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Multidimensions of sleep health among in-school adolescents in rural and urban areas in southwestern Nigeria

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ABSTRACT

Introduction: Previous studies have focused on sleep inequities among disadvantaged populations in high-income countries. However, little is known about the differences in sleep health among adolescents in Africa. We aimed to compare the multidimensions of sleep health in adolescents living in rural vs. urban communities in Nigeria.

Methods: This cross-sectional study enrolled adolescents aged 13-19 in six rural and six urban schools in Osun State, Nigeria. We measured the prevalence of poor sleep quality (Pittsburgh Sleep Quality Index score > 5), daytime sleepiness (Epworth Sleepiness Scale for Children and Adolescents score > 10), and risk of sleep apnea (Teen STOPBANG). We compared the sleep health variables between the rural and urban populations using multivariable logistic regression.

Results: Of the 900 participants (51% rural; 59% female; average age (SD) = 15.1(1.4) years), 79% had short sleep duration (< 8.5 hours), 14.9% poor sleep quality, 9.6% excessive daytime sleepiness and 9.8% risk of sleep apnea. Urban adolescents had a higher prevalence of poor sleep quality ($p = .004$), short sleep duration ($p < .001$), daytime sleepiness ($p = .044$), and risk of sleep apnea ($p = .006$) compared to rural adolescents. The adjusted odds of having poor sleep quality ($p = .008$) and daytime sleepiness ($p = .007$) were about 2-fold higher among urban compared to rural adolescents. Later school end time, having single/separated parent(s), absence of parental setting of bedtime were independently associated with poorer sleep health.

Conclusion: Adolescents in rural communities had better sleep health than adolescents in urban communities. There is a need to develop interventions to improve the sleep quality and overall sleep health of urban-dwelling adolescents.

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Introduction

Poor sleep constitutes a public health issue as it affects about half of the global population,[1] and is of particular concern among adolescents.[2-7] The period of adolescence is characterized by changes in physical, physiological, and psychological functions,[8] a physiological delay in adolescents' circadian and sleep phases with shorter sleep duration during weekdays.[4,9] Poor sleep in adolescents has been associated with risky behavior, poor academic performance, adverse mental health, and adverse cardiometabolic health.[10-12] Therefore,

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adolescent sleep issues can be linked to other aspects of their health and well-being.

In 2014, Buysse[13] defined sleep health as "a multidimensional pattern of sleep-wakefulness, adapted to individual, social, and environmental demands, that promotes physical and mental well-being." This definition has improved the understanding of poor sleep health as a "cause of adverse health outcomes, rather than just a consequence or symptom of ill health."[14-16] Sleep health, as defined by Buysse, comprises the following sleep characteristics: duration, quality, timing, variability or regularity, efficiency, and continuity.[13,14] Sleep apnea is also a notable contributor to poor sleep and adverse health outcomes,[17,18] including cardiovascular health, especially among obese adolescents.[19,20] Sleep health disparities reflect socioeconomic inequities at the family, school, community levels. Addressing sleep health disparities, by intervening on those socioeconomic inequities could in turn improve overall health.[14,21]

In high-income countries, the problems associated with poor sleep among adolescents have been studied across racial, social and ethnic groups. Reports indicate that poor sleep exists among both rural and urban-dwelling adolescents,[22,23] but the determinants of poor sleep are not the same in these populations. In urban populations, adolescent sleep-related problems include sleep deprivation and excessive daytime sleepiness,[22,24] with shorter sleep duration and later bedtimes among urban-dwelling adolescents compared to rural-dwelling adolescents.[25-27] In urban settings, technology use at bedtime, artificial light exposure at night (ALAN), environmental noise, school-related demands, and family dynamics were the major determinants of sleep health.[22,24,28] In rural communities, poor sleep has been linked to poverty, low access to public - including health - amenities, and adverse mental health.[25,27,29] However, lack of access to electricity - more prevalent in rural communities - has been associated with earlier bedtimes.[30,31] Thus, there seems to be a disparity in the determinants of sleep health problems among rural and urban-dwelling adolescents.

In Africa, the few available studies on adolescent sleep have focused on urban communities. In South Africa, Reid et al reported insufficient sleep among urban-dwelling adolescents on weekdays with 40% reporting excessive daytime sleepiness.[32] In Nigeria, rural-urban migration has led to the rural population decreasing from 70% to 46% of Nigeria's total population between 2000 and 2022.[33,34] Urban communities in Nigeria have better access to social amenities,[34] the internet,[35] technology and electricity as well as alternative energy sources which are lacking in the rural communities.[34-36] In 2020, the World Bank reported a 55.4% electricity access rate in Nigeria with a wide disparity in urban (83.9%) compared to rural areas (24.6%).[37] Technology use, electricity and ALAN disrupt the natural light-dark cycle and are associated with short sleep duration and later bedtimes.[38] These factors may contribute to a difference in sleep health characteristics between rural and urban dwellers in Nigeria.

The existing Nigerian studies also have additional limitations, including a concentration on only sleep quality or sleep duration components of adolescent sleep health.[5-7] The other components of adolescent sleep health such as daytime sleepiness and the risk for sleep apnea have not been studied individually or in combination. Therefore, this research aimed to compare the different components of sleep health, encompassing both sleep quantity and quality, between rural and urban in-school adolescents in Osun State, Nigeria. We hypothesized that adolescents living in rural communities have earlier bedtimes, earlier wake times, longer sleep duration, better sleep quality, and lower daytime sleepiness than those living in urban communities.

