

# Prevalence of Obstructive Sleep Apnea Among Saudi Pilots

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**Purpose:** To evaluate the presence of obstructive sleep apnea (OSA), using home sleep testing in pilots and first officers in Saudi-based airlines. This will allow for proper diagnosis and management of OSA in that group which can help in minimizing any possible aviation accidents related to sleep disturbances secondary to OSA.

**Materials and Methods:** This is a cross-sectional study conducted through Saudi-based aviation among pilots and first officers who were in service, active, and flying short- to medium-haul flights. Forty-one participants met the inclusion criteria. However, 39 out of 41 completed the study questionnaires (Berlin questionnaire, Epworth sleepiness scale, Pittsburgh sleep quality index (PSQI), Fatigue severity scale (FSS), Visual analog fatigue scale (VAFS), and Patient health questionnaire (PHQ9), along with home sleep testing.

**Results:** Sixty-nine percent of the study population had OSA by home sleep testing. Majority of which had mild OSA (64%) and 5% had moderate and severe OSA (2.5% each). Results of different questionnaires showed one-third of the participants had insomnia, 33.3% of the participants had severe fatigue, excessive daytime sleepiness was found in 23.1% of the participants, and 10.3% had moderate depression, while 25.6% were classified as having mild depression symptoms.

**Conclusion:** Sleep apnea is prevalent among the studied Saudi-based airline pilots and first officers. Screening for workers of this high-risk occupation needs to be considered. Fatigue, depression, and insomnia can be secondary consequences of sleep apnea and should be assessed and treated early.

**Keywords:** sleep apnea, insomnia, fatigue, depression, pilots, aviation

## Plain Language Summary

Obstructive sleep apnea (OSA) is a common problem that affects a person's breathing during sleep, during which air cannot flow normally into the lungs. The blockage in the airflow is usually caused by the collapse of the soft tissues in the back of the throat (upper airway) and the tongue during sleep.

In this study, we tested 39 participants including pilots and first officers in Saudi air line-based aviation services to see if they have any apneas during sleep. They also filled few questionnaires that provide a screening for the risk and consequences of sleep problems.

Results showed that 64% had mild OSA (which means 5–14 events per hour of sleep), 2.5% had moderate (15–30 per hour of sleep), and 2.5% had severe OSA (>30 events per hour of sleep).

One-third of participants had some problems initiating or maintaining sleep (insomnia), 33% had tiredness and fatigue, 35.9% had depression, while 23.1% were excessively sleepy during the daytime.

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We concluded that sleep apnea is common among pilots and first officers, and we strongly advise for early detection of those at high risk and treat them to prevent its complications and consequences.

## Introduction

Air travel has become the main method of transportation in the modern era. It is the fastest and most efficient mode of transportation around the globe. Concurrent with the expansion of the aviation industry, there has been an increase in concern about the health of aircrew members and the safety of both passengers and aircrew members. There is a growing need to detect and prevent various adverse physiological responses to physical stresses encountered in the aerospace environment. Many aviation accidents were reported to be secondary to human factors that could have been prevented. Human factors, including issues such as fatigue, loss of situational awareness and sleepiness, can play a crucial role in accidents that could lead to a tragic loss of life. A report from the National Transportation Safety Board (NTSB) stated that “drowsy flying can be as deadly as drowsy driving” after investigating a plane crash in February 2013.<sup>1</sup>

The NTSB determined that obstructive sleep apnea (OSA) was a factor contributing to the February 13, 2008, Mesa Airlines Flight 1002 incident. Both the captain and the first officer fell asleep during the flight. The captain was found to have undiagnosed severe OSA. The NTSB database lists 34 accidents – 32 of which were fatal – in which sleep apnea was mentioned in the pilot’s medical history, although sleep apnea was not listed as “causal” or “contributory” with regard to those accidents. The database includes an additional 294 incidents in which some type of sleep disorder was mentioned in the pilot’s history.<sup>2</sup>

