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## Association between sleep quality and secondhand smoke among non-smoker university students in Saudi Arabia: A multiple logistic regression analysis

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**ABSTRACT**

*Introduction:* Sleep quality and secondhand smoke are two different, complex health problems that can be life-threatening for humans. The purpose of this study was to determine the linkage between secondhand smoke exposure and poor sleep quality among non-smoker university students in Saudi Arabia. *Methods:* A cross-sectional investigation was undertaken among students from two universities in Saudi Arabia. Data were collected by using an online platform with a structured questionnaire. Participants' sleep quality was assessed by Pittsburgh Sleep Quality Index. A score of more than five was categorized as a poor level of sleep. Multiple logistic regression models were employed to assess the relationship. *Results:* Of the total 500 participants, 57.2% were males and 42.8% were females. The prevalence of poor sleep and secondhand smoke among non-smoker university students was 60.2% and 46.2%, respectively. The adjusted regression analysis demonstrated that students exposed to secondhand smoke were four times more likely to have poor sleep compared to their counterparts (adjusted odds ratio, aOR = 4.08; 95% confidence interval, CI: 2.55, 6.52). A significant relationship between secondhand smoke exposure and poor sleep quality was also found in both male (aOR = 2.55; 95% CI: 1.17, 5.60) and female (aOR = 5.39; 95% CI: 2.88, 10.09) subgroups. *Conclusion:* A statistically significant linkage between secondhand smoke exposure and poor sleep quality was found among Saudi Arabian students. Therefore, taking precautions against secondhand smoke exposure and encouraging smoking cessation to improve university students' sleep quality is crucial.

**Keywords:** Poor sleep quality, secondhand smoke, university students, Saudi Arabia

## 1. INTRODUCTION

Sleep is a physiological activity crucial for maintaining individuals' health and well-being (Carley and Farabi, 2016). Globally, poor sleep quality has become a life-threatening problem for public health. For example, in Saudi Arabia, several studies indicated a greater prevalence of poor sleep among students, ranging from 63.2% to 74.2% (Al-Khani and Saquib, 2019; Ibrahim et al., 2018; Mahfouz et al., 2020; Siddiqui et al., 2016). Consequently, inadequate and inappropriate sleep could result in serious morbidity and complications such as cardiovascular diseases, obesity, psychological problems and neurodegenerative diseases (Bayon and Chennaoui, 2014; Cappuccio and Miller, 2011; Cheng and Feng, 2018; Malhotra, 2018).

Sleep quality was generally associated with several factors, with environmental and behavioral factors playing a key role (Halperin, 2014; Lund and Prichard, 2010). It is well-recognized that active cigarette smoking is linked to sleep disturbances (Mcnamara et al., 2014). However, the effect of alternative types of tobacco exposure such as secondhand smoke (SHS)/passive smoking on sleep quality is still little investigated, particularly among student sub-groups. Passive smoking is a risky by product of active smoking, which harms the cardiovascular system and lung (Juraybi et al., 2021). Inconsistent results have been found in the few research that has been studied the relationship between passive smoking and poor sleep-in particular populations. A recent study from China reported that SHS is related to poor quality of sleep among never smokers' adults (Wang et al., 2022). A meta-analysis of cross-sectional studies revealed that exposure to SHS is significantly associated with poor quality of sleep among adolescents but the relationship is not the same in adult subgroups (Safa and Chu, 2020). For public health and policy implications, a better understanding of the mechanism of this modifiable risk factor (passive smoking) of inappropriate sleep is crucial.

Adequate and proper sleep allows the brain to work at its best (i.e., cognitive enhancement), which enhances knowledge and the capacity to learn new approaches (Diekelmann, 2014). University students might struggle with poor sleep quality because of relatively high academic responsibilities, additionally students' lifestyle pattern changes during university years with increased flexibility and freedom, a shift in peer relations and new social connections with other people. As a result, they are more vulnerable to developing sleep disorders and in some cases substance abuse (Mahfouz et al., 2020; Schlarb and Claßen, 2017). Hence, in the current study, the authors anticipated that exposure to SHS is related to poor quality of sleep among vulnerable population groups like non-smoker university students in Saudi Arabia.