Participants and methods

Study design

This comparative cross-sectional study was conducted in six rural and six urban schools in Osun State, southwestern Nigeria. All data were collected between May and June 2022, among a representative sample of 900 adolescents who were selected using a stratified, multistage sampling technique.

Study setting

The site for the study is the Osun East Senatorial District, one of the three senatorial zones (regions) in Osun State, Nigeria. Osun State is one of the most populated southern Nigerian states with an estimated population of 5,521,901 and an estimated adolescent population of 810,558. Three local government areas (LGAs), namely Atakumosa West (representing rural), Ife North (representing rural) and Ife Central (representing urban), were selected from the 10 LGAs within the zone. We selected 3 LGAs out of the 10 LGAs in the district based on their geographical proximity and ethno-religious similarities. Thus, the communities are only different based on their rural vs. urban features. The rural and urban classification is based on the Osun State government categorization of the communities. One school was selected from each rural community since most of these communities had only one or two secondary schools. Six schools were selected for the study in Ile-Ife, the urban community, using the proportion-to-population approach.

Study participants

The study participants were apparently healthy adolescents aged 13-19 years attending secondary schools in the selected rural and urban communities. Adolescents using sedative medications, antiepileptics or narcotic preparations for any acute or chronic medical condition were excluded from the study using a screening questionnaire at the first school visit.

Adolescents in the final class (senior secondary school 3 [SSS 3]) were not available for the data collection process due to their final examinations and were excluded. We also excluded boarding students due to the controlled day and night schedules in the school boarding facilities. As per ethics regulations, adolescents whose parent did not sign the consent form were not enrolled (see flow chart in Fig. 1).

Sampling procedures

The multistage sampling method was used for the selection of study participants. In the first stage, the list of secondary schools in each community was obtained from the Education Office of the Osun State Ministry of Education. A stratified sampling technique was used to select six schools in the urban community and six schools in rural communities. For the second stage, we obtained the list of classes in each selected school and a class was selected from each stratum of the classes from Junior Secondary School (JSS) 1 (age range is 10-13 years old in urban areas, 10-16 years old in rural areas) to Senior Secondary School (SSS) 2 (age range urban areas 14-16 years old; age range rural areas 14-19 years old) using the stratified sampling technique. In the third stage, the simple random sampling technique was used to select a predetermined number of students per class. This was done using a proportionate-to-population approach to ensure that the number of students selected per class was proportional to the class population.

Ethical considerations

We obtained approval for the study from the Health and Research Ethics Committee of the University of Witwatersrand, Johannesburg, South Africa (Reference number M210745) and the Obafemi Awolowo University, Ile-Ife, Osun State, Nigeria (Reference number HREC NO: IPHOAU/12/1850). We also obtained permission to conduct the study from the State Education Authority, the School

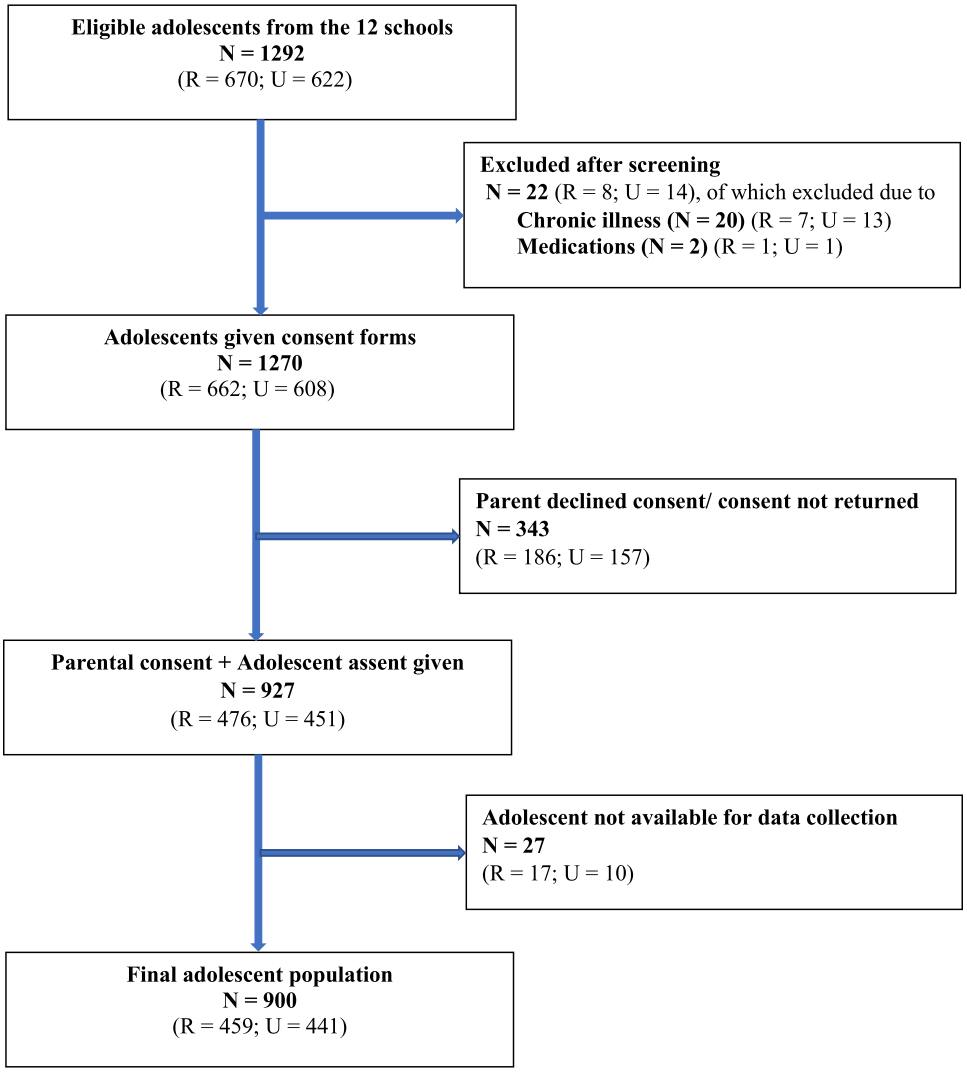


Fig. 1. Flow chart of participant recruitment process from the rural and urban communities in Osun State, Nigeria. R, rural; U, urban

