Reduced Forced Vital Capacity in an African Population

Prevalence and Risk Factors

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Abstract

Rationale: Black Africans have reduced FVC compared with white persons, but the prevalence and determinants of reduced values are not well understood.

Objectives: To evaluate the prevalence and factors leading to reduced FVC in a Nigerian population and to examine current theories regarding the determinants of this difference.

Methods: We studied the ventilatory function of 883 adults aged 40 years or older participating in the Burden of Obstructive Lung Disease Study in Ile-Ife, Nigeria. Respondents completed pre- and post-bronchodilator spirometry test and provided information on their smoking history, respiratory symptoms, risk factors, and diagnoses, including anthropometric details. We used standard categories to define body mass index as either underweight, normal, overweight, or obese. We defined reduced FVC as a post-bronchodilator FVC below the lower limit of normal using National Health and Nutrition Examination Survey (NHANES) equations, Global Lung Function Initiative 2012 equations, and local reference equations based on nonsmoking study participants without a respiratory diagnosis. We fit multivariate linear regression models to FVC as a continuous measure, adjusting for age, sex, height, and other confounders.

Results: The prevalence of reduced FVC was 70.4% for men and 72.8% for women when using NHANES values for white Americans, 17.8% for men and 14.4% for women using NHANES equations for African Americans, and 15.5% for men and 20.5% for women using the Global Lung Function Initiative 2012 equations. Using the equations derived from nonsmoking respondents in the survey without a respiratory diagnosis, the prevalence of reduced FVC was less than 4% for both men and women. FVC was lower in participants who had less than 7 years of education (FVC, −96 ml; 95% confidence interval [CI], −172 to −19), were underweight (FVC, −269 ml; 95% CI, −464 to −73), were overweight (FVC, −132 ml; 95% CI, −219 to −46), and were obese (FVC, −222 ml; 95% CI, −332 to −112).

Conclusions: There is a wide variation in the prevalence of reduced FVC based on the reference standard used. This variation is not satisfactorily explained by factors thought to affect FVC within individual populations. However, the prevalence strongly associates with both education level and body mass index in this population, regardless of the specific standard used.

Keywords: lung function; spirometry; FVC; Nigeria

(Received in original form August 10, 2016; accepted in final form February 22, 2017)

The study was sponsored by the Wellcome Trust through a master's training fellowship awarded to D.O.O. (089405/Z/09/Z) and a project grant to the Burden of Obstructive Lung Disease Study (085790/Z/08/Z). The sponsor of the study had no role in the study design, data collection, data analysis, data interpretation, or writing of the report.

Author Contributions: D.O.O. and G.E.E.: initiated the study and organized it in collaboration with P.G.B. and E.A.S.B. O.F.A., B.O.A., and O.O.A.: provided advice and supervision for data collection and made important comments; D.O.O.: had full access to all the data in the study and had final responsibility for the decision to submit the manuscript for publication; D.O.O. and P.G.B.: performed the data analysis and wrote the first draft of the manuscript; and all authors: provided input into the subsequent analysis and writing of the manuscript and approved the final version.

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Ann Am Thorac Soc Vol 14, No 5, pp 714–721, May 2017

DOI: 10.1513/AnnalsATS.201608-598OC
Internet address: www.atsjournals.org

An analysis of the Atherosclerosis Risk in Communities Study showed that participants with a lower FVC had higher age- and sex-adjusted mortality, that African American participants had a lower FVC than white participants, and that the higher mortality in African Americans could be explained by the lower FVC (1). Other studies have consistently shown that both Africans and African Americans have lower FVC than white individuals (2, 3). For example, low FVC has been reported in asymptomatic, apparently healthy Nigerian populations (4, 5). Explanations offered for this observation include differences in anthropometry, genetic background, socioeconomic status, and environment between blacks and whites; these explanations are neither mutually exclusive nor necessarily independent of each other (2, 6, 7).

Because a low FVC may be a risk factor for higher mortality, these differences in FVC deserve to be explored further in populations that are geographically dispersed and have different risk factors. In our present study, we aimed to evaluate the prevalence and factors leading to reduced FVC in a Nigerian population and examine current theories about its determinants in light of our data. We used post-bronchodilator measurements of FVC and four different sets of normative values to define "below normal" FVC.

