Prevalence of sleep disordered breathing in an African general population: The Benin Society and Sleep (BeSAS) study

Ablo Prudence Wachinou[1,2,3], Corinne Houehanou[3,4], Serge Ade[5], Terence Totah[3], Mathieu Berger[6], Geoffroy Solelhac[6], Salmane Amidou[3], Attanon Arnauld Fiogbe[2], Frederic Alovokpinhou[2], Philipe Lacroix[7], Pierre-Marie Preux[7], Pedro Marques-Vidal [8], Gildas Agodokpessi[1,2], Dismand Houinato[1,3], Raphael Heinzer[6]

[1]Faculty of Health Sciences, University of Abomey-Calavi, Cotonou, Benin

[2]National Teaching Hospital for Tuberculosis and Pulmonary Diseases, Cotonou, Benin

[3]Laboratory of Epidemiology of Chronic and Neurologic Diseases, Faculty of Health Sciences, University of Abomey-Calavi, Cotonou, Benin

[4]National School of Public Health (ENATSE), University of Parakou

[5]Faculty of Medicine, University of Parakou, Parakou, Benin

[6]Center of Investigation and Research on Sleep (CIRS), University Hospital of Lausanne (CHUV) and University of Lausanne (UNIL), Lausanne, Switzerland

[7]INSERM, University of Limoges, CHU Limoges, IRD, U1094 Tropical Neuroepidemiology, Institute of Epidemiology and Tropical Neurology, Limoges, France

[8]Department of Internal Medicine, University Hospital of Lausanne (CHUV) and University of Lausanne (UNIL), Lausanne, Switzerland

Corresponding author: Ablo Prudence Wachinou, MD, 01BP321, Akpakpa, Cotonou, Benin· Tel: +229 67 17 30 68· Email: wachinouprudence@yahoo·fr

SUMMARY (245 words)

Background. There are very little data on the prevalence of sleep-disordered breathing (SDB) in the African general population and a better understanding is urgently needed. This study aimed to objectively determine the prevalence of, and factors associated with, SDB in a large sample in Benin, West Africa.

Methods. The Benin Society and Sleep (BeSAS) study was conducted from April 2018 to January 2021. Participants were recruited from both urban and rural areas. Subjects underwent polygraphy at home using a type III device. Clinical and morphometric data were also collected. SBD severity categories were defined according to apnoea-hypopnoea index (AHI): mild-to-severe (AHI ≥5/h, moderate-to-severe (AHI ≥15/h) or severe (AHI ≥30/h).

Findings. For the 1810 participants with complete polygraphic data (age 46±15 years, 64·2% women), the prevalence (95% confidence interval [CI]) of mild-to-severe SDB (AHI ≥5/h) was 43·2% (40·9–45·5), of moderate-to-severe SDB (AHI ≥15/h) was 11·6% (10·2–13·1), and of severe SDB (AHI ≥30/h) was 2·7% (2·0-3·5). Factors independently associated with SBD were advanced age, male sex, large neck circumference, abdominal obesity, overweight/obesity and snoring. After multivariable adjustment, severe SDB was independently associated with hypertension in women (odds ratio 3·99 [95% CI 1·04–15·33]; *p*-trend=0·044) but not in men.

Interpretation. The BeSAS study provides the first large scale objective evaluation of SDB prevalence and associated factors in Africa. The high prevalence of SDB identified should stimulate the development of public health policies to prevent and treat this condition in African countries.

Funding. Ligue Pulmonaire Vaudoise, Switzerland.

Key words. Sleep apnoea; epidemiology; Africa; hypertension

Research in context

Evidence before this study

To the best of our knowledge, no previous large national cohort has objectively assessed the prevalence of sleep-disordered breathing (SDB) in Africa.

Added value of this study

There was a high prevalence of SBD (apnoea-hypopnoea index ≥5/h) in Africa (43·2% [95% confidence interval: 40·9-45·5]), comparable to similar studies from other continents. The main risk factors for SBD in this population were advanced age, male sex, large neck circumference, abdominal obesity, overweight/obesity, and snoring. There was also an association between increasing SDB severity and hypertension in women, but not in men.

Implications of all the available evidence

This study objectively measured SDB prevalence from a large random convenience sample in Benin which will facilitate better overall estimates of SDB prevalence and pave the way for further epidemiological research on sleep in Africa. The high prevalence of SDB in this study should stimulate the development of public health policies to prevent and treat SDB in African countries.

