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Influence of self-reported socio-economic status on lung function of adult Nigerians

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Abstract

Objectives Low socio-economic status is known to be associated with reduced lung function in childhood and early adulthood, and an increased risk of cardiovascular disease in older adults. The lung function of people in developing nations is known to be lower than that of their counterparts in developed nations. This study assessed whether childhood socio-economic status is related to lung function in adults in Nigeria.
Design Cross-sectional study.
Setting Ife central local government, Ile-Ife, Nigeria.
Participants One thousand nine hundred and thirty healthy adults aged 40 to 80 years took part in the study. Forced vital capacity (FVC) and forced expiratory volume in 1 second (FEV_1) were measured with a spirometer, and peak expiratory flow (PEF) was measured with a mechanical peak expiratory flow meter. The socio-economic status questionnaire gave equal importance to education, occupation and family income. Based on the score, the subjects were classified as lower, middle or higher status.
Main outcome measures Spirometry, assessment of peak flow meter and questionnaire to assess socio-economic status.
Results The results showed a difference between the group with the highest socio-economic status and the other two groups [mean (standard deviation) FVC: high 3.63 l (0.33), middle 3.57 l (0.41), low 3.38 l (0.35)]. The mean difference between the high and middle socio-economic groups was 0.07 l [95% confidence interval (CI) 0.02 to 0.11]. A similar difference existed for FEV_1: high 3.16 l (0.28), middle 3.06 l (0.31), low 2.94 l (0.34). The mean difference between the high and middle socio-economic groups was 0.11 l (95% CI 0.07 to 0.15). Values for PEF were: high 404.30 l/second (35.98), medium 390.56 l/second (41.53), low 376.03 l/second (45.81). The mean difference between the high and medium socio-economic groups was 13.74 l/second (95% CI 8.42 to 19.06). There was a weak but significant association between socio-economic status and FVC ($r = 0.28$), FEV_1 ($r = 0.26$) and PEF ($r = 0.25$).
Conclusion Self-reported low socio-economic status is associated with lower lung function among adult Nigerians. This may increase their risk for respiratory and cardiovascular disease.

Keywords: Socio-economic status; Lung function; Spirometry; Adult Nigerians

Introduction

Assessment of lung function has gained importance as an index of cardiopulmonary status. Measurement of forced vital capacity (FVC), forced expiratory volume in 1 second (FEV_1) and peak expiratory flow (PEF) is critical in sub-Saharan Africa due to the high prevalence of chronic obstructive pulmonary disease (COPD) and asthma. Spirometry is helpful in detection, differentiation and diagnosis of various respiratory diseases, and also for monitoring disease progression or improvement following therapeutic intervention [1].

Poor lung function in adulthood may reflect early lung exposures which influence lung growth and development as well as the risk of adult disease [2,3]. Some of the early life factors that affect normal lung growth during the uterine period and childhood include maternal smoking, low birth

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weight and prematurity, and infection [4]. All are associated with low socio-economic status.

Impairment of fetal growth has a significant effect on adult lung function [5]. Aside from genetic influences, socio-economic status is one of the main factors influencing birth weight, childhood growth and development [6]. Few studies have reported the relationship between adult lung function and socio-economic status in early life [2–7].

The purpose of this study was to assess the relationship between self-reported childhood socio-economic status and adult lung function. Since the majority of the population in developing nations live in economic hardship, the outcome of the study may help to develop healthcare policy for the citizens.

Methods

Participants

The study sample was selected from an urban area of Ife central local government in Ile-Ife; a city with a population of approximately 200,000. Ile-Ife is believed to be the cradle of the Yorubas, one of the three major ethnic groups in Nigeria. The city is located in the south-west of Nigeria and is approximately 120 km from Lagos, the former capital city. The major occupation is farming, followed by trading. The city has a high concentration of people who are literate because of the presence of institutions such as Obafemi Awolowo University, which includes the major teaching hospital in the south-west of Nigeria. Malaria and tuberculosis are major infectious diseases that are endemic in Ile-Ife.

Nigeria is the largest country in West Africa, with a population of more than 140 million. However, mean life expectancy is only 47 years.

A stratified two-stage cluster sampling technique was adopted for this study. The first stage was a random selection of six of 11 political wards in Ife central local government. The second stage was selection of adults aged 40 years or more from these wards. Each ward was expected to produce at least 350 volunteers. After obtaining the approval of each political leader and traditional rulers in each ward, subjects were asked to report to the study site within their community.

