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Original Research Article

PREVALENCE OF HIGH RISK OF OBSTRUCTIVE SLEEP APNEA AND ITS ASSOCIATION WITH ANTHROPOMETRIC AND CHRONIC DISEASE VARIABLES AMONG THE RURAL POPULATION OF VISAKHAPATNAM, ANDHRA PRADESH, INDIA: A CROSS-SECTIONAL STUDY

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ABSTRACT

Background: Obstructive Sleep Apnea (OSA) is a common but under-recognised sleep-related breathing disorder that is increasingly relevant to public health in developing countries because of its association with obesity, hypertension, diabetes mellitus and cardiovascular disease. Data on the burden of OSA in the Indian rural population remain limited. **Objectives:** To estimate the prevalence of high risk of OSA among the rural population of the field practice area of a Rural Health Training Centre in Visakhapatnam, and to determine its association with anthropometric variables and chronic disease conditions.

Materials and Methods: A community-based, descriptive cross-sectional study was conducted over two months (28 September to 27 November 2022) among 608 adults aged 18 years and above, selected by simple random sampling from the field practice area of the Rural Health Training Centre. Data on socio-demographic and anthropometric variables, chronic disease conditions, and risk of OSA (using the STOP-BANG questionnaire) were collected using a pre-tested, semi-structured, interviewer-administered questionnaire. A STOP-BANG score of 0-2 was classified as low risk and a score of ≥3 as high risk of OSA. Associations were tested using the chi-square test Fisher's exact test and unpaired t-test, with $p<0.05$ considered statistically significant.

Results: Of the 608 participants (292 males, 316 females), 101 (16.6%) were found to be at high risk of OSA. High risk of OSA was more common in males (19.5%) than in females (13.9%) and increased sharply with age, from 4.5% in the 18-29 years age group to 51.6% among those aged 50 years and above ($p<0.001$). The mean BMI (27.45 ± 6.72 vs 24.12 ± 4.67, $p<0.0001$) and mean waist-hip ratio (0.95 ± 0.14 vs 0.88 ± 0.085, $p<0.0001$) were significantly higher among participants at high risk of OSA. A significantly higher proportion of participants with hypertension, diabetes mellitus and stroke were at high risk of OSA ($p<0.05$ for each), whereas no significant association was found with asthma.

Conclusion: Nearly one in six adults in this rural population was at high risk of OSA, with age, male gender, obesity, central obesity, hypertension, diabetes and stroke identified as significant correlates. These findings support the need for opportunistic screening for OSA in primary care settings serving similar rural populations.

Keywords: Obstructive Sleep Apnea; STOP-BANG Questionnaire; Prevalence; Rural Population; Risk Factors; Cross-Sectional Study.

INTRODUCTION

Obstructive Sleep Apnea (OSA) is a common clinical condition characterized by repeated episodes of partial or complete upper airway obstruction during sleep, leading to recurrent apneas and hypopneas.[1] The syndrome is particularly prevalent among middle-aged and older adults. The mechanism of upper airway collapse is multifactorial, and includes obesity, craniofacial abnormalities, altered upper airway muscle function, pharyngeal neuropathy, and fluid shift toward the neck. The resulting intermittent hypoxia, hypercapnia, recurrent arousals and increased respiratory effort lead to secondary sympathetic activation, oxidative stress and systemic inflammation. The most common complaints of OSA are loud snoring, disrupted sleep and excessive daytime sleepiness, all of which contribute to fragmented sleep. Rising urbanization and lifestyle changes, together with a probable role in the increasing prevalence of obesity and cardiovascular disease, have made OSA an important public health concern in developing countries such as India. OSA is known to diminish quality of life and is associated with several common comorbid conditions.[2] Studies have shown a higher risk of coronary artery disease, hypertension, cerebrovascular accidents, gastroesophageal reflux disease, congestive heart failure and myocardial infarction among patients with OSA.[3,4] OSA is also associated with excessive daytime sleepiness, cardiovascular morbidity and mortality, and metabolic dysfunction.[6] Polysomnography performed in a sleep laboratory remains the gold-standard diagnostic test for OSA, but it is expensive and not widely accessible, particularly in rural and resource-limited settings.[7]

A survey conducted in a semi-urban Indian population found that approximately 6.2% of the total sample were diagnosed with high-risk OSA, and 33.5% of the obese population were at high risk.[8] There remains a paucity of data on the prevalence of OSA in the Indian rural population. This study was therefore designed to estimate the prevalence of high risk of OSA using the STOP-BANG questionnaire among a rural population and to examine its correlates.