INTRODUCTION

Sleep-disordered breathing (SDB) is a major public health concern that remains under recognised in resource-limited settings.[1–4] Worldwide prevalence of SDB is increasing, in parallel with the upward epidemic curve of obesity, a major SDB risk factor.[2,5] SDB is characterised by recurrent episodes of apnoea and hypopnoea, which result in intermittent hypoxaemia and sleep disruption.[6] In addition to its immediate consequences (excessive daytime sleepiness and fatigue), SDB has been linked, in the long term, to a higher risk of chronic diseases such as hypertension, diabetes mellitus, metabolic syndrome, cardiovascular diseases, depression, and cancers [7], and increased all-cause mortality.[8]

It was recently estimated that 425 million adults (aged 30–69 years) worldwide have moderate-to-severe SDB, with a prevalence exceeding 50% in some countries.[9] However, most of the available data on the prevalence of SDB, its risk factors, and health consequences come from studies conducted in North America, Europe and Asia, while data from the African continent are scarce.[2,9,10] Indeed, only a few studies attempted to estimate the prevalence of SBD in Africa, but they were based on self-administered questionnaires, or were conducted in small-sized clinical populations referred for suspected SDB.[11–14] Recently, a study was conducted in a rural setting in South Africa using polysomnographic-derived data. However, this study was performed on a small sample (n=75), precluding to estimate the precise SDB prevalence in that population .[15] There are thus very limited data on the prevalence of sleep-disordered breathing (SDB) in the African general population and a better understanding is urgently needed.

Moreover, epidemiological studies have suggested that the prevalence of SDB might vary by patient ethnicity. Data from both the Multi-Ethnic Study of Atherosclerosis (MESA)[16] and the Jackson Heart Sleep Study[17] conducted in the United States of America (USA) suggested that SDB was more prevalent, and presumably more severe, in African Americans compared with White Americans.[16,17] However, this assumption of higher SDB prevalence in populations of African descent has not yet been confirmed by studies conducted in African populations living on the African continent. Therefore, the objective of the Benin Society and Sleep (BeSAS) study was to assess the prevalence, risk factors, and associated comorbidities of SDB such as hypertension and diabetes mellitus in a large national cohort in Benin.

METHODS

Design and setting

BeSAS was a cross-sectional study that relied on a large national cohort that used a random convenience sampling approach to capture a diverse sample. The study was conducted from April 2018 to January 2021 in Benin Republic, West Africa (a low-income country with approximately 12 million inhabitants). The research project was approved by the National Ethics Committee of Benin (reference No. 45, 25 October 2017) with regular annual approval renewal throughout its course. Participants were enrolled on a voluntary basis and provided written informed consent. If a subject was unable to read or write, a family member able to read was asked to assist with providing information.

Participants

In Benin, 51·6% of the total population lives in rural areas[18], thus participants were recruited from both the rural and urban general population. Rural participants were recruited from Tanve, a village of 2721 inhabitants, located 200 km north of Cotonou. This village is typical of African rural areas, with little access to electricity, internet or modern lifestyle, minimal road traffic, agriculture as the primary activity, and no modern buildings. Residents of Tanve already participate in a prospective population-based cohort, the Tanve Health Study (TAHES), set up in 2015 with the aim of evaluating the incidence of cardiovascular risk factors in an African rural population.[19] A preliminary survey conducted at the beginning of the TAHES study reported that the total population aged ≥25 years comprised 1308 individuals. For the BeSAS study, the goal was to include at least 90% of that adult population, giving a sample size of 1177, rounded to 1200 participants.

The urban population was selected from Cotonou, the economic capital of Benin with 685,000 inhabitants, which has all the main characteristics of African urban settings (high population density, modern marketplaces, modern buildings, and access to electricity and the internet). To match the number of participants recruited in the rural area (48% of Benin population lives in cities), the goal was to include at least 1200 individuals from the urban area.

The average household size in Cotonou is four individuals aged 25 years and older (2013 census). Thus, it was estimated that at least 300 households needed to be included to reach the recruitment target. These households were randomly selected from a representative area of Cotonou, the third subcity. We randomly selected 9 districts out of the 13 comprising this subcity. The number of households to be

recruited in each district was determined according to its size (see full description of the selection process in supplement material). We then determined for each district the ratio between the number of households to be recruited and the total number of households of the district. If this ratio was for example 1 out of 5, the field investigators contacted every 5th household. The initial household of each district was randomly selected by lottery method. This method consists of randomly choosing the first household in a district by numbering slips of paper of same size, shape and colour with number ranging from 1 to n, where n is equal the ratio between number of households in the district and number of households to be selected. Then, the papers were folded and mixed up in a box. A blindfold selection of a paper was made by an investigator to determine the first household to be selected. At each selected household, all consenting adults aged 25 years or above were recruited. In the case, no participant could be recruited in a selected household, the sampling process continued to the next household.

