they are feeling sleepy, or that this has contributed to a crash, then employers will likely underestimate the potential sleepiness problem within their organisation.

One way to increase reporting of sleepiness related incidents would be to introduce a fatigue risk management system (FRMS) across the whole London bus network (Williamson & Friswell, 2013). This is a multidimensional approach to fatigue management which involves a shared responsibility, reporting, and monitoring of fatigue (Dawson & McCulloch, 2005). This approach works best when implemented within an open safety culture, and is currently being used within aviation and other transport industries (Gander et al., 2011).

4.2. Contributory factors to sleepiness

In terms of the causes of driver sleepiness, this research identified a series of contributory factors. Similar to Anund et al. (2016), the current survey found that higher scores on five sleep indexes predicted whether a driver had to fight sleepiness, or had a sleep related incident. Higher scores on these indexes were some of the strongest predictors of having to fight sleepiness, and of experiencing a close call. In both cases, the sleepiness index was the strongest predictor of the five indexes. This index contained five statements: feeling sleepy at work, feeling sleepy during leisure time, involuntarily falling asleep at work, involuntarily falling asleep during leisure time, and having to fight to stay awake during the day. A potential approach to screening drivers for risk of sleepiness at work could therefore be to ask these five questions. The sleepiness index also emerged as one of the highly significant predictors in the Swedish survey (Anund et al., 2016), suggesting that this index could be a useful screening tool across bus drivers from different countries.

Other strong predictors (those with an odds ratio greater than 2) relating to sleep were whether or not the respondent had a sleep condition and poor self-reported sleep quality. A large proportion (70%) of the sample reported not obtaining enough sleep before a shift. This lack of sleep is likely to be leading to increased sleepiness during the working day, which in turn can contribute to the sleep related incidents reported by drivers.

Poor sleep may be caused by a combination of different factors, many of which may relate to the shift schedule of a bus driver. Shift working has been shown to contribute to poor sleep quality and

quantity (Åkerstedt, 1991). With this working pattern, drivers may find it challenging to incorporate good quality sleep into their life when combined with work and personal factors. For example, drivers who reported a variability in their shift start times were more likely to have to regularly fight sleepiness, and were more likely to have had a close call. Due to the variability in start times, these drivers may find it difficult to plan their sleep and obtain adequate rest prior to starting a shift.

In terms of reducing sleepiness amongst drivers, simply telling drivers to obtain more sleep prior to a shift is unlikely to be effective. As well as work, drivers will have other commitments during the day, and may also be unaware of the importance of obtaining good quality sleep before a shift. Previous research has indicated that there is a need for greater education relating to sleep hygiene and the importance of sleep amongst bus drivers (Deza-Becerra et al., 2017; Razmpa, Niat, & Saedi, 2011). However, even after receiving appropriate education, drivers may not alter their behaviour, continuing to drive whilst sleepy (Nordbakke & Sagberg, 2007).

Scoring highly on the suspected obstructive sleep apnoea (OSA) scale was a univariate predictor for having to fight sleepiness and having had a close call, as was having a diagnosed sleep disorder (with 35% of respondents with a disorder having sleep apnoea). Within the risks associated with OSA there are two specific groups which should be considered. Firstly, those with diagnosed OSA. Among car drivers there is evidence that drivers who are successfully treated show no impairments when driving (Tregear, Reston, Schoelles, & Phillips, 2010; Yamamoto, Akashiba, Kosaka, Ito, & Horie, 2000), this is recognised by the UK Driver and Vehicle Licensing Agency (DVLA) who report that those whose condition is controlled by treatment are fit to drive (DVLA, 2019). However, treated car driving OSA patients have been demonstrated to be more vulnerable to sleep loss, showing greater driving impairment following a short night of sleep even with treatment (Filtiness, Reyner, & Horne, 2011). The pressures of poorly managed shift work e.g. inadequate time off between shifts, may have greater adverse effects on this group than those without OSA. Second, drivers with undiagnosed OSA may be at an increased risk of crashing (George, 2004). Sleep quality may be

particularly poor for these drivers who scored highly on the suspected OSA index. Using basic screening questions such as those in the OSA index or the STOP-Bang (Nagappa et al., 2015), could identify those most at risk so that targeted interventions can be put in place. Taking drivers' sleep quality and sleep status into consideration may be a useful recommendation, especially by avoiding putting those drivers on demanding shifts such as late nights, early mornings, and split shifts.

