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Excessive daytime sleepiness and associations with sleep-related motor vehicle accidents: results from a nationwide survey

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Abstract

Objective/background Insufficient sleep can have fatal consequences, and up to 30% of motor vehicle accidents (MVAs) are related to driving when drowsy. The objective of this study was to investigate how sleep quality and excessive daytime sleepiness (EDS) affect falling asleep while driving and sleep-related MVAs/near-misses.

Participants/methods A population-wide sample of Saudi adults was surveyed. The questionnaire gathered data on sleep quality, EDS (Epworth Sleepiness Scale), and episodes of falling asleep while driving and sleep-related MVAs/near-misses in the previous year. Univariable and multivariable analyses were used to assess associations.

Results A total of 19% (902/3802) and 10% (474/4229) of respondents had fallen asleep while driving or had a sleep-related MVA/near-miss in the preceding year, respectively. Being male, married, having a shorter sleep duration, being an office worker, having poor subjective sleep quality, and having moderate or severe EDS were associated with an increased risk of having fallen asleep while driving in the previous year. Younger age, male gender, having worse subjective sleep quality [OR 2.11 (95% CI 1.36–3.29); $p < 0.0001$ for "very bad" sleep quality], and having moderate or severe EDS [ESS ≥ 13; OR 1.90 (95% CI 1.38–2.60); $p < 0.0001$ and OR 2.39 (95% CI 1.56–3.67); $p < 0.0001$, respectively] were associated with having had/nearly had an accident due to being tired or falling asleep while driving in the previous year.

Conclusions Sleepy driving and sleep-related accidents/near-misses are common in Saudi Arabia, and sleep quality and EDS contribute to the burden of MVAs. Further efforts are required to quantify the contribution of sleepiness to MVAs to develop and prioritize interventions to prevent MVA-related injuries and death.

Keywords Epworth sleepiness scale · Excessive daytime sleepiness · Motor vehicle accidents · Sleep hygiene

Introduction

Attaining good quality sleep is essential for mental and physical well-being [1]. It is also essential for maintaining the attention, recall, reaction times, hand-eye coordination, and vigilance required to safely execute complex tasks such as driving. Excessive daytime sleepiness (EDS) can be defined as the subjective or objective inclination to sleep when intending to be awake [2], and it affects up to a third of individuals depending on its definition and how it is measured [3].

Driving while feeling sleepy or fatigued is a major cause of motor vehicle accidents (MVAs) [4–7], with up to a third of fatal accidents thought to involve sleepy drivers [8]. MVAs are a leading cause of death and disability in every country and incur huge societal and financial burdens, with Saudi Arabia witnessing particularly high MVA fatalities of nearly 20 deaths per day from over half a million traffic accidents annually [9, 10]. Despite being a high-income country, the estimated road traffic death rate in Saudi Arabia (28.8 per 100,000 population) is as high as low-income countries (27.5 per 100,000) and much higher than middle- (19.2 per 100,000) or other high-income countries (8.3 per 100,000) [11]. Furthermore, MVAs disproportionately affect younger individuals, with 72.7% occurring in the 30–49-year age group [12]. MVAs are therefore a "neglected epidemic" [12], and efforts are clearly required to identify the causes of, and provide interventions to prevent, MVAs in Saudi Arabia and other countries.

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Although several studies have examined predictors of sleep-related MVAs in specific groups such as individuals with obstructive sleep apnea [13, 14] and professional drivers (e.g., truck drivers) [15, 16], there are few population-level studies on the relationship between EDS and sleep-related MVAs. Furthermore, few studies have specifically examined the contribution of subjective sleep quality on driving outcomes in large populations. This study therefore examined if sleep quality and EDS affect falling asleep while driving and sleep-related MVAs/near-misses through a population-wide survey of adults in Saudi Arabia.

Methods

Population and study survey

This cross-sectional study was conducted online between November 6, 2019, and December 6, 2019, as previously reported [17]. Briefly, participants aged 18 years and older were randomly selected from the Saudi Telecom Company database, which covers all 13 Saudi provinces, and invited to participate by e-mail and telephone. Participants were informed of the research purpose and the investigator details. Each participant provided electronic consent.