Principals and the Proprietors. We conducted the study in accordance with the Declaration of Helsinki. Written informed consent was obtained from each parent of the adolescents aged less than 18 years, and the adolescents also gave signed assent. Adolescents aged 18-19 years gave written informed consent. During the first contact with the students, the lead researcher (OEO) provided general information about the study on the assembly ground in each school. Thereafter, the adolescents were given an information sheet about the study for delivery to their parents. The completed parental consent forms were collected from the adolescents the following day. Once parental consent and the adolescent's assent were obtained, we arranged for fully trained research assistants to be present at the school in the afternoons for 1-2 weeks for the data collection.

Data collection tools and measures

We used a pilot-tested questionnaire to obtain a self-report of information about the sociodemographic features, covariates and sleep characteristics of the rural and urban-dwelling adolescents. The questions on the sociodemographic information and other covariates were compiled by the research team based on earlier reported factors contributing to sleep characteristics,[5-7] while the sleep health variables were obtained using standardized sleep questionnaires. Each adolescent was interviewed in the school setting to gather self-reported sociodemographic and sleep characteristics and school schedule variables. The sociodemographic information obtained included the adolescent's age, sex, ethnicity, family type, nature of school (public or private) and class (grade) they were in (the variable was dichotomized into the junior secondary school classes JSS 1-3 and senior secondary school classes SSS 1-2). For analyses, we split age into 3 categories: Early adolescence: 13-14, Middle adolescence: 15-17, and Late adolescence: 18-19. We asked questions about the type of family, parental setting of bedtimes, bed sharing, ethnicity, nature of school, school start times, home-to-school commuting time, and the class in school.

Social class

We determined the social class of the respondents using the method described by Ibadin.[39] The occupation and the highest educational attainment of each parent were given a score from 1 to 6 based on the rating scale. The aggregate score for the respondents' social class was computed by dividing by four the score obtained from the occupation and the highest educational attainment of each parent (two, where only one parent or caregiver was available) and the derived value was approximated to the nearest integer. The resultant score range of 1-6 was further used to classify the social classes into Upper class (scores 1-2), Middle class (scores 3-4) and Lower class (scores 5-6).

Sleep quality

The Pittsburgh Sleep Quality Index (PSQI) was used to assess sleep over a 1-month time interval. It has been validated among a Nigerian population of late adolescents and older young people in a university setting.[40] It comprises 19 items, which are used to generate component scores across the seven domains: subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleeping medication, and daytime dysfunction. A total score of 21 is obtainable from the composite scores from each domain. A cumulative score with Global PSQI > 5 (out of 21) is considered poor sleep quality.

Sleep pattern

We used the components of the PSQI which contained questions about the adolescents' usual bedtime, wake time, total time in bed, self-reported sleep duration and sleep efficiency. For the logistic regression analysis, we dichotomized sleep duration in adolescents who slept < 8.5 hours/night (insufficient sleep duration) and those who slept ≥8.5 hours per night (sufficient sleep duration). Only eight (8) adolescents were in the long sleep duration category (sleep duration > 10 hours). Therefore, we decided to merge the adolescents who had a sleep duration of ≥8.5 hours in the sufficient sleep duration category.

Daytime sleepiness

It was assessed using the Epworth Sleepiness Scale for Children and Adolescents (ESS-CHAD, a modified form of the Epworth Sleepiness Scale [ESS] for children and adolescents). ESS-CHAD comprises 8 items and has been validated in children and adolescents aged 12-18 years of age.[41] It assesses the presence and degree of daytime sleepiness in more or less active situations, on a Likert scale of 0-3 per item (with 0 representing the least chance of dozing and 3 representing the worst). The participant is asked to recall their situations over the past month in answering the questions, and a composite score is obtained from the sum of the score for each domain. A score of > 10 for the ESS-CHAD is considered excessive daytime sleepiness.

Risk of sleep apnea

A modified STOP-Bang (teen STOP-Bang) questionnaire was used for assessing the risk of sleep apnea in adolescents.[42] A score of "1" was given for a "Yes" answer to each of the parameters which include snoring, tiredness, observed apnea, blood pressure ≥95th percentile for height and age, body mass index (BMI) > 95th percentile, academic problems and male gender. To calculate BMI (weight (kg)/(height (m))^2), we measured the adolescents' standing height (cm) to the nearest 0.01 cm with a standard calibrated stadiometer, and the body weight (kg) using a standard weighing scale to the nearest 0.1 kg with the adolescent dressed in minimal clothing. BMI was then subclassified into > 95th percentile or not, using the growth chart of the World Health Organization (WHO).[43] We measured each adolescent's blood pressure on the right arm in the sitting position using an appropriate-sized cuff. Blood pressure was then classified as ≥95th percentile for the sex and age in this population, or < 95th percentile. The total score obtained with the Teen STOPBANG was classified as "no risk" if < 3, while a total score of ≥3 being classified as risk of sleep apnea.