Participants were recruited at the headquarters of each of the six political wards. They were informed about the study during a public enlightenment campaign on the causes of respiratory diseases. Letters were also delivered by hand within the communities chosen for the study.

Those who met the inclusion criteria were recruited for the study.

Potential participants were screened for study eligibility by a pulmonary physician. In total, 1960 adults aged 40 to 80 years without self-reported respiratory problems and who were current non-smokers were recruited. Adults who reported symptoms related to respiratory and cardiac diseases, and those with abdominal and nasal surgery were excluded from the study. None of the subjects had a history of poliomyelitis or any physical disability. Chest x-ray was not considered in this study.

Procedure

The data of 1930 subjects (1110 males, 820 females) are presented for analysis. The purpose of the study was explained to the participants and all signed an informed consent form. The study protocol was approved by the Obafemi Awolowo University Teaching Hospitals Complex Ethics Committee.

Height was measured using a stadiometer (Seca Corporation, Hamburg, Germany), and weight was measured with the subjects wearing light clothing and without shoes.

Lung function tests

The lung function tests (FVC and FEV_1) were carried out with the aid of a wedge-bellows spirometer (Vitalograph S, Buckingham, UK) which was calibrated daily. The quality checks of the instruments followed the manufacturers' specifications. PEF was measured after spirometry with a peak flow meter (Micro Medical, Chatham Maritime, Kent, UK); three measurements were taken and the highest score was recorded.

FEV_1 and FVC were calculated. Spirometry tests were conducted by six technologists who were trained and supervised by a pulmonologist. In order to limit test variability, each ward was assigned one technologist. All the participants were tested by the same technologist in a given ward.

The procedure was demonstrated to the participants and they were given the opportunity to perform several practice efforts. Measurements were made in an upright seated position without nose clips. One-way disposable mouthpieces were used and the inside of the rubber bellows was cleaned regularly with methylated spirit to minimise cross-infection. Three spirometry trials were then performed in accordance with the American Thoracic Society criteria to ensure uniformity. The highest values for FVC and FEV_1 with less than 5% deviation from the other readings were recorded for analysis [8].

Socio-economic status

Each participant was given a questionnaire that classified the respondents into three different socio-economic strata. Previous criteria used to classify Nigerians into different socio-economic groups were based on annual income, level of education and occupation, and this was therefore adopted for this study [9,10]. The participants were divided into three groups: lower, middle and higher socio-economic status.

The questionnaire used by Balogun *et al.* was modified to suit the present Nigerian economy based on inflationary trends and current basic salaries [10]. The questionnaire has been validated and was used in the authors' previous study [11]. The participants were asked to recall their childhood while completing the questionnaire. The questionnaire requested information on the highest educational attainment, landed properties, type of housing estate, number of rooms and persons in the household, and number of household appliances (e.g. musical stereo, gas cooker, refrigerator, etc.). Scores were assigned to all these items. The minimum and maximum scores possible were 1 and 27, respectively. Individuals scoring 1 to 9 were classified as being of low socio-economic status, those scoring between 10 and 18 were categorised as being of middle socio-economic status, and those scoring above 18 were classified as being of high socio-economic status.

The crowding index was also evaluated. This is the ratio of the number of rooms to the number of persons in the house. Less than 0.5 and above 1 were rated 0.5 and 1, respectively. The questionnaire also considered ownership of a car, a house and other household appliances.

Data analysis

Analysis of variance was used to determine whether or not there was a difference in lung function among the participants in the three socio-economic groups. Where significant differences were found, least significant difference post-hoc analysis was performed to determine where these differences lay. The Spearman Rho correlation coefficient was calculated to determine whether there was a linear relationship between socio-economic scores and the variables measuring lung function. The relationship between age and physical characteristics and adult lung function was analysed using a Pearson product moment analysis. Regression analysis was performed to generate equations for predicting lung function. Statistical tests were performed using Statistical Package for the Social Sciences, Version 11.0 (SPSS Inc., Chicago, IL, USA).

Results

The male and female participants were comparable in age but males were significantly taller ($P<0.01$). FEV_1/FVC% showed no significant gender difference.

Table 1
Physical characteristics and lung function of the participants.