Procedures

Respiratory polygraphy (PG) was performed using ApneaLink™ Plus (ResMed R&D, Germany) devices. This type III portable recorder measures airflow through a nasal pressure sensor, respiratory effort (thoracic movement), and pulse oximetry (Nonin provided by Resmed). Participants were provided with one of these devices that was set up in their home between 8pm and 10pm by one of the four trained research assistants, who returned the next morning to collect the device. The equipment was set for a fixed period of the night but participants were asked to provide “Light off” and “lights on times”. All PG data were transformed into European Data Format (EDF) files to allow reading in Noxturnal software (version 6.2, Nox Medical, Reykjavik, Iceland).

The sleep recordings were then manually scored by a certified sleep physician (APW) with more than 10 years of experience in respiratory sleep medicine who was unaware of the participant's data. Only PG data with ≥4 hours of recording with airflow, pulse oximetry and respiratory effort signal were considered valid and included in the analysis. Respiratory events were scored according to the 2012 American Academy of Sleep Medicine (AASM) manual.[20] Sleep apnoea was defined as a ≥90% reduction in airflow for ≥10 seconds. Hypopnoea was defined as ≥30% airflow reduction for ≥10 seconds during sleep associated with a desaturation of ≥3%. The apnoea-hypopnoea index (AHI) was calculated as the sum of all apnoeas and hypopnoeas divided by the estimated sleep time based on participant's report. SDB was defined as mild-to-severe (AHI ≥5/h), moderate-to-severe (AHI ≥15/h) or severe (AHI ≥30/h).

Demographic data (age, sex and area of residence), alcohol intake and smoking habits were collected by self-declaration. Height was measured with a rigid gauge and weight was measured in a standing position, with as little clothing as possible and without shoes, using mechanical devices (Seca, Hamburg, Germany). Nutritional status was assessed using body mass index (BMI), calculated as weight divided by height squared. Normal BMI was defined as <25 kg/m^2, overweight as ≥25 and <30 kg/m^2, and obesity ≥30 kg/m^2. Neck and waist circumferences were measured using standardised procedures. Abdominal obesity was defined as waist circumference ≥102 cm in men and ≥88 cm in women. Blood pressure was measured three times on both arms (Spengler, France) and the average of the last two readings for each arm was calculated. Hypertension was defined as systolic blood pressure ≥140 mmHg, diastolic blood pressure ≥90 mmHg on at least one arm, or current use of antihypertensive drugs. A capillary fasting glycaemia test was performed for each subject using a glucometer (Accuchek Performa®, Roche Diagnostics, Basel,

Switzerland). Diabetes mellitus was defined as a self-reported medical history of diabetes mellitus or capillary fasting glycaemia ≥7 mmol/L.

The Pittsburgh Sleep Quality Index (PSQI) was used to assess subjective sleep quality over a 1-month time period.[21] The total score ranges from 0 to 21; a score ≥6 indicates poor sleep quality. Daytime sleepiness was determined using the Epworth Sleepiness Scale (ESS),[22] with a total score of 0 to 24 and excessive daytime sleepiness indicated by a score of ≥11. ESS was only calculated if the participants were able to answer the eight questions of the scale. Two other scales were used as predictors of sleep apnoea: the Neck-Obesity-Snoring-Age-Sex (NoSAS) score and the Berlin questionnaire. The NoSAS score ranges from 0 to 17 and a score ≥8 indicates a high risk of obstructive sleep apnoea. A Berlin questionnaire score ≥2 is considered to indicate a high risk of sleep apnoea. Most clinical data were collected during face-to-face interviews using KoBoToolbox (Harvard Humanitarian Initiative, Cambridge, USA) software on digital tablets by trained and experienced interviewers.

Statistical analysis

All statistical analyses were conducted using Stata version 14 (College Station, TX, USA) and R (version 4.1.1) on R Studio (version 1.4.1717).

Continuous variables were summarised as medians with interquartile range (IQR) or mean with standard deviation (SD), and categorical variables as proportions (%). Between-group comparisons were performed using the Chi^2 test, Student's test or Wilcoxon's rank-sum test, as appropriate. Baseline characteristics of participants who underwent PG were compared with BeSAS participants with no valid PG data, and the effect size of any between-group differences found was evaluated using Cohen's d for continuous variables and Cramer's v for categorical variables.