Methods

The study, which took place in Ile-Ife in southwestern Nigeria, followed the Burden of Obstructive Lung Disease (BOLD) Study protocol, which has been described in detail previously (8, 9). Ile-Ife is an ancient city in Nigeria consisting of two local government districts (Ife Central and Ife East) with an estimated total population of 250,000 (10).

Using a multistage cluster sampling method, we identified a representative sample of adults aged 40 years and older. This method provided a stratified random sample of 76 enumeration areas, selected proportionately (45 enumeration areas in Ife Central and 31 in Ife East) from a combined total of 1,658 enumeration areas in the two districts (Figure 1). A preliminary team conducted a minicensus of the selected enumeration areas to generate a sampling frame by collecting data on the age and sex distribution of the population. A second team of interviewers began collecting study data 3 months later.

The sample included all households in the selected enumeration areas and all eligible individuals in the selected households. However, for safety reasons, the sample excluded individuals precluded from lung function testing, including those with a history of a heart attack in the past 3 months; any hospitalization for heart problems within the last month; a history of eye, chest, or abdominal surgery in the preceding 3 months; a resting pulse greater than 120 beats per minute; currently taking medications for tuberculosis (TB); and women in the last trimester of pregnancy. Participating centers in the BOLD Study recruited at least 600 participants in the final sample. In Ile-Ife, we exceeded this goal to account for the variance inflation associated with our cluster sampling technique.

Spirometry

We measured ventilatory function based on the joint American Thoracic Society (ATS)/European Respiratory Society (ERS) guidelines using the EasyOne spirometer (model 2001, SN 100902-4/2010; ndd Medical Technologies, Zurich, Switzerland) (11). We tested participants while they were in a seated position and obtained both pre- and post-bronchodilator measurements, at least 15 minutes apart, after administering two puffs of salbutamol (200 μg) via a metered-dose inhaler with a valved spacer (Volumatic; GlaxoSmithKline, Research Triangle Park, NC). To remain consistent with the BOLD Study standard protocol, we used a 200-μg dose instead of the 400-μg dose recommended by the ATS/ERS task force on lung function testing (11). The lower dose had been selected because, although serious side effects are rare, we were testing healthy volunteers in their homes without further backup.

We checked the calibration status of the spirometers daily using a 3.00-L syringe. All spirograms were checked locally at the study site and then sent via a secure Internet transfer to the BOLD Study operations center at Imperial College London for further quality control checks using the ATS guidelines (11). Acceptable spirograms had to consist of at least three trials, with two free from zero-flow errors, artifacts, termination prior to 3 seconds or before a plateau was evident on the volume–time tracing, extra breaths, or coughing in the first second of the trial. In addition, the back-extrapolated volume had to be less than 5.0% of FVC. For repeatability criteria, we accepted slightly greater variation in the highest and next-highest spirograms, provided that the difference was less than 200 ml, a slight relaxation of the ATS/ERS recommendation shown to have very little impact on quality while reducing missing data (12). Analysis included only spirometry tests meeting these criteria.

Anthropometry

We measured height with a portable stadiometer (HM200P PortStad Portable Stadiometer; Charder Medical, Taichung City, Republic of China) to the nearest centimeter while the participant was standing erect, shoulders level, hands at sides, knees and thighs together, weight evenly distributed on both legs, and with feet flat and both heels comfortably together. We measured weight to the nearest hectogram (0.1 kg) using a flat, firm surface with the participants wearing normal indoor clothing. We divided the weight by the square of the height in meters to obtain the body mass index (BMI) and categorized BMI into underweight ($<$18.5 kg/m^2), normal (18.5–24.9 kg/m^2), overweight (25.0–29.9 kg/m^2), or obese ($>$29.9 kg/m^2).

Questionnaire Data

We obtained information about sociodemographics; respiratory symptoms; diagnosis; and risk factors, including exposure to cigarette smoking, occupational dust, and biomass fuels. Trained and certified field staff administered the BOLD Study questionnaires face to face with participants, using the Yoruba version of the questionnaires. This version of the questionnaire followed the BOLD Study standard method for translation using forward and backward translation, reconciliation, and piloting (8).

Data Analysis

We performed all analyses using Stata 13 software (StataCorp, College Station, TX). To describe the characteristics of the population, we included all respondents with complete core questionnaire data (1,148), but estimation of ventilatory function included only respondents who had usable spirometry (883).