Variables	Male ($n=1110$) Mean ± SD	Female ($n=820$) Mean ± SD
Age (years)	49.1 ± 7.8	48.8 ± 6.9
Weight (kg)	67.8 ± 11.6	67.6 ± 8.9
BMI (kg/m^2)	23.3 ± 4.0	23.7 ± 3.2
Height (m)	1.71 ± 0.1	1.69 ± 0.1*
FEV_1 (l)	3.16 ± 0.27	2.84 ± 0.31
FVC (l)	3.66 ± 0.36	3.27 ± 0.29
FEV_1/FVC%	86.4 ± 5.2	86.7 ± 3.3
PEF (l/second)	6.6 ± 0.5	6.2 ± 0.9

BMI, body mass index; FEV_1, forced expiratory volume in 1 second; FVC, forced vital capacity; PEF, peak expiratory flow; SD, standard deviation.
* Significant at $P<0.05$.

Table 2
Age distribution.

Age range (years)	Male	Female
40–44	142	82
45–49	320	280
50–54	306	178
55–59	145	143
60–64	100	102
65–69	58	25
70–74	30	3
75–80	9	7

The physical characteristics of the subjects are presented in Table 1 and the age distribution is shown in Table 2. Subjects in the three groups were comparable in age ($P=0.2$), height ($P=0.4$) and weight ($P=0.9$). One-way analysis of variance showed that there was a significant difference in lung function among the three socio-economic groups: FEV_1 ($F=76$; $P<0.001$), FVC ($F=80$; $P<0.001$); PEF ($F=64$; $P<0.001$). Post-hoc analysis showed that the lower and middle socio-economic groups had significantly lower scores for all the lung function indices compared with the higher socio-economic group. However, no significant difference existed between the lung function of the lower and middle socio-economic groups. Mean differences and 95% confidence intervals are presented in Table 3.

The results show a low positive correlation between self-reported childhood socio-economic status and adult lung function: FEV_1 ($r=0.26$); FVC ($r=0.28$); PEF ($r=0.25$) (Table 4). After correcting for age, height and weight, a low

Table 3
Summary of analysis of variance and least square difference across the three different socio-economic status (SES) groups.

Variables	Lower SES Mean (SD)	Middle SES Mean (SD)	High SES Mean (SD)	Mean difference (H/M) (95% CI)	Mean difference (H/L) (95% CI)	Mean difference (M/L) (95% CI)
FVC (l)	3.38 (0.35)	3.57 (0.41)	3.63 (0.33)	$0.07^{a,b}$ (0.02 to 0.11)	0.25^{b} (0.21 to 0.29)	0.18^{c} (0.14 to 0.22)
FEV_1 (l)	2.94 (0.34)	3.06 (0.31)	3.16 (0.28)	$0.11^{a,b}$ (0.07 to 0.15)	0.23^{b} (0.19 to 0.27)	0.12^{c} (0.09 to 0.15)
PEF (l/second)	376.07 (45.81)	390.56 (41.53)	404.30 (35.98)	$13.74^{a,b}$ (8.42 to 19.06)	28.23^{b} (23.18 to 33.27)	14.49^{c} (10.18 to 18.80)

For a particular variable, mode means with different superscript letters are significantly ($P<0.01$) different. Mode means with the same superscript letter are not significantly ($P>0.01$) different. FEV_1, forced expiratory volume in 1 second; FVC, forced vital capacity; PEF, peak expiratory flow; H/M, high SES vs middle SES; H/L, high SES vs low SES; M/L, middle SES vs low SES; SD, standard deviation; CI, confidence interval.

Table 4
Relationship between socio-economic status and lung function.

Dependent variables	Correlation
FEV_1 (l)	0.26*
FVC (l)	0.28*
PEF(l/second)	0.25*

FEV_1, forced expiratory volume in 1 second; FVC, forced vital capacity; PEF, peak expiratory flow.
* Correlation significant at $P < 0.01$ (Spearman's Rho).

Table 5
Relationship between socio-economic status and lung function corrected for age, height and weight.

Dependent variables	Correlation
FEV_1 (l)	0.1612*
FVC (l)	0.1520*
PEF(l/second)	0.1392*

FEV_1, forced expiratory volume in 1 second; FVC, forced vital capacity; PEF, peak expiratory flow.
* Correlation significant at $P < 0.01$ (Spearman's Rho).

Table 6
Relationship between age, physical characteristics and lung function.

Variable	PEF (l/second)	FVC (l)	FEV_1 (l)
Age (years)	−0.548*	−0.602*	−0.692*
Weight (kg)	0.412*	0.124*	0.138*
Height (m)	0.395*	0.173*	0.200*

FEV_1, forced expiratory volume in 1 second; FVC, forced vital capacity; PEF, peak expiratory flow.
* Correlation significant at 0.01 level (Pearson, two-tailed).

positive correlation was found between socio-economic status and lung function (Table 5). The results also demonstrate a high negative relationship between age and lung function, and a positive relationship between height and weight and lung function (Table 6).