Several work-related factors were also found to be significant predictors. Many of these were specifically related to the shift schedules experienced by bus drivers. These include working on morning shifts, having a rota with daytime and evening shifts, having less than 11 h rest between shifts, working more than 6 days without a rest day, having a short notice of shifts, a variability in start times, and working long hours. Previous work has shown that shift scheduling can impact sleepiness amongst bus drivers (Abdullah & Von, 2011; Wang & Wu, 2019). Shift patterns may lead to drivers not being able to obtain enough sleep between shifts. Additionally, long working hours may lead to fatigue as a result of working on the same task for too long. In conditions where these long working hours are particularly stressful, spending a prolonged amount of time on a highly complex task can lead to fatigue as a result of cognitive overload (Makowiec-Dabrowska et al., 2015; May & Baldwin, 2009).

A further work-related issue which emerged was related to break times. Respondents who believed they did not get enough time to eat or rest during their break, or had insufficient facilities during their break (such as nowhere to sit and not having an indoor rest area) were more likely to suffer from sleepiness. In most cases, a driver will drive the bus for a number of hours before receiving a meal break, and then return to driving the bus for several more hours before finishing their shift. These results suggest that the time drivers have between these two drives are not perceived to be sufficient for drivers to recover and rest before returning to the bus. Although there are regulations in place to ensure that drivers receive some break time (a 30-minute break after 5 and a half hours driving), these findings suggest that drivers require a longer break before returning to their duty.

One general demographic factor which was found to be a significant predictor of sleepiness was age, with younger drivers being more likely to suffer from sleepiness than older drivers. Young drivers are more sensitive to sleepiness than older drivers (Lowden, Moreno, Holmbäck, Lennernäs, 2010). Research has shown that younger drivers are more prone to driving whilst sleepy despite being aware of the risks (Obst, Armstrong, Smith, & Banks, 2011), and experience greater driving impairments following sleep loss (Filtner et al., 2012). In the case of London bus drivers, younger drivers may not obtain enough sleep prior to work as they may try to engage in more social activities, and may be less informed on sleep management techniques when doing shift work than older drivers.

The combination of predictive factors found in the current study suggests that when designing any interventions with the goal of reducing driver sleepiness, a multifaceted approach should be taken. Such interventions should be targeted at both the individual drivers e.g. emphasizing the importance of sleep during time off, and at organisations e.g. in designing shift schedules in a way which optimises rest opportunity. However, as previously discussed, any interventions to reduce driver sleepiness will be most effective if they are implemented within an open culture (Gander et al., 2011).

4.3. Limitations

As with any survey, there is a possibility of a response bias. Every effort was made to recruit participants from a range of operators, to gather a variety of experience. Where sufficient representation of a particular operator was not obtained, they were not included so as not to bias the results. Although the current survey had a reasonably large sample size, the respondents were only a small percentage of all London bus drivers. Additionally, the self-selection non-probabilistic sampling method used may have influenced which drivers responded to the survey as drivers who believe fatigue was a problem may have been more likely to participate.

All participants were informed that their answers would be anonymous and not reported back to their employer, however, it is possible that some participants were not honest due to fear of potential feedback to their employer. As such, it may be the case that the number of sleepiness related incidents in the current survey is also an underestimate. It should also be noted that union representatives encouraged drivers to participate in the survey.

In relation to the gender balance within the sample, whilst the current sample accurately represented the gender split within the bus driving industry (a predominantly male workforce), the gender split of respondents does not represent each gender equally. Further work may wish to explore whether there are factors related to fatigue which are unique to female bus drivers.

