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A study to estimate prevalence and risk factors of Obstructive Sleep Apnea Syndrome in a semi-urban Indian population

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Abstract

Obstructive Sleep Apnea Syndrome (OSAS) has been recognised as a major cause of morbidity and mortality in developing countries like India. There is still a paucity of Indian studies regarding the prevalence of OSAS. The current single centre prospective cross-sectional study was undertaken to know prevalence estimates for key symptoms and features that can indicate the presence of OSAS in an Indian population. A survey was conducted on subjects with age groups ≥25 years at King George's Medical University, Lucknow, Uttar Pradesh, India from August 2009 to July 2011. Data was recorded during the interview on the basis of Berlin Questionnaire (BQ). Risk factors for OSAS were also evaluated. Risk group categorization for OSAS was done with the help of a questionnaire and overnight polysomnography was performed in each group to measure apnea and hypopnea index (AHI). Out of 1816 subjects, 1512 (response rate 83.3%) finally participated in the survey with mean age 42.6±11.2 years, males 67.9% and females 32.1%. Of them 6.2% were found to be at high-risk OSAS; 12.2% were obese (Body Mass Index ≥30 kg/m^2) and 33.5% of the obese population were at high-risk OSAS. Among high-risk patients with OSAS, 62.4% had hypertension. Statistically significant and independent risk factors found for OSAS were obesity, large neck size, alcoholism and use of sedatives/tranquillizers. High-risk category predicted an AHI ≥5 with a sensitivity of 86.3% (95% CI 73.1-93.8), specificity of 93.1% (95% CI 89.1-95.7), positive and negative predictive values of 70.9% (95% CI 57.9-81.4) and 97.2% (95% CI 94.1-98.8) respectively. It can be concluded that BQ questionnaire can still be used as a pre-assessment tool for predicting persons at risk for OSAS in clinical practice. Further studies on estimation of prevalence of OSAS by applying BQ are warranted in near future from other regions of India.

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Research Highlights:

- Obstructive Sleep Apnea Syndrome (OSAS) has been recognised as a major cause of morbidity and mortality in recent years.
- It still remains largely unrecognised and undiagnosed in developing countries like India.
- There is a paucity of literature on prevalence and risk factors of OSAS in adults from various regions of India as current information is insufficient.
- The high sensitivity of Berlin Questionnaire in this study has made an impression that it still can be used as a pre-assessment tool for predicting persons at risk for OSAS in clinical practice as performing polysomnography on every subject is labour intensive.
- OSAS is a common disease and there is high demand for its awareness, evaluation, diagnosis and management among primary care physicians.

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Introduction

Obstructive sleep apnea syndrome (OSAS) is a disorder of breathing during sleep characterized by prolonged partial upper airway obstruction or intermittent complete obstruction that disrupts normal sleep patterns and are often associated with arousals, sleep fragmentation, intermittent hypoxia and hypercapnia along with serious neurobehavioral and cardio-respiratory consequences, including excessive daytime sleepiness (EDS), growth failure, school failure, behavioral problems or cor-pulmonale, automobile accidents or even sudden death. OSAS has long been recognised as a major contributor to morbidity and mortality in developed countries. The prevalence of OSAS based on the Wisconsin cohort study performed in the USA involving middle-aged adults 30-60 year of age, is 2% in females and 4% in males [1]. The public health impact of OSAS is now enormous in developing countries like India because of increasing urbanisation as well as lifestyle modification and its potential contribution to the increased rates of cardiovascular disease and obesity. A study has estimated OSAS prevalence of 3.6% in an Indian community based sample translating to over 36 million affected individuals as when extrapolated to the overall population of over one billion in India that carries a substantive public heath significance [2]. Overnight supervised in-laboratory polysomnography (PSG) is recommended for establishing the diagnosis and further prioritizing management strate-

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gies. However, these studies are time-consuming, expensive and labour intensive. The occurrence of first night effect leads to subjective discomfort making it more impracticable. Therefore, it is rarely feasible to use PSG as a screening test in large-scale epidemiological studies. Unattended portable home PSG using portable digital recorders is an emerging and reliable alternative in resource-limited settings. It can overcome many disadvantages of former but still has limitations such as inferior data quality due to lack of supervision and electroencephalography (EEG) leads and variable scoring schemes as well as sensor devices. This could lead to increase false positive and negative cases. Therefore, clinical assessment is necessary for validation of findings with portable PSG. It would be useful to rely on a screening test that could reliably identify either high-risk patients requiring full PSG or low-risk patients in whom PSG could be avoided among densely populated countries. Therefore, the development of screening or case-finding instruments such as Berlin Questionnaire (BQ) is imperative to identify and treat OSAS. Despite deliberate efforts made by researchers in India with resource-limited settings in the last decade, OSAS still remains largely unrecognised and undiagnosed [2-6]. The primary care physicians are still unaware of OSAS. The current study was conducted to know the prevalence estimates of key symptoms and features that can indicate the presence of OSAS in an Indian semi-urban population.