Study questionnaire

The study survey was designed to establish how sleep quality and EDS impact social functioning and a range of outcomes not limited to falling asleep while driving and sleep-related MVAs/near-misses, such as occupational outcomes, as described elsewhere [17]. Briefly, the questionnaire (see the "Supplementary information" section) was administered in Arabic and assessed as follows: (i) demographics (gender, age, height, weight, marital status, type of work (manual/office)); (ii) sleep quality (subjective assessment of sleep quality, sleep latency, sleep duration, sleep efficiency (proportion of time spent asleep while in bed, expressed as a percentage)); (iii) the Epworth sleepiness scale (ESS; validated Arabic version [18]), subcategorized as per [19] into 0–10 normal daytime sleepiness, 11–12 mild excessive daytime sleepiness, 13–15 moderate excessive daytime sleepiness, 16–24 severe excessive daytime sleepiness; and (iv) whether the respondent had ever fallen asleep while driving a vehicle or had ever had an accident or a near accident due to falling asleep or being too tired while driving.

Statistical analysis

Student's t test was used to assess differences between continuous variables and the chi-squared test was used to assess differences between categorical variables. Parameters with p values < 0.25 in univariate analysis were selected to design the most appropriate binary logistic regression model for each outcome variable, since lower p value thresholds such as 0.05 can fail to identify variables known to be important [20, 21]. There were no strong intercorrelations between variables. Adjusted odds ratios were calculated with 95% confidence intervals (CIs). A p value of < 0.05 was considered statistically significant. All analyses were performed using SPSS Statistics v24 (IBM Statistics, Armonk NY).

Results

Respondent characteristics

Four thousand seven hundred eight (47%) of the 10,106 respondents were drivers. The demographics and sleep quality/daytime sleepiness of the driving population are presented in Table 1. Driving respondents were an average of 32.3 (SD ± 11.3) years old. The average BMI was 29.5 (SD ± 7.8) kg/m^2. About half of respondents were married, 47% were single, 2% were divorced, and 0.2% were widowed. A total of 16% had taken sleeping medication in the month before the survey, although the majority (12%) who had taken sleeping medication had taken it infrequently. Overall, 19% (902/3802) and 10% (474/4229) of respondents reported having fallen asleep, even briefly, while driving a vehicle or had an accident or near-miss due to sleepiness or falling asleep in the preceding year, respectively.

Prevalence of sleep quality parameters and daytime sleepiness

Overall, sleep quality was poor in the study population, with 29.0% and 9.5% of respondents reporting "fairly bad" or "very bad" sleep quality. Respondents slept an average of 6.5 h (SD ± 1.96) each night with an average sleep efficiency of 82.6% (SD ± 27.9%). A majority (58.8%) of respondents reported at least mild EDS, and the average ESS was 7.6 (SD ± 4.4) (Table 1).

Univariable analysis of demographics, sleep quality, EDS, and sleep-related driving outcomes

In univariable analysis, older individuals ($p < 0.0001$), men ($p < 0.0001$), individuals with a higher BMI ($p < 0.0001$), singletons ($p < 0.0001$), shorter sleep duration ($p < 0.0001$), worse sleep efficiency ($p = 0.003$), and higher ESS ($p < 0.0001$) were associated with having fallen asleep while driving in the previous year. With respect to having had/nearly had an accident due to being tired or falling asleep while driving in the previous year, younger individuals ($p = 0.01$), men ($p < 0.0001$), use of sleeping medications ($p = 0.01$), poorer subjective sleep quality ($p < 0.0001$), and higher ESS ($p < 0.0001$) were associated with a negative outcome (Table 1).