In Saudi Arabia, several studies have evaluated sleep quality among students (medical and non-medical university students) (Al-Khani et al., 2019; Ibrahim et al., 2018; Mahfouz et al., 2020; Siddiqui et al., 2016). These studies reported the prevalence of sleep quality and documented several factors of sleep quality like depression, anxiety stress, academic performance, sleep behaviors, mobile phone addiction and physical activity. Even though both SHS and decreased quality of sleep are prevalent in Saudi Arabia, no study assesses the relationship between these parameters in the country. Therefore, the purpose of this survey was to assess the relationship between SHS exposure and poor sleep quality among a sample of non-smoker university students in Saudi Arabia. The findings of this study could bridge the knowledge gap and provide baseline data for policymakers to develop control measures.

## 2. MATERIALS AND METHODS

### **Survey design, procedure and data source**

A cross-sectional investigation was carried out among 500 university students from King Abdulaziz University and University of Jeddah, Saudi Arabia to determine the linkage between SHS exposure and poor quality of sleep. The study eligibility criterion was as follows: Any student studying in the two universities who is a non-smoker. However, students with serious illnesses, psychological issues and unwillingness to participate were the exclusion criteria of this study. The survey was conducted between August and November 2022.

Data were collected by an online platform using a Google survey link. The Google link contained the survey questionnaire, which was structured and the questions were close-ended. At first, the study team obtained the students' contact details (such as email account) from the relevant department(s) of the university. Then, we randomly emailed the survey link to the student's institutional email addresses. In the email body, the main objectives, eligibility criteria of the study and confidentiality statement were described briefly. We used a primary screening question to screen non-smoking students. The screening question was (yes vs. no), "Have you smoked in the last month?" The students who responded "no" (i.e., non-smokers) were encouraged to participate in the study by clicking the attached Google survey link. This study had no scope to participate in this study for current-smoker students. Initially, the study team emailed the survey link to 850 students and data-taking was stopped when 500 responses were obtained. To conduct this study, 500 samples were a higher sample than our calculated sample size.

We calculated a minimum sample of 354 participants using a single sample proportion test considering the following assumptions: (i) 63.9% prevalence of poor level of sleep among Saudi Arabian university students ( $p = 0.64$ ) based on the previous study (Mahfouz et al., 2020), (ii) 95% level of confidence ( $Z = 1.96$ ) and (iii) 5% margin of error ( $e = 0.05$ ).

**Study variables and measurement**

Sleep quality is the dependent variable of this study. Pittsburgh Sleep Quality Index (PSQI) was utilized to evaluate the subject quality of sleep over the last 30 days (Buysse et al., 1991). This 19-items scale is broken down into seven categories and the score of each category varies from 0 to 3. The seven domain’s ratings are added up to create the overall PSQI score, which ranges from 0 to 21. Finally, a PSQI score above 5 was considered as poor sleep quality. The internal consistency of this scale was within the acceptable limit (Cronbach's alpha= 0.70). Several Saudi Arabian studies used this scale, particularly among student groups (Al-Khani et al., 2019; Ibrahim et al., 2018; Mahfouz et al., 2020; Siddiqui et al., 2016).

Secondhand smoke exposure (the main predictor variable) of the participants was assessed based on the previous study (Wang et al., 2022). The assessment question was (yes vs. no): “Are you exposed to secondhand smoke in a confined environment for more than 15 minutes at a time within a week?” This study also included other factors as covariates. This includes respondents’ gender, age, family income, educational background, marital status, residence, self-reported body mass index (BMI), screen time, owning a laptop, physical activity and history of chronic disease. All of these covariates were included based on the previous literature.