Materials and Methods

A single-center prospective, cross-sectional study was conducted on consecutive and apparently healthy attendants with no complaints, who were attending the of Kasturba Chest Hospital, Department of Pulmonary Medicine, King George's Medical University (KGMU), Lucknow, Uttar Pradesh, India. The attendants were interviewed face to face using pretested BQ on three days of every week (Monday, Tuesday and Wednesday) from August 2009 to July 2011. The apparently healthy attendants with age ≥25 years were recruited in this study. These subjects were coming along with patients referred to outdoor of this tertiary care referral centre from all districts of Uttar Pradesh which is the highest populated state carrying almost one-fourth burden of entire population of India. The BQ as a screening tool was developed in 1996 and its origin and use in primary care has been reported previously [7]. This contains a set of known symptoms and clinical feature associated with OSAS. One introductory question and four follow-up questions concerned snoring, witnessed apneas and the frequency of such events. Three questions addressed EDS with a sub-question about drowsy driving. One question was asked for a history of hypertension. Body mass index (BMI) in kg/m^2 was calculated from height and weight recorded on proforma. Bilingual physicians translated the questionnaire from its original English version into Hindi. Translation was performed from Hindi back into English by other bilingual physician and was consistent with the intent of the original version. Criteria for exclusion were patients having age <25 years, co-existing systemic diseases like connective tissue disorder, chronic liver disease, chronic renal disease, chronic lung diseases, immunosuppressive disease, malignancies and some heart diseases (except hypertension or vascular morbidity), moribund state and pregnant as well as lactating females. The patients directly reporting with symptoms of OSAS were also excluded in order to avoid selection bias. The study population ready to participate and co-operate in the study with the help of informed consent, were enrolled and their data was recorded on a pre-designed proforma. The subjects were interviewed on the basis of BQ to elicit information from the subjects themselves and from their partners about the occurrence of snoring, cessation of breathing during sleep, tiredness, sleepiness while driving or any past history of hypertension. Some of the subjects along with their partners were interviewed on telephone in order to get appropriate information regarding snoring habits. The EDS was also assessed by Epworth sleepiness scale (ESS) [8]. Questions were also asked to evaluate possible risk factors for OSAS like smoking, alcoholism and use of sedatives or tranquilizers. Categorization of the subjects in two groups (high-risk and low-risk) was done with the help of questionnaire. Risk grouping for high-risk and low-risk for OSAS was based on responses grouped into three categories. In category 1, a positive score for high-risk was defined as frequent symptoms (*i.e.*, "more than three to four times per week or almost every day") in two or more questions about snoring and witnessed apneas. In category 2, a positive score for high-risk was frequent symptoms in two or more questions about awakening sleepy or tiredness after sleeping, wake time sleepiness and/or drowsy driving. In category 3, a positive score for high-risk was defined as presence of hypertension and/or obesity (BMI 30 kg/m^2). To score "high-risk" for OSAS, an individual's questionnaire should have had positive scores in two of the three categories, or in all three. Those patients who denied having symptoms with such frequency or who qualified in only one category were placed into a lower risk group. Neck size (in inches) was measured at the level of cricoid cartilage. Blood pressure measurement (in mm of Hg) was recorded in sitting and standing position after at least ten minutes of rest according to Joint National Committee (JNC)-7 criteria [9]. Another recording was done further after ten minutes along with any previous history of any anti-hypertensive medication in case of first recording was found to be abnormal. This was done in order to reduce the probability of false risk group categorization. Obesity was defined by calculation of body mass index according to classification (30 kg/m^2) recommended by World Health Organization (WHO) [10]. All the subjects from high-risk OSAS category were invited for PSG. However, only 20% of the subjects from low-risk OSAS category (selected using a computer-generated random number list) were invited for PSG due to operational as well as financial constraints in order to achieve wide variance in the expected Apnea and Hypopnea index (AHI) scores. AHI is the sum of the total number of obstructive apnea and the total number of hypopneas divided by total sleep time in hours. All consented subjects underwent overnight PSG within one week of screening by estimation of AHI scores. These subjects were also examined for upper airway anomalies such as macroglossia, pharyngeal crowding, bulky uvula, retrognathia, tonsillar enlargement and deviated nasal septum by a specialist otorhinolaryngologist. Further routine checkup was done including complete blood count, liver and renal function test, lipid profile, thyroid function test, fasting and post-prandial blood sugar as well as spirometry. Blood pressure was recorded before and after the sleep study. All subjects underwent PSG within seven days of completing the questionnaire with proper instructions such as avoidance of alcohol anxiolytic/ sedative drugs/ caffeine intake and also not to sleep in the afternoon. Subjects were attached to S-7000 computerized polysomnography machine (manufactured by Cogent Technologies in UK for Embla System Inc.) with 20 channel inputs by standard gold cups after cleansing the area of attachment by spirit followed by application of Nuprep. Subject was requested to sleep at around 10:00 p.m. Various parameters were observed including Electroencephalogram (EEG), Electrooculogram (EOG), Electrocardiogram (ECG), Chin and leg electromyogram (EMG), nasal airflow, thoracoabdominal movements and body position. PSG was recorded for at least 6 hours. Sleep data recorded by the computer was cross-checked manually for scoring of sleep stages, apneas and hypopneas regarding each subject. Apnea was defined as cessation of airflow for at least 10 seconds whereas hypopnea as abnormal respiratory event with at least a 30% reduction in thoracoabdominal movement or airflow as compared to baseline lasting at least 10 seconds and with >4% oxygen desaturation or an electroencephalographic arousal. Subjects with polysomnographic evidence of AHI ≥5 per hour were considered to be cases whereas subjects with AHI <5 per hour as controls. Sleep period time is the time in minutes from sleep onset to the final awakening. Total