Objectives

- To estimate the prevalence of risk of Obstructive Sleep Apnea among the rural population of the field practice area of the Rural Health Training Centre.
- To determine the association between anthropometric variables and OSA.
- To determine the association between chronic disease conditions and OSA

MATERIALS AND METHODS

A descriptive, cross-sectional study was conducted among the rural population of Visakhapatnam, Andhra Pradesh, India, in the field practice area of the Rural Health Training Centre (RHTC), over a period of two months, from 28 September to 27 November 2022.The study population comprised adults aged 18 years and above who were permanent residents of the field practice area of the RHTC. The sample size was calculated using the formula $n > Z^2pq / l^2$ for estimating a true population prevalence, based on a previously reported OSA prevalence of 13.7%.[9] With an absolute precision (l) of 5%, a 95% confidence interval ($Z = 1.96$), a sample size of 608 was estimated and adding 10% for non-response, the total sample size was 668. To get a minimum sample size of 608. 668 people were surveyed. All residents of the field practice area above 18 years of age were enlisted, and the required sample was selected from this list using a random number table by simple random sampling technique. Adults aged 18 years and above who were cooperative and willing to participate in the study were included. Individuals who had suffered a myocardial infarction and those who had undergone upper-airway surgery were excluded from the study. Prior to the commencement of the study, written informed consent was obtained from all participants after explaining the nature, purpose and procedure of the study. Participants were briefed regarding the objectives of the study and the data collection instrument. Data were collected using a pre-tested, pre-designed, semi-structured questionnaire, translated into the local vernacular language, through interviews conducted at the households of selected participants after ensuring strict confidentiality. Data were securely stored electronically, with access restricted to the investigator and the guide. The questionnaire captured socio-demographic variables, anthropometric variables, chronic disease conditions, and the STOP-BANG questionnaire.[5]

The STOP-BANG questionnaire was developed as a concise screening tool for OSA in pre-operative settings and comprises eight dichotomous (yes/no) items covering Snoring (S), Tiredness (T), Observed Sleep Apnea (O), high blood Pressure (P), Body mass index >35 kg/m² (B), Age >50 years (A), Neck circumference >40 cm(approximately 16 inches) (N), and male Gender (G). Each affirmative response scores one point, giving a total score ranging from 0 to 8; a score of 0-2 indicates low risk, 3-4 intermediate risk, and ≥5 (or, per common convention, ≥3) high risk of OSA. For the purposes of statistical analysis in this study, participants were dichotomised into a low-risk group (score 0-2) and a high-risk group (score ≥3). The questionnaire has demonstrated in earlier studies high sensitivity (84% for any sleep apnea, 93% for moderate-to-severe, and 100% for severe sleep apnea at a cut-off score of 3), with corresponding specificities of 56.4%, 43% and 37% respectively.

Neck circumference was measured with a measuring tape at the level of the thyroid notch (Adam's apple) in men and at the mid –neck level in women or individuals without a prominent larynx. Height was measured by a portable stadiometer, weight was measured using a digital weighing balance and BMI was calculated. Waist circumference was measured at the narrowest point and hip circumference at the widest point, and the waist-hip ratio was calculated to assess the obesity status of participants. The blood pressure was measured using a calibrated digital blood pressure monitor. The measurements were recorded immediately to avoid transcription errors. The Snoring, Tiredness and Observed Sleep Apnea were recorded by the self-reported responses of the study subjects and also based on information from a bed partner or family member for Observed Sleep Apnea. Data were compiled and analysed using standard statistical software,SPSS v.23. Categorical variables were expressed as frequencies and percentages, and continuous variables as mean ± standard deviation. The Chi-square test and Fisher exact test were used to assess the association between the risk of OSA and categorical variables (age group, gender, neck circumference, and chronic disease conditions), and the unpaired t-test was used to compare mean BMI and mean waist-hip ratio between the low-risk and high-risk groups. A p-value <0.05 was considered statistically significant.

RESULTS

A total of 608 adults were included in the study, comprising 292 (48.0%) males and 316 (52.0%) females. Overall, 34.7% of participants reported habitual loud snoring and 23.0% reported daytime tiredness or sleepiness.