Unfortunately, aircrew members are at high risk of having sleep disorders.<sup>3</sup> They are forced to cope with very early and very late flights, crossing different time zones, and sleep deprivation. These disorders can lead to fatigue and increase medical and mental health complications.<sup>4</sup> Moreover, the prevalence of obesity is high among commercial airline pilots and constitutes a public health problem in this population. Excess weight has been found to be associated with working night shifts, difficulty relaxing after work, inadequate sleep on days off, having other chronic diseases, and physical inactivity.<sup>5</sup>

Sleep disorders are common. Given the rate of increase in obesity, the prevalence of sleep disorders is expected to

continue to increase in the coming decades. In Saudi Arabia, the prevalence of OSA is estimated to be 8.8% (12.8% in men, 5.1% in women) according to a study by Wali et al<sup>6</sup> However, the prevalence of OSA among Saudi pilots has not yet been objectively studied.

A few studies worldwide have highlighted the prevalence of the complications of sleep disturbance, such as fatigue and excessive daytime sleepiness, in aircrew members. In Portugal, Reis et al<sup>3</sup> concluded that among pilots, the prevalence of sleep complaints, excessive daytime sleepiness, and fatigue was 34%, 53%, and 90.6%, respectively, especially among those on short- and medium-haul flights.

A recent study performed by Aljurf et al<sup>7</sup> assessed the prevalence of fatigue, depression, and sleepiness and the risk of OSA among commercial airline pilots in the Gulf region. They found that 34.1% of the pilots had an ESS score  $\geq 10$ , indicating excessive daytime sleepiness; 34.5% of the pilots had an abnormal HADS depression score; and 29.3% were at high risk for OSA and needed further assessment.<sup>7</sup>

A position paper published in 2015 stated that commercial pilots may be at risk for OSA, making screening for OSA an urgent flight safety issue. The Aerospace Medical Association encourages any initiatives that enhance awareness and lead to the treatment of this condition because it affects flight safety and pilot performance.<sup>5</sup>

Many patients, including pilots, are unaware of having sleep disturbances, and the symptoms are not easily recognizable. Pilots suffering from OSA do not necessarily have to lose their license. Diagnosis and treatment, with regular check-ups, can be recommended instead. Panton et al<sup>8</sup> even suggested that questions about sleep need to be included in routine pilot health examinations.

There is a lack of studies addressing different sleep-related disorders in pilots and other aircrew members in Saudi-based airlines. In this study, we objectively evaluated OSA to improve early detection and treatment to minimize airplane accidents secondary to human factors related to this condition.

## Materials and Methods

### Research Design

This was a cross-sectional study conducted through Saudi-based aviation services in collaboration with the sleep medicine department and a research center at King

Abdulaziz University Hospital targeting pilots and first officer. The target sample size was 46 participants.

## Target Population

Active airline pilots working for a Saudi-based airline constituted the study population. This study targeted narrow-bodied aircraft (Airbus A-320) pilots and first officers who were flying short- to medium-haul flights. As there was more than one category of pilots in service, only active and regular pilots were included.

The other categories of A-320 pilots, such as management pilots, instructor pilots (IPs), and check pilots or check airmen, were excluded. Pilots who were undergoing training (initial, transition, upgrade, and/or requalification) were also excluded from participating in this study.

The total number of potential participants was 46. Among these, 41 participants met the inclusion criteria. However, only thirty-nine (39) pilots agreed to participate in the study. All participants were asked to fill out the related questionnaires, and they were assured of the confidentiality of their responses and the results of testing; this was accomplished by sending a copy of the questionnaires by mail with clear instructions and assurances. Then, paper questionnaires were distributed by the fleet manager's office to ensure confidentiality.

## Questionnaires

### Demographics and Professional Characteristics

Age and nationality were the demographic variables assessed. The professional characteristics were as follows: rank, type of pairing, type of flight, number of take-offs (TOs) and landings per month, duty time, and timing of flight (day or night).