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sleep time (TST) is time in minutes from sleep onset until the final awakening, less wake after sleep onset (WASO). Sleep onset is time in minutes after lights out when the first 30-sec epoch of any stage of sleep is observed. Sleep latency is the time in minutes from lights out to sleep onset. Rapid Eye Movement (REM) sleep latency is elapsed time in minutes from sleep onset, to, but not including, the first score-able epoch of REM sleep. Sleep stage percentages are percentages of total sleep time in each particular stage of sleep (Stages S1, S2, S3, S4, REM), determined by dividing recording time in each stage by TST. Arousal indexes are mean number of arousals per hour of sleep calculated by total number of arousals multiplied by 60 and divided by the total sleep time (N x 60/TST). The protocol of the study has been shown in Figure 1. The ethical committee of KGMU approved this present study.

Statistical analysis

All statistical analyses were performed using SPSS statistical software 16.0 (SPSS Inc., USA). Descriptive statistics of all continuous variables were calculated as means and standard deviation, whereas categorical data were expressed as percentages. A comparison between groups was done using Student's *t*-test for continuous variables, and chi-square test or Fisher's exact test was used for discrete variables. Rate differences between variables were calculated by odd ratios (ORs) and the corresponding 95% confidence intervals (CIs). Variables showing association with a p-value of <0.05 in univariate analysis were considered as candidate risk factors to be used in multivariate analysis. Stepwise multiple logistic regression analysis was used to identify significant independent risk factors of OSAS. All tests were two-sided and a p<0.05 was considered statistically significant.

Results

In our study, 1512 apparently healthy adult subjects above the age group of 25 years underwent screening with BQ. The demographic profile of 1512 subjects has been illustrated in Table 1. The mean body

Table 1. Demographic profile of the study population (n=1512).

Variables	Values (%)
Age (years)	
25-34	197 (13.1%)
35-44	477 (31.5%)
45-54	476 (31.4 %)
55-64	308 (20.4%)
≥65	54 (3.6%)
Sex	
Male	1028 (67.9%)
Female	484 (32.1%)
Habitat	
Urban	1047(69.3%)
Rural	465 (30.7%)
Body Mass index	
≤24.9 (healthy & underweight)	942 (62.3%)
25-29.9 (overweight)	385 (25.5%)
≥30 (obese)	185 (12.2%)
Neck size (≥17 inch in male or ≥15 inch in female)	
Yes	73 (4.8%)
No	1439 (95.2%)
Excessive Daytime Sleepiness Score	
≥11	78 (5.2%)
<11	1434 (94.8%)
Snoring	
Yes	530 (35.1%)
No	982 (64.9%)
Hypertension	
Yes	133 (8.8%)
No	1379 (91.2%)
Smoking	
Yes	419 (27.7%)
No	1093 (72.3%)
Alcoholism	
Yes	179 (11.8%)
No	1333 (88.2%)
Sedative or tranquillizers use	
Yes	65 (4.3%)
No	1447 (95.7%)

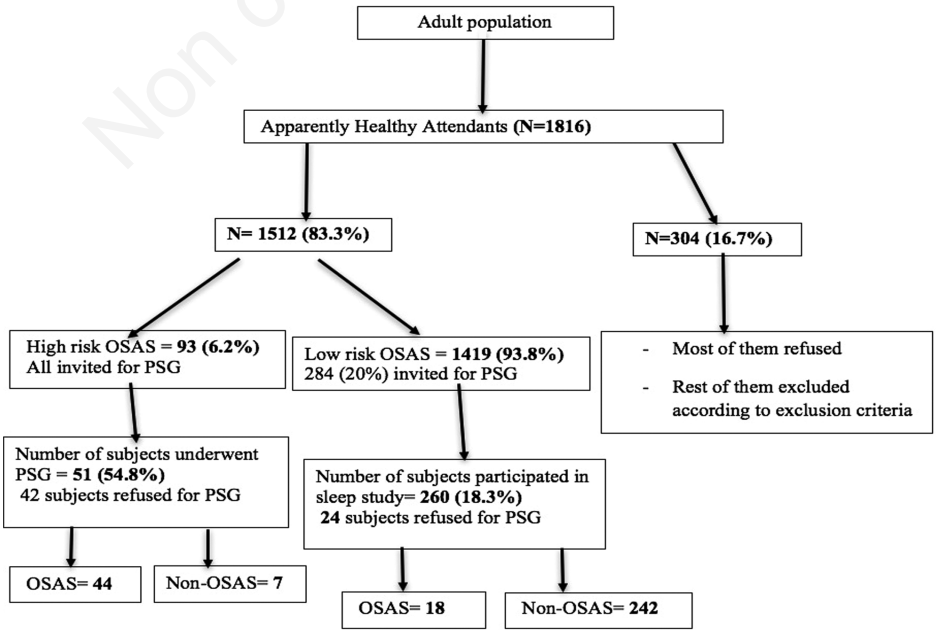

Figure 1. Protocol of the study.