Table 1: Prevalence of risk of Obstructive Sleep Apnea among the rural population (n = 608)

Risk of OSA	Number of Individuals	Prevalence (%)
Low risk (score 0-2)	507	83.39
High risk (score ≥3)	101	16.61
Total	608	100.00

Of the 608 participants screened, 101 (16.61%) were found to be at high risk of Obstructive Sleep Apnea, while the remaining 507 (83.39%) were at low risk.

Table 2: Age-wise distribution of risk of OSA among study participants

Age Group years	Low Risk of OSA n (%)	High Risk of OSA n (%)	Total
18-29	128 (95.52)	6 (4.48)	134
30-39	160 (88.89)	20 (11.11)	180
40-49	158 (94.05)	10 (5.95)	168
≥50	61 (48.41)	65 (51.59)	126
Total	507	101	608

The prevalence of high risk of OSA increased steeply with advancing age, rising from 4.48% in the 18-29 year age group to 51.59% among participants aged 50 years and above, indicating that risk of OSA was highest among older adults and lowest among young adults. There is a significant statistical association of age with risk of OSA (p<0.001). Compared with the youngest age group (18-29 years, reference), the odds of high OSA risk were significantly higher among participants aged 30-39 years (OR = 2.67, 95% CI: 1.04-6.84) and substantially and significantly higher among those aged ≥50 years (OR = 22.73, 95% CI: 9.34-55.36). The odds in the 40-49 year group were not significantly different from the reference (OR = 1.35, 95% CI: 0.48-3.81). These findings indicate that advancing age, particularly beyond 50 years, is strongly associated with increased risk of Obstructive Sleep Apnea in this rural population, consistent with known age-related physiological changes.

Table 3: Gender-wise distribution of risk of OSA among study participants

Gender	Low Risk of OSA n (%)	High Risk of OSA n (%)	Total
Females	272 (86.08)	44 (13.92)	316
Males	235 (80.48)	57 (19.52)	292
Total	507 (100.00)	101 (100.00)	608

The prevalence of high risk of OSA was higher among males (19.52%) than among females (13.92%), suggesting that male gender is associated with a greater risk of OSA in this population. The association of gender with risk of OSA is not statistically significant (p=0.064). The odds of high OSA risk were 1.5 times higher in males compared to females, though the association was not statistically significant (OR = 1.50, 95% CI: 0.97-2.31).

Table 4: Comparison of mean BMI between participants at low and high risk of OSA

Statistic	Low Risk of OSA	High Risk of OSA
Mean BMI (kg/m²)	24.12	27.45
Standard Deviation	4.67	6.72

Statistic	Value
Mean Difference	3.330
Standard Error	0.552
95% Confidence Interval	2.246 – 4.414
t-statistic (df = 606)	6.033, p<0.0001

Participants classified as low risk for OSA had a mean BMI of 24.12 kg/m² (SD = 4.67), which falls within the "normal weight" range. Participants classified as high risk for OSA had a mean BMI of 27.45 kg/m² (SD = 6.72), which falls within the "overweight" range. This showed that, on average, individuals at high risk of OSA had a higher BMI than those at low risk. The mean difference between the two group means was 3.33 (27.45 − 24.12 ≈ 3.33). The standard error measures the precision of this estimated mean difference and was 0.552 . The t-statistic was calculated by dividing the mean difference by its standard error. (3.330 / 0.552 ≈ 6.03).

The association between BMI and risk of OSA ($p<0.0001$) was found to be statistically significant.

Table 5: Comparison of mean waist-hip ratio between participants at low and high risk of OSA

Statistic	Low Risk of OSA	High Risk of OSA
Mean Waist-Hip Ratio	0.88	0.95
Standard Deviation	0.085	0.14

Statistic	Value
Mean Difference	0.070
Standard Error	0.010
95% Confidence Interval	0.0494 – 0.0906
t-statistic (df = 606)	6.673, p<0.0001

The mean waist-hip ratio among participants at low risk of OSA was 0.88 ± 0.085, compared with 0.95 ± 0.14 among those at high risk, indicating that central obesity is associated with a greater risk of OSA. Participants classified as low risk for OSA had a mean waist-hip ratio (WHR) of 0.88 (SD = 0.085). Participants classified as high risk for OSA had a mean waist-hip ratio of 0.95 (SD = 0.14). This shows that, on average, individuals at high risk of OSA had a higher waist-hip ratio (indicating more central/abdominal obesity) than those at low risk. The mean difference between the two group means (0.95 − 0.88 = 0.07). It tells us that, on average, the high-risk group's waist-hip ratio was about 0.07 units higher than the low-risk group's. The standard error 0.010 reflects the precision of this estimated mean difference. The 95% Confidence Interval showed that the true mean difference in waist-hip ratio between high- and low-risk groups (in the wider population) lies somewhere between 0.0494 and 0.0906. The t-statistic is calculated by dividing the mean difference by its standard error (0.070 / 0.010 ≈ 6.67). There association between waist-hip ratio and risk of OSA was found to be statistically significant ($p<0.0001$).