Data analysis

The data obtained were analyzed using Stata-15 software (StataCorp. 2017. Stata Statistical Software: Release 15. College Station, TX: StataCorp LLC). Descriptive analysis was used for the sociodemographic characterization of the study participants and other relevant variables, such as age, sex, class, place of residence, and ethnicity. We categorized the adolescents based on their place of residence since the factors that may affect the adolescent's sleep go beyond the school, to the environment where they live and sleep. At the bivariate level, a Chi-square test was used to assess the association between the category of residence (urban and rural) and the categorical adolescent sleep health variables (sleep quality, excessive daytime sleepiness, sleep duration < 8.5 hours, and risk of sleep apnea). An independent Student *t* test was used to assess the relationship between the category of residence and the continuous adolescent sleep health variables (bedtime, wake time, time in bed, sleep duration and sleep efficiency). Multivariable analysis was undertaken using the binary logistic regression model to assess the relationship between urban-rural location and sleep health, with the following sociodemographic variables controlled for: sex, age, social class, family type, ethnicity, parental setting of bedtimes, bed-sharing, nature of the school, class in school, school start and end times, and commuting time. A *p*-value < .05 was considered significant for all statistical analyses.

Results

Sociodemographic characteristics

Nine hundred adolescents participated in the study, with a mean ± SD age of 15.1 ± 1.4. Fifty-one percent were rural-dwelling adolescents, 59% were female, and 77.9% were in senior secondary school. Most respondents were of Yoruba ethnicity – the dominant ethnic group in southwest Nigeria (Table 1). School start time did not differ between the rural and urban-dwelling adolescents however school end time was later while their commuting time was shorter for the rural-dwelling adolescents.

Sleep quality

Overall prevalence of poor sleep quality was 14.9%. The urban-dwelling adolescents had statistically significant higher prevalence of poor-quality sleep (18.4%) compared to rural-dwelling adolescents (11.6%) ($p = .004$) (Table 2).

Excessive daytime sleepiness

Excessive daytime sleepiness was present in 86 (9.6%) of the in-school adolescents. Urban-dwelling adolescents had a significantly higher prevalence of excessive daytime sleepiness compared to rural-dwelling adolescents (11.6% vs. 7.6%, $p = .044$).

Sleep patterns

The mean ± SD sleep duration of the adolescents was 7:10 ± 1:40 hours while their mean total time in bed was 7:40 ± 1:29 hours (Table 2 and Fig. 2). The mean sleep duration and total time in bed were shorter among the urban-dwelling adolescents (both $p \leq .001$) while the sleep efficiency was not different. The urban-dwelling adolescents also had later bedtimes compared to their rural-dwelling counterparts; while there was no difference in their wake times (Table 2 and Fig. 2).

Risk of sleep apnea

Risk of sleep apnea was recorded in 87 (9.8%) adolescents. Urban-dwelling adolescents had a significantly higher prevalence of risk of sleep apnea compared to rural-dwelling adolescents (12.6% vs. 7.1%, $p = .006$).

Table 1
Participant's characteristics in rural vs. urban communities

Sociodemographic characteristics	Overall (N = 900) N (%)	Rural (N = 459) N (%)	Urban (N = 441) N (%)	*p*
Sex				
Female	531 (59.0)	274 (59.7)	257 (58.3)	.665*
Male	369 (41.0)	185 (40.3)	184 (41.7)	
Age in years				
Mean ± SD	15.1 ± 1.4	15.4 ± 1.4	14.8 ± 1.4	**<.001**#
13-14 (early adolescence)	323 (35.9)	123 (26.8)	200 (45.3)	**<.001**
15-17 (middle adolescence)	535 (59.4)	308 (67.1)	227 (51.5)	
18-19 (late adolescence)	42 (4.7)	28 (6.1)	14 (3.2)	
Social class				**<.001**
Upper	127 (14.1)	8 (1.7)	119 (26.9)	
Middle	323 (35.9)	137 (29.9)	186 (42.2)	
Lower	442 (49.1)	310 (67.5)	132 (29.9)	
Unclassified (no response)	8 (0.9)	4 (0.9)	4 (0.9)	
Ethnicity				**.002**
Yoruba	814 (90.4)	429 (93.5)	385 (87.3)	
Others	86 (9.6)	30 (6.5)	56 (12.7)	
Family type				**<.001**
Monogamous	672 (74.7)	308 (67.1)	364 (74.7)	
Polygamous	193 (21.4)	131 (28.5)	62 (14.1)	
Has single parents	22 (2.4)	13 (2.8)	9 (2.0)	
Have separated parents	13 (1.4)	7 (1.5)	6 (1.4)	
Parental setting of bedtime				.892
Yes	296 (32.9)	150 (32.7)	146 (33.1)	
No	604 (67.1)	309 (67.3)	295 (66.9)	
Bed-sharing				**<.001**
Yes	456 (50.7)	262 (57.1)	194 (44.0)	
No	444 (49.3)	197 (42.9)	247 (56.0)	
School start time (hh:mm)[a]	07:45 ± 0:12	07:45 ± 0:12	07:45 ± 0:12	.289
School end time (hh:mm)[a]	15:30 ± 1:06	15:36 ± 1:18	15:24 ± 0:54	**.021**#
Home-to-school commuting time (min)	24 ± 15	22 ± 14	26 ± 15	**<.001**#
Nature of school				
Public	553 (61.4)	373 (81.3)	180 (40.8)	**<.001**
Private	347 (38.6)	86 (18.7)	261 (59.2)	
Class in school		127 (27.7)		**<.001**
JSS1-JSS3	199 (22.1)	127 (27.7)	72 (16.3)	
SSS1-SSS2	701 (77.9)	332 (72.3)	369 (83.7)	

*Chi-square test.
#Independent *t* test.
P values in bold indicate statistically significant differences between the urban and rural adolescent characteristics.
[a] Mean ± SD.