Comparison of prevalence by age groups, sex, nutritional status, and area of residence were performed using multiple proportion comparison tests.

Ordinal logistic regressions were used to estimate the factors associated with SDB. Individuals with missing data (5 for neck circumference and 40 for diabetes) were excluded. Assumption of linearity for each continuous covariate was checked using locally weighted scatterplot smoothing (LOWESS). In the case of non-linearity, continuous variables were transformed into categorical variables based on clinically relevant cut-offs. We identified important covariates by analyzing contingency tables and fitting univariate ordinal logistic regression. We selected all the variables whose p-value < 0.20 along with the variables of known clinical importance. We performed a multivariable ordinal logistic regression analysis using the STATA command *ologit*. Results are presented in the form of proportional odds ratio and corresponding 95% confidence interval (CI). To assess collinearity between covariates, the variance inflation factor (VIF) was calculated for each. All covariates had a VIF ≤ 5 suggesting no collinearity. No interaction term was found between sex and SDB.

To estimate the association between SDB severity and the risk of associated comorbidities such as diabetes mellitus and hypertension, the sample was divided into four groups based on usual AHI cut-offs (no SDB: <5/h, mild: 5–14/h, moderate:15–29/h and severe ≥30/h). Several logistic regression models were applied. Model 1 was adjusted for age and area of residence; model 2 was additionally adjusted for alcohol and tobacco consumption; model 3 was additionally adjusted for body mass index (BMI) and model 4 was additionally adjusted for neck circumference, and abdominal obesity. Considering previously reported sex differences in the association between SDB and comorbidities, we further performed a sex stratified analysis.

The different models were compared with the likelihood ratio test. A two-tailed p-value <0.05 was considered statistically significant.

Role of the funding sources

The study was funded by the “Ligue Pulmonaire Vaudoise, Lausanne, Switzerland”, a non-governmental organisation dedicated to pulmonary health. The funder had no role in study design, data collection, data analysis, data interpretation, or writing of the report. All authors had full access to study database and the corresponding author had final responsibility for the decision to submit for publication.

RESULTS

Study population

Of 2909 participants recruited in the BeSAS study, 2168 underwent respiratory PG; 396 tests failed and 203 of them were repeated. Overall, no valid recording was obtained from 358 participants and these individuals were excluded from further analysis (Figure 1). Complete polygraphic data were obtained for 1810 participants.

Demographic and clinical characteristics and description of polygraphic data for the 1810 participants with valid PG are shown in Table 1. The population was predominantly women (64·2%), over half (52·8%) were from rural areas, and the majority (57·6%) were aged ≥40 years (Table 1). Overweight/obese participants represent 40·3% of the sample. Hypertension and diabetes were found in 46·2% and 4·2% respectively. The median AHI was 4·2 (2·0-8·1) (Table 1).

Compared to BeSAS participants who did not have PG data, participants with valid PG data were similar in terms of age, snoring, PSQI, alcohol and smoking habits, Berlin questionnaire and NoSAS scores. There were some slight between-group

differences in sex, neck circumference, waist circumference, smoking, ESS but but Cohen's d (for continuous variables) and Cramer's v (categorical variables) values suggested a small effect size (Table S1).

Prevalence of SDB

The prevalence (95% CI) of mild-to-severe, moderate-to-severe and severe SDB was 43·2% (40·9–45·5), 11·6% (10·2-13·1) and 2·7% (2·0-3·5), respectively. The prevalence of mild-to-severe and moderate-to-severe SDB was significantly higher in men (p<0·001) than in women (p=0·006) (Figure 2A). Individuals aged ≥60 years had a higher prevalence of SDB than younger participants in each SDB categories (p≤0·001, Figure 2B). In addition, SDB was more prevalent in participants living in urban versus rural areas (p<0·001, Figure 2C), and there was a gradual increase in SDB prevalence with increasing BMI (p<0·001, Figure 2D).

Standardized prevalence values according to age and sex distribution of the 2019 Benin population are shown in Table 2. For mild-to-severe SDB, the highest prevalence was found in the age group 60-69 for men while it was earlier, in the age group 50-59, for women.

Factors associated with SDB

Factors associated with moderate-to-severe SDB on univariate ordinal logistic regression analysis were older age, male sex, overweight/obesity, large neck circumference, abdominal obesity, snoring, hypertension, diabetes, smoking, alcohol consumption, and living in urban area (Table 3).