An additional limitation of the current research is that both predictors and outcome measures were self-reported by drivers. As such, respondents may over or underestimate their own sleepiness leading to inflated or potentially missed relationships. Additionally, the use of a self-report survey for all variables means that common method variance may influence the relationship between variables. Further work should validate the current findings by using more objective measures of sleepiness, work conditions, and incident rates.

4.4. Conclusion

The findings of this study have shown that sleepiness is a problem amongst London bus drivers, with a considerable percentage of drivers experiencing sleepiness at work and having crashed the bus as a result. This widespread driver sleepiness is a safety concern which it is important to manage. It is clear that sleepiness amongst London bus drivers is not the result of a singular issue, but rather a combination of work and personal factors. Therefore, when taking steps to reduce fatigue amongst bus drivers this combination of factors should be taken into account, using a multifaceted approach.

References

- Abdullah, D. N. M. A., & Von, H. L. (2011). Factors of fatigue and bus accident. In *Proceedings of the 2nd International Conference on Innovation, Management and Service: International Proceedings of Economics Development and Research* (Vol. 14, pp. 317-322).
- Ahlström, C., Anund, A., Fors, C., & Åkerstedt, T. (2018). Effects of the road environment on the development of driver sleepiness in young male drivers. *Accident Analysis & Prevention*, 112, 127-134.
- Ahlström, C., Jansson, S., & Anund, A. (2017). Local changes in the wake electroencephalogram precedes lane departures. *Journal of sleep research*, 26(6), 816-819.
- Åkerstedt, T. (1991). Sleepiness at work: Effects of irregular work hours. In T. H. Monk (Ed.), *Human performance and cognition. Sleep, sleepiness and performance* (pp. 129-152). Oxford, England: John Wiley & Sons.
- Åkerstedt, T. (2000). Consensus statement: fatigue and accidents in transport operations. *Journal of sleep research*, 9(4), 395-395.
- Åkerstedt, T., & Wright, K. P. (2009). Sleep loss and fatigue in shift work and shift work disorder. *Sleep medicine clinics*, 4(2), 257-271.
- Anderson, C., & Horne, J. A. (2013). Driving drowsy also worsens driver distraction. *Sleep medicine*, 14(5), 466-468.
- Anund, A., Fors, C., Ihlström, J., & Kecklund, G. (2018). An on-road study of sleepiness in split shifts among city bus drivers. *Accident Analysis & Prevention*, 114, 71-76.
- Anund, A., Ihlström, J., Fors, C., Kecklund, G., & Filtness, A. (2016). Factors associated with self-reported driver sleepiness and incidents in city bus drivers. *Industrial health*, 54(4), 337-346.

457 Anund, A., Kecklund, G., Peters, B., Forsman, A., Lowden, A., & Åkerstedt, T. (2008). Driver
458 impairment at night and its relation to physiological sleepiness. *Scandinavian journal of*
459 *work, environment & health*, 34(2), 142.

460 Biggs, H. C., Dingsdag, D. P., & Stenson, N. J. (2006). Fatigue issues for metropolitan bus drivers:
461 Ramifications of quantitative and qualitative research findings for safety management.
462 Paper presented at the 2006 Australasian Road Safety Research, Policing and Education
463 Conference. Surfers Paradise, Queensland.

464 Biggs, H., Dingsdag, D., & Stenson, N. (2009). Fatigue factors affecting metropolitan bus drivers: A
465 qualitative investigation. *Work*, 32(1), 5-10.

466 Bioulac, S., Franchi, J. A. M., Arnaud, M., Sagaspe, P., Moore, N., Salvo, F., & Philip, P. (2017). Risk of
467 motor vehicle accidents related to sleepiness at the wheel: a systematic review and meta-
468 analysis. *Sleep*, 40(10).