**Data analysis**

Data were analyzed by Statistical Package for the Social Sciences (SPSS) software (SPSS, IBM version 23.0, Armonk, NY, USA). Descriptive statistics such as responses, percentages and means were computed to summarize the variable of interest. A chi-square test was done to assess the distribution of sleep quality status (outcome variable) across the other variables. A multiple logistic regression analysis was employed to identify the association between SHS exposure and poor sleep quality. Several covariates, along with SHS exposure, were included in the adjusted regression model to assess the estimated adjusted effect. Subgroups analysis (i.e., male and female subgroups) was also performed. The regression models' fitness criteria were checked by Hosmer and Lemeshow test. The odds ratio with a 95% confidence interval (CI) was estimated for both unadjusted and adjusted regression models. A statistical significance was set at  $<0.05$  ( $p < 0.05$ ).

**3. RESULTS**

Participants' characteristics are summarized in Table 1. More than half (57.2%) of the participants were male with a mean age of 22.6 years (SD: 1.55). The chi-square test showed gender ( $p = 0.001$ ) and SHS exposure ( $p < 0.001$ ) were significantly associated with sleep quality (Table 1)

**Table 1** Distribution of sleep quality based on participants’ characteristics (n=500)

Variables	Categories	Total, n (%)	Sleep Quality, n (%)		P value
			Good	Poor	
Gender	Male	286 (57.2%)	96 (33.6)	190 (66.4)	0.001
	Female	214 (42.8%)	103 (48.1)	111 (51.9)	
Age (years)	18-21	137 (27.4%)	56 (40.9)	81 (59.1)	0.686
	22-25	250 (50.0%)	102 (40.8)	148 (59.2)	
	>25	113 (22.6%)	41 (20.6)	72 (63.7)	
Family Income (SR)	<5,000	78 (15.6%)	38 (48.7)	40 (51.3)	0.151
	5,000-9,999	125 (25.0%)	41 (32.8)	84 (67.2)	
	10,000-15,000	184 (36.8%)	73 (39.7)	111 (60.3)	
	>15,000	113 (22.6%)	47 (41.6)	66 (58.4)	
Subject of Study	Medicine	80 (16.0%)	24 (30.0)	56 (70.0)	0.138
	Education	210 (42.0%)	81 (38.6)	129 (61.4)	
	Science	185 (37.0%)	83 (44.9)	102 (55.1)	
	Others	25 (5.0%)	11 (44.0)	14 (56.0)	
Marital Status	Single	460 (92.0%)	185 (40.2)	275 (59.8)	0.518
	Married	40 (8.0%)	14 (35.0)	26 (65.0)	

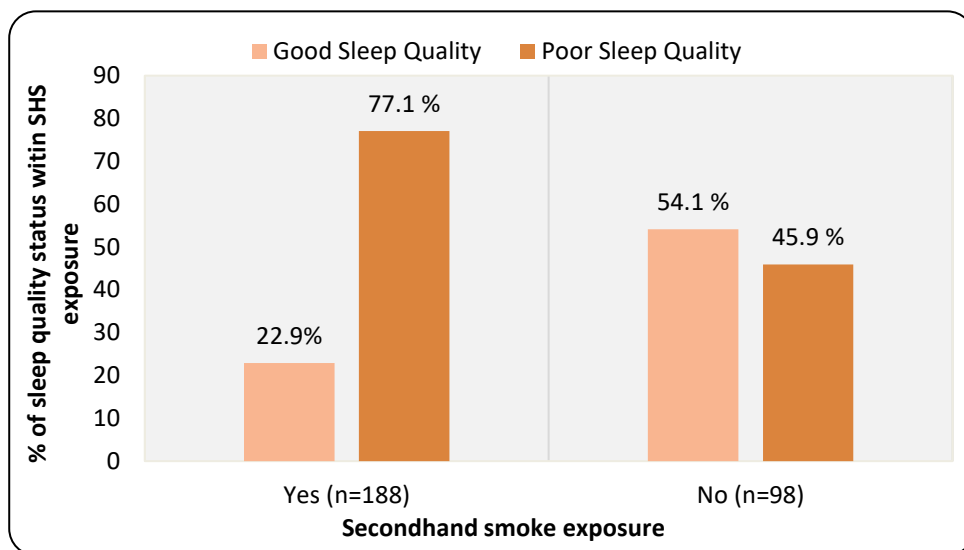
Residence	Own house	180 (36.0%)	77 (42.8)	103 (57.2)	0.224
	Rented house	85 (17.0%)	27 (31.8)	58 (68.2)	
	Dormitory	235 (47.0%)	95 (40.4)	140 (59.6)	
Self-reported BMI	Underweight	79 (15.8%)	40 (50.6)	39 (49.4)	0.068
	Normal weight	330 (66.0%)	121 (36.7)	209 (63.3)	
	Overweight	91 (18.2%)	38 (41.8)	53 (58.2)	
Screen Time	<5 hours	127 (25.4%)	47 (37.0)	80 (63.0)	0.388
	5-10 hours	178 (35.6%)	78 (43.8)	100 (56.2)	
	>10 hours	195 (39.0%)	74 (37.9)	121 (62.1)	
Own a laptop	Yes	324 (64.8%)	125 (38.6)	199 (61.4)	0.450
	No	176 (35.2%)	74 (42.0)	102 (58.0)	
Physical Activity	Physically inactive	87 (17.4%)	36 (41.4)	51 (58.6)	0.740
	Moderate activity	209 (41.8%)	79 (37.8)	130 (62.2)	
	Regular activity	204 (40.8%)	84 (41.2)	120 (58.8)	
Chronic Disease	Yes	140 (28.0%)	49 (35.0)	91 (65.0)	0.171
	No	360 (72.0%)	150 (41.7)	210 (58.3)	
SHS exposure	Yes	231 (46.2%)	55 (23.8)	176 (76.2)	<0.001
	No	269 (53.8%)	144 (53.5)	125 (46.5)	
SR= Saudi Riyals (currency), BMI= body mass index, SHS= secondhand smoke, Bolded and italic values indicate statistically significant.					