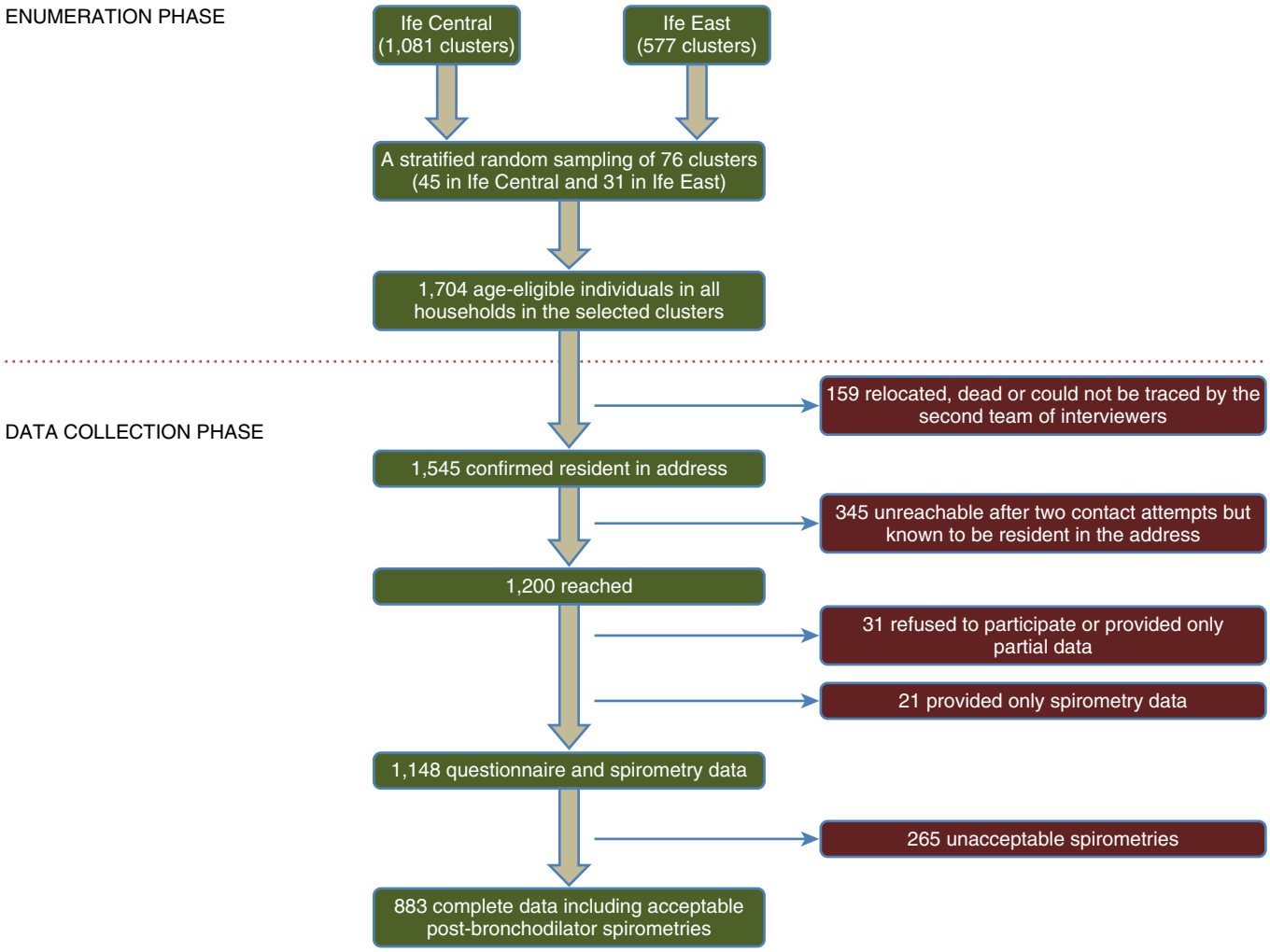

Figure 1. Sampling plan. Sampling process of Burden of Obstructive Lung Diseases (BOLD) study, Ile-Ife, Nigeria. NB: Different teams of interviewers conducted the enumeration and data collection phases of the study. The data collection phase began three months after completion of enumeration. Adapted by permission from Reference 20.

