Unrecognized Respiratory Morbidity among Adolescents and Young Adults in Nigeria: Implications for Future Health Outcomes

Obianuju B. Ozoh[1,2], Joy N. Eze[3], Olufunke O. Adeyeye[4], Ojiebun Eromosele[2], Sandra K. Dede[2], Chizalu I. Ndukwu[5], Richard Van Zyl-Smit[6]

[1]Department of Medicine, College of Medicine, University of Lagos, Lagos, Nigeria, [2]Department of Medicine, Lagos University Teaching Hospital, Idi-Araba, Lagos, Nigeria, [3]Department of Pediatrics, College of Medicine, University of Nigeria/University of Nigeria Teaching Hospital, Ituku Ozalla, Enugu, Nigeria, [4]Department of Medicine, Lagos State University College of Medicine and the Lagos State University Teaching Hospital, Lagos, Nigeria, [5]Department of Paediatrics, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria, [6]Department of Medicine, Division of Pulmonology, University of Cape Town and Groote Schuur Hospital, Cape Town, South Africa

Abstract

Background: Lung function impairment is a major determinant of morbidity and mortality. Unrecognized respiratory morbidity may be a missed opportunity to improve future health outcomes. **Aim:** The aim of this study was to investigate the prevalence of respiratory symptoms and the relationship to spirometry abnormalities and respiratory diagnosis among medical students in Lagos, Nigeria. **Methods:** This was a cross-sectional study among students aged 16–35 years. We assessed frequency of respiratory symptoms, previous respiratory diagnosis, and spirometry abnormalities. The relationship between respiratory symptoms, spirometry pattern, and previous respiratory diagnosis was determined using the Chi-square test and stepwise forward logistic regression analysis. **Results:** Of 640 participants, 464 (72.5%) performed good quality spirometry tests. Two hundred and forty-four (52.6%) had at least one respiratory symptom. Preexisting conditions were only identified in 60 (12.9%): 49 (7.7%) asthma, 29 (4.5%) allergic rhinitis, 16 (2.5%) treated tuberculosis, and 8 (1.3%) bronchitis/chronic obstructive pulmonary disease. Using the Global Lung Function Initiative (GLI) lung function predicted values, obstructive (8.4%) and restrictive abnormalities (25.4%) were common. An obstructive pattern was associated with previous diagnosis of asthma, but there was no significant association for the restrictive spirometry pattern. **Conclusions:** Among otherwise healthy students, respiratory symptoms and lung function abnormalities are common. The vast majority are without a formal diagnosis. Asthma accounted for the majority of obstructive spirometry pattern seen, but the restrictive abnormalities based on GLI equations remain unexplained. Further research is required to determine the cause of these abnormalities and long-term implications in apparently healthy young individuals.

Keywords: Adolescents, Nigeria, respiratory diagnosis, respiratory symptoms, spirometry abnormalities, young adult

Introduction

The burden of respiratory impairment among adolescents and young adults in low-middle-income settings of Africa has not been extensively evaluated. Impairment in lung function (reduced forced expiratory volume in 1 s [FEV_1] and forced vital capacity [FVC]) is a major determinant of future multimorbidity including cardiopulmonary disease, metabolic disease, dementia, mild cognitive impairment, and all-cause mortality.[1-5] Lung function in early adulthood also predisposes to future morbidity and mortality, and underrecognition at a young age may be a missed opportunity for early interventions to improve outcome.[6]

Lung volumes increase with age from infancy to early adulthood. The peak lung function reached provides the starting point for the age-related decline seen in adults. Consequently, lung function abnormalities in older adults may

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Address for correspondence: Dr. Joy N. Eze, Department of Pediatrics, College of Medicine, University of Nigeria/ University of Nigeria Teaching Hospital, Ituku Ozalla, Enugu 400001, Nigeria. E-mail: joy.eze@unn.edu.ng

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be the result of pathological accelerated lung function decline and/or failure to reach the expected peak volume during the first two decades of life. Reduced lung function in adolescents and young adults therefore may be as a result of suboptimal lung growth due to prenatal, early childhood, and adolescent life influences such as nutritional deficiencies, low birth weight, prematurity, exposure to air pollution, infections, low socioeconomic status, poverty, and genetic factors.[7-10] Many of these risk factors are more prevalent in sub-Saharan Africa and may contribute to the increased burden of respiratory morbidity reported in this region.[11]

Population-based studies in some regions of sub-Saharan Africa among older adults have demonstrated a high burden of respiratory symptoms and high prevalence of restrictive spirometry impairment (RSI).[12-14] In adulthood, few interventions are able to improve lung function and earlier identification may provide an opportunity to intervene during active lung growth.

