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Risk Stratification, Prevalence, and Predictors of High Risk for Obstructive Sleep Apnea–Hypopnea Syndrome Among Adults With Type 2 Diabetes Mellitus in Northern Uganda

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Article

Keywords: Obstructive Sleep Apnea – Hypopnea Syndrome, Type 2 Diabetes Mellitus, STOP-BANG

Posted Date: November 20th, 2026

DOI: https://doi.org/10.21203/rs.3.rs-11256573/v1

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Additional Declarations: No competing interests reported.

Abstract

Background

Obstructive sleep apnea-hypopnea syndrome (OSAHS) is a common but frequently underdiagnosed condition among adults with type 2 diabetes mellitus (T2DM). Despite this substantial burden, the prevalence and associated factors of OSAHS among adults with T2DM in Uganda remain insufficiently documented, limiting the integration of OSAHS screening into routine diabetes care.

Methods

Between 1 November 2025 and 31 May 2026, we conducted a hospital-based cross-sectional study among adults with T2DM attending Gulu Regional Referral Hospital and St. Mary's Hospital–Lacor in Gulu City, northern Uganda. Participants were consecutively enrolled using convenience sampling. OSAHS risk was assessed using the STOP-BANG questionnaire, with scores of 0–2, 3–4, and ≥ 5 indicating low-, intermediate-, and high-risk OSAHS, respectively. Anthropometric measurements, blood pressure, and random blood glucose (RBG) levels were recorded. Adjusted prevalence ratios (aPRs) with 95% confidence intervals (CIs) were reported, and $p < 0.05$ was considered statistically significant.

Results

A total of 250 participants were enrolled, with a mean age of 54.2 ± 14.8 years. Among participants with T2DM, 18.8% (n = 47; 95% CI: 14.0%–23.6%) were at high risk for OSAHS, 41.2% (n = 103) at intermediate risk, and 40.0% (n = 100) at low risk. The most frequently reported STOP-BANG components were tiredness (66.8%), hypertension (62.0%), and snoring (44.0%), while observed apnoea, male sex, age > 50 years, neck circumference > 40 cm, and BMI > 35 kg/m² were reported in 14.4%, 19.6%, 11.2%, 2.0%, and 0.8% of participants, respectively. Male participants had a higher prevalence of high-risk OSAHS than female participants (aPR 1.399, 95% CI: 1.241–1.577; $p < 0.001$). Hypertension was also independently associated with high-risk OSAHS (aPR 1.168, 95% CI: 1.040–1.311; $p = 0.009$). Compared with single participants, widowed participants had a higher prevalence of high-risk OSAHS (aPR 1.199, 95% CI: 1.007–1.428; $p = 0.042$).

Conclusion

Nearly one in five adults with T2DM attending the two tertiary hospitals in Gulu City were at high risk for OSAHS. Routine OSAHS screening in T2DM care, particularly among men, older adults, and those with hypertension or obesity, could support earlier identification and referral, improve clinical outcomes, and reduce the burden of this treatable comorbidity.

Introduction

Sleep disorders related to breathing such as Obstructive sleep apnea - hypopnea syndrome (OSAHS) can be characterized by episodes of either complete (apnea) or partial collapse (hypopnea) of the upper airway causing decreased oxygen saturation and/or arousal from sleep (1). OSAHS is a common clinical condition characterized by repeated episodes of upper airway obstruction during sleep, leading to disrupted breathing and oxygen desaturation. OSAHS is seen in all age groups but the risk increases with age, family history of OSAHS, obesity, smoking and male sex; however, this is particularly prevalent in middle-aged and older adults (2). OSAHS is particularly significant among individuals with type 2 diabetes mellitus (T2DM) and it presents with daytime sleepiness, loud snoring, frequent night time awakening, nocturia, morning headache, memory problems and hypertension which worsens complications and reduces the quality of life and thus, OSAHS is considered a likely contributing factor to the pathogenesis and exacerbation of poor glucose metabolism (3). More than 420 million adults are affected by OSAHS globally, however, prevention and treatment of T2DM can help reduce the global burden of OSAHS (3).