Multivariate ordinal logistic regression showed a significant association between SDB and older age, overweigh/obesity, large neck circumference, abdominal obesity and snoring (Table 3).

Association of SDB with hypertension and diabetes mellitus

Increasing SDB severity was associated with hypertension in model 1 and model 2, with a significant p-trend across the disease severity categories (*p*-trend =0·001); this association was no longer significant after adjustment for BMI (model 3), and neck circumference and abdominal obesity (model 4) (Figure S1). There were no significant associations between SDB and diabetes in any of the 4 models (Figure S1 and Table S3).

After stratification by sex, the fully adjusted model showed a significant association between SDB and hypertension in females (odds ratio 3·99, 95% CI 1·04–15·33; *p*-trend =0·044 across SDB severity categories) but not in males (Figure 3).

DISCUSSION

To the best of our knowledge, this is the first study reporting the objectively measured prevalence of SDB and its associated factors in a large sample in Africa. Our data show a high burden of SDB in an African general population, which was similar to reported prevalence rates on other continents. They also show that the factors associated with SDB are comparable to those reported in the literature.

Prevalence of SDB

Compared to other studies with objective measures, the prevalence rate of 43·2% found for mild-to-severe SDB in our study was similar to the prevalence of 46% (95% CI 44·4–47·4) recently reported in the SHIP-Trend cohort in Germany.[23] However, the prevalence rate for mild-to-severe SDB in our study is lower than that reported in the HypnoLaus cohort from Switzerland (at 72%)[24]. Still, HypnoLaus was based on a

much older population (median age 57 years compared with 46 years in our study), who had higher rates of obesity and a higher proportion of males compared with ours. Moreover, polysomnography recorders used in this cohort tend to provide higher AHI values than the polygraphy recordings used in BeSAS. Three decades ago, Young *et al.* reported a lower SDB prevalence of 24% in men and 9% in women from the pioneer Wisconsin cohort study,[25] but these results are difficult to compare with the findings of the current study due to differences in respiratory event definitions and recording techniques (thermistor vs nasal pressure).

More recently, the Jackson Heart Sleep study was conducted in an African American cohort in the USA and reported a prevalence of moderate-to-severe SDB that was more than double that found in our study (23·6% vs 11·6%).[17] However, it is worth noting that participants in the Jackson cohort were older (mean age 63·1 years) and more obese (mean BMI 32 kg/m^2) compared with participants in the BeSAS study (mean age and BMI 46 years and 23·6 kg/m^2, respectively). Interestingly, in our sample, the prevalence of moderate-to-severe SDB was 25·5% in participants with a BMI ≥30 kg/m^2 and 22·6% in those aged ≥60 years, which is quite similar to the prevalence rate in the Jackson study. Given that most African Americans are originally from West Africa where the BeSAS study was conducted, it would be interesting to perform an in-depth and comprehensive comparison between the two databases and other epidemiological studies to see whether any ethnic specificity can be identified.

Our data also showed that the prevalence of SDB in men increased with age up to 60–69 years and then decreased, while in women the highest SDB prevalence was reached earlier (in individuals aged 50–59 years). This early rise in prevalence in women compared to other cohorts [23,24] may be explained by the higher proportion of obesity in women in our study and by an earlier onset of menopause in African

342 women[26]. According to findings from the HypnoLaus cohort, menopause may
343 represent a major determinant even more than age for prevalence changes.[24]
344 Of note, there were many parts of the ESS questionnaire that could not be answered
345 by participants in the BeSAS study due to their lifestyle differing from that in individuals
346 from other continents. For example, a fair proportion of participants did not drive or do
347 not go to the theatre. Therefore, we could not reliably assess the prevalence of sleep
348 apnoea syndrome (AHI ≥5/h + excessive daytime sleepiness) in our sample. This
349 raises the question of the reliability of this scale in African populations and other low-
350 income areas in which driving a car, going to the cinema or watching TV are not
351 common activities. It is therefore necessary to develop an alternative tool, or to adapt
352 the ESS, to be able to accurately assess daytime sleepiness in African and similar
353 populations.
354

355 **Factors associated with SDB**

356 Consistent with the findings from other epidemiological sleep studies,[23,24,25] the main
357 factors associated with SDB on univariate analyses in our study were male sex, older
358 age, overweight/obesity, large neck circumference, abdominal obesity, snoring,
359 hypertension, diabetes mellitus, alcohol consumption and smoking. In the
360 multivariable analysis, only older age, male sex, neck circumference, abdominal
361 obesity, overweigh/obesity, and snoring remained independently associated with
362 SDB. Our data also showed an association between SDB and living in urban areas,
363 as already reported in China.[27] However, this association was likely due to differences
364 in anthropometric characteristics, such as the higher obesity rate in the urban
365 population, because it was no longer statistically significant in the adjusted models.