469 Caldwell, J. A., Caldwell, J. L., Thompson, L. A., & Lieberman, H. R. (2019). Fatigue and its
470 management in the workplace. *Neuroscience & Biobehavioral Reviews*, 96, 272-289.

471 Chaiard, J., Deeluea, J., Suksatit, B., & Songkham, W. (2019). Factors associated with sleep quality of
472 Thai intercity bus drivers. *Industrial Health*, 2018-0168.

473 Connor, J., Norton, R., Ameratunga, S., Robinson, E., Civil, I., Dunn, R., ... & Jackson, R. (2002). Driver
474 sleepiness and risk of serious injury to car occupants: population-based case control study.
475 *Bmj*, 324(7346), 1125.

476 Dawson, D., & McCulloch, K. (2005). Managing fatigue: it's about sleep. *Sleep Medicine Reviews*, 9(5),
477 365-380.

478 Department for Transport. (2019). Annual bus statistics: England 2018/19. London, UK: The Stationery
479 Office.

480 Deza-Becerra, F., de Castro, J. R., Gonzales-Gonzales, C., León-Jiménez, F. E., Osada-Liy, J., & Rosales-
481 Mayor, E. (2017). Sleep habits, fatigue, and sleepiness in Chiclayo-Peru's bus drivers. *Sleep*
482 *and Breathing*, 21(3), 745-749.

483 Driver & Vehicle Licensing Agency (DVLA) (2019). *Assessing fitness to drive – a guide for medical*
484 *professionals*. London, UK: DVLA.

485 Edwards, A., Barrow, A., O'Connell, S., Krishnamurthy, V., Khatry, R., Hylands, N., ... & Knight, I.
486 (2018). *Analysis of Bus Collisions and Identification of Countermeasures*. London, UK:
487 Transport for London.

488 Filtiness, A. J., Armstrong, K. A., Watson, A., & Smith, S. S. (2017). Sleep-related vehicle crashes on
489 low speed roads. *Accident Analysis & Prevention*, 99, 279-286.

490 Filtiness, A. J., Reyner, L. A., & Horne, J. A. (2011). Moderate sleep restriction in treated older male
491 OSA participants: greater impairment during monotonous driving compared with
492 controls. *Sleep medicine*, 12(9), 838-843.

493 Filtiness, A. J., Reyner, L. A., & Horne, J. A. (2012). Driver sleepiness—Comparisons between young
494 and older men during a monotonous afternoon simulated drive. *Biological psychology*, 89(3),
495 580-583.

496 Gander, P., Hartley, L., Powell, D., Cabon, P., Hitchcock, E., Mills, A., & Popkin, S. (2011). Fatigue risk
497 management: Organizational factors at the regulatory and industry/company level. *Accident*
498 *Analysis & Prevention*, 43(2), 573-590.

499 George, C. F. P. (2004). Sleep- 5: Driving and automobile crashes in patients with obstructive sleep
500 apnoea/hypopnoea syndrome. *Thorax*, 59(9), 804-807.

501 Gillberg, M., Kecklund, G., & Åkerstedt, T. (1996). Sleepiness and performance of professional drivers
502 in a truck simulator—comparisons between day and night driving. *Journal of Sleep*
503 *Research*, 5(1), 12-15.

504 Hallvig, D., Anund, A., Fors, C., Kecklund, G., Karlsson, J. G., Wahde, M., & Åkerstedt, T. (2013).
505 Sleepy driving on the real road and in the simulator—A comparison. *Accident Analysis &*
506 *Prevention*, 50, 44-50.

507 Hege, A., Lemke, M. K., Apostolopoulos, Y., & Sönmez, S. (2018). Occupational health disparities
508 among US long-haul truck drivers: the influence of work organization and sleep on
509 cardiovascular and metabolic disease risk. *PloS one*, 13(11), e0207322.

510 Horne, J. A., & Reyner, L. A. (1995). Sleep related vehicle accidents. *Bmj*, 310(6979), 565-567.

511 Ihlström, J., Kecklund, G., & Anund, A. (2017). Split-shift work in relation to stress, health and
512 psychosocial work factors among bus drivers. *Work*, 56(4), 531-538.