Table 1 Demographics of the survey respondents and associations with falling asleep at the wheel or having an accident/near miss in the preceding year

Variable		Total driving population		Fell asleep while driving previous year				Accident while driving previous year			
		Number	Percentage or mean (± SD0	No [mean ± SD/ number (%)]	Yes [mean ± SD/ number (%)]	Univariable analysis (*p* value)	Multivariable analysis (OR (95% CI); *p* value)	No [mean ± SD/ number (%)]	Yes [mean ± SD/ number (%)]	Univariable analysis	Multivariable analysis (OR (95% CI); *p* value)
Age (years)		4679	32.3 (11.3)	31.9 (11.4)	33.8 (10.9)	< 0.0001	0.99 (0.98–1.00; 0.26)	32.4 (11.5)	31.0 (10.1)	0.01	**0.98 (0.97–0.99; 0.001)**
Gender	Male	4071	86.5	3190 (83.9)	877 (97.2)	< 0.0001		3614 (85.5)	452 (95.4)	<0.0001	–
	Female	638	13.5	612 (16.1)	25 (2.8)		**0.14 (0.09–0.22; <0.0001)**	615 (14.5)	22 (4.6)		**0.20 (0.13–0.33; <0.0001)**
BMI (kg/m^2)		4668	29.5 (7.8)	29.1 (7.8)	31.0 (7.4)	< 0.0001	1.01 (1.00–1.02; 0.08)	29.4 (7.8)	20.1 (7.3)	0.07	1.00 (0.99–1.01; 0.89)
Marital status	Married	2376	50.5	1837 (48.4)	538 (61.1)	< 0.0001		2150 (51.1)	224 (48.2)	0.68	NA
	Divorced	97	2.1	75 (2.0)	21 (2.4)		1.24 (0.74–2.07; 0.41)	86 (2.0)	11 (2.4)		
	Single	2197	46.7	1872 (49.3)	321 (36.5)		**0.70 (0.56–2.07; 0.002)**	1964 (46.7)	229 (49.2)		
	Widowed	9	0.2	9 (0.2)	0 (0)		NA	8 (0.2)	1 (0.2)		
Type of employment	Manual	469	10.0	349 (9.2)	119 (13.5)	< 0.0001		410 (9.7)	58 (12.5)	0.07	–
	Office	3386	71.9	2724 (71.8)	658 (74.8)		**1.58 (1.15–2.17; 0.004)**	3043 (72.3)	338 (72.7)		1.19 (0.81–1.74; 0.38)
	Unemployed	824	17.5	721 (19.0)	103 (11.7)		1.25 (0.98–1.59; 0.12)	755 (17.9)	69 (14.8)		1.04 (0.78–1.38; 0.81)
Sleeping medications	Never	3959	84.1	3209 (84.4)	746 (82.7)	0.64	NA	3580 (84.7)	374 (78.9)	0.01	–
	Several days	546	11.6	431 (11.3)	114 (12.6)			473 (11.2)	72 (15.2)		**1.38 (1.04–1.82; 0.03)**
	More than half of days	117	2.5	92 (2.4)	25 (2.8)			100 (2.4)	17 (3.6)		1.39 (0.80–2.42; 0.24)
	Nearly every day	87	1.8	70 (1.8)	17 (1.9)			76 (1.8)	11 (2.3)		1.32 (0.68–2.55; 0.41)
Subjective sleep quality	Very good	724	15.4	603 (15.9)	120 (13.3)	0.13		680 (16.1)	43 (9.1)	<0.0001	–
	Fairly good	2172	46.1	1762 (46.3)	409 (45.3)		1.17 (0.92–1.49; 0.20)	1949 (46.1)	221 (46.6)		**1.60 (1.12–2.27; 0.009)**
	Fairly bad	1366	29.0	1085 (28.5)	279 (30.9)		**1.36 (1.04–1.78; 0.03)**	1215 (28.7)	149 (31.4)		**1.63 (1.12–2.38; 0.01)**
	Very bad	447	9.5	352 (9.3)	94 (10.4)		**1.54 (1.09–2.18; 0.02)**	385 (9.1)	61 (12.9)		**2.11 (1.36–3.29; 0.001)**
Sleep latency	0–5 min	349	7.4	267 (7.0)	81 (9.0)	0.09	–	313 (7.4)	36 (7.6)	0.84	NA
	5–15 min	1297	27.5	1033 (27.2)	262 (29.0)		0.80 (0.59–1.08-2.18; 0.15)	1159 (27.4)	136 (28.7)		
	15–30 min	1354	28.8	1102 (29.0)	251 (27.8)		**0.69 (0.51–0.94; 0.02)**	1223 (28.9)	128 (27.0)		
	> 30 min	1709	36.3	1400 (36.8)	308 (34.1)		**0.62 (0.46–0.85; 0.007)**	1534 (36.3)	174 (36.7)		
Sleep duration (h)		4709	6.5 (1.96)	6.6 (2.0)	6.2 (1.8)	< 0.0001	**0.91 (0.85–0.97; 0.007)**	6.5 (1.9)	6.4 (2.1)	0.21	0.95 (0.88–1.04; 0.25)
Sleep efficiency (%)		4661	82.6 (27.9)	83.2 (28.3)	80.2 (25.9)	0.003	1.00 (1.00–1.01; 0.19)	82.8 (27.8)	81.1 (29.2)	0.19	1.00 (1.00–1.01; 0.36)
Excessive daytime sleepiness	Normal	1941	41.2	1546 (40.7)	393 (43.6)	< 0.0001	–	1753 (41.5)	185 (39.0)	<0.0001	–
	Low	2145	45.6	1836 (48.3)	306 (33.9)		**0.66 (0.55–0.78; < 0.0001)**	1954 (46.2)	188 (39.7)		0.90 (0.73–1.12; 0.36)
	Moderate	415	8.8	272 (7.2)	143 (15.9)		**2.46 (1.92–3.16; <0.0001)**	351 (8.3)	64 (13.5)		**1.90 (1.38–2.60; < 0.0001)**
	Severe	208	4.4	148 (3.9)	60 (6.7)		**2.36 (1.64–3.42; < 0.0001)**	171 (4.0)	37 (7.8)		**2.39 (1.56–3.67; < 0.0001)**