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mass index, neck size and ESS score were higher in those patients who were at high risk of OSAS than the general adult population [30.8±5.2 *vs* 25.1±4.4, (p<0.05); 15.9±1.9 *vs* 14.2±1.6, (p=0.10); 13.5±6.0 *vs* 5.3±3.4, (p<0.001)]. Risk categorization for OSAS on the basis of responses to questionnaire has been illustrated in Table 2. Prevalence of high-risk OSAS was 70 (6.8%) among total 1028 males whereas for 484 females, prevalence was 23 (4.8%) with an overall prevalence of high-risk OSAS was 93 (6.2%). Prevalence of high-risk OSAS was higher in males than females with statistically no significant difference; (p=0.35) 406/1028 (39.5%), males *vs* 124/484 (25.6%) females were snorers (p=0.003).

Out of 1512 subjects, 530 (35.1%) were snorers and 982(64.9%) were non-snorers of which 357 (36.4%) did not know whether they snore. Among 530 snorers, 312 (58.9%) were loud snorers (*i.e*., more than talking) and 218 (41.1%) were non-loud snorers (*i.e*., not more than talking); 335 (63.2%) did snore frequently with (≥3-4) times per week or more and 195 (36.8%) snored less frequently (≤1-2) times per week; 231 (43.6%) were bothersome snorers and 299(56.4%) were non-bothersome snorers. And 48 (9.1%) subjects reported frequent breathing pauses (≥3-4 times/week or more), while 482 (90.9%) subjects reported less frequent breathing pauses including those who had experienced never or almost never breathing pauses. One hundred and thirty-one (8.7%) had reported morning tiredness ≥3-4 times/week or more, while 138 1(91.3%) reported less morning tiredness ≤1-2 times/week or less, including those who had experienced never or almost never morning tiredness. One hundred and seventeen (7.7%) had reported wake time tiredness ≥3-4 times/week or more, while 1395(92.3%) reported less wake time tiredness ≤1-2 times/week or less including those who had experienced never or almost never wake time tiredness. Seven hundred and twenty-six (48.1%) were non-drivers as they did not know to drive or need not to drive (mainly villagers and females) and 786 (51.9%) used to drive vehicles. Among 786 subjects, 52 (6.6%) reported drowsiness while driving ≥3-4 times/week or more while 734 (93.4%) reported drowsiness ≤1-2 times/ week or less including those who had never or almost never experienced drowsiness while driving. Seventy-eight (5.2%) subjects were having excessive daytime sleepiness (ESS score ≥11) and the remaining 1434 (94.8%) were not having EDS (ESS score <11) (p<0.001). Prevalence of excessive daytime sleepiness (ESS score ≥11) was 49 (52.7%) among high-risk and 26 (1.8%) low-risk OSAS subjects respectively (p<0.001). Prevalence of obesity was 185 (12.2%) with 62/185 (33.5%) were at a high risk for OSAS. One hundred and thirty-three (8.8%) subjects were hypertensive with 58/133 (62.4%) of them were at high risk of OSAS. Out of 1512 subjects, 40 (2.6%) with 31 (2.1%) males and 9 (0.5%) females were having a clinically significant form of OSAS defined as obesity and snored at least 3-4 times per week and had associated EDS (ESS score ≥11). Evaluation of risk Factors for OSAS in the adult population has been illustrated in Table 3. Obesity, neck size, alcoholism and sedatives/ tranquillisers use were risk factors associated with statistical significance for high-risk OSAS and all were considered to be independent risk factors for OSAS when analysed further with a multivariate model. Fifty-one (54.8%) high-risk OSAS and 260 (18.3%) low-risk OSAS subjects finally participated for PSG (total number 311). Polysomnographic parameters such as ESS Score, AHI/hour, total oxygen desaturation, snore time, Stage 1 sleep (S1), Stage 2 sleep (S2), Arousal Index were statistically significant for OSAS (62) as compared to the non-OSAS cases (249) as mentioned in Table 4. The distribution of upper airway abnormalities among OSAS and non-OSAS cases are shown in Table 5. Mallampatti Grade III and IV are more commonly observed in OSAS cases as compared to non-OSAS cases where Mallampatti Grade I and II are observed more frequently. High-risk category predicted an AHI ≥5/hr with sensitivity 86.3%, specificity 93.1%, positive and negative predictive values of 70.9% and 97.2%, respectively. AHI distribution in various risk groups has also been illustrated in Table 6. The diagnostic capability of BQ at various levels of cut off for AHI (≥5/hr, ≥15/hr, ≥30/hr) has been described in Table 7.