T2DM is a chronic metabolic disorder characterized by hyperglycemia due to a combination of insulin resistance and inadequate insulin secretion. DM has become a public health challenge especially in low income and middle-income countries such as Uganda and other African countries (4). In people with T2DM, cardinal features of OSAHS including intermittent hypoxemia and sleep fragmentation, are directly linked to abnormal glucose metabolism. OSAHS and T2DM have also been interlinked having shared risk factors including obesity, age and physical inactivity or lack of adequate physical exercise (5). OSAHS is prevalent among obese and overweight patients and current evidence shows a robust association between OSAHS and insulin resistance, glucose intolerance and the risk of T2DM, independent of obesity (6). The relationship between OSAHS and T2DM may be bidirectional in nature given the fact that diabetic neuropathy can affect central control of respiration and upper airway neural reflexes, promoting sleep-disordered breathing (5). Despite this established relationship, the prevalence of OSAHS and T2DM, particularly in resource limited countries of Africa such as Uganda, remains poorly studied.

Studies in high income countries shows that the prevalence of OSAHS among individuals with T2DM ranges from 23% to 58% depending on the population and diagnostic criteria used (6). Studies have showed that about 28% of individuals with poor glycemic control suffer from OSAHS (7). However, such findings may not be directly applicable to sub-Saharan Africa, where variations in genetics, lifestyle and access to healthcare services influences the patterns of disease occurrence. Studies have reported considerable variation in its prevalence across populations, with approximately 18% reported among individuals with T2DM in Poland (8), compared with a pooled prevalence of 56.0% in Sub-Saharan Africa (9). Higher prevalence has also been reported in Benin, where 39% of patients with T2DM were at risk of OSAHS (7), and in Southwest Ethiopia, where 45.5% were classified as high risk using STOP-BANG (10). Globally, the combined prevalence of OSA has been estimated at 54% (11).

OSAHS and T2DM have obesity as a common risk factor. OSAHS, T2DM and obesity all contribute to risk of cardiovascular diseases. OSAHS contributes to insulin resistance and poor glycemic control through intermittent hypoxia and sleep fragmentation, meanwhile T2DM predisposes individuals to OSAHS by promoting obesity and upper airway dysfunction (5). The pathophysiological association between OSAHS and T2DM are still unclear, but intermittent hypoxia may be an important mechanism (12). The interplay between OSAHS and T2DM involves complex inflammatory and neuroendocrine mechanisms that may worsen insulin resistance and glycemic control, however, the pathophysiological link between OSAHS and T2DM still remains unclear (12). Intermittent hypoxia induced by OSAHS leads to release of reactive oxygen species; increasing oxidative stress, release of inflammatory cytokines (IL6, TNF-α) that interfere with insulin signaling pathways exacerbating T2DM, furthermore, there is reduced tone of pharyngeal dilator muscles which results from peripheral neuropathy secondary to T2DM causing airway collapse contributing to OSAHS (5). In this study, we determined the prevalence and factors associated with OSAHS among adults with T2DM in Northern Uganda.

Methods

Study design

This was a hospital based cross-sectional study using a quantitative approach. The design was chosen because it allows for the determination of the prevalence of OSAHS and associated factors at a single point in time, providing a snapshot of the burden of OSAHS.

Study area

This study was conducted at the diabetes clinics of Gulu Regional Referral Hospital (GRRH) and St. Mary's Hospital Lacor (SMHL), both located in Gulu City, Northern Uganda, which is about 335 KM from Kampala, the capital city of Uganda. GRRH is a government owned referral hospital serving the Acholi sub-region and neighbouring districts. SMHL is a private non-profit hospital operated by the Comboni Missionaries, also serving a large catchment population. Both Hospitals have dedicated diabetes clinics that operate weekly from Monday to Friday with a combined attendance of over 75 patients per week. The clinics have dedicated registers for patient records, capacity to perform blood glucose testing, making them ideal for investigating the prevalence of OSAHS among adults with T2DM.

Study population and eligibility criteria

The study included adults attending the diabetes clinics of SMHL and GRRH who met the inclusion criteria. Adults aged 18 years and above, who had a documented diagnosis of T2DM and could provide written informed consent were included. Pregnant mothers and individuals with psychiatric conditions were excluded and therefore not eligible.

Sample size estimation

Sample size determination was obtained using a formula by Kish and Leslie (1965). Using an estimated P value of 0.18; OSAHS affects approximately 18% of individuals with T2DM (8). A 10% non-responsive rate was determined with a final sample size of 250 participants.