Nevertheless, the higher prevalence of SDB in urban vs rural settings may help to identify target populations for public health actions.

Association of SDB with hypertension and diabetes mellitus

Several studies have shown a direct association between SDB severity and hypertension.[29,30] In our study, there was a positive and independent association of SDB with hypertension with linear trend across SDB severity categories in women, but not in men. This is consistent with findings in Switzerland where a study conducted on the HypnoLaus cohort also found this association exclusively in women.[31] This could suggest that SDB treatment could have a greater effect on hypertension in women compared to men, but further studies are needed to confirm this assumption and investigate the underlying cause of this sex difference.

Strengths and limitations

The main strengths of this study include the fact that it was conducted in a large sample that relied on both rural and urban participants in Benin. Moreover, SDB was assessed using objective sleep measures. However, there are some limitations that should be mentioned. First, the sample, although large and from multiple geographic settings, represents random individuals that agreed to participate and may not represent the population in Benin. Second, female participants were disproportionally represented in our sample because they were more available to participate to the study during the survey visits. Therefore, to account for this recruitment difference, SDB prevalence data were reported by sex. Third, due to the acceptance and availability of study subjects and temporary COVID-19 restrictions, only about 60% of

BeSAS study participants could undergo respiratory PG according to pre-set quality criteria. However, there were no important differences between participants who underwent PG and those who did not. Fourth, we used PG to record sleep respiratory events while the gold standard is polysomnography (PSG). Although the PG has been validated for SDB diagnosis,[32] its use may have underestimated the true SDB prevalence because arousals could not be considered to score hypopnoeas, and the AHI was calculated based on estimated sleep time instead of measured total sleep time. Fifth, among SDB associated comorbidities, only hypertension and diabetes could be assessed in this study whereas several other conditions such as mood disorders, metabolic syndrome, cognitive decline and cardiovascular diseases could also be associated with SDB. Lastly, although night/day duration and temperature variations are very mild over the year in Benin (close to the equator line), we acknowledge that no adjustment was made in our results regarding the time of the year.

Despite these limitations, we believe that, by providing the first objectively measured data on SDB in an large national cohort from Africa, the BeSAS study fills a major gap in the sleep apnoea epidemiology literature and paves the way for further research on the African continent. Furthermore, our data could help to refine the worldwide modelized estimates of SDB prevalence by Benjafield *et al.*, who did not include any objective data from Africa in their model.[9] As a result, their estimated prevalence of moderate-to-severe SDB in Benin for example was 22·9%,[9] whereas we found a prevalence twice lower (11·6%) in our study. Although this difference may be due, in part, to a possible underestimation of the prevalence by the polygraphic (instead of PSG) recordings, it strengthens the need for more data in the African continent.

Conclusion

In conclusion, we showed that more than one in three women and one in two men was affected by mild-to-severe SDB in Benin, a prevalence high but similar to that reported on other continents. Advanced age, male sex, large neck circumference, abdominal obesity, overweight/obesity and snoring were the factors independently associated with SDB our population. In addition, we found an independent association between hypertension and SDB exclusively in women. The high SDB prevalence rate documented in this study should stimulate the development of public health policies to prevent and treat SDB in Benin and other African countries.

Acknowledgments

We acknowledge the contributions of the following persons who were involved in data acquisition on the field: Salanon Elfried, Biaou Boni Richard, Loko Hermionne, Adjiha Sylvia, Akpaki Ulrich, Dossou Mauricette all the contributors of the TAHES cohort study in Tanve. We also acknowledge the support of Alexandre Bonvin from ResMed who granted us a free licence to read the Apnealink data in Noxturnal software.

Declaration of interest

RH is member of the medical advisory board of Dreem and Nightbalance (Philips) and received honorariums, grants or speakers' fees from ResMed, Jazz, Inspire, Philips and Dreem.

All the other authors have no conflict of interest to disclose.