Table 2
Comparison of sleep characteristics of Nigerian in-school adolescents in rural vs. urban communities

Sleep variables	Overall N (%)	Rural N (%)	Urban N (%)	*p*
Sleep quality (n = 899)				**.004***
Good	765 (85.1)	406 (88.4)	359 (81.6)	
Poor	134 (14.9)	53 (11.6)	81 (18.4)	
Excessive daytime sleepiness (n = 900)				**.044***
Absent	814 (90.4)	424 (92.4)	390 (88.4)	
Present	86 (9.6)	35 (7.6)	51 (11.6)	
Risk of sleep apnea				**.006***
No risk	805 (90.2)	422 (92.9)	383 (87.4)	
Risk of apnea	87 (9.8)	32 (7.1)	55 (12.6)	
Self-reported:	Mean ± SD	Mean ± SD	Mean ± SD	
Sleep duration (h:mm)	7:10 ± 1:40	7:23 ± 1:34	6:55 ± 1:44	**<.001**#
Bedtime (hh:mm)	21:49 ± 1:11	21:34 ± 1:08	22:05 ± 1:11	**<.001**#
Wake time (hh:mm)	05:27 ± 0:47	05:29 ± 0:46	05:25 ± 0:50	.190#
Time in bed (h:mm)	7:40 ± 1:29	7:55 ± 1:23	7:24 ± 1:31	**<.001**#
Sleep efficiency (%)	92.1 ± 13.2	92.3 ± 12.5	91.9 ± 14.0	.570#

*Chi-square test.
#Independent *t* test.
P values in bold indicate statistically significant differences between the urban and rural adolescent sleep characteristics.

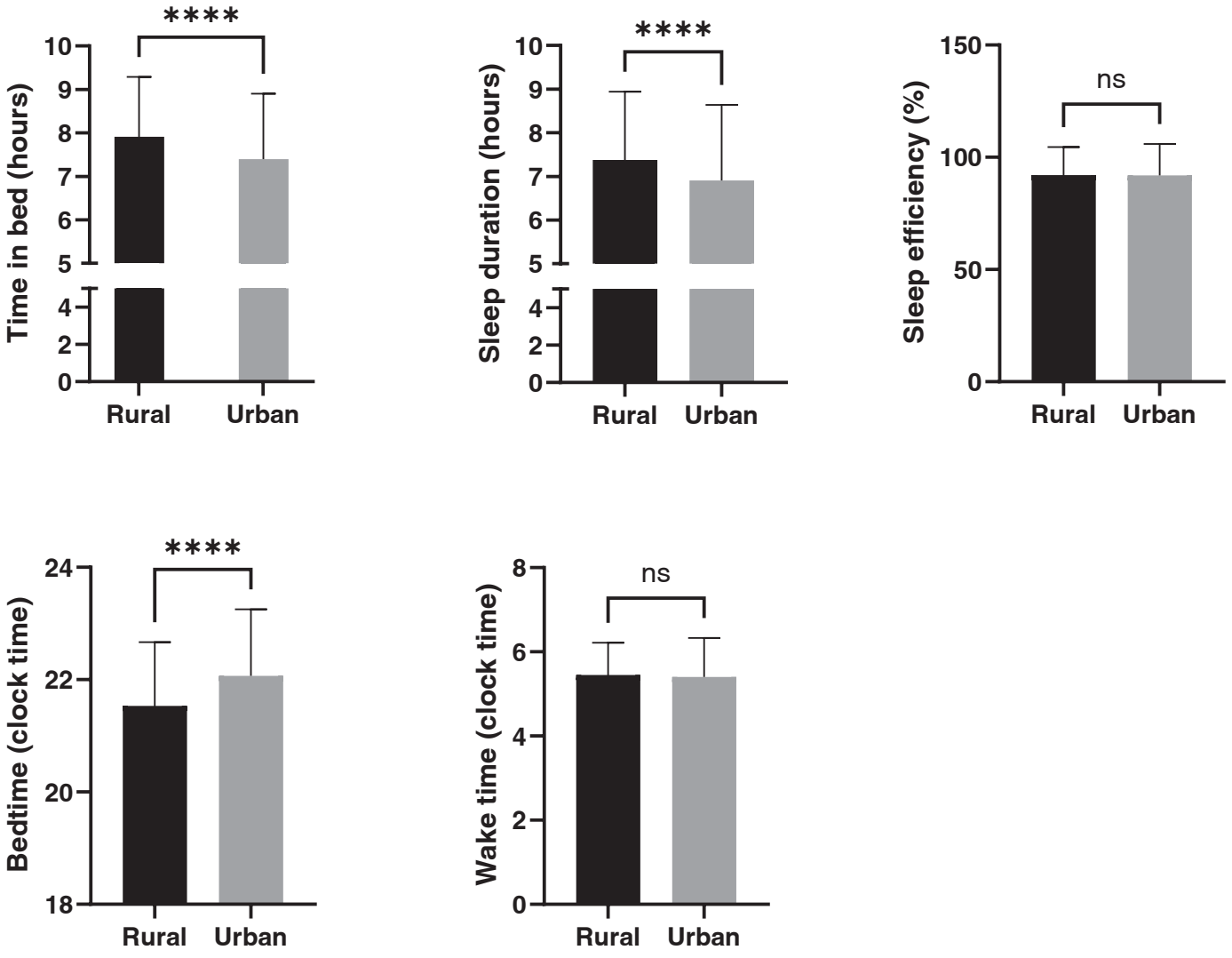


Fig. 2. Mean ± SD self-reported time in bed, sleep duration, bedtime, wake time and sleep efficiency extracted from the Pittsburgh Sleep Quality Index in rural vs. urban adolescents living in Osun State, Nigeria. ****$p < .001$, ns: nonsignificant, using an independent t test