$\mathrm{n} = \frac{\mathrm{Z}^2 \times \mathrm{P} \times (1-\mathrm{P})}{\mathrm{d}^2}$ where;

$$\mathrm{n} = \text{sample size}$$

$\mathrm{Z} = \mathrm{Z} - \text{statistic at } 95\% \text{ confidence interval } (1.96) \quad \mathrm{p} \text{ is estimated prevalence of OSAHS among type 2 diabetes patients } (\text{from previous}$

Sampling procedure

Convenient sampling technique was used, and eligible participants were enrolled consecutively. All patients attending the diabetes clinics during the study period who met the inclusion criteria were approached and invited to participate. The data collection process for this study utilized a variety of tools to gather comprehensive information. A semi-structured questionnaire was interviewer-administered to capture participants' socio-demographic details, lifestyle factors, and medical history, providing a foundational understanding of their background. Additionally, the STOP-Bang questionnaire, a validated screening tool, was used to assess the risk of OSAHS, identifying patients at high risk based on specific criteria related to their symptoms and characteristics.

Study variables

The dependent variable was intermittent hypoxia caused by OSAHS and inflammatory markers associated with OSAHs and T2DM. Independent variables included sociodemographic factors such as age, gender, and educational level, occupation, lifestyle factors like, physical activity, smoking, alcohol consumption, and dietary habits, clinical factors like BMI, waist-hip ratio, blood pressure, HBA_1c levels, co-morbidities,

Data collection tool and procedure

This data was collected by the four investigators of this study who are medical students in their clinical years. Eligible participants were first identified and thoroughly briefed about the study's objectives to ensure they understand the purpose and procedures involved. Following this, written informed consent was

obtained from each participant, ensuring that their participation was voluntary and based on a clear understanding of the study. Investigators then administered the structured questionnaires and the STOP-BANG tool, ensuring consistency and accuracy in data collection.

STOP-BANG is an assessment tool which includes 4 STOP Questions and 4 BANG assessment parameters. The STOP questions assess if the participant Snores during sleep, if they feel Tired, fatigued or sleepy during daytime; if anyone Observed them stop breathing during sleep, or if they have been diagnosed or received treatment for high blood Pressure. The BANG assessment looks out for BMI $> 35Kg/m^2$, Age > 50, Neck $circumference > 40cm$ and male Gender. Each parameter of the STOP-BANG assessment tool scores 1 (Total of 8). For each of these questions and parameters, a "Yes" scored a 1 (one) and a "No" scored a 0 (zero) and this determined their risk of developing OSAHS. Participants who scored 0 to 2 were considered to have low risk for OSAHS; those that scored 3 to 4 were considered to have intermediate risk for OSAHS while a score of 5 to 8 was considered to have OSAHS (High risk for OSAHS). These were further grouped into no OSAHS (For low and intermediate risk) and OSAHS (for high risk).

Finally, clinical measurements were conducted using standardized equipment and procedures, ensuring reliability and accuracy in capturing key health indicators, such as anthropometric data, blood pressure, and glycemic control metrics. These steps ensured that the study was conducted with rigor and ethical compliance.

Data management and analysis

Data collected was anonymized to ensure participant privacy and securely stored in password-protected systems, preventing unauthorized access. In addition, hard copies of the data collection tools were securely stored in files within locked cabinets, accessible only to the research team to further protect the integrity and confidentiality of the information. To comply with data retention policies, the data will be retained for five years after publication, after which it will be securely destroyed to ensure that no personal or sensitive information is kept beyond the required period. These measures will be in place to safeguard the privacy and security of all participant data throughout and after the study.

Data was analyzed in SPSS version 24.0 Categorical variables were summarized as frequencies and percentages, and continuous variables as means ± standard deviation or medians with interquartile ranges (IQR), depending on distribution. OSAHS prevalence was calculated as the proportion of participants classified as high risk on STOP-BANG. Bivariable Poisson regression with robust variance was used to screen candidate factors, with variables at $p < 0.20$ carried forward into a multivariable Poisson regression model with robust variance, refined by backward elimination. Crude and adjusted prevalence ratios (cPR, aPR) with 95% confidence intervals are reported, $p < 0.05$ was considered statistically significant.

Results

Socio-demographic, lifestyle and behavioral characteristics of the participants with T2DM attending the Diabetes clinics of the two tertiary hospitals.