Multiple regression equations were determined using age, socio-economic status, height and weight as independent variables (Table 7).

Table 7
Regression equations.

Male

$FVC = 4.054 - 0.027 \times age + 0.291 \times ht + 0.005 \times wt + 0.005 \times SES$ (R^2 41%, SEE 0.276)

$FEV_1 = 3.177 - 0.023 \times age + 0.416 \times ht + 0.003 \times wt + 0.006 \times SES$ (R^2 56%, SEE 0.183)

$PEF = 5.935 - 0.017 \times age - 0.587 \times ht + 0.002 \times wt + 0.037 \times SES$ (R^2 95%, SEE 0.106)

Female

$FVC = 4.23 - 0.038 \times age + 0.770 \times ht - 0.006 \times SES$ (R^2 90%, SEE 0.092)

$FEV_1 = 4.114 - 0.043 \times age + 0.746 \times ht - 0.007 \times SES$ (R^2 96%, SEE 0.063)

$PEF = -0.647 - 0.108 \times age + 7.687 \times ht - 0.013 \times SES$ (R^2 99%, SEE 0.114)

FEV_1, forced expiratory volume in 1 second; FVC, forced vital capacity; PEF, peak expiratory flow; ht, height in metres; wt, weight in kg; SES, socio-economic status (range 1 to 27); SEE, standard error of estimate.

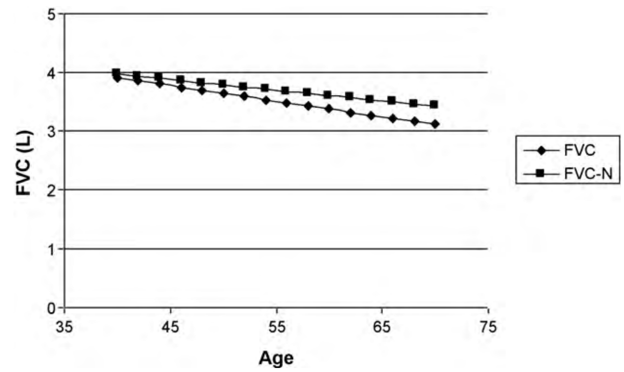

Fig. 1. Predicted forced vital capacity (FVC) vs age for Nigerian (FVC-N) males in the current study compared with FVC of African-American males using equation from Hankinson *et al.* [12] and the current study.

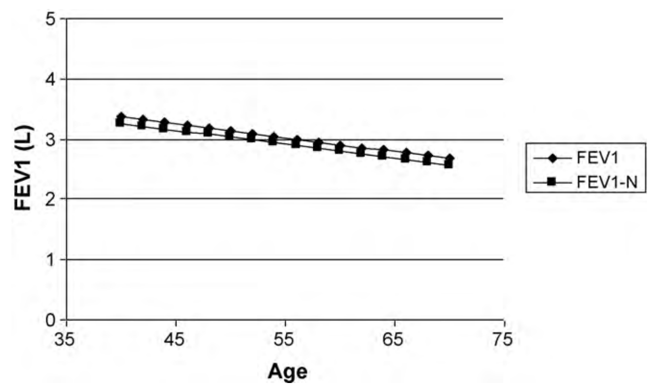

Fig. 2. Predicted forced expiratory volume in 1 second (FEV_1) vs age for Nigerian (FEV_1-N) males in the current study compared with FEV_1 of African-American males using equation from Hankinson *et al.* [12] and the current study.

Figs. 1–6 compare National Health and Nutrition Examination Survey (NHANES III) data for African-Americans with the study population [12]. African-American men and women had lower PEF values than Nigerian subjects (Figs. 3 and 6). However, Nigerian men had lower FVC but higher FEV_1 values (Figs. 1 and 2) than African-American men. Nigerian women had similar FVC and higher

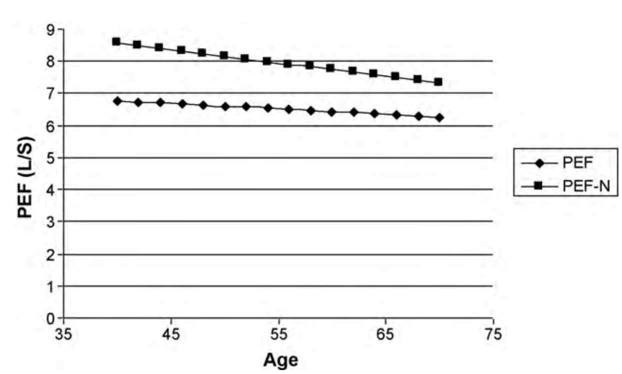

Fig. 3. Predicted peak expiratory flow (PEF) vs age for Nigerian (PEF-N) males in the current study compared with PEF of African-American males using equation from Hankinson *et al.* [12] and the current study.