The aim of this study was to describe the burden of unrecognized respiratory morbidity among otherwise healthy adolescents and young adults attending a medical school in Lagos, Nigeria. Understanding the burden of respiratory morbidity in this age group will provide important insight into unrecognized respiratory disease in young people and serve as an opportunity to inform policy to improve the respiratory health of adolescents and young adults in a developing country.

Methods

We conducted a cross-sectional survey among adolescents and young adults attending a College of Medicine. All 1822 students of the College of Medicine were eligible and invited to participate. This comprised students in the faculties of clinical sciences, dental sciences, and basic medical sciences. We included consenting students 16–35 years old and excluded those with specific contraindications to spirometry such as recent surgery, active respiratory infection including tuberculosis, pregnancy, or an uncontrolled medical condition.

Questionnaire administration

The participants self-completed a questionnaire to obtain sociodemographic data and information on respiratory symptoms and previous respiratory diagnosis. We used the Modified Medical Research Council (MMRC) questionnaire on respiratory symptoms to assess respiratory symptoms, and a previous physician diagnosed respiratory conditions of interest (asthma, chronic bronchitis/chronic obstructive pulmonary disease (COPD), hay fever, and previous tuberculosis). The MMRC questionnaire on respiratory symptoms is a 17-item questionnaire that assesses respiratory symptoms (cough, phlegm, breathlessness, and wheeze) and smoking history (ever smoker was defined as having smoked at least one stick of cigarette daily for 1 year or up to 100 sticks of cigarette in the lifetime). It reliably relates symptoms and lung function and has been used to study respiratory epidemiology for several decades.[15] The questionnaire did not require translation as all university students in Nigeria are fluent in English.

We categorized the symptoms on the MRC questionnaire into:

- "Shortness of breath (SOB):" Breathlessness hurrying on level ground or a slight hill (with increasing severity based on additional symptoms such as getting short of breath when walking with other people of the same age or if has to stop for breath when walking at own pace)
- "Exercise-induced symptoms:" Cough, wheeze, or chest tightness when running or climbing steps fast
- "Sleep-related symptoms:" Sleep broken or early awakening from wheeze or difficulty in breathing
- "Trigger-related symptoms:" Wheeze triggered by a dusty or smoky environment
- "Cough:" Recurrent morning, daytime, or night cough during cold weather (with increased severity if it occurred on most days for as long as 3 months each year)
- "Phlegm:" Recurrent morning, daytime, or nighttime sputum production during cold weather (with increased severity if it occurred on most days for as long as 3 months each year)
- "Any respiratory symptom:" The presence of any of the above respiratory symptoms.

We also categorized those with any previous diagnosis of asthma, bronchitis/COPD, allergic rhinitis or tuberculosis as "any respiratory diagnosis" and measured oxygen saturation (SPO_2) using the Econet® pulse oximeter from the middle finger, after 1 min of recording.

Spirometry testing

The Vitalograph® Spirotrac V Pneumotrac spirometer was used to perform spirometry according to the American Thoracic Society/European Respiratory Society (ATS/ERS) standards for measurement of spirometry.[16] All test results were individually checked and independently verified for quality. Acceptable prebronchodilator tests were included for analysis and the FEV_1, FVC, and FEV_1/FVC ratio categorized into the following ventilatory patterns:

- Obstructive impairment: FEV_1/FVC <the lower limit of normal (LLN) with FVC ≥LLN
- RSI: FVC <LLN with FEV_1/FVC ≥LLN
- Mixed (obstructive and restrictive): FEV_1/FVC <LLN with FVC <LLN
- Normal: FEV_1/FVC ≥LLN with FVC ≥LLN.

The presence of any of the abnormal patterns was considered as "abnormal spirometry."

We utilized the Global Lung Function Initiative (GLI) reference equation for "others" to determine spirometry pattern[17] and categorized the severity of impairment for the FEV1 and FVC, respectively, using the z-scores as proposed by Quanjer *et al*.[18] as follows:

- Mild: z-score ≥−2
- Moderate: −2.5 less than or equal z-score <−2
- Moderately severe: −3 less than or equal z-score <−2.5

- Severe: −4 less than or equal z-score <−3
- Very severe: z-score <−4.

To further evaluate the presence of lung function abnormalities and the impact of choice of reference equation on the frequency, the ERS/Polgar reference equation with 13% correction for Africans[19] and the newly developed local reference equation from a Nigerian population,[20] respectively, were also applied.