A total of 250 participants were enrolled in this study, with the majority; 167 (66.8%) recruited from GRRH and the remaining 83 (33.2%) from SMHL. The mean age of participants was 54.19 ± 14.80 years, with a median (IQR) of duration with T2DM diagnosis 7.00 (4.00–12.00) years. The study population was predominantly female, 161 (64.4%). More than half of the participants were married 138 (55.2%). Slightly more than half of the participants resided in urban areas. Fifty participants (20.0%) had had no formal education, 55 participants (22.0%) attained up to secondary level and only 30 (12.0%) managed to reach tertiary level. Most participants were self-employed 107 (42.8%), non-smokers 229 (91.6%) and did not consume alcohol 21 (81.2%). More than half of the participants had hypertension 137 (54.8%). Physical activity levels were predominantly moderate, reported by 146 (58.4%) participants, while low and high physical activity were observed in 66 (26.4%) and 38 (15.2%) of participants, respectively, Table 1.

Table 1
Socio-demographic, Lifestyle and Behavioral characteristics of the participants with type 2 diabetes mellitus attending the diabetes clinics of the two tertiary hospitals in Northern Uganda

Variable (N = 250)	**Frequency**	**Percentage (%)**
Age, mean±SD, years 54.19 ± 14.80 years	55	54.2
Duration of Diagnosis with T2DM (**Median (IQR)**, years	7.00	4.00–12.00
Tertiary Hospital		
GRRH	167	66.8
SMHL	83	33.2
Gender		
Male	89	35.6
Female	161	64.4
Marital Status		
Single	28	11.2
Married	138	55.2
Divorced	21	8.4
Widowed	63	25.2
Residence		
Rural	111	44.4
Urban	139	55.6
Level of Education		
No formal Education	50	20.0
Primary	115	46.0
Secondary	55	22.0
Tertiary	30	12.0
Employment Status		
Unemployed	93	37.2
Employed	50	20.0
Self-Employed	107	42.8
Smoker	21	8.4
Alcohol Consumption	47	18.8
Blood Pressure		
Normal Blood Pressure	113	45.2
Stage 1 HTN	107	42.8
Stage 2 HTN	24	9.6
Stage 3 HTN	6	2.4
Body mass index class		
Underweight	3	1.2
Normal weight	117	46.8
Overweight	77	30.8
Obesity Class I	38	15.2
Obesity Class II	13	5.2
Extreme Obesity (Class III)	2	0.8

Variable (N = 250)	Frequency	Percentage (%)
Hypertension	137	54.8
Physical Activity		
Low	66	26.4
Moderate	146	58.4
High	38	15.2

Diabetes management and medical history of participants attending the diabetes clinics of the two tertiary hospitals.

All 250 participants were receiving treatment for T2DM. Metformin was the most used medication by 91.6% (n = 229) of the participants, followed by glibenclamide 30.4% (n = 76). Insulin injections were used by 10.4% (n = 26) of the participants and glimepiride by 8.0% (n = 20) of participants. Only 6.8% (n = 17) of participants reported having ever been diagnosed with a sleep disorder, Table 2.

Table 2
Diabetes management and medical history

Variable (N = 250)	Frequency	Percentage (%)
On any current treatment for T2DM	250	100
Metformin	229	91.6
Glibenclamide	76	30.4
Insulin Injection	26	10.4
Glimepiride	20	8.0

Anthropometric and clinical examination findings of the participants attending the diabetes clinics of the two tertiary hospitals

The mean neck circumference was 35.23 (SD = 2.9982) cm, and the mean height was 1.67 (SD = 0.0906) meters. The median BMI was 25.11(IQR: 22.84–29.08) kg/m^2, median random blood sugar was 8.9 (IQR: 6.8–11.2) mmol/dL, median systolic BP was 134 (IQR: 121–149) mmHg, median diastolic BP was 87 (IQR: 78–96) mmHg, median weight was 71.0(IQR: 64.8–79.6) kg, median sleep duration was 7(IQR: 6–8) hours per night and the median duration of diagnosis with T2DM was 7.00 (IQR: 4.00–12.00) years, Table 3.

Table 3
Anthropometric and clinical examination findings of the participants attending the diabetes clinics of the two tertiary hospitals.

Variable (N = 250)	Summary statistics
	Mean ± SD
Neck circumference (cm) (mean ± SD)	35.23 ± 2.9982
Height (m) (mean ± SD)	1.67 ± 0.0906
	Median (IQR)
Body Mass Index (kg/m^2)	25.11 (22.84–29.08)
Random Blood Sugar (mmol/dL)	8.9 (6.8–11.2)
Systolic BP (mmHg)	134 (121–149)
Diastolic BP (mmHg)	87 (78–96)
Weight (kg)	71.0 (64.8–79.6)
Hours of sleep per night	7 (6–8)

Prevalence of High risk for OSAHS among participants with T2DM attending the diabetes clinics of the two tertiary hospitals.