Table 6: Association between neck circumference and risk of OSA

Neck Circumference	High Risk of OSA	Low Risk of OSA
≥16 inches	41 (68.33%)	19 (31.67%)
<16 inches	60 (10.95%)	488 (89.05%)
Total	101 (16.61%)	507 (83.39%)

The prevalence of high risk of OSA was more (68.33%) in study subjects with neck cirumference ≥16 inches compared to those (10.95%) with neck cirumference <16 inches . The association of neck circumference with risk of OSA was found to be statistically significant .($p < 0.0001$). The Odds Ratio was 17.55 (95% CI: 9.57 – 32.19). The odds of being classified as high risk for OSA were about 17.6 times higher among individuals with a neck circumference ≥16 inches compared to those with a neck circumference <16 inches. Since the 95% confidence interval (9.57–32.19) is above 1, this association is statistically significant and represents a strong effect size consistent with neck circumference being a meaningful clinical screening marker for OSA risk.

Table 7: Distribution of selected STOP-BANG screening responses among study participants (n = 608)

STOP-BANG Item	Yes n (%)	No n (%)
Habitual loud snoring	211 (34.7)	397 (65.3)
Daytime tiredness / fatigue / sleepiness	140 (23.0)	468 (77.0)

Observed apnea (witnessed breathing cessation / choking / gasping during sleep)	6 (1.0)	602 (99.0)
Neck size ≥16 inches / 40 cm (self-reported shirt-collar size)	58 (9.5)	550 (90.5)

Habitual loud snoring was reported by 34.7% of participants and daytime tiredness or sleepiness by 23.0%. Witnessed apnea (observed stoppage of breathing or choking/gasping during sleep) was uncommon, reported for only 1.0% of participants. Self-reported large neck/shirt-collar size (≥16 inches/40 cm) was affirmed by 9.5% of participants; this self-reported figure is considerably lower than the tape-measured neck circumference ≥16 inches shown in Table 6 (90.1%), which likely reflects the difference between an objective clinical measurement and a subjective self-report of shirt-collar size, with participants tending to under-report their own neck/collar size.

Table 8: Association between individual chronic disease conditions and risk of OSA

Condition	Low Risk n (%)	High Risk n (%)	χ^2	p-value	OR (95% CI)
Hypertension	44 (8.68%)	69 (68.32%)	197.97	p < 0.00001	22.69 (13.48–38.20)
Diabetes mellitus	35 (6.90%)	35 (34.65%)	63.66	p < 0.00001	7.15 (4.19–12.21)
Asthma	17 (3.35%)	7 (6.93%)	2.84	p = 0.0918	2.15 (0.87–5.32)
Stroke	1 (0.20%)	6 (5.94%)	24.41	p < 0.00001	31.96 (3.80–268.48)

Hypertension was far more common among high-risk participants (68.32%) than low-risk participants (8.68%). This difference was highly statistically significant (χ^2 = 197.97, p < 0.00001). The odds of being high risk for OSA were about 22.7 times higher among participants with hypertension compared to those without (OR = 22.69, 95% CI: 13.48–38.20) — the strongest association among the four conditions examined.

Diabetes was present in 34.65% of high-risk participants compared to only 6.90% of low-risk participants, a highly significant difference (χ^2 = 63.66, p < 0.00001). Participants with diabetes had about 7.2 times higher odds of being high risk for OSA (OR = 7.15, 95% CI: 4.19–12.21).

Asthma was present in 6.93% of high-risk participants versus 3.35% of low-risk participants. Unlike the other conditions, this difference did not reach statistical significance (χ^2 = 2.84, p = 0.0918). The odds ratio (OR = 2.15, 95% CI: 0.87–5.32) also reflects this.

Stroke was rare overall but showed a striking difference: 5.94% of high-risk participants had a history of stroke compared to just 0.20% of low-risk participants (only 1 person). This difference was statistically significant (χ^2 = 24.41, p < 0.00001), and the odds ratio was very large (OR = 31.96, 95% CI: 3.80–268.48).