Multivariable analysis

Table 3 shows the crude and adjusted relationship between the type of residence (rural-urban) and poor sleep quality, excessive daytime sleepiness, low sleep duration and the risk of sleep apnea in adolescents. The adjusted odds of having poor sleep quality and excessive daytime sleepiness were higher by almost 2-fold among the urban-dwelling adolescents compared to those living in the rural communities. Adjusted odds of reporting insufficient sleep duration (< 8.5 hours/ night) or risk of sleep apnea between the rural and urban communities were not significant (Table 3).

The full multivariable model of the rural-urban difference is shown in Table 4 and shows other factors associated with sleep health.

Female adolescents had higher odds of having poor sleep quality, but lower odds of having risk of sleep apnea than did male adolescents. Adolescents from lower and middle social classes had lower odds of having poor sleep quality and short sleep duration but

Table 3
Binary logistic regression analysis of the sleep health characteristics in Nigerian in-school adolescents in rural vs. urban communities in crude (cOR) and adjusted analyses (aOR)[a]

Variable name	Poor sleep quality		Excessive daytime sleepiness		Sleep duration < 8.5 h		Risk of sleep apnea	
Residence urban	Crude	Adjusted	Crude	Adjusted	Crude	Adjusted	Crude	Adjusted
OR95%CI	**1.73**	**1.95**	**1.58**	**2.25**	1.26	1.07	**1.89**	1.57
	1.19-2.51	**1.19-3.18**	**1.01-2.49**	**1.25-4.05**	0.91-1.73	0.72-1.60	**1.20-2.99**	0.87-2.85
	0.004	**0.008**	**0.046**	**0.007**	0.162	0.741	**0.006**	0.136

We modeled the odds of having poor sleep quality (PSQI > 5) over good sleep quality (PSQI ≤5), the odds of having excessive daytime sleepiness (ESS-CHAD > 10) over having normal daytime sleepiness (ESS-CHAD ≤10), the odds of having low sleep duration (< 8.5 hours) over the odds of having normal sleep duration (≥8.5 hours) and the odds of having risk of sleep apnea over the odds of having low risk of sleep apnea. Results (odds ratios and p values) in **bold** indicate a significant association between the independent variable (residence urban, compared to rural) and the sleep outcome variable tested.

[a] Binary logistic regression controlling for the confounders: sex, age, social class, family type, nature of the school, class in school, ethnicity, parental setting of bedtimes, bed-sharing, school start time, school closing time, and home-to-school commuting time.

Table 4
Multivariable analysis of the sleep health characteristics among the Nigerian in-school adolescents in rural vs. urban communities

Variable name	Poor sleep quality		Excessive daytime sleepiness		Sleep duration < 8.5 h		Risk of sleep apnea	
	aOR (95% CI)	*p*	aOR (95% CI)	*p*	aOR (95% CI)	*p*	aOR (95% CI)	*p*
Residence[a]								.136
Urban	**1.95 (1.19-3.18)**	**.008**	**2.25 (1.25-4.05)**	**.007**	1.07 (0.72-1.60)	.741	1.57 (0.87-2.85)	
Sex[b]								**< .001**
Female	**1.60 (1.06-1.41)**	**.024**	1.11 (0.68-1.79)	.681	0.98 (0.70-1.39)	.928	**0.27 (0.16-0.44)**	
Age[c]								.846
Middle adolescence	0.99 (0.62-1.60)	.981	1.10 (0.61-1.96)	.758	1.40 (0.93-2.11)	.103	0.95 (0.54-1.66)	
Late adolescence	0.98 (0.36-2.67)	.965	1.57 (0.54-4.59)	.410	2.12 (0.80-5.63)	.133	2.78 (0.99-7.84)	.053
Social class[d]								.658
Middle	**0.46 (0.26-0.82)**	**.007**	**2.51 (1.08-5.83)**	**.028**	**0.29 (0.14-0.61)**	**.001**	1.17 (0.58-2.36)	
Lower	**0.46 (0.25-0.87)**	**.017**	**2.70 (1.09-6.69)**	**.032**	**0.28 (0.13-0.61)**	**.001**	0.85 (0.38-1.88)	.683
Ethnicity[e]								
Not Yoruba	1.16 (0.62-2.20)	.650	1.79 (0.91-3.53)	.091	1.58 (0.85-2.94)	.145	0.59 (0.24-1.46)	.256
Family type[f]								.428
Polygamous	1.59 (0.99-2.54)	.054	1.13 (0.68-1.99)	.681	1.47 (0.96-2.27)	.079	1.28 (0.69-2.37)	
Single	**2.80 (1.06-7.42)**	**.038**	1.61 (0.43-5.92)	.504	2.03 (0.56-7.40)	.284	**4.95 (1.59-15.40)**	**.006**
Separated	1.15 (0.23-5.88)	.863	––		2.83 (0.48-16.78)	.250	**5.97 (1.43-24.87)**	**.014**
Parent set[g] bedtime	**0.58 (0.37-0.91)**	**.018**	**0.36 (0.20-0.67)**	**.001**	0.79 (0.56-1.13)	.205	1.13 (0.68-1.85)	.643
Bed sharing[h]	0.82 (0.54-1.22)	.327	0.81 (0.50-1.31)	.383	0.78 (0.55-1.10)	.156	1.00 (0.61-1.65)	.989
Type of school[i]								.095
Private	**0.55 (0.31-0.97)**	**.040**	1.10 (0.57-2.12)	.782	0.94 (0.57-1.57)	.825	1.85 (0.90-3.82)	
Class in school[j]								.463
Senior	1.07 (0.62-1.87)	.805	0.70 (0.37-1.30)	.254	1.24 (0.81-1.90)	.322	0.78 (0.41-1.50)	
School start time (decimal time in hours)[k]	1.30 (0.55-3.08)	.556	0.57 (0.23-1.43)	.230	0.88 (0.43-1.83)	.748	0.54 (0.19-1.53)	.246
School end time (decimal time in hours)[l]	**1.29 (1.02-1.62)**	**.031**	**1.37 (1.03-1.83)**	**.032**	1.17 (0.97-1.41)	.097	0.99 (0.74-1.31)	.924
Commuting time (min)[m]	1.01 (0.99-1.02)	.170	1.00 (0.98-1.01)	.669	1.01 (0.99-1.02)	.174	1.01 (0.99-1.02)	.255