Among the 250 participants, the distribution of OSAHS risk was as follows: 100 participants (40.0%) were classified as low risk for OSAHS, 103 participants (41.2%) were classified as intermediate risk, and 47 participants (18.8%) were classified as having OSAHS (High Risk). Cumulatively, 81.2% of the participants fell into the combined low and intermediate risk categories, while 47 participants (18.8%) were considered to have high risk OSAHS. The details are summarized in Table 4 and Fig. 2 below.

Table 4
Risk stratification for obstructive sleep apnea-hypopnea syndrome among adults with type 2 diabetes in Northern Uganda

STOP BANG Total Score	Frequency (N = 250)	Percentage (%)	Risk Score for OSAHS
0–2	100	40.0	Low
3–4	103	41.2	Intermediate
5–8	47	18.8	High

Factors associated with High risk for OSAHS

In the bivariable analysis, high risk for OSAHS was significantly associated with male sex, secondary education, low physical activity, hypertension, smoking, high-sugar diet, frequent waking, morning headaches, normal weight and obesity class III. Significant associations were also observed with increasing age, random blood glucose, duration of T2DM and neck circumference, while greater hours of sleep were inversely associated with high OSAHS risk (all $p < 0.05$).

In the multivariable analysis, several associations persisted after adjustment for potential confounders. Male participants had a higher prevalence of high OSAHS risk compared with females (aPR 1.399, 95% CI 1.241–1.577; $p < 0.001$). Hypertension was also independently associated with high OSAHS risk (aPR 1.168, 95% CI 1.040–1.311; $p = 0.009$). Compared with participants who were single, widowed participants had a higher prevalence of high OSAHS risk (aPR 1.199, 95% CI 1.007–1.428; $p = 0.042$).

Among continuous variables, increasing age was associated with a 2.0% higher prevalence of high OSAHS risk for each additional year (aPR 1.020, 95% CI 1.016–1.025; $p < 0.001$). Similarly, each 1 mmol/L increase in random blood glucose was associated with a 2.1% higher prevalence (aPR 1.021, 95% CI 1.003–1.039; $p = 0.021$), while each 1-cm increase in neck circumference was associated with a 2.6% higher prevalence (aPR 1.026, 95% CI 1.007–1.038; $p = 0.005$).

Table 5
Bivariable and multivariable analysis of factors associated with high risk for obstructive sleep apnoea–hypopnoea syndrome among adults with type 2 diabetes mellitus

Variable	cPR	95% CI	p-value	aPR	95% CI	p-value
Gender						
Female (Ref.)	1.00	—	—	1.00	—	—
Male	1.271	1.116–1.449	< 0.001	**1.399**	**1.241–1.577**	**< 0.001**
Marital status						
Single (Ref.)	1.00	—	—	1.00	—	—
Married	0.913	0.793–1.051	0.205	0.929	0.709–1.219	0.596
Divorced	1.121	0.916–1.372	0.266	1.088	0.996–1.226	0.164
Widowed	—	—	—	**1.199**	**1.007–1.428**	**0.042**
Level of education						
Tertiary (Ref.)	1.00	—	—	0.932	0.782–1.111	0.984
No formal education	1.067	0.869–1.312	0.534	1.00	—	—
Primary	0.950	0.777–1.161	0.617	1.107	0.930–1.316	0.570
Secondary	0.741	0.580–0.945	0.016	1.087	0.937–1.262	0.386
Employment status						
Employed (Ref.)	1.00	—	—	—	—	—
Unemployed	1.062	0.914–1.235	0.432	—	—	—
Self-employed	0.937	0.782–1.122	0.477	—	—	—
Physical activity level						
High (Ref.)	1.00	—	—	1.00	—	—
Moderate	1.076	0.884–1.308	0.465	1.024	0.780–1.354	0.589
Low	1.387	1.135–1.693	0.001	1.028	0.808–1.297	0.596
Blood pressure						
Normal (Ref.)	1.00	—	—	1.00	—	—
Hypertension	1.594	1.385–1.835	< 0.001	**1.168**	**1.040–1.311**	**0.009**
Smoking						
No (Ref.)	1.00	—	—	1.00	—	—
Yes	0.837	0.714–0.980	0.027	1.124	0.950–1.330	0.178
Alcohol consumption						
No (Ref.)	1.00	—	—	1.00	—	—
Yes	0.675	0.380–1.199	0.180	1.086	0.871–1.357	0.837
Sleep disorder						
No (Ref.)	1.00	—	—	—	—	—
Yes	0.744	0.657–0.843	< 0.001	—	—	—
Frequent waking						
No (Ref.)	1.00	—	—	1.00	—	—
Yes	0.631	0.535–0.745	< 0.001	0.931	0.817–1.062	0.273
Morning headache						
No (Ref.)	1.00	—	—	1.00	—	—
Yes	0.707	0.620–0.805	< 0.001	0.910	0.825–1.003	0.053
Body mass index						
Underweight (Ref.)	1.00	—	—	1.00	—	—