Of the total sample, 60.2% (n=301) of the students had poor sleep quality and 39.8% (n=199) had good sleep quality. Approximately, 46.2% (n=231) of students reported SHS exposure. Moreover, the prevalence of poor levels of sleep was higher in students who were exposed to SHS than in those who were not exposed to SHS (76.2% vs. 46.5%) (Table 1). Adjusted regression analysis demonstrated that students who were exposed to SHS were 4 times higher likely to have poor sleep compared to their counterparts (adjusted odds ratio, aOR = 4.08; 95% CI: 2.55, 6.52) (Table 2).

**Table 2** Association between secondhand smoke exposure and poor sleep quality among non-smoker university students in Saudi Arabia

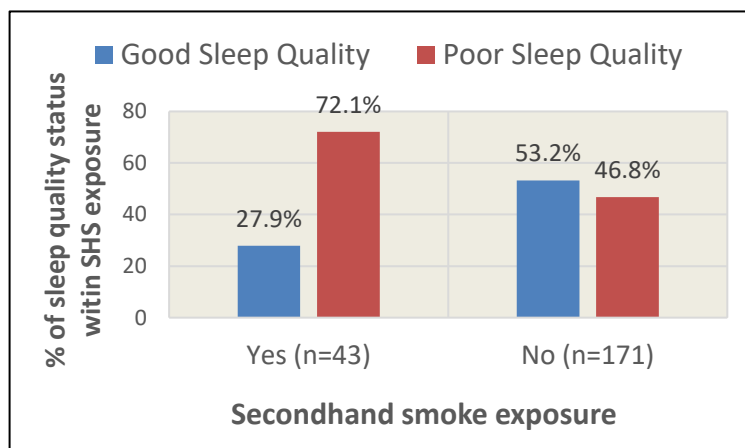
Varibale	Unadjusted regression model				Adjusted regression model			
	OR	95% CI		P value	aOR	95% CI		P value
		Lower	Upper			Lower	Upper	
SHS exposure (yes vs. no)								
All sample (n=500) †	3.69	2.51	5.42	<0.001	4.08	2.55	6.51	<0.001
Males (n=286) ††	2.94	1.42	6.10	0.004	2.55	1.17	5.60	0.019
Females (n=214) †††	3.97	2.35	6.70	<0.001	5.39	2.88	10.09	<0.001
Note: SHS=secondhand smoke, aOR= adjusted odds ratio, CI=confidence interval and bolded values indicate statistically significant. † Hosmer and Lemeshow test: Chi-square (df) =8.0361 (8) and P value= 0.430. In the adjusted regression, model variables were adjusted for gender, age, family incom, and educational background, marital status, residence, self-reported BMI, screen time, owning a laptop, physical activity and having chronic disease. † † Hosmer and Lemeshow test Chi-square (df) = 8.680 (8) and P value= 0.370. In the adjusted regression model, all variables except gender were adjusted. ††† Hosmer and Lemeshow test: Chi-square (df) =6.955 (8) and P value= 0.541. In the adjusted regression model, all variables except gender were adjusted.								