513 Kim, S. M., Um, Y. H., Kim, T. W., Jeong, J. H., Seo, H. J., Song, J. H., & Hong, S. C. (2017). Excessive
514 Daytime Sleepiness and Its Risk Factors for Commercial Bus Drivers in Korea. *Sleep Medicine*
515 *Research*, 8(2), 76-80.

516 Krueger, J. M., Nguyen, J. T., Dykstra-Aiello, C. J., & Taishi, P. (2019). Local sleep. *Sleep medicine*
517 *reviews* 43, 14-21.

518 Lee, S., Kim, H. R., Byun, J., & Jang, T. (2017). Sleepiness while driving and shiftwork patterns among
519 Korean bus drivers. *Annals of occupational and environmental medicine*, 29(1), 48.

520 Liendo, G. R., Castro, C. L., & de Castro, J. R., (2010). Fatigue and sleepiness in interprovincial road
521 bus drivers: comparative study between formality and informality. *Revista peruana de*
522 *medicina experimental y salud publica*, 27(2), 187-194.

523 Lowden, A., Moreno, C., Holmbäck, U., Lennernäs, M., & Tucker, P. (2010). Eating and shift work-
524 effects on habits, metabolism, and performance. *Scandinavian journal of work, environment*
525 *& health*, 150-162.

526 Makowiec-Dabrowska, T., Siedlecka, J., Gadzicka, E., Szyjowska, A., Dania, M., Viebig, P., ... &
527 Bortkiewicz, A. (2015). Work fatigue in urban bus drivers. *Medycyna pracy*, 66(5), 661-677.

528 May, J. F., & Baldwin, C. L. (2009). Driver fatigue: The importance of identifying causal factors of
529 fatigue when considering detection and countermeasure technologies. *Transportation*
530 *research part F: traffic psychology and behaviour*, 12(3), 218-224.

531 Miyama, G., Fukumoto, M., Kamegaya, R., & Hitosugi, M. (2020). Risk Factors for Collisions and Near-
532 Miss Incidents Caused by Drowsy Bus Drivers. *International Journal of Environmental*
533 *Research and Public Health*, 17(12), 4370.

534 Miyata, S., Noda, A., Ozaki, N., Hara, Y., Minoshima, M., Iwamoto, K., ... & Koike, Y. (2010).
535 Insufficient sleep impairs driving performance and cognitive function. *Neuroscience*
536 *letters*, 469(2), 229-233.

537 Nagappa, M., Liao, P., Wong, J., Auckley, D., Ramachandran, S. K., Memtsoudis, S., ... & Chung, F.
538 (2015). Validation of the STOP-Bang questionnaire as a screening tool for obstructive sleep
539 apnea among different populations: a systematic review and meta-analysis. *PloS one*, 10(12),
540 e0143697.

541 National Health Service [NHS] Digital (2018). *Health survey for England 2017*. London: UK, Health and
542 Social Care Information Centre.

543 Nordbakke, S., & Sagberg, F. (2007). Sleepy at the wheel: Knowledge, symptoms and behaviour
544 among car drivers. *Transportation Research Part F: Traffic Psychology and Behaviour*, 10(1),
545 1-10.

546 Obst, P., Armstrong, K., Smith, S., & Banks, T. (2011). Age and gender comparisons of driving while
547 sleepy: Behaviours and risk perceptions. *Transportation research part F: traffic psychology*
548 *and behaviour*, 14(6), 539-542.

549 Philip, P., Chaufton, C., Orriols, L., Lagarde, E., Amoros, E., Laumon, B., ... & Sagaspe, P. (2014).
550 Complaints of poor sleep and risk of traffic accidents: a population-based case-control
551 study. *PloS one*, 9(12), e114102.