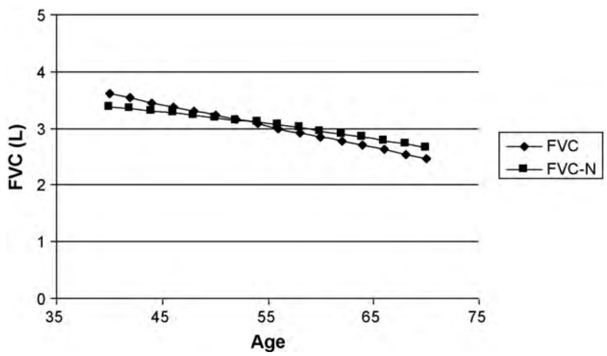

Fig. 4. Predicted forced vital capacity (FVC) vs age for Nigerian (FVC-N) females in the current study compared with FVC for African-American females using equation from Hankinson *et al.* [12] and the current study.

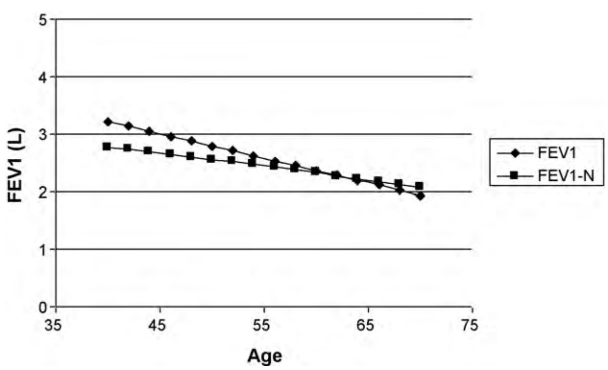

Fig. 5. Predicted forced expiratory volume in 1 second (FEV_1) vs age for Nigerian (FEV_1-N) females in the current study compared with FEV_1 of African-American females using equation from Hankinson *et al.* [12] and the current study.

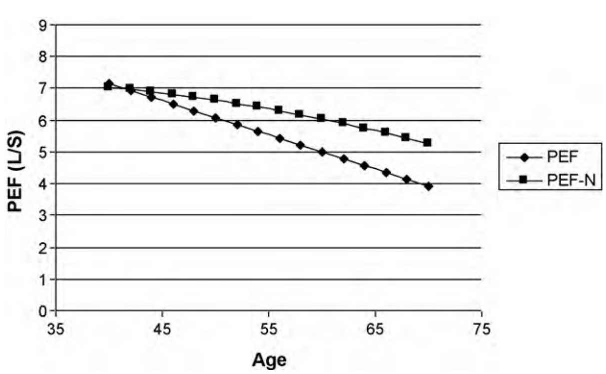

Fig. 6. Predicted peak expiratory flow (PEF) vs age for Nigerian (PEF-N) females in the current study compared with PEF of African-American females using equation from Hankinson *et al.* [12] and the current study.

FEV_1 values compared with African-American women (Figs. 4 and 5).

Discussion

The results of this study revealed a small but significant relationship between socio-economic status and lung function of adult Nigerians. Lower childhood socio-economic status was found to be associated with reduced lung function in adulthood, corrected for age, height and weight. The outcome corroborates the work of others in Indian children [3] and British women [1]. Raju *et al.* reported the influence of socio-economic status on lung function and physical characteristics among Indian children. Their study revealed significant differences in growth variables such as height, weight, fat-free mass and lung function, before and after adjusting for physical characteristics, between the high-income group and the middle- or low-income group [3].

Lawlor *et al.* revealed that childhood poverty is associated with poorer lung function in women aged 60–79 years. They concluded that the adverse childhood conditions that affect lung growth may cause cardiovascular disease in adulthood [2].