We defined the response rate as the proportion of eligible respondents who completed both the post-bronchodilator spirometry (regardless of the quality) and the core questionnaire, and we defined the cooperation rate as the proportion of those who provided full questionnaire data and spirometry when successfully reached by the interviewers in their homes. We defined airflow obstruction by the FEV_1/FVC ratio using a lower limit of normal (LLN) based on equations from the Global Lung Function Initiative (GLI) for black persons. FVC was considered reduced if it was less than the LLN based on reference equations from participants in the Third National Health and Nutrition Examination Survey (NHANES), GLI 2012, and participants in the present survey (13, 14).

We used the NHANES equations both for white Americans and for African Americans. The calculation of local equations was a separate exercise in which we used age, sex, and height data from participants in the present survey who had never smoked and who did not report current asthma, chronic bronchitis, emphysema, or a history of TB. To derive sex-specific equations, we regressed lung volumes (FEV_1, FVC) against age and height, with FEV_1/FVC ratios determined by regressing against age alone.

We used a regression analysis to evaluate risk factors for reduced FVC, and we selected variables for the study on the basis of current literature. Age, sex, and height are strong predictors of lung function, as is smoking (13). Mean FVC is strongly associated with gross national product, and we included education as a marker of socioeconomic status (15). Both low and high BMI have been associated with an increased risk of abnormal lung function, including reduced FVC (16). Farming and occupational dust exposures have both been associated with reduced lung function, and both are common in Ile-Ife (17).

The role of biomass use for cooking is controversial but could also be a risk factor for reduced FVC (18). Other known lung diseases have been associated with reduced FVC either because of destruction

of parenchyma, such as pulmonary TB, or because of gas trapping and a rise in residual volume, as in asthma (19). We adjusted for these potential confounders in the regression model except diagnosed TB, asthma, heart disease and cigarette smoking because of the very small numbers in our sample.

To account for the sampling design, we employed the 'svy' set of commands in the Stata statistical software program to adjust for the effects of stratification and clustering. We used the sampling weights to generate the population prevalence estimates of reduced FVC. We also plotted the prevalence of reduced FVC against gross national income (GNI) using data from other BOLD Study sites to compare with the results from Ile-Ife (15). The ethics committee of Obafemi Awolowo University Hospital approved the study (ERC/2011/01/04), and all study participants provided written informed consent.

Results

Previous literature has described the details of recruitment (20). Figure 1 illustrates the key aspects of the recruitment process. Out of a total of 1,148 respondents who provided both core questionnaire and spirometry data, 883 performed spirometry that met our stringent quality control criteria.

Overall, the response rate was 76% (1,169 of 1,545), and 97% (1,169 of 1,200) of the respondents provided data (cooperation rate). Of the respondents, 89% had never smoked, and only 2.3% were current smokers. The prevalence rates of doctor-diagnosed asthma, heart disease, and TB were all less than 1%, and 47% had less than 7 years of education (Table 1). In terms of BMI, 6.4% were underweight, 48.3% were of normal weight, 28.0% were overweight, and 17.3% were obese. Wood, crop residue, or coal was the main source of domestic fuel for 67% of the respondents, and 40% of these reported having a chimney in their kitchen.

The respondents with usable spirometry were more likely to be men ($P = 0.004$) and to be younger ($P < 0.001$) than those without usable spirometry. They also had more education; had a higher BMI; and were more likely to use wood, crop residue, or coal for cooking or heating. However, there was no significant difference in doctor-diagnosed asthma, heart disease, or smoking status.