### Berlin Questionnaire

The risk of sleep apnea was assessed with the Berlin questionnaire, which has 3 sections.<sup>9,10</sup> The patient was considered at high risk if they had positive scores in at least 2 sections.

### Epworth Sleepiness Scale

Daytime sleepiness in 8 different daily situations was assessed with this scale; the probability of falling asleep in each situation was rated on a scale from 0 to 3. Scores of 10 or greater were considered abnormal.<sup>11</sup>

### Pittsburgh Sleep Quality Index (PSQI)

Sleep quality was assessed over a 1-month period with the PSQI.<sup>12</sup> The questionnaire is composed of 19 individual

items divided into 7 components: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medications and daytime dysfunction. A score for each component is obtained and summed to yield the global PSQI score. A total score of 5 or greater is indicative of poor sleep quality.

### Fatigue Severity Scale (FSS)

The FSS is a validated self-reported fatigue questionnaire with nine questions assessing the prevalence of severe fatigue. Severe fatigue was indicated by a score  $\geq 36$ .<sup>13</sup>

### Visual Analog Fatigue Scale (VAFS)

Traditionally, a visual analog scale (VAS) consists of a 10-cm horizontal line with written descriptions at each end; subjects are asked to mark on the line the point that they feel represents their current state.<sup>14</sup> The possible score ranges from 0 to 100, measured in millimeters on the 10-cm vertical line. In this study, the score was obtained by measuring the line from "No Fatigue" to the point indicated by the subject as representative of their fatigue level; the higher the VAFS score was, the more fatigued the pilot.

### Patient Health Questionnaire (PHQ9)

The PHQ is a tool used to screen for major depressive disorder. It consists of 9 questions, each of which is scored from 0 to 3.<sup>15</sup> Patients who score less than 4 are unlikely to have depression. The lowest possible score is 0, and the highest is 27. Higher scores suggest more severe depression.

## Procedure Details

After completing the questionnaires, a home sleep apnea test (HSAT) was conducted for all participants. The HSAT was performed using the SOMNOtouch™ system (Somnomedics GmbH, Randersacker, Germany), which has the following integrated sensors: flow and snoring (nasal cannula), thorax and abdomen effort, SpO<sub>2</sub>, pulse rate, body position, and movement (for sleep/wake time estimations). It also has external sensors (AUX connections for extended recordings, eg, periodic leg movements (PLMs), electrocardiogram (ECG), electroencephalogram (EEG), electrooculography (EOG), and electromyography (EMG)).<sup>16</sup>

The HSAT was performed at the participants' homes. All participants were interviewed individually prior to the sleep study and were trained how to apply and disconnect the SOMNOtouch™ system. HSAT records were collected

and scored in accordance with the technical guidelines for scoring and staging sleep based on the updated American Academy of Sleep Medicine (AASM) Scoring Manual 2018 version 2.5.<sup>17</sup>

Abnormal obstructive breathing events that were recorded were scored according to the latest recommendation of the AASM as follows: a decrease in airflow by 90% or more from baseline for at least 10 seconds was scored as apnea, while hypopnea was defined by a reduction in airflow of at least 30% from the baseline according to nasal pressure in addition to a reduction in oxygen saturation of at least 3% and/or subsequent EEG arousal despite the movement of chest and abdominal muscles in an attempt to overcome the obstruction.<sup>17</sup> EEG arousal was defined according to the recommendations of the AASM. (AASM manual 2018 version 2.5). The average number of these apnea and hypopnea events per hour of sleep (ie, the apnea-hypopnea index [AHI]) was then calculated.

Subjects with an AHI score  $\geq 5$  were categorized as having OSA.<sup>18</sup>

The severity classifications used were mild (AHI = 5–14), moderate (AHI = 15–30), and severe (AHI > 30).<sup>19</sup>

## Analysis

Statistical analyses were performed using Statistical Package for the Social Sciences (SPSS) version 22. Categorical variables were summarized and are presented in tables. Numerical variables are represented as the means and standard deviations and were assessed with unpaired Student's *t*-tests, linear correlation coefficients, analysis of variance [ANOVA], chi-square tests, and logistic regression. The results were considered significant if the calculated *p* values were less than 0.05.