Multivariable analysis of demographics, sleep quality, EDS, and sleep-related driving outcomes

In multivariable analysis (Table 1), being female [OR 0.14 (95% CI 0.09–0.22); $p < 0.0001$], single [OR 0.70 (95% CI 0.56–2.11); $p = 0.002$], taking longer to fall asleep [OR 0.62 (95% CI 0.46–0.85; $p = 0.007$ for > 30 min sleep latency], and having a shorter sleep duration [OR 0.91 (95% CI 0.84–0.97); $p = 0.007$] were associated with a reduced odds of having fallen asleep while driving in the previous year while being an office worker [OR 1.58 (95% CI 1.15–2.17; $p = 0.004$], having fairly or very bad sleep quality [OR 1.36 (95% CI 1.04–1.78); $p = 0.03$ and OR 1.54 (95% CI 1.09–2.18); $p = 0.02$, respectively], and having moderate or severe EDS [OR 2.46 (95% CI 1.92–3.16); $p < 0.0001$ and OR 2.36 (95% CI 1.64–3.42); $p < 0.0001$, respectively] were associated with an increased odds of having fallen asleep while driving in the previous year. With respect to having had/nearly had an accident due to being tired or falling asleep while driving in the previous year, younger age [OR 0.98 (95% CI 0.97–0.99); $p = 0.001$], being male [OR 0.20 (95% CI 0.13–0.33); $p < 0.0001$], having worse subjective sleep quality [OR 2.11 (95% CI 1.36–3.29); $p < 0.0001$ for "very bad" sleep quality], and having moderate or severe EDS [OR 1.90 (95% CI 1.38–2.60); $p < 0.0001$ and OR 2.39 (95% CI 1.56–3.67); $p < 0.0001$] were associated with a negative outcome.

Discussion

Insufficient sleep can have fatal consequences, and up to 30% of MVAs are related to drowsy driving [8]. This study shows that sleep dysfunction in Saudi Arabia is highly prevalent: sleep quality was "fairly" or "very bad" in 39% of respondents, and 13% had moderate or severe EDS. The average sleep duration of the sample was six and a half hours, less than reported in the Australian 2016 Sleep Health Foundation National Survey (7 h; [22]) and under the 7–9 h recommended by the National Sleep Foundation [23].