Data analysis

We described characteristics of the population using data for all students who completed the questionnaire but only included the data for those with adequate spirometry tests for the description of ventilatory function and other analyses. A comparison of the frequency of respiratory symptoms and previous respiratory diagnosis among those with adequate spirometry and those without was performed using the Chi-square test and Student's *t*-test.

We used descriptive statistics to report the participant characteristics and explored the relationship between respiratory symptoms, spirometry pattern, and previous respiratory diagnosis, respectively, using the Chi-square test. Independent determinants of respiratory symptoms and abnormal spirometry pattern were assessed using stepwise forward logistic regression analysis. For the multiple regression models, we included only variables with $P < 0.02$ in bivariate analysis. Age and sex were included as prior variables in the model for the spirometry patterns. A two-sided $P < 0.05$ was considered significant for all associations.

We obtained ethical approval from the Health Research Ethics Committee of the Lagos University Teaching Hospital (approval number: ADM/DCST/HREC/APP/2162; dated June 27, 2016) and written informed consent from each participant.

Results

A total of 640 of the 1822 eligible students participated in the study, giving a participation rate of 35.1%. Of the students that participated, 464/640 (72.5%) performed good quality spirometry tests. The age of participants ranged from 16 years to 35 years and 2.7% were current tobacco smokers. All participants had normal SPO_2 (≥ 95%) and 74% had normal body mass index (BMI) (18.5–24.9 kg/m^2). Participants with good quality spirometry had higher mean SPO_2 compared to those with poor quality spirometry [Table 1].

Respiratory symptoms

Two hundred and forty-four (52.6%) had "any respiratory symptom." The frequencies of reported symptoms (in descending order of frequency) were as follows: "trigger-related symptoms" 159 (24.8%), "exercise-induced symptoms" 158 (24.7%), "SOB" 124 (24.1%), "cough" 118 (18.4%), "phlegm" 106 (16.6%), and "sleep-related symptoms" 90 (14.1%), respectively.

Thirty-four (5.3%) experienced cough and 50 (7.8%) wheeze on moderate exercise such as climbing stairs, 13 (2.0%) had a combination of cough, wheeze, and chest tightness, 57 (8.9%) had sleep broken by difficulty in breathing, and 140 (21.9%) experienced wheeze on exposure to dust. Eleven (1.7%) were incapacitated by SOB and had to stop when walking at own pace on level ground. One hundred and eight (16.9%) reported cough and 86 (13.4%) reported phlegm during the day or night

Table 1: Sociodemographic characteristics of participants with and without good spirometry

Characteristic	All participants (*n*=640)	Participants with good quality spirometry (*n*=464)	Participants without good quality spirometry (*n*=176)	*P*
Mean age±SD	21.7±2.9	21.5±3.0	22.0±2.4	0.04*
Age group				
16-19	132 (20.6)	114 (24.6)	18 (10.2)	<0.001*
20-24	428 (66.9)	289 (62.3)	139 (79.0)	
25-29	66 (10.3)	49 (10.6)	17 (9.7)	
30-35	14 (2.2)	12 (2.6)	2 (1.1)	
Sex				
Female	338 (52.8)	246 (53.0)	92 (52.3)	0.87
Male	302 (47.2)	218 (47.0)	84 (47.7)	
Height	1.69±0.08	17.0±0.08	1.69±0.09	0.67
BMI in kg/m$^{2\#}$				
Underweight (<18.5)	36 (5.6)	23 (5.0)	13 (7.4)	0.36
Normal (≥18.5 and <25)	473 (74.0)	339 (73.2)	134 (76.1)	
Overweight (25-29.9)	102 (16.0)	81 (17.5)	21 (11.9)	
Obesity class 1 (30-35)	23 (3.6)	17 (3.7)	6 (3.4)	
Obesity class 2 (>35)	5 (0.8)	3 (0.6)	2 (1.1)	
SPO_2	98.0±0.7	98.0±0.7	97.8±0.8	0.003*
Years of schooling	15.4±2.2	15.4±2.3	15.3±2.0	0.74
Current tobacco smoking	17 (2.7)	14 (3.0)	3 (1.7)	0.36

#One female missing among participants with good quality spirometry, *P* value for comparison between those with good quality spirometry and those without, *Significant difference. SPO_2 – Oxygen saturation; SD – Standard deviation in cold weather. Twenty-two (3.4%) and 34 (5.3%) had cough and phlegm respectively that lasted up to 3 months/year. There was no difference in the frequency of respiratory symptoms between those with good quality spirometry and those with poor quality spirometry [$P = 0.59$; Supplementary Table 1], suggesting that inability to perform spirometry was likely due to technical errors.

Figure 1 and Supplementary Table 2 show the frequency of respiratory symptoms across age groups among participants with good quality spirometry for males and females, respectively.