Contributors statementAPW, CH, SA, SA, DM and RH designed the study; APW, TT, FA, AAF, GA participated to data acquisition; APW, TT, AAF, GA, RH verified, analyzed and interpreted the data; MG, GS, PL, PMP, PMV, DM interpreted the data and critically reviewed the report; APW, MB, GA, PMV wrote the report. All co-authors have full access to the data and are responsible for the submission of the manuscript.

Data sharing statement

The data supporting the study findings can be shared upon direct request to the corresponding author in a collaborative research approach.

REFERENCES

1. Cowie MR. Sleep apnea: state of the art. *Trends Cardiovasc Med.* 2017; **27**(4): 280–9.
2. Lévy P, Kohler M, McNicholas WT, Barbé F, McEvoy RD, Somers VK, et al. Obstructive sleep apnoea syndrome. *Nat Rev Dis Prim.* 2015; **1**: 15015.
3. Chang JWR, Akemokwe FM, Marangu DM, Chisunkha B, Irekpita E, Obasikene G, et al. Obstructive sleep apnea awareness among primary care physicians in Africa. *Ann Am Thorac Soc.* 2020; **17**(1): 98–106.
4. Ozoh, Obianuju Beatrice, et al. Prospective assessment of the risk of obstructive sleep apnea in patients attending a tertiary health facility in Sub-Saharan Africa. *Pan Afr Med J*. 2014; **17**: 302.
5. Peppard PE, Hagen EW. The last 25 years of obstructive sleep apnea epidemiology and the next 25? *Am J Respir Crit Care Med.* 2018; **197**(3): 310–2.
6. Fogel RB, Malhotra A, White DP. Sleep. 2: pathophysiology of obstructive sleep apnoea/hypopnoea syndrome. *Thorax.* 2004; **59**(2): 159–63.
7. Cowie MR, Linz D, Redline S, Somers VK, Simonds AK. Sleep disordered breathing and cardiovascular disease: JACC State-of-the-Art Review. *J Am*

Coll Cardiol. 2021; **78**(6): 608–24.

8. Pan L, Xie X, Liu D, Ren D, Guo Y. Obstructive sleep apnoea and risks of all-cause mortality: preliminary evidence from prospective cohort studies. *Sleep Breath.* 2016; **20**(1): 345–53.

9. Benjafield AV, Eastwood PR, Heinzer R, Morrell MJ, Federal U, Paulo DS, et al. Sleep apnoea : a literature-based analysis. *Lancet Respir Med.* 2020; **7**(8): 687–98.

10. Whitesell PL, Obi J, Tamanna NS, Sumner AE. A review of the literature regarding sleep and cardiometabolic disease in African descent populations. *Front Endocrinol.* 2018; **9**: 140.

11. Ouedraogo AR, Ouedraogo G, Adambounou AS, Boncoungou K, Maiga S, Koalga R, et al. Prevalence of symptoms of sleep apnoea syndrome in Burkina Faso. *African J Thorac Crit Care Med.* 2019; **25**(2): 38.

12. Sogebi OA, Oyewole EA, Olusoga-Peters OO. Sleep disordered breathing (SDB) experiences associated with snoring in adult Nigerians. *Afr Health Sci.* 2011; **11**(3): 309–14.

13. Jniene A, el Ftouh M, el Fassy Fihry MT. Sleep apnea syndrome: experience of the pulmonology department in Ibn Sina Hospital, Rabat, Morocco. *Pan Afr Med J*. 2012; **13**: 28.

14. Komolafe, Morenikeji A., et al. "Sleep medicine in Africa: past, present, and future." *J Clin Sleep Med.* 2021*;* **17**(6): 1317-1321.

15. Roche J, Rae DE, Redman KN, Knutson KL, von Schantz M, Gómez-Olivé FX et al. Impact of obstructive sleep apnea on cardiometabolic health in a random sample of older adults in rural South Africa: Building the case for the treatment of

489 sleep disorders in underrresourced settings. *J Clin Sleep Med*. 2021;**17**(7):1423–
490 1434