Discussion

The public health impact of OSAS is enormous, particularly given some studies suggesting increased prevalence of OSAS in India compared to other countries and its potential contribution to the increased rates of cardiovascular disease noted in India, especially as life expectancy continues to increase. Its impact in developing countries like India is now being appreciated, as awareness regarding this entity was low among the general public as well as physicians previously. Our study was conducted on 1512 apparently healthy adults that were administered BQ for screening high risk for OSAS. The reason for taking cut off age limit as 25 years in the current study was that OSAS is more common in middle-aged subjects. The population above 65 years of age constitute only 3.5% of our study population as the chances of central sleep apnea are high in such age group rather than OSA and also a frequent association with various co-morbid illnesses which may give the false high prevalence of OSAS. We have used original version of BQ to find out prevalence of high-risk OSAS, which was first used by Netzer *et al*. [7]. In our study, the prevalence of high risk and clinically significant OSAS were 6.2% (males- 4.6% and females- 1.5%) and 2.6% (males- 2.1% and females-0.5%) respectively. The prevalence of high-risk OSAS estimated worldwide was 4.6%-27.3% on the basis of studies using BQ without assessment of PSG whereas the prevalence of OSAS based on studies using BQ with assessment of PSG estimated to be 1.7%-12.2% [1,2,4-6,11-20]. Estimates of the prevalence of OSAS worldwide and even within different regions of India provide widely different figures probably because of differences in definitions, in the design of the studies and the investigations performed and in the age, sex and other characteristics of the population surveyed. Young *et al.* also reported 4% of men and 2% had sleep apnea syndrome in their study [1]. However, Netzer NC *et al.* reported the prevalence of OSAS in the adult population was 37.5%, in 44.5% males and 33% females, which was much higher due to more obese population and more positive way of responding to questionnaire in their study [7]. The major drawback is that sleep questionnaires despite being useful in assessing risk for OSAS, are not interchangeable with instrumental sleep studies and cannot quantify the severity of the disease. Therefore, the prevalence of people at high risk for OSAS based on questionnaires cannot be simply converted into the prevalence of OSAS. In our study of adults in the age group 25-65 years, 35.1% were snorers, 63.6% were non-snorers and 36.4% did not know whether they snore. The prevalence of snoring estimated among various studies was 4.6%-59.1% [1,2,4-6,11-22]. Netzer *et al.* reported that 52.2% subjects were snorers, 30% non-snorers and 15.9% did not know whether they snore [7]. 43.9% males and 38.5% females were snorers in this current study. Lugaresi *et al.* also reported that 40% men and 28% of women were snorers [21]. The prevalence of high-risk OSAS, in adult obese population, was 33.5% significantly more than non-obese population (p<0.001) when the cut-off point for obesity was taken as BMI ≥30 kg/m^2 according to western population. However, when cut off value was taken as BMI ≥25 kg/m^2 for Asian population prevalence was found to be 18.8% [23]. These observations suggest that a significant percentage of our non-obese subjects by Western or Asian standards still had high-risk OSAS leading to postulate that other risk factors for OSAS such as upper airway abnormalities assume greater pathogenic significance in Indian subjects and may be responsible for our higher prevalence. Various studies in India

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Table 2. Risk categorization for OSAS on the basis of responses to Berlin Questionnaire.