Variable	cPR	95% CI	p-value	aPR	95% CI	p-value
Normal weight	0.556	0.317–0.975	0.040	—	—	—
Overweight	0.858	0.533–1.381	0.527	—	—	—
Obesity class I	1.026	0.639–1.646	0.915	—	—	—
Obesity class II	1.088	0.673–1.758	0.732	—	—	—
Obesity class III	1.692	1.046–2.739	0.032	**1.031**	**1.018–1.044**	**< 0.001**
Age (per 1 year)	1.021	1.017–1.025	< 0.001	**1.020**	**1.016–1.025**	**< 0.001**
Random blood sugar (per 1 mmol/L)	1.042	1.023–1.060	< 0.001	**1.021**	**1.003–1.039**	**0.021**
Duration with T2DM (per 1 year)	1.021	1.014–1.029	< 0.001	1.006	0.994–1.019	0.312
Neck circumference (per 1 cm)	1.069	1.045–1.093	< 0.001	**1.026**	**1.007–1.038**	**0.005**
Hours of sleep (per 1 hour)	0.926	0.890–0.964	< 0.001	—	—	—

cPR = crude prevalence ratio; aPR = adjusted prevalence ratio; CI = confidence interval; T2DM = type 2 diabetes mellitus; Ref. = reference category. Bold values indicate statistically significant associations in the multivariable analysis ($p < 0.05$).

Discussion

In this study, we found that 18.8% of adults with T2DM were at high risk for OSAHS, while 41.0% and 40.0% were at intermediate and low risk, respectively. In the multivariable analysis, male sex, older age, hypertension, higher random blood glucose, greater neck circumference, and widowed marital status were independently associated with high risk for OSAHS. These findings indicate that a substantial proportion of adults receiving routine diabetes care may have unrecognized risk for OSAHS and highlight the potential value of integrating OSAHS risk assessment into T2DM management.

Our finding is comparable to a primary care estimate from Poland, which reported that approximately 18% of individuals with T2DM had OSAHS (8). However, the prevalence observed in the present study was markedly lower than the pooled sub-Saharan African estimate of 56.0% (9). Higher prevalence rates have been reported in several African settings. In Parakou City, Benin, the risk of OSAHS among patients with T2DM was 39%, of whom 14% were categorized as high risk and 25% as intermediate risk (7). Similarly, a study conducted in Nigeria reported that 27% of participants with T2DM had OSAHS (13), while a hospital-based cross-sectional study in Southwest Ethiopia using the STOP-BANG assessment tool reported a high-risk OSAHS prevalence of 45.5% (10). A scientific statement from the American Heart Association further reported that the prevalence of OSAHS among male patients with cardiovascular disease was 34%, compared with 17% among females with the same comorbidity (14). At the global level, a meta-analysis assessing the prevalence of OSAHS and associated risk factors reported a combined prevalence of OSAHS of 54% (11). The relatively lower prevalence observed in the present study may be explained by differences in population characteristics, including genetic predisposition, dietary patterns, body habitus, and obesity prevalence. In this study, only 21.2% of participants were obese, which may partly account for the lower prevalence observed. Differences in screening tools and their respective thresholds may also have contributed to the variation in prevalence across studies. For example, the Nigerian study used the Berlin Questionnaire and Epworth Sleepiness Scale (ESS), whereas the Ethiopian study used the STOP-BANG questionnaire (10). In another study among candidates for bariatric surgery, STOP-BANG demonstrated high sensitivity of over 90% for detecting moderate-to-severe OSAHS, although its specificity was relatively low at approximately 34%. Meanwhile, the Excessive Daytime Sleepiness Scale (EDSS) and ESS did not demonstrate an association with the presence of OSAHS (15). Therefore, STOP-BANG is primarily useful for identifying individuals at increased risk of moderate-to-severe OSAHS and should not be considered a diagnostic tool for confirming OSAHS (15). Differences in the performance and application of screening tools may therefore partly explain the lower prevalence of high-risk OSAHS observed in this study compared with other studies.