## Results

In total, 39 participants agreed to undergo the HSAT. This sample population included both captains (48.7%) and first officers (51.3%). The mean age and BMI were  $43.26 \pm 9.49$  years and  $24.47 \pm 2.418$  kg/m<sup>2</sup>, respectively (Table 1).

The workload and experience variables are summarized in Tables 1; 59% of the participants had more than 15 years of experience. The majority of the participants performed 30–40 TOs and landings per month. The flights included both domestic and international flights for approximately 92.3% of the participants.

**Table 1** Demographic Data and Work Characteristics of the Study Sample

<b>SOMNOtouch</b>	<b>N</b>	<b>%</b>
<b>Nationality</b>		
Saudi	7	17.9%
Non-Saudi	32	82.1%
<b>Rank</b>		
Captain	19	48.7%
First Officer	20	51.3%
<b>Experience, years</b>		
<5	3	7.7%
5–10	7	17.9%
10–15	6	15.4%
>15	23	59.0%
Range	3–19	
Mean $\pm$ SD	14.436 $\pm$ 5.097	
<b>Age</b>		
Less than 30 years	2	5.1%
30–40 years	16	41.0%
40–50 years	10	25.6%
More than 50 years	11	28.2%
Range	27–59	
Mean $\pm$ SD	43.256 $\pm$ 9.499	
<b>Number of TOs and Landings/Month</b>		
<30	3	7.7%
30–35	19	48.7%
35–40	15	38.5%
40–45	2	5.1%
>45	0	0.0%
Range	26–40	
Mean $\pm$ SD	33.821 $\pm$ 3.308	
<b>Typical pairing</b>		
Domestic pairing	3	7.7%
International pairing	0	0.0%
Mixed pairing (domestic and international)	36	92.3%
<b>Typical daily duty time</b>		
Less than 8 hours	13	33.3%
8–14 hours	16	41.0%
More than 14 hours	10	25.6%
<b>Number of sectors/Day</b>		
2 Sectors/day	1	2.6%
3 Sectors/day	0	0.0%
More than 3 sectors/day	38	97.4%
<b>Timing of Flight</b>		
Day	0	0.0%
Night	0	0.0%
Both	39	100.0%

(Continued)

**Table 1** (Continued).

SOMNOtouch	N	%
<b>BMI</b>		
Range	19.0–29.39	
Mean±SD	24.47±2.418	

The Berlin questionnaire was used to assess the risk of OSA, and further analysis was performed to evaluate different risk factors for OSA, including age, rank, experience, number of TOs and landing/month, typical pairing, duty times, and number of sectors per day. However, none of these factors were associated with an increased risk of OSA in our study population (Table 2).

Based on the Berlin questionnaire, 5.1% of the participants were categorized as being at high risk for OSA (Figure 1). However, based on the objective HSAT, a total of 69.2% of the pilots were found to have OSA (Table 3).

The mean total sleep time was approximately 5 hours, and the majority of participants (79.5%) had normal sleep efficiency.

According to the AHI results, 25 (64%) participants had mild OSA, 1 (2.5%) had moderate OSA and 1 (2.5%) had severe OSA (Table 3).

The results of different questionnaires used to assess the relevant characteristics of the participants' sleep history, eg, insomnia, fatigue, depression and quality of sleep, are shown in Figure 1. One-third of the participants had insomnia according to the Athens insomnia scale (AIS). Regarding fatigue, the FSS showed that 33.3% of the participants had severe fatigue (score >36), while 23% scored less than 5 on the VAFS (with zero being worst and 10 indicating a normal state). Excessive daytime sleepiness was found in 23.1% of the participants. The majority of participants (64.1%) had no or minimal depression. Only 10.3% had moderate depression, while 25.6% were