Table 1. Characteristics of responders with and without usable spirometry

Variables/Categories		All Responders* (*n = 1,148*)	Responders with Usable Spirometry† (*n = 883*)	Responders without Usable Spirometry (*n = 265*)
Age group, yr	40–49	406 (35.4%)	325 (36.8%)	81 (30.6%)
	50–59	282 (24.6%)	231 (26.2%)	51 (19.3%)
	60–69	257 (22.4%)	213 (24.1%)	44 (16.6%)
	70+	203 (17.6%)	114 (12.9%)	89 (33.5%)
Sex, n (%)	Male	424 (36.9%)	345 (39.1%)	79 (29.8%)
	Female	724 (63.1%)	538 (60.9%)	186 (70.2%)
Height‡, cm, mean (SD)		162 (7.8)	163 (7.7)	161 (8.2)
Smoking status	Current	26 (2.3%)	23 (3%)	3 (1%)
	Former	97 (8.4%)	71 (8%)	26 (10%)
	Never	1,025 (89.3%)	789 (89%)	236 (89%)
Education, yr of schooling	7+	607 (52.9%)	485 (54.9%)	122 (46.0%)
	0–6	541 (47.1%)	398 (45.1%)	143 (54.0%)
BMI‡, kg/m^2	<18.5	71 (6.4%)	45 (5.1%)	26 (11.2%)
	18.5–24.9	539 (48.3%)	423 (47.9%)	116 (50.0%)
	25.0–29.9	312 (28.0%)	250 (28.3%)	62 (26.7%)
	⩾30	193 (17.3%)	165 (18.7%)	28 (12.1%)
Doctor-diagnosed asthma		8 (0.7%)	6 (1%)	2 (1%)
Doctor-diagnosed heart disease		2 (0.2%)	1 (0.1%)	1 (0.4%)
Doctor-diagnosed TB		4 (0.4%)	4 (0.5%)	—
Ever worked as a farmer for ⩾3 mo		497 (43.4%)	393 (44.6%)	104 (39.7%)
Ever worked in dusty job for ⩾1 yr		413 (36.0%)	312 (35.3%)	101 (38.1%)
Ever used wood, coal, or crop residue for indoor cooking/heating for 6 mo		763 (66.6%)	599 (67.8%)	164 (62.6%)

Definition of abbreviations: BMI = body mass index, TB = tuberculosis.
*Responders are those who completed post-bronchodilator spirometry and the core questionnaire.
†Usable spirometry was defined as post-bronchodilator spirogram that met quality control standard.
‡33 with missing data.

Table 2 shows the prevalence of a reduced FVC (FVC less than LLN) and chronic airflow obstruction (FEV_1/FVC less than LLN) for men and women. In total, the prevalence of reduced FVC was 70.4% for men and 72.8% for women when using the NHANES values for white Americans, 17.8% for men and 14.4% for women when using NHANES values for African Americans, 15.5% for men and 20.5% for women when using the GLI 2012 reference equation, and less than 4% for both men and women when using locally derived norms. Contrastingly, the prevalence rates of obstruction were 8.7% and 6.7% for men and women, respectively, just above the 5% expected to be below the LLN in a normal asymptomatic population.

Table 3 shows a multivariate regression of the risk factors for reduced FVC, regardless of reference equations, adjusted for possible confounders such as age, sex, height, BMI, years of schooling, occupation, and use of biomass fuels. We explored whether having a kitchen chimney modified the effect of exposure to biomass on FVC, but it made no significant difference. We also fitted interaction terms into the model to explore whether there was any relationship between biomass exposure and sex, but we found no significant interaction (data not shown). Significant determinants of FVC included having less than 7 years of education (FVC, −96 ml; 95% confidence interval [CI], −172 to −19), a BMI less than 18.5 kg/m^2 (FVC, −269 ml; 95% CI, −464 to −73), a BMI from greater than or equal to 25.0 to 29.9 kg/m^2 (FVC, −132 ml; 95% CI, −219 to −46), and a BMI greater than or equal to 30 (FVC, −222 ml; 95% CI, −332 to −112).

Figure 2 shows the prevalence of reduced FVC using the NHANES equations for white Americans plotted with other BOLD Study centers against per capita GNI. The high prevalence of a reduced FVC that we found in Nigeria, with its low per capita income, fits well with the data from other BOLD Study centers describing

Table 2. Estimated population prevalence (SE) of FVC and FEV_1/FVC less than lower limit of normal