Previous respiratory diagnosis

Preexisting respiratory conditions were diagnosed in 60 (12.9%) of the participants: 49 (7.7%) had a history of asthma, 29 (4.5%) allergic rhinitis, 16 (2.5%) treated tuberculosis, and 8 (1.3%) bronchitis/COPD. The frequency of respiratory diagnosis did not also differ between those with good quality spirometry and those with poor quality spirometry (data not shown).

Spirometry pattern and severity of impairment

For participants with acceptable spirometry, the frequency of obstructive impairment was 8.4% (10.6% in females and

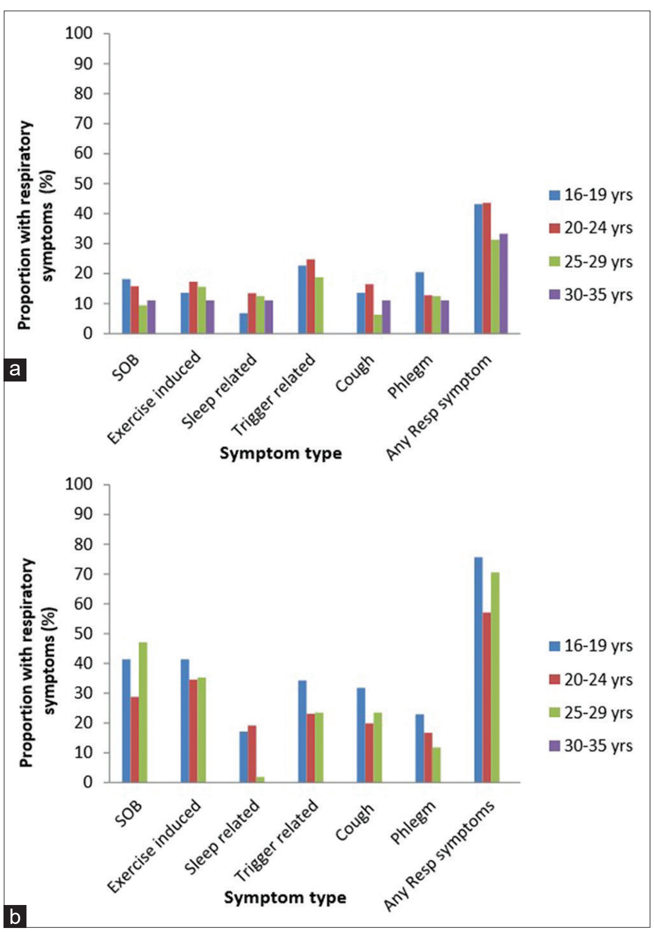

Figure 1: (a) Frequency of respiratory symptoms across age groups in males. (b) Frequency of respiratory symptoms across age groups in females

Table 2: Frequency of abnormal spirometry pattern among participants by age group and body mass index categories

Variable	Categories	Obstructive impairment (%)						Restrictive spirometry impairment (%)						Mixed spirometry impairment (%)					
		GLI equation		ERS/Polgar		Local equation		GLI equation		ERS/Polgar		Local equation		GLI equation		ERS/Polgar		Local equation	
		Sex																	
		Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
Age	16-19	8 (11.4)	4 (9.1)	3 (4.3)	1 (2.3)	1 (1.4)	4 (9.1)	19 (27.1)	16 (36.4)	9 (12.9)	6 (13.6)	6 (8.6)	3 (6.8)	-	1 (2.3)	-	-	-	-
	20-24	18 (11.5)	8 (6.0)	4 (2.6)	4 (3.0)	7 (4.5)	12 (9.0)	34 (20.5)	36 (27.1)	9 (5.8)	4 (3.0)	1 (0.6)	1 (0.8)	2 (1.3)	4 (3.0)	-	1 (0.8)	-	-
	25-29	-	1 (7.7)	-	2 (6.3)	-	3 (9.4)	7 (41.2)	7 (21.9)	3 (17.6)	-	-	-		2 (6.3)	-	-	-	-
	30-35	-	-	-	-	-	-	-	1 (11.1)	-	-		-		-	-	-	-	-
BMI*	<18.5	-	1 (16.7)	-	-	-	1 (16.7)	-	3 (50.0)	3 (17.6)	2 (33.3)	-	1 (16.7)	-	-	-	-	-	-
	18.5-24.9	14 (8.3)	9 (5.2)	4 (2.4)	3 (1.7)	6 (3.6)	13 (7.5)	6 (35.3)	52 (29.9)	16 (9.5)	8 (4.6)	3 (1.8)	3 (1.7)	2 (1.2)	5 (2.9)	-	1 (0.6)	-	-
	25-29.9	9 (19.1)	3 (10.0)	3 (6.4)	4 (13.3)	-	5 (16.7)	47 (27.8)	4 (13.3)	1 (2.1)	-	4 (8.5)	-	-	2 (6.7)	-	-	-	-
	30-34.9	2 (22.2)	-	-	-	1 (11.1)	-	4 (8.5)	1 (12.5)	1 (11.1)	-	-	-	-	-	-	-	-	-
	>35	-	-	-	-	-	-	1 (11.1)	-	-	-	-	-	-	-	-	-	-	-