Table 9: Association between combined chronic disease conditions and risk of OSA

Combined Conditions	Low Risk n (%)	High Risk n (%)	χ^2 / Fischer's exact Test	p-value	OR (95% CI)*
Hypertension + Diabetes mellitus	15 (2.96%)	18 (17.82%)	36.25	p < 0.00001	7.04 (3.45–14.37)
Hypertension + Diabetes mellitus + Stroke	0 (0.00%)	5 (4.95%)	—†	p = 0.0001†	57.85 (3.17–1054.83)
Hypertension + Diabetes mellitus + Asthma	0 (0.00%)	3 (2.97%)	—†	p = 0.0045†	36.07 (1.85–703.76)
Hypertension + Asthma	0 (0.00%)	3 (2.97%)	—†	p = 0.0045†	36.07 (1.85–703.76)

**OR calculated using the Haldane–Anscombe correction (0.5 added to all cells) because one or more cells contained a zero count. † For rows with a zero cell, expected cell counts fall below 5, so the chi-square approximation is unreliable; Fisher's exact test p-value is reported instead.*

Hypertension and Diabetes mellitus were present in 17.82% of high-risk participants compared to only 2.96% of low-risk participants, a highly significant difference (χ^2 = 36.25, p < 0.00001). Participants with both hypertension and diabetes had about 7 times higher odds of being high risk for OSA (OR = 7.04, 95% CI: 3.45–14.37). No (0.00%) low-risk participants had this triad of conditions Hypertension , Diabetes Mellitus and Stroke , while 4.95% of high-risk participants did have. A statistically significant difference (Fisher's exact p = 0.0001) was found and the corrected odds ratio was very large (OR = 57.85, 95% CI: 3.17–1054.83). No (0.00%) low-risk participants had the combination of Hypertension, Diabetes Mellitus and Asthma, while 2.97% of high-risk participants had all the three. This difference was found to be statistically significant (Fisher's exact p = 0.0045), with a corrected OR of 36.07 (95% CI: 1.85–703.76). Combination of Hypertension and Asthma was not found (0.00%) in low risk subjects while 2.97% of high risk subjects had these both. This difference was found to be statistically significant (Fisher's exact p = 0.0045), with a corrected OR of 36.07 (95% CI: 1.85–703.76).

DISCUSSION

The present study found an overall prevalence of high risk of OSA of 16.6% among the rural population of Visakhapatnam, with a higher prevalence among males (19.52%) than females (13.92%). The risk of OSA was directly correlated with age, BMI, neck circumference, waist-hip ratio, hypertension, diabetes mellitus, and stroke.

Foroughi M et al,[9] in study conducted in Tehran, Iran, similarly reported that the risk of OSA was directly correlated with BMI, advancing age, and a history of cardiovascular disease and diabetes; however, that study reported a considerably higher overall prevalence of high risk of OSA (38.6%; 51.4% in males and 26.5% in females), which may reflect differences in the study population and screening cut-offs used.

The findings of the present study are consistent with a study conducted by Alqahtani AJ, et al,[12] in the Aseer region of Saudi Arabia, which reported that more than two-thirds of adults were at moderate-to-high risk of OSA, with the highest prevalence among older male adults with a high BMI.

A study conducted by Pinto AM et al,[13] in South India reported a lower overall prevalence of OSA of 8.72% (7.4% in males and 11.7% in females), and similarly identified older age, hypertension, obesity, and a higher Mallampati score as significant correlates of high risk of OSA.

Dubey A et al,[14] in a study conducted in Lucknow reported a high OSA risk in 20.6% of subjects, with high blood pressure, older age, larger neck circumference, tiredness and snoring being the most frequently reported risk factors, broadly comparable with the correlates identified in the present study.

Pattanaik S et al,[15] in a study conducted in Odisha in 2018 similarly found that the prevalence of OSA increased with age, being highest among those aged 50-59 years (21.7%), with a higher prevalence among males (14.8%) than females (12.9%); however, unlike the present study, the association of OSA with age did not reach statistical significance in that study.

Mathiyalagen P et al,[16] a study conducted in Puducherry reported a higher overall prevalence of high risk of OSA (25.8%; 27.9% in men and 23.8% in women) and similarly found significant associations between risk of OSA and diabetes mellitus, hypertension, BMI, neck, waist and hip circumference, waist-hip ratio, and blood pressure.