Berlin Questionnaire	High-risk OSAS Number (%)	Low-risk OSAS Number (%)	Total	p-value
Category 1				
Do you snore?				p=0.18
Yes	**87 (93.5%)**	**443 (31.1%)**	**530 (35.1%)**	
No	4 (4.3%)	621 (43.8%)	625 (41.3%)	
Do not know	2 (2.2%)	355 (25.1%)	357 (23.6%)	
Total	**93**	**1419**	**1512**	
Snoring Loudness				p<0.001
Loud as breathing	3 (3.4%)	91 (20.5%)	94 (17.8%)	
Loud as talking	8 (9.2%)	116 (26.2%)	124 (23.4%)	
Louder than talking	**35 (40.2%)**	**145 (32.7%)**	**180 (33.9%)**	
Very loud	**41 (47.2%)**	**91 (20.6%)**	**132 (24.9%)**	
Total	**87**	**443**	**530**	
Snoring Frequency				p<0.001
Almost everyday	**72 (82.8%)**	**172 (38.8%)**	**244 (46.1%)**	
3-4 times/week	**8 (9.2%)**	**83 (18.7%)**	**91 (17.2%)**	
1-2 times/week	3 (3.4%)	108 (24.5%)	111 (20.9%)	
1-2 times/month	2 (2.3%)	64 (14.4%)	66 (12.4%)	
Never or almost never	2 (2.3%)	16 (3.6%)	18 (3.4%)	
Total	**87**	**443**	**530**	
Does your snoring bother other people				p<0.001
Yes	**74 (85.1%)**	**157 (35.4%)**	**231(43.6%)**	
No	13 (14.9%)	286 (64.6%)	299(56.4%)	
Total	**87**	**443**	**530**	
How often your breathing pauses been noticed				p<0.001
Almost every day	**26 (29.9%)**	**2 (0.4%)**	**28 (5.3%)**	
3-4 times/week	**13 (14.9%)**	**7 (1.6%)**	**20 (3.8%)**	
1-2 times/week	10 (11.5%)	2 (0.4%)	12 (2.3%)	
1-2 times/month	11 (12.6%)	63 (14.3%)	74 (13.9%)	
Never or almost never	27 (31.1%)	369 (83.3%)	396 (74.7%)	
Total	**87**	**443**	**530**	
Category 2				
Are you tired after sleeping?				p<0.001
Almost every day	**50 (53.8%)**	**27 (1.9%)**	**77 (5.1%)**	
3-4 times/week	**19 (20.4%)**	**35 (2.4%)**	**54 (3.6%)**	
1-2 times/week	5 (5.4%)	76 (5.4%)	81 (5.4%)	
1-2 times/month	6 (6.5%)	257 (18.1%)	263 (17.3%)	
Never or almost never	13(13.9%)	1024 (72.2%)	1037 (68.6%)	
Total	**93**	**1419**	**1512**	
Are you tired during wake time?				p<0.001
Almost every day	**54 (58.1%)**	**24 (1.7%)**	**78 (5.2%)**	
3-4 times/week	**15 (16.1%)**	**24 (1.7%)**	**39 (2.6%)**	
1-2 times/week	4 (4.3%)	113 (7.9%)	117 (7.7%)	
1-2 times/month	7 (7.6%)	170 (11.9%)	177 (11.7%)	
Never or almost never	13 (13.9%)	1088 (76.8%)	1101 (72.8%)	
Total	**93**	**1419**	**1512**	
Are you driving?				
Yes			786 (51.9%)	
No			726 (48.1%)	
How often you ever nodded off or fallen asleep while driving?				p<0.001
Almost every day	**28 (30.1%)**	**3 (0.4%)**	**31 (3.9%)**	
3-4 times/week	**16(17.2%)**	**5 (0.7%)**	**21 (2.7%)**	
1-2 times/week	3 (3.2%)	8 (1.2%)	11 (1.4%)	
1-2 times/month	11(11.8%)	74 (10.6%)	85 (10.8%)	
Never or almost never	35 (37.7%)	603 (87.1%)	638 (81.2%)	
Total	**93**	**693**	**786**	
Category 3				
Whether hypertensive on Examination?				p<0.001
Yes	**58 (62.4%)**	**75 (5.3%)**	**133 (8.8%)**	
No	35 (37.6%)	1344 (94.7%)	1379 (91.2%)	
Total	**93**	**1419**	**1512**	
Has your weight changed? Whether BMI is ≥ 30 kg/m²?				p<0.001
Yes	**62 (66.7%)**	**123 (8.7%)**	**185 (12.2%)**	
No	31 (33.3%)	1296 (91.3%)	1327 (87.8%)	
Total	**93**	**1419**	**1512**	

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Table 3. Evaluation of risk factors for OsaS in adult population.

Risk factors	Categories of risk factors	High risk OSAS No. (%)	Low risk OSAS No. (%)	Total No. (%)	Unadjusted Odds Ratio (95% CI)	p-value	Adjusted Odds Ratio (95% CI)	p-value
Obesity (BMI ≥30 Kg/m²)	Present	62 (66.7%)	123 (8.7%)	185 (12.2%)	26.15 (14.84-47.38)	p<0.001	22.31 (12.84-43.20)	p<0.001
	Absent	31 (33.3%)	1296 (91.3%)	1327 (87.8%)				
Neck size (≥17" in male or ≥15" in female)	Present	29 (31.2%)	44 (3.1%)	73 (4.8%)	8.52 (4.51-16.08)	p<0.001	6.72 (2.25-13.63)	p<0.001
	Absent	64 (68.8%)	1375 (96.9%)	1439 (95.2%)				
Male sex	Present	70 (75.3%)	958 (67.5%)	1028 (67.9%)	1.32 (0.74-2.37)	p=0.42		
	Absent	23 (24.7%)	461 (32.5%)	484 (32.1%)				
Smoking	Present	30 (32.3%)	389 (27.4%)	419 (27.7%)	1.32 (0.75-2.34)	p=0.40		
	Absent	63 (67.7%)	1030 (72.6%)	1093 (72.3%)				
Alcoholism	Present	27 (29.1%)	152 (10.7%)	179 (11.8%)	2.56 (1.46-4.49)	p<0.001	2.02 (1.51-3.83)	p<0.01
	Absent	66 (70.9%)	1267 (89.3%)	1333 (88.2%)				
Sedative or tranquiliser use	Present	15 (16.1%)	50 (3.5%)	65 (4.3%)	4.41 (2.17-8.99)	p<0.001	3.69 (2.15-6.55)	p<0.001
	Absent	78 (83.9%)	1369 (96.5%)	1447 (95.7%)				

Table 4. Comparison of polysomnography parameters in the OSAS and non-OSAS groups.