552 Razmpa, E., Niat, K. S., & Saedi, B. (2011). Urban bus drivers' sleep problems and crash
553 accidents. *Indian Journal of Otolaryngology and Head & Neck Surgery*, 63(3), 269-273.

554 Sando, T., Mtoi, E., & Moses, R. (2010). Potential Causes of Driver Fatigue: A Study on Transit Bus
555 Operators in Florida. In *Transportation Research Board of the National Academies' 2011 90th*
556 *Annual Meeting* (No. 11-3398).

557 Smith, S. S., Horswill, M. S., Chambers, B., & Wetton, M. (2009). Hazard perception in novice and
558 experienced drivers: The effects of sleepiness. *Accident Analysis & Prevention*, 41(4), 729-
559 733.

560 Transport for London [TfL]. (n.d.). Buses. Retrieved June 04 2019 from
561 <https://tfl.gov.uk/corporate/about-tfl/what-we-do/buses>.

562 Tregear, S., Reston, J., Schoelles, K., & Phillips, B. (2010). Continuous positive airway pressure
563 reduces risk of motor vehicle crash among drivers with obstructive sleep apnea: systematic
564 review and meta-analysis. *Sleep*, 33(10), 1373-1380.

565 Tse, J. L., Flin, R., & Mearns, K. (2007). Facets of job effort in bus driver health: Deconstructing
566 "effort" in the effort-reward imbalance model. *Journal of Occupational Health Psychology*,
567 12(1), 48.

568 Useche, S. A., Gómez, V., Cendales, B., & Alonso, F. (2018). Working conditions, job strain, and traffic
569 safety among three groups of public transport drivers. *Safety and health at work*, 9(4), 454-
570 461.

571 Useche, S. A., Ortiz, V. G., & Cendales, B. E. (2017). Stress-related psychosocial factors at work,
572 fatigue, and risky driving behavior in bus rapid transport (BRT) drivers. *Accident Analysis &*
573 *Prevention*, 104, 106-114.

574 Van Dongen, H. P. A., Belenky, G., & Krueger, J. M. (2011). A local, bottom-up perspective on sleep
575 deprivation and neurobehavioral performance. *Current topics in medicinal chemistry*, 11(19),
576 2414-2422.

577 Vakulin, A., Baulk, S. D., Catcheside, P. G., Anderson, R., van den Heuvel, C. J., Banks, S., & McEvoy, R.
578 D. (2007). Effects of moderate sleep deprivation and low-dose alcohol on driving simulator
579 performance and perception in young men. *Sleep*, 30(10), 1327-1333.

580 Vennelle, M., Engleman, H. M., & Douglas, N. J. (2010). Sleepiness and sleep-related accidents in
581 commercial bus drivers. *Sleep and breathing*, 14(1), 39-42.

582 Wang, S. Y., & Wu, K. F. (2019). Reducing intercity bus crashes through driver rescheduling. *Accident*
583 *Analysis & Prevention*, 122, 25-35.

584 Watling, C. N., Armstrong, K. A., & Smith, S. S. (2013). Sleepiness: How a biological drive can
585 influence other risky road user behaviours. In *Proceedings of the 2013 Australasian College*
586 *of Road Safety (ACRS) National Conference* (1-12).

587 Williamson, A., & Friswell, R. (2013). Fatigue in the workplace: causes and countermeasures. *Fatigue:*
588 *Biomedicine, Health & Behavior*, 1(1-2), 81-98.

589 Williamson, A., Lombardi, D. A., Folkard, S., Stutts, J., Courtney, T. K., & Connor, J. L. (2011). The link
590 between fatigue and safety. *Accident Analysis & Prevention*, 43(2), 498-515.

591 Yamamoto, H., Akashiba, T., Kosaka, N., Ito, D., & Horie, T. (2000). Long-term effects nasal
592 continuous positive airway pressure on daytime sleepiness, mood and traffic accidents in
593 patients with obstructive sleep apnoea. *Respiratory medicine*, 94(1), 87-90.