In the male subgroup (n=286), the prevalence of poor level sleep and SHS exposure was 66.4% (n=190) and 65.7% (n = 188), respectively. Figure 1 depicts that students who were exposed to SHS had a higher prevalence of poor sleep quality (77.1% vs. 45.9%). Adjusted regression analysis showed that poor sleep quality was 2 times higher among male students with SHS exposure than those without SHS exposure (aOR = 2.55; 95% CI: 1.17, 5.60) (Table 2).



**Figure 1** Distribution of male students' level of sleep quality within the category of secondhand smoke exposure (n=286)

In the female subgroup (n = 214), approximately 20.1% (n=43) of them were exposed to SHS and 51.9% (n=111) of them reported poor sleep quality. Similarly, the prevalence of poor sleep quality was higher in female students who were exposed to SHS than in those who were not (72.1% vs. 46.8%) (Figure 2). Adjusted regression analysis showed that poor sleep quality was 5 times higher among female students with SHS exposure than those without SHS exposure (aOR = 5.39; 95% CI: 2.88, 10.09) (Table 2).



**Figure 2** Distribution of female students' level of sleep quality within the category of secondhand smoke exposure (n=214)

#### 4. DISCUSSION

Sleep quality and secondhand smoke exposure are two distinct, complex health problems that can be life-threatening for humans. There is evidence of a correlation between secondhand smoke exposure and poor sleep among different subgroups, including children, adolescents and adults, but the results are mixed. However, no such research has investigated this relationship among Saudi Arabians. The present study is one of the very first studies that investigated the association between secondhand smoke exposure and poor level of sleep among a sample of non-smoker university students in Saudi Arabia. This study reported the prevalence of poor levels of sleep among university students and exhibited its relation to SHS exposure.

In this study, the prevalence of poor levels of sleep among non-smoker university students was 60.2%. The finding is somewhat similar to previous Saudi Arabian studies (Al-Khani et al., 2019; Mahfouz et al., 2020). For example, a Saudi Arabian study conducted among undergraduate university students reported that 63.9% of the students had poor quality of sleep (Mahfouz et al., 2020). The prevalence rate is alarming; therefore, university authorities and the country's public health practitioners should take the necessary steps and implement policies to improve sleep quality. The current study also found 46.2% of the students had been exposed to secondhand smoke which is comparable to a previous study (Algabbani and Bindhim, 2020). A recent nationwide survey conducted in 13 zones of Saudi Arabia reported that secondhand smoke exposure among non-smokers was 44% (Algabbani and Bindhim, 2020). Despite the existing tobacco control laws and regulations in Saudi Arabia, different forms of smoking (active



and passive smoking) is common in Saudi Arabia and adversely affect vulnerable population groups (Alarifi and Albali, 2022; Abdulrahman et al., 2022). Hence, smoking control measures (Alshahrani and Alqahtani, 2020) as well as public awareness programs is required to safeguard the population from the dangers of passive smoking.