Sleep parameters	Total mean ± SD	OSAS cases (n=62)	Non-OSAS cases (n=249)	Significance
Epworth sleepiness scale (ESS) Score	9.1±5.8	12.9 ± 5.5	5.1 ± 2.4	p<0.001
Total sleep period	521.1±55.8	526.9 ± 50.8	514.9 ± 60.8	p=0.25
Total wake time	234.1±89.6	248.7 ± 101.1	218.5 ± 74.3	p=0.10
Total sleep time (TST)	287.1±91.9	278.3 ± 99.4	296.4 ± 83.9	p=0.50
Sleep latency	30.6±32.2	29.9 ± 39.7	31.4 ± 22.2	p=0.50
Rapid eye movement (REM) latency	116.8±72.9	122.1 ± 77.5	111.2 ± 79.2	p=0.60
Apnea hypopnea index (AHI)/hour	26.7 ±33.1	50.4 ± 30.9	1.6 ± 1.2	p<0.001
Total oxygen desaturation	104.3±143.3	194.1 ± 152.9	9.4 ± 8.2	p<0.001
Snore time	22.3±24.4	27.8 ± 27.3	16.4 ± 20.9	p<0.05
Stage 1 (S1) (%TST)	19.3±16.4	26.3 ± 18.4	11.9 ± 9.5	p<0.001
Stage 2 (S2) (%TST)	19.7±15.7	23.7 ± 16.2	15.9 ± 14.4	p<0.05
Stage 3 (S3) (%TST)	19.9±11.1	17.9 ± 11.8	21.9 ± 10.1	p=0.1
Stage 4 (S4) (%TST)	23.1±15.9	19.7 ± 16.7	26.7 ± 14.4	p<0.05
Rem (%TST)	18.3±17.9	16.3 ± 13.2	20.1± 19.5	p=0.20
Average oxygen saturation	93.6±6.1	90.2 ± 6.6	97.2 ± 2.3	p<0.001
Minimum oxygen saturation	81.7±15.7	69.8 ± 12.9	94.4 ± 4.6	p<0.001
Arousal index	5.9 ± 5.1	8.3 ± 5.6	3.4 ± 2.9	p<0.001

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Table 5. Upper respiratory tract (URT) abnormalities in OSAS (n=62) and non-OSAS cases (n=249).

URT abnormalities	OSAS cases (n=62)	Non-OSAS cases (n=249)	Total (n=311)
Macroglossia	17 (27.4%)	3 (1.2%)	20 (6.4%)
Pharyngeal crowding	26 (41.9%)	11 (4.4%)	37 (11.9%)
Bulky uvula	20 (32.3%)	9 (3.6%)	29 (9.3%)
Retrognathia	33 (53.2%)	18 (7.2%)	51 (16.4%)
Tonsillar enlargement	8 (12.9%)	3 (1.2%)	11 (3.5%)
Deviated nasal septum	35 (56.5%)	21 (8.4%)	56 (18.1%)
Mallampatti Grade I	6 (9.7%)	112 (44.9%)	118 (37.9%)
Mallampatti Grade II	16 (25.8%)	93 (37.3%)	109 (35.1%)
Mallampatti Grade III	22 (35.5%)	44 (17.7%)	66 (21.2%)
Mallampatti Grade IV	14 (22.3%)	4 (1.6%)	18 (5.8%)

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Table 6. Apnea hypopnea index (AHI) distribution in various risk groups for OSAS.

AHI/hr (Grading)	High risk OSAS	Low risk OSAS	Total
< 5	7 (13.7%)	242 (93.1%)	249 (80.1%)
≥ 5 and < 15 (Mild)	6 (11.8%)	11 (4.3%)	17 (5.5%)
≥ 15 and ≤ 30 (Moderate)	14 (27.5%)	6 (2.3%)	20 (6.4%)
>30 (Severe)	24 (47.1%)	1 (0.1%)	25 (8.1%)
Total	**51**	**260**	**311**

Table 7. Diagnostic capability of BQ at various levels of cut off for AHI (≥5/hr, ≥15/hr, ≥30/hr).

	AHI ≥ 5 (95% Confidence Interval)	AHI ≥ 15 (95% Confidence Interval)	AHI ≥ 30 (95% Confidence Interval)
Sensitivity	86.3% (73.1-93.8)	78.7% (66.1-87.8)	47.1% (33.2-61.4)
Specificity	93.1% (89.1-95.7)	97.7% (94.8-99.1)	99.6% (97.5-99.9)
Positive predictive value	70.9% (57.9-81.4)	88.9% (76.7-95.4)	96.0% (77.7-99.8)
Negative predictive value	97.2% (94.1-98.8)	95.1% (91.6-97.3)	90.6% (86.4-93.6)
Positive likelihood ratio	12.5 (7.9-19.7)	18.0 (9.8-20.1)	24.2 (8.6-27.2)
Negative likelihood ratio	0.2 (0.1-0.3)	0.1 (0.0-0.2)	0.1 (0.0-0.2)
Odds ratio	4.5 (1.3-14.2)	6.4 (2.2-17.5)	7.9 (2.6-23.5)
Area under curve	0.9 (0.8-0.9)	0.8 (0.7-0.9)	0.8 (0.7-0.9)