Several factors were independently associated with OSAHS in the present study. The prevalence of OSAHS was 40% higher among males, which is consistent with findings from the Sub-Saharan African meta-analysis and studies from Nigeria and the Gulf region that reported a substantially higher risk of OSAHS among men (13). This difference may be related to greater upper-airway collapsibility, central and neck fat deposition, and hormonal influences on upper-airway tone. The finding is also consistent with global evidence from a meta-analysis identifying male sex, higher BMI, and increasing age as important risk factors for OSAHS (11). Increasing age was independently associated with OSAHS, in keeping with evidence that OSAHS prevalence increases with advancing age (16). This association may be explained by age-related decline in pharyngeal dilator muscle tone, increased parapharyngeal fat deposition, and the accumulation of cardiometabolic comorbidities. Similarly, a systematic review assessing the prevalence of OSAHS among adults in the general population confirmed that advancing age, male sex, and higher body-mass index increase the prevalence of OSAHS (17). Both BMI and neck circumference remained independently associated with OSAHS after mutual adjustment, suggesting that they may capture distinct aspects of obesity-related risk. While BMI reflects overall adiposity, neck circumference provides an indication of fat deposition around the upper airway, which may contribute to airway narrowing and increased collapsibility (10). This supports the clinical value of assessing neck circumference alongside BMI, particularly in low-resource settings where advanced imaging and formal sleep studies may not be readily available. This finding is also consistent with an African study which demonstrated that increasing weight, BMI, neck circumference, and waist circumference were associated with high-risk OSAHS among individuals with T2DM (18).

Hypertension and higher random blood sugar were also independently associated with OSAHS. This is consistent with the well-described relationship between OSAHS and cardiometabolic abnormalities, whereby intermittent hypoxia may promote sympathetic activation, oxidative stress, and insulin resistance, while hyperglycaemia-related neuropathy and inflammation may in turn contribute to upper-airway collapse (19). Furthermore, a meta-analysis study by the American Heart Association among individuals with cardiovascular disease showed that individuals with poorly controlled hypertension have

OSAHS and therefore qualify for routine screening for OSAHS (14). The use of random blood sugar rather than HbA1c in this study may, however, have limited assessment of long-term glycaemic control and potentially influenced the observed strength of the association between glycaemia and OSAHS. Overall, these findings support prioritizing OSAHS screening among older, male, hypertensive, and higher-BMI patients with T2DM and reinforce calls from other African studies for the integration of routine, low-cost OSAHS screening into diabetes care pathways.

Study strengths and limitations

The study was strengthened using the STOP-BANG questionnaire, which is a well-validated screening tool for OSAHS, with established sensitivity and specificity across various populations. Practical clinical skills were used during the study; the use of simple, non-invasive measurements (neck circumference, BMI, blood pressure) makes the findings applicable to resource-limited settings such as Northern Uganda. Limitations include the cross-sectional design, which precludes causal deductions and assumptions, potential recall or social desirability bias in self-reported behaviors, convenience sampling which may limit generalizability, use of random blood sugar rather than HbA1c to characterize glycemic control and these findings can only be generalized to institutions with similar settings. Furthermore, because STOP-BANG is a screening instrument and several of its components were also examined as explanatory variables, the observed associations should be interpreted cautiously. Prospective multicenter studies incorporating objective sleep studies are needed to determine the prevalence of confirmed OSAHS and its clinical and metabolic correlates among adults with T2DM in Uganda.

Implications of study findings

These findings support integrating routine OSAHS screening into diabetes care at tertiary hospitals with similar settings. Given that STOP-BANG relies only on parameters already collected during routine diabetes review, blood pressure, weight, height and brief symptom history. Its addition would require minimal extra resource investment. Because confirmatory polysomnography remains largely unavailable in this and similar settings, a risk stratified approach is more feasible than universal referral. Prioritizing screening and onward referral for older, male, hypertensive and higher BMI patients would concentrate limited diagnostic capacity where yield is greatest. This raises the possibility that OSAHS screening as part of diagnostic work up of patients with T2DM, with treatment of confirmed OSAHS could potentially contribute to better metabolic and cardiovascular outcomes.