Overall, approximately 20% and 10% of respondents reported having fallen asleep, even briefly, while driving a vehicle or having had an accident or near-miss due to sleepiness or falling asleep while driving in the preceding year. These data corroborate data from other nationwide or population-level surveys. In their study of 4774 drivers in France, Sagaspe et al. [7] found that 28% of drivers experienced at least one episode of severe sleepiness while driving, and approximately 5% had a near-miss or actual driving accident associated with sleepiness in the previous year. In a smaller study of 1219 (non-professional) drivers interviewed in the waiting rooms of bus stations, train stations, and hospitals in Saudi Arabia, 25.2% of respondents had fallen asleep at the wheel in the preceding 6 months and 7.4% self-reported having an accident caused by sleepiness [10]. In a large US survey of 150,000 drivers in 19 states and the District of Columbia, 4.2% reported having fallen asleep while driving during the previous 30 days [8]. Despite differences in methodologies and populations, a significant proportion of the population admits to falling asleep while driving or sleepiness contributing to an MVA. Given that drivers may feel reluctant to admit dangerous behavior or having been involved in sleep-related accidents, these figures may well be an underestimate.

Several attempts have been made to identify risk factors for falling asleep while driving or sleep-related MVAs, but the data are heterogeneous. In the current cohort, the vast majority of drivers were male (86.5%), with women only having been allowed to drive in Saudi Arabia since June 2018. Despite this potential source of bias, being male was the strongest predictor of both falling asleep while driving (OR 0.14 (95% CI 0.09–0.22); $p < 0.0001$ for women compared to men) and having an accident or near miss while driving (OR 0.20 (95% CI 0.13–0.33); $p < 0.0001$ for women compared to men), consistent with previous studies [5, 7, 24], although the magnitude of effect seen in the current study might suggest that the relatively new cohort of female Saudi drivers might be extremely cautious. Although other studies have reported younger age as an independent risk factor for sleepiness while driving [7, 25] or sleep-related MVAs [10], in our cohort the risk associated with younger age and sleep-related MVAs or near misses was extremely small (OR 0.98), perhaps due to the age of the population, which, although representative, was young; approximately 30% of the Saudi population is in the young age group (between 15 and 29 years old) [10]. Consistent with a study of 4097 drivers in Tokyo, we similarly detected that shorter sleep duration was associated with an increased risk of falling asleep while driving [24], but a shorter sleep duration was not associated with sleep-related MVAs/near-misses. Similarly, sleep latency was protective against falling asleep while driving (OR 0.62 for > 30 min to fall asleep) and was not associated with sleep-related MVAs/near misses. This finding was surprising given that insomnia, where difficulty falling asleep is one of the cardinal symptoms [26], is usually associated with an increased risk of MVAs and other unintentional fatal injuries [15]. However, insomnia was not formally assessed in the current study (i.e., to include difficulty maintaining sleep and early morning wakening), which might explain the conflicting findings. Nevertheless, these differences in risk factors between falling asleep while driving and actual accidents highlight that while falling asleep at the wheel is a known risk factor for MVAs [4–7], occurrences of falling asleep while driving far outnumber MVAs and the factors that govern these processes are different and multifactorial.

However, sleepiness as measured by the ESS was consistently associated with falling asleep while driving and sleep-related MVAs/near misses, with the effect proportional to EDS severity and an ESS ≥ 16 associated with an ~2.5-fold increased risk of both outcomes. In this sample, 58.8% of respondents reported at least mild EDS and 13.2% moderate or severe EDS. The data on EDS and sleep-related MVAs are conflicting. Several studies have similarly detected independent associations between EDS as measured by the ESS and sleepy driving accidents in both the general driving population [25, 27] and in professional truck drivers [16]. For example, Philip et al. [25] similarly detected an ordered relationship between ESS scores and the risk of sleep-driving accidents; similar to here, individuals with an ESS between 11 and 15 had a 2.2-fold risk of a sleep-driving accident and those with an ESS $\geq$ 15 a fivefold risk of an accident in adjusted models. Powell et al. [27] also found that ESS was independently associated with near-misses or actual accidents, with a one-unit increase in ESS conferring a 4.4% increase in having at least one accident. Other studies have failed to detect this association [7, 10, 28–30]. However, three of these investigations were case-control studies in which cases were individuals receiving treatment having been in an accident [28, 29], so drivers were identifiable, involved in the immediate aftermath of the accident, and may have therefore been less willing to be honest about predisposing factors for fear of blame. The current study was not subject to such bias, since respondents were anonymous. Another possible reason for these differences might include the different timeframes over which events were reported (6 months to 3 years) [7, 10], and in contrast to these studies not detecting an association between EDS and falling asleep while driving/MVA-related accidents, the current population had a much higher prevalence of EDS, improving the statistical power to detect an effect. Subjective sleep quality conferred a 1.36–1.54-fold risk of falling asleep at the wheel and a 1.60–2.11-fold risk of sleep-related MVAs/near-misses, increasing with severity.