Reference categories: a: rural; b: males; c: early adolescence; d: social class: upper – missing social class for n = 8; e: Yoruba; f: monogamous; g: no parental setting of bedtime; h: no bed sharing; i: public; j: junior; k and l: the odds ratios show the odds of having the outcome for each later hour in the school start/school end times; m: the odds ratio shows the odds of having the outcome each incremental minute in commuting time. Results (odds ratios and p values) in **bold** indicate a significant association between the independent variable and the sleep outcome variable tested.

higher odds of daytime sleepiness relative to those in the upper class. The odds of reporting poor sleep quality increased almost 3-fold in adolescents from single-parent families compared to adolescents from monogamous family settings. Adolescents from families where the parents were separated or from single-parent families had higher odds of having risk of sleep apnea than adolescents from monogamous family settings. Furthermore, parental setting of bedtimes for adolescents was associated with lower odds of reporting poor sleep quality and excessive daytime sleepiness. Finally, every later hour in the school end (closing) time, was associated with about 1-fold increase in the odds of having poor sleep quality and excessive daytime sleepiness while school start times and commuting time were not associated with any sleep outcome.

Discussion

This study aimed to compare the sleep health of in-school adolescents in rural and urban communities within the Osun East Senatorial District, southwestern Nigeria using validated sleep questionnaires. About 15% of respondents reported poor sleep quality. The overall mean sleep duration was short (7 hours) for the general population of the participants. The odds of having poor sleep quality and excessive daytime sleepiness increased almost 2-fold among urban-dwelling adolescents compared to rural-dwelling students. Also, we found a shorter mean sleep duration, time in bed and later bedtimes among urban adolescents compared to rural adolescents.

The shorter sleep duration among urban-dwelling adolescents found in this study may be due to their later bedtime as they had similar wake times as the rural adolescents. Earlier studies have reported similar findings of a short sleep duration[6,7] and poor sleep quality[5] among urban-dwelling Nigerian adolescents. This may be due to some sleep stealers that reduce the sleep opportunities of urban-dwelling adolescents. Technology use at bedtime, artificial light exposure, environmental noise, school-related demands, and family dynamics were the major determinants of sleep health problems reported earlier in urban settings.[22,24,28] The active late-night life in urban communities is often enhanced by the availability of electricity and the increased access to artificial light at night. Artificial light in turn may chronically cause circadian phase delays in urban-dwelling adolescents, contributing to their later bedtimes. Also, adolescents in urban communities are more likely to stay up late at night watching TV or chatting at night on social media due to access to electricity.[7] The higher odds of poor sleep quality and excessive daytime sleepiness among the adolescents whose schools close late supports the contribution of school end time to adolescents' sleep health found in urban-dwelling adolescents in Ile-Ife.[44] However, the later school end time we found among the rural adolescents (who overall showed better sleep quality) shows that school end time alone does not explain the higher prevalence of poor sleep quality among urban vs. rural adolescents.

We found no association between school start times and sleep health outcomes. School start times did not differ in the urban vs. rural settings, nor did they vary substantially from one school to another (standard deviation = 0:12 hour). Conversely, school end times were more varied (standard deviation = 1:06 hours). The lack of variability in school start times in our sample may have precluded us from finding an effect of school start times on overall sleep health outcomes. Nevertheless, our findings suggest that at identical early school start times, later school end times may also be associated with poorer sleep health.

Sleep health of rural-dwelling adolescents has been reported to be adversely affected by poverty, poor amenities, poor access to health and adverse mental health.[25,27,29] However, the effect of these factors on the sleep of rural adolescents may not be as severe as the factors that limit the sleep of urban-dwelling adolescents. The higher odds of excessive daytime sleepiness among urban adolescents is probably a direct result of their poor sleep quality and lower sleep duration. Previously we showed that the pressure of schoolwork and extracurricular activities, was associated with a lower

sleep opportunity of adolescents and lead to a worsened delay in bedtime.[7] The urban adolescents had shorter sleep duration compared to their rural counterparts. Therefore, the higher daytime sleepiness in urban adolescents is probably secondary to both poor sleep quality and short sleep duration. Parental setting of bedtimes was associated with lower odds of both poor sleep quality and excessive daytime sleepiness, possibly by mitigating the phase delay in bedtimes and allowing for longer time in bed.