have used BMI ≥25 kg/m² as a cut-off value for obesity providing similar inferences [2,4,6,24]. The prevalence of high-risk OSAS, in obese males as well as females were 48.4% and 43.3% respectively which was not significant (p=0.6). Vgontzas *et al.* [5] reported that in a large group of severely or morbidly obese patients, 40% men and 3% of women demonstrated OSAS severe enough to warrant therapeutic intervention. In our study among adults, the prevalence of hypertension was 62.4% in high-risk OSAS patients and 5.3 % in low-risk OSAS adult subjects. The prevalence of hypertension was significantly higher in high-risk OSAS patients than low-risk OSAS subjects. Various studies also found significant association between high-risk OSAS and hypertension [26-28]. In our study, the risk factors for OSAS with statistical significance were obesity (p<0.001), neck size (17 inches in male or 15 inch in female) (p<0.001); alcoholism (p<0.001) and sedatives/ tranquillizers use (p<0.001). Flemons WW *et al* also reported neck size even 16.1±1.4 inch was significant risk factor for OSAS (p<0.001) [29]. Several studies have found a significant association between OSAS and measures of excess body weight [1,11,13,30-39]. Many studies in which defined quantities of alcohol were administered to healthy subjects or patients with OSAS before bedtime have demonstrated harmful effects on nocturnal respiration including increased number and duration of hypopnea and apnea events [40-45]. Many cross-sectional epidemiological studies of OSAS have found positive associations with cigarette smoking [4,46-48]. Another analysis from Sleep Heart Health Studies also found an inverse association between current smoking and OSAS, after adjusting for several factors including age and BMI, current smokers had significantly fewer respiratory disturbance events as assessed by in-home polysomnography [49]. A high-risk group for OSAS was predicted with a sensitivity of 86.3%, specificity of 93.1%, positive predictive value of 70.9% and negative predictive value of 97.2%. The predictive performance of the BQ varies among different populations studied worldwide. The original BQ study conducted by Netzer NC *et al.* depicted sensitivity=88%, specificity=76%, positive predictive value=88% and negative predictive value=81% [7]. The performance of the BQ in our population is comparable to that of studies conducted in other Indian population and Arabia with a sensitivity of 86% and specificity of 95%, and a sensitivity of 97% and specificity of 90% respectively at a cut-off of AHI ≥5 where a modified version of the BQ was used [23,50]. The results of our study differ from other studies in the literature, where the BQ was shown to have lower sensitivity and specificity (68% and 49% for AHI ≥5) in one study, sensitivity and specificity, 62.5% and 53.8% with a cut-off for AHI ≥10 in patients undergoing pulmonary rehabilitation, sensitivity and specificity of 72% and 50% for AHI ≥5 in a sleep laboratory in Portugal, in a hypertension clinic (86% and 65% for AHI >10), in pre-operative patients (69% and 56% for AHI ≥5) and in Greece (76% and 40% for AHI ≥5) [51-56]. The reasons for the difference in the predictive performance across the various studies might be related to several possible factors such as heterogeneity in demographic profiles of patients, the difference in methods for assessing patients at risk including modifications of the questionnaire and different types of sleep monitoring devices used. The developing countries like India are heavily populated with diverse social norms and many groups live in an underdeveloped environment. These factors can be considered as obstacles in assessing the disease burden by performing polysomnography which is labour intensive and time-consuming. Therefore, BQ can screen those subjects with symptoms of high-risk OSAS from this population and can undergo PSG on a priority basis for management as compared to subjects with low-risk OSAS.

Our study has several strengths. This study is the first to estimate the prevalence of OSAS in a semi-urban population from this region of India where majorities of the general public are more unaware of disease severity with less interest to undergo treatment in contrast to the population in urbanised metropolitan cities on which previous studies were conducted. There was still satisfactory response rate with robust sample size as conducted in resource-limited settings. The predictive performance of risk categorization by BQ was compared to gold standard supervised in-laboratory polysomnography in the current study. The apparently normal attendants accompanying patients reporting to a tertiary care referral centre from all parts of the state that were having no complaints were recruited in this study. The patients directly reporting with symptoms of OSAS were not included in order to avoid selection bias.

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This study has also several limitations. Most of the subjects are attendants of patients thereby not representing actual proportion of the community, therefore, the findings have to be generalised by conducting community-based surveys. Community studies are more likely to portray epidemiology with better accuracy than single-centre hospital studies. Second, the hospital studies usually recruit patients with a high pre-test probability of diagnosis, which is true for studies using questionnaires/ symptomatology as well as polysomnography studies. Third, the mean BMI of the population in this study was high that was likely to have affected the sensitivity and specificity of the BQ, as the BMI contributes significantly into the scoring of the BQ. Fourth, a larger number of subjects could have been recruited for polysomnography especially from low-risk OSAS subjects as only the high-risk OSAS subjects who had sleep symptoms selectively consented to the overnight PSG. The proportion of females is less as compared to males (33%). The practical reason for fewer females was bearing in mind Indian social norms as they would have been reluctant to allow a male technician to allow for overnight PSG and more lack of awareness regarding the severity of disease as compared to males. Most Indian females are non-drivers thereby leading to inappropriate risk categorization by BQ.

The sensitivity of 86.3 % (for an AHI ≥5) has made an impression regarding the BQ that it still can be used as a pre-assessment tool for predicting persons at risk for OSAS in clinical practice. The prediction value of BQ can be enhanced by further modification according to the requirement of respective settings. However, physician judgment is still needed to initiate a management system, to detect unusual cases, or to recognise causes for wake time sleepiness other than sleep apnea. Further studies on applying the BQ in a larger sample of patients are warranted in near future from other regions of India.

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