**Table 2** Correlations Between Demographic Data, Including Work Characteristics, and the Risk of Sleep Apnea According to the Berlin Questionnaire

Demographic Data		Berlin Questionnaire Score						Chi-Square	
		Low Risk		High Risk		Total			
		N	%	N	%	N	%	X <sup>2</sup>	P-value
<b>Rank</b>	<b>Captain</b>	17	45.9%	2	100.0%	19	48.7%	2.990	0.084
	<b>First Officer</b>	20	54.1%	0	0.0%	20	51.3%		
<b>Experience, years</b>	<5	3	8.1%	0	0.0%	3	7.7%	2.187	0.534
	5–10	7	18.9%	0	0.0%	7	17.9%		
	10–15	6	16.2%	0	0.0%	6	15.4%		
	>15	21	56.8%	2	100.0%	23	59.0%		
<b>Age</b>	<b>Less than 30 years</b>	2	5.4%	0	0.0%	2	5.1%	5.346	0.148
	<b>30–40 years</b>	16	43.2%	0	0.0%	16	41.0%		
	<b>40–50 years</b>	10	27.0%	0	0.0%	10	25.6%		
	<b>More than 50 years</b>	9	24.3%	2	100.0%	11	28.2%		
<b>Number of TOs and Landings/ Month</b>	<30	3	8.1%	0	0.0%	3	7.7%	2.990	0.393
	30–35	17	45.9%	2	100.0%	19	48.7%		
	35–40	15	40.5%	0	0.0%	15	38.5%		
	40–45	2	5.4%	0	0.0%	2	5.1%		
<b>Typical pairing</b>	<b>Domestic pairing</b>	3	8.1%	0	0.0%	3	7.7%	0.329	0.566
	<b>Mixed pairing (domestic and international)</b>	34	91.9%	2	100.0%	36	92.3%		
<b>Typical daily duty time</b>	<b>Less than 8 hours</b>	12	32.4%	1	50.0%	13	33.3%	1.245	0.537
	<b>8–14 hours</b>	15	40.5%	1	50.0%	16	41.0%		
	<b>More than 14 hours</b>	10	27.0%	0	0.0%	10	25.6%		
<b>Number of sectors/day</b>	<b>2 Sectors/Day</b>	1	2.7%	0	0.0%	1	2.6%	0.107	0.744
	<b>More than 3 sectors/day</b>	36	97.3%	2	100.0%	38	97.4%		