Few studies have investigated the impact of subjective sleep quality on MVAs. However, Philip et al. [30] examined subjective sleep quality using a case-control methodology of hospitalized drivers and control drivers and found a 3.35-fold risk of having had an accident in individuals reporting pretty bad/very bad sleep quality in the preceding 3 months. In their study of 339 high school student drivers, Pizza et al. similarly reported a 1.9-fold risk of having had a crash in individuals reporting bad sleep quality [31]. With respect to falling asleep while driving, Abe et al. [24] similarly found that subjective insufficiency of nocturnal sleep was independently associated with falling asleep while driving.

Like any self-reporting cross-sectional survey study, it had a number of important limitations, and causality cannot be inferred. Since respondents were selected from an online panel, there may have been selection bias, not least from those experiencing sleep problems. Individuals can overestimate how long it takes to get to sleep and underestimate how long they have been asleep [32]; furthermore, the responses to sleep and driving questions were self-reported and may have been subject to recall bias. There may also have been responder bias, since prospective participants were told about the purpose of the research. Nevertheless, the median age of respondents (29 years vs. 30.0 years) and high prevalence of obesity (BMI $\geq$ 30; 32% vs. 44.6%) are consistent with Saudi Arabian sociodemographic data [33], increasing confidence that the survey represents the wider population. As noted above, the unique situation in Saudi Arabia of women only recently having been permitted to drive meant that men were significantly overrepresented, introducing some bias; however, this also provides some insights into the current minimal contribution of female drivers to MVAs in Saudi Arabia. Furthermore, near misses and actual accidents were not explicitly differentiated. The ESS enquires about an individual's propensity to fall asleep in different scenarios (e.g., while watching television) in the "present or recent past", while the survey questionnaire asked respondents to consider their driving over the previous year, which may have introduced recall bias. However, the ESS has been shown to have good levels of internal consistency when tested and re-tested in sleepy drivers over a 3-year period [34]. The answers to the ESS are subjective and although the instrument is well validated, it may not reflect objective measures of sleepiness [35].

Nevertheless, this is the largest population-based analysis of associations between sleep factors and sleepy driving in Saudi Arabia, and the first data to include female drivers in Saudi Arabia. Sleepy driving and sleep-related accidents/near-misses are common in Saudi Arabia. The data show that, in addition to demographic factors, EDS was consistently associated with falling asleep while driving and a history of a sleep-related accident or near miss. Further efforts are required to quantify the contribution of sleepiness to MVAs to develop and prioritize interventions to prevent MVA-related injuries and death. Road safety campaigns must encourage drivers to practice good sleep hygiene at all times.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s11325-020-02260-5.

Author contributions SA conceived and designed the study, conducted research, provided research materials, collected, and organized data, analyzed and interpreted data, wrote the initial and final draft of the article, and provided logistic support. He has critically reviewed and approved the final draft and is responsible for the content and similarity index of the manuscript.

Compliance with ethical standards

Ethical approval The internal review board (IRB) of Imam Mohammad Ibn Saud Islamic University (IMSIU) reviewed the project, and participants provided electronic consent before participation.

Conflict of interest No conflict of interest.