*One female participant with missing BMI has obstructive pattern on the GLI and local equations, respectively, and normal pattern on the ERS/Polgar. BMI – Body mass index; ERS – European Respiratory Society; GLI – Global Lung Function Initiative

6.0% in males), using the GLI equation. If the ERS/Polgar equations were applied, the prevalence was 3.0% (2.8% in females and 3.2% in males), and using the local equation, it was 5.8% (3.3% in females and 8.7% in males). The frequency of RSI was 25.4% (23.6% in females and 27.5% in males) using the GLI equation, 6.7% (8.5% in females and 4.6% in males) using the ERS/Polgar, and 2.4% (2.8% in females and 1.8% in males) using local equation, respectively. There was a statistically significant difference in the distribution of spirometry pattern between the GLI equation and the ERS/Polgar equation, between the GLI equation and the local equation, and between the ERS/Polgar equation and the local equation, respectively ($P < 0.001$ in all instances). Table 2 shows the frequency of abnormal spirometry pattern among participants by age group and BMI categories.

Based on the FEV1 z-score, 13 (2.8%), 52 (11.2%), 15 (3.2%), and 13 (2.8%) of all 464 participants had mild, moderate, moderately severe, and severe impairment, respectively.

When based on the FVC z-score, 15 (3.2%), 46 (9.9%), 17, (3.7%), 6 (1.3%), and 2 (0.4%) had mild, moderate, moderately severe, severe, and very severe impairment, respectively.

Relationship between abnormal spirometry, respiratory symptoms, and previous respiratory diagnosis

The mixed spirometry pattern was merged into the RSI and the obstructive impairment, respectively, due to the limited number of persons with mixed impairment. There was no significant association between "abnormal spirometry" and "any respiratory symptom" ($P = 0.60$) nor between "abnormal spirometry" and "any respiratory diagnosis" ($P = 0.09$). There was a significant association between "any respiratory diagnosis" and "any respiratory symptom" ($P < 0.001$).

Females with sleep-related symptoms had a significantly higher proportion of obstructive pattern compared to the proportion with RSI and normal patterns, respectively ($P = 0.02$). Figure 2 and Table 3 show the relationships between respiratory symptoms, respiratory diagnosis, and abnormal spirometry, respectively. There was a significant association between obstructive pattern compared to RSI or normal pattern among those with a diagnosis of asthma in both females and males ($P = 0.02$ for females and $P = 0.03$ for males).

Factors associated with respiratory symptoms

The factors associated with respiratory symptoms for participants with good quality spirometry only were evaluated. In multivariate analysis, females were 2.71 (95% confidence interval [CI]: 1.71–4.30), 2.82 (95% CI: 1.79–2.47, and 1.82 (95% CI: 1.12–2.95) times more likely to have SOB, "exercise-induced symptoms," and "cough," respectively, compared to males [Table 4]. There were no independent determinants for "sleep-related symptoms," "trigger-related symptoms," "phlegm," and current smoking. There was an increased risk of "any respiratory symptom" among those 16–19 years old and females, respectively.

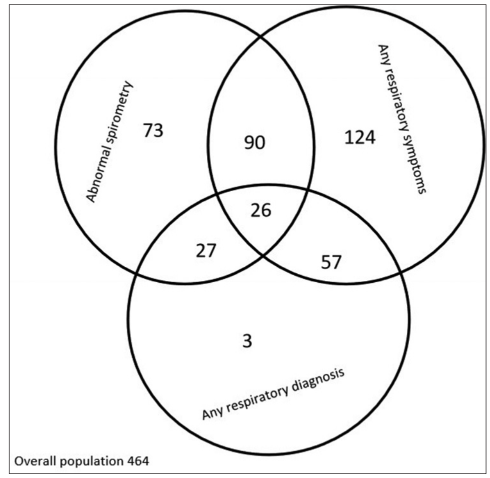

Figure 2: Relationship between abnormal spirometry, respiratory symptoms, and previous respiratory diagnosis. $P = 0.60$, $P = 0.11$, and $P < 0.001$ for relationship between abnormal spirometry and any respiratory symptom, abnormal spirometry and any respiratory diagnosis, and any respiratory symptom and any respiratory diagnosis, respectively

Factors associated with restrictive and obstructive spirometry impairment

The factors associated with restrictive and obstructive spirometry impairment based on the GLI equation were evaluated. Age, sex, BMI, or smoking status was not associated with either restrictive or obstructive impairment in both bivariate and multivariate analyses.