Conclusions

Nearly one in five adults with T2DM attending the two tertiary hospitals in Gulu City were at high risk for OSAHS. Routine OSAHS screening in T2DM care, particularly among men, older adults, and those with hypertension or obesity, could support earlier identification and referral, improve clinical outcomes, and reduce the burden of this treatable comorbidity.

Declarations

Ethical considerations and consent to participate

The study was approved by the Gulu University Research Ethics Committee (GUREC-2025-1204), with administrative clearance from GRRH and SMHL. This study was conducted in accordance with the ethical principles of the Declaration of Helsinki (2013 revision) and the Uganda National Council for Science and Technology (UNCST) Guidelines for Ethical Conduct of Research Involving Humans. Written informed consent was obtained from all participants before proceeding with the interview.

Consent for publication

All participants provided informed consent, including consent to have their data published in scientific meetings and peer-reviewed publications.

Competing interests

The authors declare that they have no competing interests

Funding

This research received no specific grant from any funding agency in the public, commercial or nonprofit sectors

Author Contribution

G.M.E., J.M.N., S.O. and D.O. conceptualized the study, developed the methodology, conducted the data analysis, and drafted the initial manuscript. J.M.N., G.M.E., M.O.O., D.L.O., D.O, F.O.B., D.S.E., F.B. provided overall guidance on the study design, data interpretation, and manuscript revision. All authors read and consented to submission to the current journal; approved the final version to be published; and agreed to take responsibility for all aspects of the work.

Acknowledgement

All data relevant to the study are included in the article.

Data Availability

All data relevant to the study are included in the article

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Figures

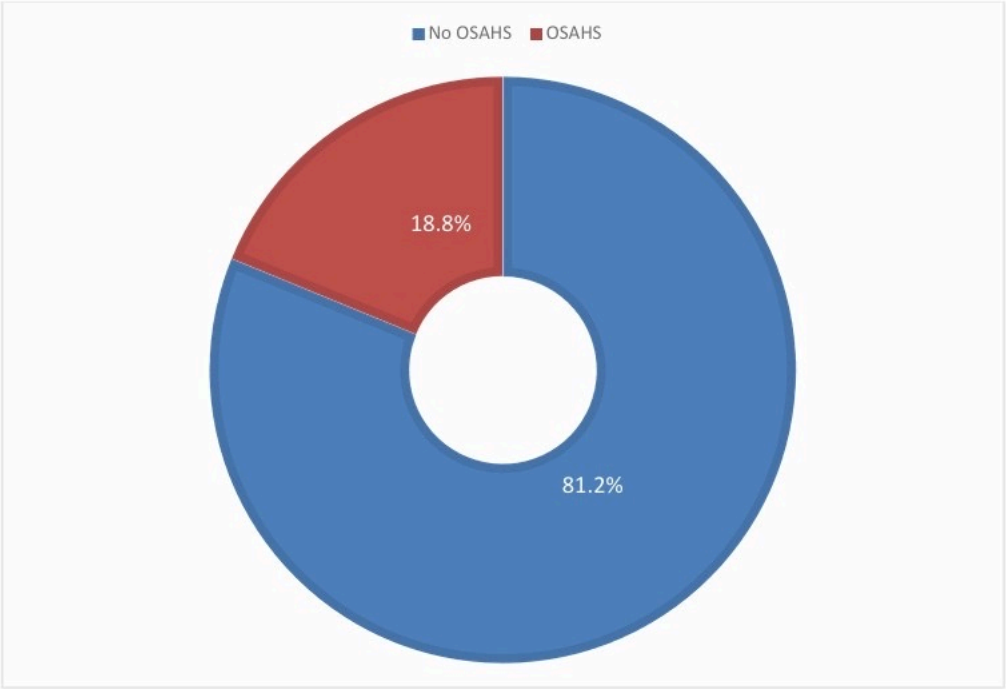


Figure 1: Doughnut chart showing the proportion of participants with T2DM attending the diabetes clinics of the two tertiary hospitals who were at high risk for obstructive sleep apnoea–hypopnea syndrome.

Figure 1

See image above for figure legend.