References

1. Chanchlani N (2017) Health consequences of shift work and insufficient sleep. BMJ 356:i6599. https://doi.org/10.1136/sbmj.i6599
2. Young TB (2004) Epidemiology of daytime sleepiness: definitions, symptomatology, and prevalence. J Clin Psychiatry 65(Suppl 16):12–16
3. Kolla BP, He JP, Mansukhani MP, Frye MA, Merikangas K (2020) Excessive sleepiness and associated symptoms in the U.S. adult

population: prevalence, correlates, and comorbidity. Sleep Health 6(1):79–87. https://doi.org/10.1016/j.sleh.2019.09.004
4. de Mello MT, Narciso FV, Tufik S, Paiva T, Spence DW, Bahammam AS, Verster JC, Pandi-Perumal SR (2013) Sleep disorders as a cause of motor vehicle collisions. Int J Prev Med 4(3): 246–257
5. Nabi H, Gueguen A, Chiron M, Lafont S, Zins M, Lagarde E (2006) Awareness of driving while sleepy and road traffic accidents: prospective study in GAZEL cohort. BMJ 333(7558):75. https://doi.org/10.1136/bmj.38863.638194.AE
6. Phillips RO, Sagberg F (2013) Road accidents caused by sleepy drivers: update of a Norwegian survey. Accid Anal Prev 50:138–146. https://doi.org/10.1016/j.aap.2012.04.003
7. Sagaspe P, Taillard J, Bayon V, Lagarde E, Moore N, Boussuge J, Chaumet G, Bioulac B, Philip P (2010) Sleepiness, near-misses and driving accidents among a representative population of French drivers. J Sleep Res 19(4):578–584. https://doi.org/10.1111/j.1365-2869.2009.00818.x
8. Centers for Disease Control and Prevention (2013) Drowsy driving - 19 states and the District of Columbia, 2009-2010. MMWR Morb Mortal Wkly Rep 61(51–52):1033–1037
9. Ageli M, Zaidan A (2013) Road traffic accidents in Saudi Arabia: an ardl approach and multivariate granger causality. Ageli, Mohammed Moosa (2013)'Road Traffic Accidents in Saudi Arabia: An ARDL Approach and Multivariate Granger Causality' Journal of Economics and Finance 5 (7)
10. BaHammam AS, Alkhunizan MA, Lesloum RH, Alshanqiti AM, Aldakhil AM, Pandi-Perumal SR, Sharif MM (2014) Prevalence of sleep-related accidents among drivers in Saudi Arabia. Ann Thorac Med 9(4):236–241. https://doi.org/10.4103/1817-1737.140138
11. World Health Organization (2016) Global Health Observatory (GHO) Road Safety Data. https://www.who.int/gho/road_safety/mortality/en/. Accessed 14 Oct 2020
12. Ghaffar U, Ahmed S (2015) A review of road traffic accident in Saudi Arabia: the neglected epidemic. Indian journal of forensic and community medicine 2(4):242–246
13. Engleman HM, Asgari-Jirhandeh N, McLeod AL, Ramsay CF, Deary IJ, Douglas NJ (1996) Self-reported use of CPAP and benefits of CPAP therapy: a patient survey. Chest 109(6):1470–1476. https://doi.org/10.1378/chest.109.6.1470
14. Krieger J, Meslier N, Lebrun T, Levy P, Phillip-Joet F, Sailly JC, Racineux JL (1997) Accidents in obstructive sleep apnea patients treated with nasal continuous positive airway pressure: a prospective study. The Working Group ANTADIR, Paris and CRESGE, Lille, France Association Nationale de Traitement a Domicile des Insuffisants Respiratoires Chest 112 (6):1561–1566. doi:https://doi.org/10.1378/chest.112.6.1561
15. Garbarino S, Magnavita N, Guglielmi O, Maestri M, Dini G, Bersi FM, Toletone A, Chiorri C, Durando P (2017) Insomnia is associated with road accidents. Further evidence from a study on truck drivers. PLoS one 12 (10):e0187256. doi:https://doi.org/10.1371/journal.pone.0187256
16. Howard ME, Desai AV, Grunstein RR, Hukins C, Armstrong JG, Joffe D, Swann P, Campbell DA, Pierce RJ (2004) Sleepiness, sleep-disordered breathing, and accident risk factors in commercial vehicle drivers. Am J Respir Crit Care Med 170(9):1014–1021. https://doi.org/10.1164/rccm.200312-1782OC