Discussion

We found a high burden of respiratory symptoms and low rates of respiratory diagnosis in a "healthy" student population. Over half of the students reported at least one chronic respiratory symptom, and only 5.6% with both respiratory symptoms and abnormal spirometry had a respiratory diagnosis. The frequency of abnormal spirometry pattern was high, mostly RSI, but also a substantial burden of obstructive impairment. While the obstructive impairment was recognized by a previous diagnosis of asthma and "sleep-related symptoms," respectively, the RSI has no significant associations and therefore was mostly unrecognized.

This study evaluating respiratory symptoms, abnormal spirometry, and previous respiratory diagnosis among medical students is unique in many ways. First, we assessed the burden of disease in a young and potentially privileged group (likely of the middle-upper socioeconomic class) with relatively good access to health-care services. Second, we explored the relationship between respiratory morbidity and respiratory diagnosis to assess gaps and unmet needs in respiratory care delivery for this age group, and third, we used different reference equations to determine spirometry patterns.

The use of three reference equations in this study clearly demonstrates the disparity in the burden of respiratory morbidity based on choice of reference equation. There was a significant

Table 3: Relationship between abnormal spirometry pattern, respiratory symptoms, and respiratory diagnosis

Variable	Abnormal spirometry pattern					
	Females			Males		
	RSI (*n*=60), *n* (%)	Obstructive (*n*=26), *n* (%)	*P*	RSI (*n*=67), *n* (%)	Obstructive (*n*=13), *n* (%)	*P*
Respiratory symptoms						
SOB	19 (31.7)	8 (30.8)	0.89	9 (13.4)	2 (15.4)	0.90
Exercise-induced symptoms	21 (35.0)	11 (42.3)	0.79	14 (20.9)	2 (15.4)	0.43
Sleep-related symptom	6 (10.0)	9 (34.6)	0.02	9 (13.4)	1 (7.7)	0.83
Trigger-related symptom	22 (36.7)	7 (26.9)	0.08	19 (28.4)	4 (30.8)	0.24
Cough	13 (21.7)	8 (30.8)	0.62	7 (10.4)	1 (7.7)	
Phlegm	9 (15.0)	6 (23.1)	0.66	12 (17.9)	2 (15.4)	0.58
Any respiratory symptom	37 (61.7)	18 (69.2)	0.76	30 (44.8)	5 (38.5)	0.78
Previous diagnosis						
Ever had asthma	3 (5.0)	5 (19.2)	0.02	8 (11.9)	4 (30.8)	0.03
Ever had bronchitis/COPD	-	1 (3.8)	0.33	3 (4.5)	-	0.34
Ever had allergic rhinitis	3 (5.0)	1 (3.8)		3 (4.5)	1 (7.7)	0.10
Previous tuberculosis treatment	3 (5.0)	-	1.19	-	-	0.31

SOB – Shortness of breath; COPD – Chronic obstructive pulmonary disease; RSI – Respiratory spirometry impairment

Table 4: Multivariate regression analysis for determinants of respiratory symptoms

Variable	OR (95% CI)						
	Any SOB	Exercise induced	Sleep related	Trigger related	Cough	Sputum production	Any respiratory symptom
Age group							
16-19	3.83 (0.46-31.58)	3.96 (0.47-33.75)	-	-	-	-	4.02 (1.01-16.02)
20-24	2.48 (0.31-20.05)	3.42 (0.41-28.41)	-	-	-	-	2.53 (0.66-9.74)
25-29	2.96 (0.34-26.13)	3.46 (0.38-31.46)	-	-	-	-	2.32 (0.55-9.81)
30-35	Reference	Reference	-	-	-	-	
Female sex	2.71 (1.71-4.30)	2.82 (1.79-2.47)	-	-	1.82 (1.12-2.95)	-	2.25 (1.54-3.29)
BMI				-	-	-	
Underweight	-	0.17 (0.01-2.29)	-	-	-	-	
Normal weight	-	0.25 (0.02-2.77)	-	-	-	-	
Overweight	-	0.42 (0.04-4.87)	-	-	-	-	
Obesity class 1	-	0.40 (0.02-5.57)	-	-	-	-	
Obesity class 2	-	Reference	-	-	-	-	