The higher prevalence of risk of sleep apnea in the urban-dwelling adolescents in our study supports the multiple dimensions of sleep health disparities in adolescents. In addition, adolescents living in single-parent family settings had higher odds of poor sleep quality and risk of sleep apnea. These findings may be driven by lifestyle differences.[45,46] Hence, there is a need to further study the contributory factors to the overall sleep health of adolescents in urban and rural communities. There may be lessons to learn from rural-dwelling adolescents that can improve the sleep of their urban-dwelling counterparts.

The few comparative studies of urban vs. rural-dwelling adolescents have been focused on sleep duration. Boraita et al[47] found a higher sleep duration and better quality of life among adolescents in rural populations when compared to their urban-dwelling counterparts in Spain.

In another study, among adolescents aged 12-15 years, daytime somnolence and disorders of initiating and maintaining sleep were more prevalent in the urban compared to the suburban population.[48] Pereira et al[49] in a study of the sleep duration of rural adolescents in southern Brazil (Paraná) and its determinants concluded that "not all adolescents are sleep-deprived" because the rural adolescents had sufficient mean sleep duration of 9.6 hours on weekdays and 10.1 hours on weekends; however, they did not compare them with urban adolescents. In two Brazilian studies, urban dwellers had significantly later bedtimes and waketimes than rural-dwelling adolescents.[30,50] Within the rural population, adolescents with access to electricity and television had shorter sleep duration than their peers without such facilities.[28] Our findings suggest that rural adolescents in Nigeria may be experiencing some sleep enablers that are worth studying.

The higher odds of poor sleep quality among the female adolescents in our study are in accordance with other studies showing lower sleep quality in female vs. male adolescents.[43] Adolescents from the lower and middle classes had lower odds of poor sleep quality, short sleep duration but higher odds of excessive daytime sleepiness than those from the upper class. The higher number of rural-dwelling adolescents in the low and middle social class category may be contributory to this observation. However, the higher odds of daytime sleepiness in the same category require further studies. In one of our earlier studies among urban adolescents in Ile-Ife, we found low social class to be associated with short sleep duration.[7] The protective effect of low and middle social class in the present study may be more among the rural-dwelling adolescents who have other factors that enhance their sleep, possibly offsetting the adverse effects of low social class. These findings suggest the need to further study the factors predictive of the sleep health of adolescents.

Limitations

Our study has a few limitations: first, the sleep health characteristics of the adolescents were assessed with the use of self-report questionnaires, which can be subject to recall bias and social desirability bias. This limitation may have been mitigated by our use of multiple instruments, which have been previously validated. Secondly, we could not use an objective measure of the adolescents' sleep such as polysomnography due to its capital-intensive nature. However, the use of actigraphs and sleep diaries can be explored in our population where polysomnography is presently unavailable. Furthermore, the cross-sectional design of our study does not allow for cause-and-effect evaluations.

Strengths of the study

This present study has the following strengths: first, to the best of our knowledge this is the first study comparing the multi-dimensions of sleep health variables among rural and urban-dwelling adolescents in Africa. Secondly, we had a large sample size of adolescents in rural vs. urban communities. Thirdly, it employed the use of multiple instruments to measure the dimensions of sleep health, rather than the use of single measures such as sleep duration only.

Conclusions

This study showed that rural-dwelling adolescents living in Southwestern Nigeria have better sleep health than urban-dwelling adolescents. Further investigation of the risk and protective factors that affect the sleep health of adolescents in rural and urban communities can help guide the development of effective sleep health interventions. Therefore, we recommend further studies to better understand the sleep health of rural and urban–dwelling adolescents and the sleep health of out-of-school adolescents, including those living in slums. Qualitative surveys will be of help in exploring the perception of adolescents about their sleep and the consequences of their sleep health.

Dr. Czeisler's contributions to this work

Dr. Czeisler's research on the effects of circadian misalignment on sleep quality[51] and in turn on cognitive performance and health[52] has inspired us to investigate circadian and sleep health in African adolescents. Specifically, Dr. Czeisler showed that human circadian rhythms were entrained to the 24-hour Earth light-dark cycle by light.[53] With the rapid growth of urbanization[54] and concomitant higher access to artificial lighting and smartphones in Africa, the effects of light at night on adolescent circadian rhythms and sleep quality are of particular concern. As predicted from Dr. Czeisler's circadian and sleep research, our study shows that adolescents living in an urban area in Nigeria have lower sleep duration, worse sleep quality and later bedtimes than adolescents living in rural areas, where access to artificial lighting/smartphone technology is more limited. In addition, Dr. Scheuermaier is also grateful to Dr. Czeisler for his support through the T32 HL07901 training grant, allowing her to complete her postdoctoral fellowship in sleep and circadian rhythms and start investigating sleep and health in Africa.

Public health relevance

We are documenting here for the first time the lower sleep duration and poorer sleep quality in urban compared to rural-dwelling adolescents in Nigeria. Those findings may help devise public policies to improve adolescent sleep, not only in Africa but also in the rest of the world, as we draw lessons from the sleep-enabling culture in the rural areas of Africa.

Author contributions

OEO, KS, AOF, and FXGO designed the study. OEO received funding from CARTA to help run the study. OEO supervised data collection and performed statistical analyses. All authors contributed to the write-up of the manuscript and have approved the final version of this manuscript.

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Declaration of conflicts of interest

There is no conflict of interest to report in this project.

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