17. AlShareef SM (2020) Occupational outcomes associated with sleep quality and excessive daytime sleepiness: results from a national survey. Nat Sci Sleep 12:875–882. https://doi.org/10.2147/NSS.S271154
18. Ahmed AE, Fatani A, Al-Harbi A, Al-Shimemeri A, Ali YZ, Baharoon S, Al-Jahdali H (2014) Validation of the Arabic version of the Epworth sleepiness scale. J Epidemiol Glob Health 4(4):297–302. https://doi.org/10.1016/j.jegh.2014.04.004
19. Johns MW (1991) A new method for measuring daytime sleepiness: the Epworth sleepiness scale. Sleep 14(6):540–545
20. Bendel RB, Afifi AA (1977) Comparison of stopping rules in forward “stepwise” regression. J Am Stat Assoc 72(357):46–53
21. Mickey RM, Greenland S (1989) The impact of confounder selection criteria on effect estimation. Am J Epidemiol 129(1):125–137
22. Adams RJ, Appleton SL, Taylor AW, Gill TK, Lang C, McEvoy RD, Antic NA (2017) Sleep health of Australian adults in 2016: results of the 2016 Sleep Health Foundation national survey. Sleep Health 3(1):35–42. https://doi.org/10.1016/j.sleh.2016.11.005
23. Khubchandani J, Price JH (2020) Short sleep duration in working American adults, 2010-2018. J Community Health 45(2):219–227. https://doi.org/10.1007/s10900-019-00731-9
24. Abe T, Komada Y, Inoue Y (2012) Short sleep duration, snoring and subjective sleep insufficiency are independent factors associated with both falling asleep and feeling sleepiness while driving. Intern Med 51(23):3253–3260. https://doi.org/10.2169/internalmedicine.51.7518
25. Philip P, Sagaspe P, Lagarde E, Leger D, Ohayon MM, Bioulac B, Boussuge J, Taillard J (2010) Sleep disorders and accidental risk in a large group of regular registered highway drivers. Sleep Med 11(10):973–979. https://doi.org/10.1016/j.sleep.2010.07.010
26. American Academy of Sleep Medicine (2005) International classification of sleep disorders. Diagnostic and coding manual:51–55
27. Powell NB, Schechtman KB, Riley RW, Guilleminault C, Chiang RP, Weaver EM (2007) Sleepy driver near-misses may predict accident risks. Sleep 30(3):331–342. https://doi.org/10.1093/sleep/30.3.331
28. Connor J, Norton R, Ameratunga S, Robinson E, Civil I, Dunn R, Bailey J, Jackson R (2002) Driver sleepiness and risk of serious injury to car occupants: population based case control study. BMJ 324(7346):1125. https://doi.org/10.1136/bmj.324.7346.1125
29. Teran-Santos J, Jimenez-Gomez A, Cordero-Guevara J (1999) The association between sleep apnea and the risk of traffic accidents. Cooperative group Burgos-Santander. N Engl J Med 340 (11):847–851. doi:https://doi.org/10.1056/NEJM199903183401104
30. Philip P, Chaufton C, Orriols L, Lagarde E, Amoros E, Laumon B, Akerstedt T, Taillard J, Sagaspe P (2014) Complaints of poor sleep and risk of traffic accidents: a population-based case-control study. PLoS One 9(12):e114102. https://doi.org/10.1371/journal.pone.0114102
31. Pizza F, Contardi S, Antognini AB, Zagoraiou M, Borrotti M, Mostacci B, Mondini S, Cirignotta F (2010) Sleep quality and motor vehicle crashes in adolescents. J Clin Sleep Med 6(1):41–45
32. Harvey AG, Tang NK (2012) (Mis)perception of sleep in insomnia: a puzzle and a resolution. Psychol Bull 138(1):77–101. https://doi.org/10.1037/a0025730
33. Index Mundi (2019) Saudi Arabia demographics profile 2018. Mundi Index. Available from:< http://www.indexmundi.com/saudi_arabia
34. Maycock G (1997) Sleepiness and driving: the experience of U.K. car drivers. Accid Anal Prev 29(4):453–462. https://doi.org/10.1016/s0001-4575(97)00024-9
35. Chervin RD, Aldrich MS (1999) The Epworth sleepiness scale may not reflect objective measures of sleepiness or sleep apnea. Neurology 52(1):125–125