BMI – Body mass index; SOB – Shortness of breath, OR – Odds ratio; CI – Confidence interval

disparity in the burden of spirometry impairment that was more profound for the RSI when any of the three equations was used. This has clinical and epidemiological consequences that make it expedient to use the most appropriate equation under the right circumstance.[21,22] For epidemiological studies, an equation with the most robust and updated statistical method that is generalizable across diverse populations is recommended as it enables comparison across studies and augurs well for public health intervention.[21] The GLI equation meets these criteria and demonstrates the highest frequency of respiratory impairment,[17,23] although this could be overdiagnosing disease based on lung function. However, the proportion with moderate-to-severe impairment (approximately 15% based on either the FEV1 or FVC) raises some concern. The ERS/Polgar equation has limitations regarding the preexisting health of the adult participants used in the development of the equation and approximation of values for females.[23] The local reference equation used simple linear regression models, which may not be robust for the statistical analysis and has a narrow age range.[20] Although locally derived reference equations may appear to be a pragmatic choice particularly in the clinical setting, previous reports suggest that they may not be the most appropriate for epidemiological purposes.[21,22] Shared exposures such as social and environmental factors that impair lung function in the general population may limit the benchmark for normality with adverse health outcomes.[24] The worldwide Burden of Obstructive Lung Disease study which demonstrated that lower FVC was positively associated with country of origin, lower gross national income, and mortality alludes to this.[25] Therefore, for epidemiological studies, the use of an equation with the highest benchmark for defining normality such as the GLI may be advocated because it facilitates early detection of impairments and guides public health interventions.[21]

The high burden of RSI in this present study is consistent but higher than in previous population-based studies in Nigeria[14] and Malawi[13] among older adults. This trend may indicate a survival benefit among those with higher lung function and warrants further evaluation.[6] At variance with previous studies,[13,14] we did not find a significant association between spirometry impairment and age, sex, BMI, or tobacco smoking, respectively, which may be related to the younger age, relatively uniform socioeconomic status, and normal BMI among our participants. The frequency of tobacco smoking in our study was low, consistent with previous reports[26] in this university, and may have had minimal effect. The consequences of these social and environmental factors on lung growth are important areas for future longitudinal research in Africa.

The rate of diagnosed asthma among these students (7.2%) is much higher than in the general population in Lagos (2.3%).[27] Schooling on a university hospital campus infers good access to high-quality medical care which is likely to promote health-seeking behavior and disease diagnosis among this group compared to the general population. Furthermore, most participants with obstructive impairment had a previous physician diagnosis of asthma, suggesting substantial clinical recognition of obstructive impairment that provides opportunity for treatment. In contrast, the RSI is surreptitious, usually clinically unrecognized and untreated boding for future adverse health outcomes.[1-5] It is, therefore, reasonable to make a public health priority the implementation of measures such as improvement in social and environmental factors for the primordial prevention of suboptimal lung growth to reduce RSI. Routine screening for early detection may also be a cost-effective approach as it may provide opportunity for early treatment. For example, leveraging on the already compulsory preadmission health screening for university students may be an opportunity for implementing routine spirometry testing among university students.

The strengths in this study include the rigorous spirometry quality assurance process taken to provide reliable data from a group of young persons from sub-Saharan Africa. The use of three reference equations is an additional strength as it highlights the disparity in burden of disease based on choice of reference equation. Evaluation of the relationship between spirometry impairment, respiratory symptoms, and previous respiratory diagnosis allowed us to recognize potential gaps in respiratory care delivery among these students with relatively good access to health care, which may not be true for the general population.

We acknowledge the voluntary participation of students in this study as a potential limitation because those concerned about suboptimal respiratory health may have chosen to participate. The limited generalizability of our finding to the general population of adolescents and young adults in Nigeria is also recognized. However, information on respiratory health among persons of relatively higher socioeconomic status in Africa is currently lacking, and our findings may be a glimpse of the best-case scenario in our region. Furthermore, self-reported respiratory diagnosis was unverified and the study was not powered to identify risks for spirometry impairment or respiratory symptoms. Therefore, the associations we have reported are only exploratory.

Conclusions

We found a high burden of respiratory symptoms and unrecognized RSI in this "healthy" population of young adults. There was a wide disparity in the burden of spirometry impairment based on choice of reference equation. The three evaluated lung function equations raise significant issues regarding the best choice for abnormality identification (epidemiologically) but not necessarily disease for treatment (clinically). This calls for further research to clearly elucidate and mitigate against recognized risk factors for suboptimal lung growth and to prospectively conceptualize and evaluate potential interventions to improve outcome.