The key result of our study is that among Saudi Arabian university students, SHS exposure is significantly linked to poor sleep quality. There is evidence of a relationship between secondhand smoke exposure and poor sleep among different subgroups, including children (Yolton et al., 2010), adolescents (Morioka et al., 2018) and adults (Wang et al., 2022). However, inconsistent and opposite findings are also observed in some studies (Davila et al., 2010; Safa et al., 2020). A study undertaken in the USA demonstrated that there was no relationship between the poor level of sleep quality and secondhand smoke exposure in the general public (Davila et al., 2010). A review study found a significant association between SHS and poor quality of sleep among adolescents; however, the opposite result was found for adult subgroups (Safa et al., 2020). This finding may be explained by the fact that adolescents have a tendency to experience a higher stress response than adults (Gunnar and Herrera, 2009), which may combine with nicotine exposure to result in more sleep disruptions. Further longitudinal studies are highly suggested to determine the causal relationship between secondhand smoke exposure and poor sleep quality with special attention to vulnerable population groups like medical students, children and adolescents.

Furthermore, subgroup analysis showed that the odds of poor sleep quality were 2 times higher for males (aOR= 2.59) and 5 times higher for females (aOR=5.39) students who were exposed to SHS. According to previous research, women are more likely than men to experience bronchial hyper responsiveness and respiratory symptoms depending on how long they are exposed to tobacco use (Franklin et al., 2004). Never-smoking women who are exposed to SHS daily have a higher risk of snoring than men who smoke (Franklin et al., 2004). Snoring and other respiratory symptoms brought on by smoking may increase the likelihood of sleep disruption and poor sleep quality. In addition, biological features may justify the cause for having a higher likelihood of poor sleep quality in female students with SHS exposure than in male counterparts. Estrogen (sex hormone) positively affects sleep quality in females (Mong et al., 2011) and tobacco smoke contains anti-estrogenic chemicals (Terry and Rohan, 2002). Therefore, females with SHS exposure might suffer much from poor sleep quality than males.

This research has some drawbacks. The cross-sectional survey is limited to determining a causal relationship. Self-reporting biases from the respondents may occur. Since this study was conducted among two universities, the findings cannot be generalized to the whole country or university students.

## 5. CONCLUSION

This study reported that secondhand smoke exposure is associated with poor sleep quality among university students in Saudi Arabia. It is crucial to take precautions against secondhand smoke exposure and also encourage smoking cessation to improve university students' sleep quality. The Government of Saudi Arabia, university authorities and the country's public health practitioners should take the necessary steps and implement existing policies to control tobacco smoking which might protect people from serious health hazards like poor sleep quality.

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### Authors' contributions

Najim Z Alshahrani: Conceptualization, methodology, software, validation, formal analysis, investigation, resources, data curation, writing-original draft preparation, writing-review and editing, visualization, supervision, project administration, funding acquisition. Meshal F Almutairi: Methodology, software, validation, formal analysis, resources, data curation, funding acquisition. Naser Abdullah AlHabjer: Software, investigation, resources, data curation, funding acquisition, writing-review and editing. Fayeze Mula Ali Alasmari: Software, investigation, resources, data curation, writing-review and editing. Mohammed Saeed M Alamri: Formal analysis, resources, data curation, funding acquisition, writing-review and editing. Saud Faisal AlJuraysi: Investigation, formal analysis, resources, data curation, funding, writing-review and editing. Rahaf Naif A Alenezi: Resources, data curation, funding acquisition, writing-review and editing. Amal M Alshahrani: Formal analysis, investigation, resources, data curation, funding acquisition, writing-review and editing. Tuqa Abdulmonem AlShaikh: Formal analysis, investigation, resources, data curation, funding acquisition, writing-review and editing. Hawra Hussain Al Radhwan: Formal analysis, investigation, resources, data curation, funding acquisition, writing-review and editing. Salem Mohammed S Alshahrani: Formal analysis, investigation, resources, data curation, funding acquisition, writing-review and editing.

**Ethical approval**

The protocol of the present study was approved by the Medical Research Ethics Committee (REC) of Faculty of Medicine at King Abdulaziz University, Jeddah, Saudi Arabia (Reference No. 245-93-68).

**Informed consent**

Written consent was obtained from all individual participants included in the study.

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This study has not received any external funding.

**Conflict of interest**

The authors declare that there is no conflict of interests.

**Data and materials availability**

All data sets collected during this study are available upon reasonable request from the corresponding author.

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