Garg S et al,[17] in study among young adults in Moradabad reported a considerably lower overall prevalence of high risk of OSA (5.93%), although, consistent with the present study, the risk was higher among males (8.31%) than females (4.12%).

Sharma SK et al,[19] in a study conducted in Delhi in 2006, one of the earliest population-based studies of OSA in the Indian subcontinent, reported a prevalence of OSA of 13.7% (4.96% in men and 2.03% in women), and similarly identified age, male gender, obesity (high BMI), and waist-hip ratio as independent risk factors for OSA, consistent with the correlates identified in the present study.

Choudhury A et al,[20] in a cross-sectional study conducted in a rural community of Odisha reported that 25% of community dwellers were at high likelihood of OSA using the Berlin questionnaire, with age >35 years, BMI ≥25 kg/m², alcoholism, and hypertension identified as significant risk factors, in keeping with the present findings regarding age, BMI, and hypertension.

Prasanna KJ et al,[21] in a study among overweight and obese collegiate students in Chennai similarly found a high prevalence of high risk of OSA (44% among overweight and 52% among obese students), reinforcing the association between excess body weight and risk of OSA observed in the present study.

In contrast, several studies reported considerably lower prevalence estimates than the present study. Asaoka S et al,[10] in a study among Japanese public transportation drivers reported an OSA prevalence of only 3.7%. A Korean population-based study by Kim Jet al,[11] reported a prevalence of OSA of 4.5% in males and 3.2% in females. A study conducted by Reddy EV et al,[18] in Delhi among a middle-aged urban population reported an estimated OSA prevalence of 9.3%, although that study similarly identified male gender, BMI ≥25 kg/m², and abdominal obesity as independent correlates of OSA. Devaraj U et al,[22] in a study comparing urban and rural subjects in Bengaluru and Anekal taluk, Karnataka, reported a similar overall OSA prevalence (4.6% urban, 3.7% rural), although urban subjects had a higher prevalence of severe OSA. Similarly, a community-based study conducted by Gothi D et al,[23] across Mumbai households reported a considerably lower prevalence of OSA of 3.42%.

Taken together, these comparisons suggest that while the direction of association between OSA and factors such as age, male gender, obesity, central obesity, hypertension and diabetes mellitus is broadly consistent across studies, the absolute prevalence of high risk of OSA varies considerably across populations, likely reflecting differences in the screening tool used (STOP-BANG versus Berlin questionnaire), risk cut-offs applied, age structure of the study population, and background prevalence of obesity and metabolic disease.

CONCLUSION

This community-based study revealed that 16.6% of the adult rural population of Visakhapatnam was at high risk of Obstructive Sleep Apnea, with a higher prevalence among males (19.52%) than females (13.92%). The prevalence of high risk of OSA increased markedly with advancing age. The risk of OSA was directly and significantly associated with age, BMI, waist-hip ratio, neck circumference, hypertension, diabetes mellitus, and stroke.

Recommendations

Opportunistic screening for OSA using a validated, low-cost tool such as the STOP-BANG questionnaire should be considered for adults attending primary health centres in rural areas, particularly those who are older, obese, or have hypertension or diabetes mellitus. Individuals identified as being at high risk of OSA should be referred for confirmatory polysomnography and appropriate clinical management where feasible. Community-based health education on the importance of weight management, central obesity reduction, and control of hypertension and diabetes mellitus may help reduce the burden of OSA in rural populations. Future longitudinal studies with polysomnographic confirmation and larger, multi-site rural samples are recommended to validate these findings and establish causal relationships.

Limitations

The cross-sectional design precludes establishing a temporal or causal relationship between OSA risk and the associated anthropometric and chronic disease variables. Risk of OSA was assessed using the STOP-BANG questionnaire, a screening tool, rather than confirmed by polysomnography, which remains the gold-standard diagnostic test; the actual prevalence of confirmed OSA may therefore differ from the prevalence of high risk reported here. Data on snoring, tiredness and observed apnea were self-reported (or reported by a bed-partner/family member) and are subject to recall and social-desirability bias. The study was conducted in a single rural field-practice area of Visakhapatnam district; findings may not be generalisable to other rural or urban populations with differing socio-demographic and lifestyle profiles. Chronic disease conditions (hypertension, diabetes mellitus, asthma, stroke) were largely based on self-reported history rather than verified clinical or laboratory records, and some sub-group cell counts (e.g., combined comorbidities) were small, limiting the precision of these estimates.

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