The high prevalence of respiratory disease and the emerging problem of cardiovascular disease in sub-Saharan Africa may be partly related to intrauterine growth retardation due to malnutrition during pregnancy and infancy [13,14]. Similar reports have been published in different countries [2–7]. However, in developing countries, urgent attention is needed as factors such as low income, lack of education, excessive stress and domestic violence are widespread.

Based on Barker's hypothesis of early life origins of adult chronic disease, low birth weight may be strong factor for the differences in lung function between the socio-economic groups. This may explain why there is reduced lung function among persons in developing nations compared with developed nations [15].

A recent study reported that the incidence of low birth weight in Nigeria is 14.8% [16]. This high prevalence is attributed to the high prevalence of teenage pregnancy, short birth intervals, maternal malnutrition, multiple pregnancy and chronic malaria in pregnancy [17,18].

Furthermore, sub-Saharan Africa is a region where the leading causes of death are predominantly infectious and parasitic diseases, especially HIV/AIDS, maternal and perinatal conditions, and nutritional deficiencies [19]. Studies are needed to determine if the lung function of individuals in developing nations declines earlier or faster compared with developed nations.

Previous studies in Nigeria have linked occupational exposure (e.g. woodworkers and welders) with lower lung function [20,21]. Ijadunola *et al.* studied the impact of grain dust exposure on the lung function of flour mill workers in Nigeria, and reported significantly reduced lung function among the study group compared with the control subjects [22]. While these results and the present study suggest that lung function of people in developing nations is lower than that of developed nations, the reason for this is yet to be proven. None of the participants in the present study had worked in industries that could have exposed them to air pollutants, although two-thirds reported using fire wood and kerosene stoves for cooking.

An earlier study showed that income and education are associated with lung function, independently of smoking, in both females and males in Denmark [23]. With a strong socio-economic gradient present in their study, the authors deduced that a decrease in lung function is partly caused by occupational exposure.

Spirometry reference values in Tunisian children were close to those of European, White US and Asian children, but higher than those of Libyan children [24]. African-American subjects seemed to have higher lung function values, with the exception of PEF, than their Nigerian counterparts [12]. The higher PEF values recorded among the Nigerian participants may be due to a difference in the instrument used in the present study. While the present study used electronic flow-sensing, rotating vane, pocket spirometers (Micro Medical) to measure PEF, the NHANES III study used volume-sensing, dry rolling-seal spirometers connected to a personal computer. This may account for the difference.

The age range of the subjects in the present study was 40 to 70 years, while participants in NHANES III were aged 20 to 70 years. Figs. 1–6 were created using mean values for height, weight and socio-economic status; therefore, they represent the middle socio-economic status in the population that was sampled. The figures compare the NHANES III data with the current study population, since NHANES III does not include socio-economic status.

Experts have warned that using reference values to produce a percentage of predicted measures can lead to serious misinterpretation of results and subsequent inappropriate diagnosis and treatment [25–27]. In selecting appropriate reference values, it is important to choose a source that used similar equipment and had a test population that included the age range, gender and ethnic group of individuals to be tested [28].

Misclassification of spirometry results was traced to poor coaching, poor inspiratory or expiratory effort, an inaccurate spirometer, or inappropriate interpretation of the spirometry tracing [28]. Experts have reported that errors up to 6% in FEV_1 and FVC can occur if ambient temperature is used instead of internal spirometer temperature. They advised that the temperature of the spirometer should be measured and not assumed to be constant, even over the course of one testing session [29].

The reference equations generated in this study might help clinicians during patient assessment, especially when patients are unable to perform rigorous lung function tests and where limited lung function equipment is available. The equations are useful for adult populations as in this study.

Study limitations

Socio-economic status cannot fully explain the lung function indices. Factors such as smoking and occupational exposure to airborne pollutants also affect lung function. This study did not include these factors because information provided by the participants on smoking history was inadequate. Many participants could not provide information on maternal smoking history, and those who claimed to be smokers were occasional smokers (less than one cigarette per day for a year). They were considered lifetime non-smokers [12].

Furthermore, participants were asked to recall their childhood circumstances in order to calculate their socio-economic status. This may have been over- or under-estimated. Nevertheless, this study has demonstrated that socio-economic inequalities have a direct effect on the lung function of Nigerian adults. Although the burden of respiratory disease in Nigeria remains unmeasured, the large number of people living in poverty suggests that it has formed the foundations for epidemic chronic disease that has now become a public health issue. The need for policy formulation on social welfare and economic empowerment of Nigerians is therefore critical.

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