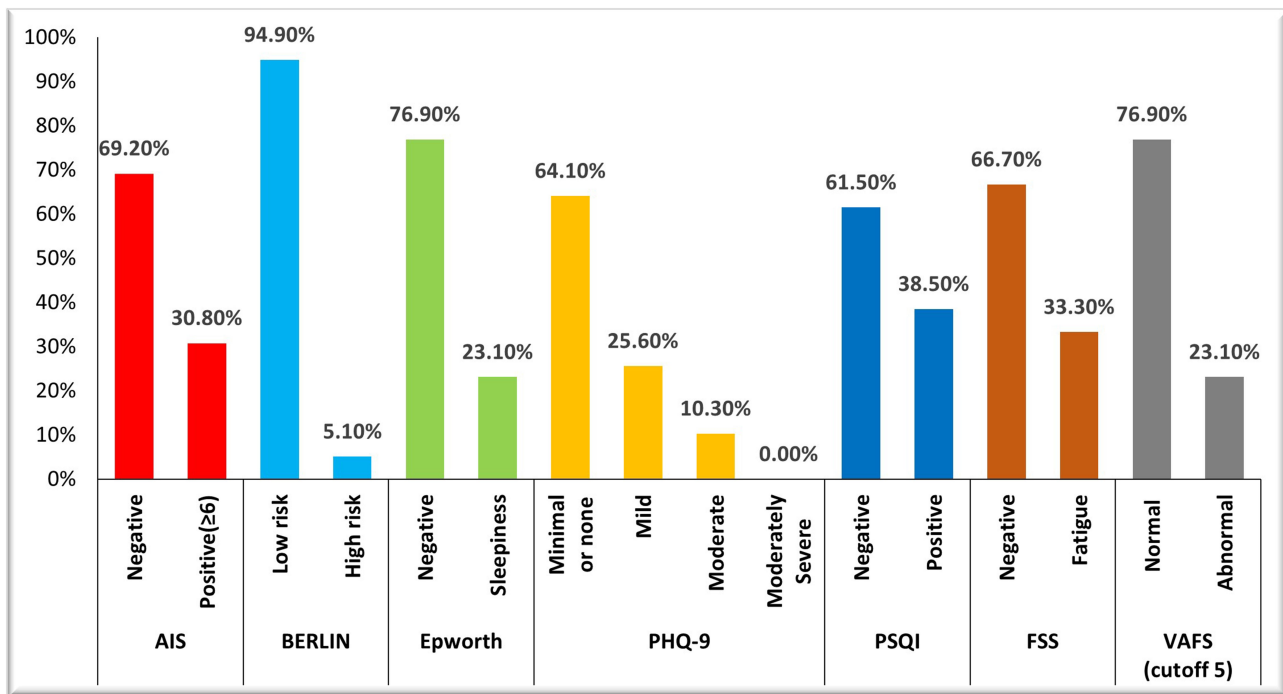


Figure 1 Characteristics of sleep history among the study sample.

classified as having mild depression. Sleep quality was suboptimal in 38.5% of the study population.

No correlation between the AHI score and BMI was found in our study. However, the correlation between the number of desaturations per hour and BMI was statistically significant, with a p value of 0.05.

Duty time (less than 8 h, 8–14 h, more than 14 h) was not associated with the sleep study parameters, eg, total sleep duration, sleep efficiency, AHI score, and number of desaturations.

## Discussion

Although the aviation industry is growing worldwide, research on OSA among aircrew members is still lacking

and has not kept pace with expansion in this field. To our knowledge, this is the first study to objectively evaluate the prevalence of OSA among captains and first officers in Saudi-based aviation services. Although the results of the Berlin questionnaire indicated that only 5.1% of pilots were at high risk of OSA, 69.2% of pilots had sleep apnea when evaluated objectively with the HSAT.

The sensitivity and specificity of the Berlin questionnaire for the diagnosis of OSA based on an AHI cutoff of 5 were 77.3% and 23.1%, respectively, with a positive predictive value of 68.0% and a negative predictive value of 22.0%<sup>20</sup> Nevertheless, in our study, there was a substantial discrepancy between the estimated risk and the actual detection of OSA.

This observation could be related to a lack of awareness or underestimation of snoring, fatigue and daytime sleepiness. Moreover, this underestimation could be due to the desire to avoid jeopardizing their job if they admit or report having sleep issues. This highlights the need for routine screening and thorough evaluation of pilots and first officers who are at risk of OSA.

The overall prevalence of OSA in the Saudi population is 8.8% (12.8% in men and 5.1% in women),<sup>6</sup> which is far lower than the 69.2% detected in our study population. Furthermore, the risk of OSA among pilots in Saudi Arabia was assessed by Aljurf et al<sup>7</sup> with the Berlin

Table 3 Sleep Study Parameters

SOMNOtouch		Group III		Score	
		N	%	Range	Mean±SD
Sleep efficiency (cutoff 75%)	Normal	31	79.5	21–95	79.133±16.035
	Abnormal	8	20.5		
AHI	Normal	12	30.77	0.4–38	8.051±6.281
	Mild	25	64.10		
	Moderate	1	2.56		
	Severe	1	2.56		

Abbreviations: AHI, apnea-hypopnea index.

questionnaire, and 29.3% of the pilots were at high risk of OSA. This may be due to difference in the sample size.<sup>7</sup>

A few studies have suggested that weight gain and sleep disturbances could have effects without actually using a validated questionnaire or an objective test to screen for OSA. In Brazil in 2016, Magna Lucia and his group reported the prevalence of overweight and obesity among pilots to be 53% and 14.6%, respectively. Risk factors for obesity included working night shifts for 6–10 years, having difficulty relaxing after work, sleeping <6 h on days off, having other coexisting medical problems, and engaging in <150 min/week of physical exercise.<sup>4</sup>

Excess body weight is an important predictor of the severity of blood oxygen desaturation during apnea and hypopnea events, potentially exacerbating the impact of sleep-disordered breathing in obese patients.<sup>21</sup>

This was consistent with our results, which showed a significant correlation between BMI and the number of desaturations.