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Conflicts of interest

There are no conflicts of interest.

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Supplementary Table 1: Respiratory symptoms and previous diagnosis among participants with and without spirometry

Variable	All participants (n=640)	Participants with good quality spirometry (n=464)	Participants without good quality spirometry (n=176)	P
Shortness of breath				
Hurrying on level ground or slight hill	154 (24.1)	115 (24.8)	39 (22.2)	0.49
Walking with age mates	28 (4.4)	20 (4.3)	8 (4.5)	0.82
Stop for breath at own pace	11 (1.7)	6 (1.3)	5 (2.8)	0.13
Exercise-induced symptoms*				
Cough	34 (5.3)	24 (5.2)	10 (5.7)	0.80
Wheeze	50 (7.8)	37 (8.0)	13 (7.4)	0.80
Chest tightness	120 (18.8)	93 (20.0)	7 (15.3)	0.17
All three symptoms	13 (2.0)	8 (1.7)	5 (2.8)	0.12
Sleep-related symptoms				
Sleep broken by wheeze	27 (4.2)	21 (4.5)	6 (3.4)	0.53
Sleep broken by difficulty breathing	57 (8.9)	41 (8.8)	16 (9.1)	0.92
Woken by wheeze	27 (4.2)	21 (4.5)	6 (3.4)	0.53
Woken by difficulty breathing	50 (7.8)	33 (7.1)	17 (9.7)	0.28
Trigger-related symptoms				
Wheeze in a smoky room	117 (18.3)	83 (17.9)	34 (19.3)	0.68
Wheeze in a dusty place	140 (21.9)	100 (21.6)	40 (22.7)	0.75
Cough				
Morning cough during cold weather	52 (8.1)	37 (8.0)	15 (8.5)	0.82
Day or night cough during cold weather	108 (16.9)	79 (17.0)	29 (16.5)	0.38
Cough on most days for 3 months/year	22 (3.4)	17 (3.7)	5 (2.8)	0.61
Phlegm				
Morning phlegm during cold weather	61 (9.5)	46 (9.9)	15 (8.5)	0.59
Day or night phlegm during cold weather	86 (13.4)	61 (13.1)	25 (14.2)	0.73
Phlegm on most days for 3 months/year	34 (5.3)	24 (5.2)	10 (5.7)	0.80
Any respiratory symptom	337 (52.7)	244 (52.6)	93 (52.8)	0.95
Number of domains with symptoms				
1	119 (18.6)	18 (17.5)	38 (21.6)	0.59
2	88 (13.8)	65 (14.0)	23 (13.1)	
3	67 (10.5)	47 (10.1)	20 (11.4)	
4	35 (5.5)	30 (6.5)	5 (2.8)	
5	19 (3.0)	14 (3.0)	2 (2.8)	
6	9 (1.4)	7 (1.5)	2 (1.1)	
Ever has bronchitis or COPD	8 (1.3)	8 (1.7)	0	0.08
Ever had asthma	49 (7.7)	39 (8.4)	10 (5.7)	0.25
Ever had allergic rhinitis	29 (4.5)	17 (3.7)	12 (6.8)	0.09
Previously treated for tuberculosis	16 (2.5)	10 (2.2)	6 (3.4)	0.36

COPD – Chronic obstructive pulmonary disease

Supplementary Table 2: Frequency of respiratory symptoms

Age group	SOB	Exercise	Sleep	Trigger	Cough	Phlegm	Any respiratory symptom
Males							
16-19	8 (18.2)	6 (13.6)	3 (6.8)	10 (22.7)	6 (13.6)	9 (20.5)	19 (43.2)
20-24	21 (15.8)	23 (17.3)	18 (13.5)	33 (24.8)	22 (16.5)	17 (12.8)	58 (43.6)
25-29	3 (9.4)	5 (15.6)	4 (12.5)	6 (18.8)	2 (6.3)	4 (12.5)	10 (31.3)
30-35	1 (11.1)	1 (11.1)	1 (11.1)	-	1 (11.1)	1 (11.1)	3 (33.3)
Females							
16-19	29 (41.4)	29 (41.4)	12 (17.1)	24 (34.3)	22 (31.8)	16 (22.9)	53 (75.7)
20-24	45 (28.8)	54 (34.6)	30 (19.2)	36 (23.1)	31 (19.9)	26 (16.7)	89 (57.1)
25-29	8 47.1)	6 (35.3)	1 (1.9)	4 (23.5)	4 (23.5)	2 (11.8)	12 (70.6)
30-35	-	-	-	-	-	-	-

SOB – Shortness of breath