491 16. Chen X, Wang R, Zee P, Lutsey PL, Javaheri S, Alcántara C, et al.
492 Racial/ethnic differences in sleep disturbances: the Multi-Ethnic Study of
493 Atherosclerosis (MESA). *Sleep.* 2015; **38**(6): 877–88.
494 17. Johnson DA, Guo N, Rueschman M, Wang R, Wilson JG, Redline S.
495 Prevalence and correlates of obstructive sleep apnea among African
496 Americans: the Jackson Heart Sleep Study. *Sleep.* 2018; **41**(10): zsy154.
497 18. Benin Demographic Profiles. Available from:
498 https://www.indexmundi.com/benin/demographics_profile.html. Accessed 20
499 Sep 2021.
500 19. Houehanou YC, Mizéhoun-Adissoda C, Amidou S, Désormais I, Houénassi M,
501 Preux PM, et al. Feasibility of a cardiovascular cohort in a Sub-Saharan Africa
502 community: preliminary report of the pilot project TAHES (Tanvè Health Study)
503 in Benin. *Glob Health Action*. 2017; **10**(1): 1270528.
504 20. Berry R, Brooks R, Gamaldo C, Harding S, Llyod R, Marcus C, et al. The
505 AASM Manual for the scoring of sleep and associated events: rules,
506 terminology and technical specifications, Version 2.1. Darien, Illinois: American
507 Academy of Sleep Medicine; 2014.
508 21. Buysse DJ, Reynolds CF, Monk TH, Berman SR, Kupfer, DJ. The Pittsburgh
509 Sleep Quality Index (PSQI): a new instrument for psychiatric research and
510 practice. *Psychiatry Res.* 1989; **28**(2): 193–213.
511 22. Johns MW. A new method for measuring daytime sleepiness: the Epworth
512 Sleepiness Scale. *Sleep.* 1991; **14**(6): 540–5.
513 23. Fietze I, Laharnar N, Obst A, Ewert R, Felix SB, Garcia C, et al. Prevalence

514 and association analysis of obstructive sleep apnea with gender and age
515 differences – Results of SHIP-Trend. *J Sleep Res.* 2019; **28**(5): e12770.
516 24. Heinzer R, Vat S, Marques-Vidal P, Marti-Solar H, Andries D, Tobback N, et al.
517 Prevalence of sleep-disordered breathing in the general population: the
518 HypnoLaus study. *Lancet Respir Med.* 2015; **3**(4): 310–318.
519 25. Young T, Palta M, Dempsey J, Skatrud J, Weber S, Badr S. The occurrence of
520 sleep-disordered breathing among middle-aged adults. *N Engl J Med.* 1993;
521 **328**(17): 1230–5.
522 26. Gold EB. The timing of the age at which natural menopause occurs. *Obstet*
523 *Gynecol Clin North Am.* 2011; **38**(3): 425–40.
524 27. Liu J, Wei C, Huang L, Wang W, Liang D, Lei Z, et al. Prevalence of signs and
525 symptoms suggestive of obstructive sleep apnea syndrome in Guangxi, China.
526 *Sleep Breath.* 2014; **18**(2): 375–82.
527 28. Nedeltcheva AV, Scheer FAJL. Metabolic effects of sleep disruption, links to
528 obesity and diabetes. *Curr Opin Endocrinol Diabetes Obes.* 2014; **21**(4): 293–
529 298.
530 29. Tufik S, Santos-Silva R, Taddei JA, Bittencourt LRA. Obstructive sleep apnea
531 ayndrome in the Sao Paulo Epidemiologic Sleep Study. *Sleep Med.* 2010;
532 **11**(5): 441–6.
533 30. Peppard PE, Young T, Palta M, Skatrud JM. Prospective study of the
534 association between sleep-disordered breathing and hypertension. *N Engl J*
535 *Med.* 2000; **342**(19): 1378–84.
536 31. Heinzer R, Marti-Soler H, Marques-Vidal P, Tobback N, Andries D, Waeber G,
537 et al. Impact of sex and menopausal status on the prevalence, clinical
538 presentation, and comorbidities of sleep-disordered breathing. *Sleep Med.*

2018; **51**: 29–36.

32. Cho JH, Kim HJ. Validation of ApneaLink™ Plus for the diagnosis of sleep apnea. *Sleep Breath.* 2017; **21**(3): 799–807.

Figure Legends

Figure 1. Participants' inclusion/exclusion

Figure 2. Prevalence of sleep-disordered breathing by sex (**A**), age (**B**), area of residence (**C**), and nutritional status (**D**)

Figure 3. Estimated risk for hypertension associated with the severity of sleep-disordered breathing (SDB) and stratified by sex.

Points and bars represent odds ratios and 95% CI. Apnea-hypopnea index severity groups defined as mild (5-14 events/hour, moderate (15-29 events/hour), severe (≥30 events/hour), were compared to the reference group (<5 events/hour). p values are for trend across severity groups. Model 1 was adjusted for age, living area; model 2 = model 1 + alcohol and tobacco consumption; model 3 = Model 2 + BMI; and model 4 = Model 3 + neck circumference and abdominal obesity.