One-third (33.3%) of the participants had severe fatigue according to the FSS, and it is well known that fatigue is a common complaint among aircrew members. Although sleepiness and fatigue were observed in our study, they might have been underestimated due to the small sample size or underreporting of the symptoms by the participants. Reis et al<sup>3</sup> reported a higher prevalence of sleepiness (59.3%) and fatigue (90.6%) among 435 pilots. This variation in the prevalence of such conditions warrants a more systemic screening of all crew members for the detection of these disorders. Education and awareness strategies should be implemented to decrease the burden of sleepiness and fatigue on those populations. Regulatory authorities may need to implement strict rules to ensure the safety of aircrew members by regulating their working hours.

Other relevant sleep history parameters that may be a consequence of sleep apnea in some cases are insomnia and depression, which were identified in 30.8% and 35.9% of the enrolled participants, respectively. In our study, the proportion of pilots who had scores consistent with depression was similar to that found by AlJurf et al<sup>7</sup> and almost three times that reported in a cross-sectional study based on an anonymous web-based survey that found that 12.6% of airline pilots had depression and 4.1% of pilots had suicidal thoughts.<sup>22</sup>

The main limitation of our study is the small sample size. Not all pilots agreed to participate in the sleep study. The hesitation regarding participation could be related to

concerns about job security and how the results could affect their promotion and future rank.

The Federal Aviation Administration requires medical examiners to routinely screen aircrew members for the risk of OSA and, if necessary, to refer them to their treating providers, who should then apply the Academy of Sleep Medicine clinical practice guidelines to determine whether further assessment, such as a sleep study, is clinically indicated.<sup>23</sup>

In Saudi Arabia, aviation services currently follow the General Authority of Civil Aviation guidelines, in which screening pilots for OSA is not mandatory but is rather dependent on physician judgment.

## Conclusions

Sleep apnea is prevalent among the studied Saudi-based airline pilots and first officers; however, the pilots and first officers do not frequently report daytime sleepiness. Thus, sleep apnea screening for all pilots and air traffic controllers should be considered. Unfortunately, subjective assessments with questionnaires were shown to be less accurate than objective HSAT, as substantial discrepancy between the subjective and objective assessments was noticed. Fatigue, depression, and insomnia can be secondary consequences of sleep apnea and should be assessed and treated early.

Further studies using objective assessments on a large scale are needed to evaluate sleep disorders among individuals with high-risk occupations to ensure the safety of all involved.

## Abbreviations

AIS, Athens insomnia scale; ESS, Epworth sleepiness scale; FSS, fatigue severity index; GCC, gulf cooperation council; PHQ, patient health questionnaire; PSQI, Pittsburgh sleep quality index.

## Data Sharing Statement

Raw data were generated at Sleep Medicine and Research Center, King Abdulaziz University Hospital, Jeddah, Saudi Arabia. Derived data supporting the findings of this study are available from the corresponding author F.H on request.

## Ethics Approval and Informed Consent

The Unit of Biomedical Ethics of King Abdulaziz University Hospital reviewed and approved the research

plan and its implementation. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed written consent was obtained from all participants prior to the commencement of the study.

## Consent for Publication

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## Author Contributions

All authors contributed to data analysis, drafting or revising the article, have agreed on the journal to which the article will be submitted, gave final approval of the version to be published, and agree to be accountable for all aspects of the work.

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## Disclosure

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