Variables	Categories	FEV_1/FVC Less Than LLN		FVC Less Than LLN							
		GLI 2012 Equations (Black)		NHANES Equations (White)		NHANES Equations (African Americans)		Local Equations		GLI 2012 Equations (Black)	
	Sex	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female
Age group, yr	40–49	6.6 (2.2)	4.5 (1.5)	74.3 (4.0)	77.2 (3.1)	20.0 (3.3)	18.8 (2.9)	4.8 (2.2)	4.9 (1.5)	20.0 (3.3)	25.6 (3.0)
	50–59	11.0 (3.5)	7.7 (2.2)	71.9 (4.2)	77.0 (3.8)	16.5 (4.0)	13.6 (2.8)	—	2.5 (1.3)	14.1 (4.0)	20.4 (3.2)
	60–69	12.6 (3.6)	5.0 (1.9)	71.2 (5.3)	72.6 (4.1)	14.1 (3.7)	10.7 (2.6)	4.7 (2.3)	2.1 (1.2)	13.1 (3.7)	13.7 (2.8)
	70+	5.1 (3.0)	17.2 (4.9)	48.1 (7.3)	38.3 (7.3)	18.3 (5.5)	1.9 (1.9)	—	1.9 (1.9)	3.7 (2.7)	8.6 (3.6)
Smoking status	Current	13.2 (8.3)	—	68.5 (10.7)	—	10.0 (6.5)	—	5.0 (4.7)	—	10.0 (6.5)	—
	Former	5.3 (3.3)	17.8 (9.5)	71.8 (6.3)	54.5 (14.0)	26.1 (5.7)	—	1.2 (1.2)	—	21.9 (5.5)	6.5 (6.3)
	Never	8.9 (1.9)	6.4 (1.0)	70.4 (3.0)	74.7 (1.8)	17.0 (2.3)	14.8 (1.7)	3.1 (1.2)	3.6 (0.8)	14.8 (2.3)	20.9 (1.8)
Education, yr of schooling	7+	6.7 (1.6)	6.2 (1.7)	71.2 (2.8)	72.6 (3.3)	16.5 (2.2)	12.5 (2.1)	2.8 (1.3)	2.9 (1.0)	14.5 (2.1)	19.7 (2.4)
	0–6	13.9 (3.6)	7.2 (1.4)	68.8 (5.3)	73.0 (2.6)	21.5 (4.3)	16.2 (2.4)	3.5 (2.0)	4.1 (1.4)	18.4 (4.3)	21.4 (2.7)
BMI, kg/m^2	<18.5	13.6 (9.1)	13.3 (5.8)	80.4 (9.8)	75.1 (7.9)	45.9 (12.6)	18.6 (8.3)	12.6 (8.5)	5.3 (5.3)	45.9 (12.6)	26.1 (9.0)
	18.5–24.9	9.8 (2.2)	6.5 (1.7)	67.6 (4.0)	62.4 (3.8)	11.9 (2.4)	8.2 (2.2)	2.1 (1.0)	2.4 (1.1)	11.0 (2.4)	11.6 (2.4)
	25.0–29.9	6.1 (2.9)	5.3 (1.6)	70.2 (5.2)	77.7 (3.0)	15.7 (4.0)	18.6 (3.7)	2.3 (1.7)	4.9 (1.7)	12.4 (3.4)	23.2 (3.7)
	⩾30	5.8 (4.5)	7.6 (2.6)	83.3 (6.3)	82.5 (4.1)	43.4 (9.1)	18.6 (3.3)	4.9 (3.5)	3.0 (1.4)	33.6 (7.5)	30.0 (4.2)
Total		8.7 (1.6)	6.7 (1.0)	70.4 (2.7)	72.8 (1.8)	17.8 (2.1)	14.4 (1.7)	3.0 (1.0)	3.5 (0.8)	15.5 (2.0)	20.5 (1.8)

Definition of abbreviations: BMI = body mass index; GLI = Global Lung Function Initiative; LLN = lower limit of normal; NHANES = National Health and Nutrition Examination Survey.
Blank spaces indicate absence of respondents with the respective data.

a relationship between the prevalence of reduced FVC and per capita GNI (15).

Discussion

We found that the prevalence of reduced FVC is high in Ile-Ife when we used any of the external norms. Given the rigorous quality control of the BOLD Study, we have confidence in our observations. However, the high prevalence of reduced FVC contrasts with the low prevalence of chronic airflow obstruction in this population. In an earlier paper, we reported the overall prevalence of chronic airflow obstruction (FEV_1/FVC less than the LLN) in this population to be 7% (only 2% more than expected in a "normal" nonsmoking population) (20).

The choice of appropriate reference equations for lung function is controversial and depends on the question being asked (7, 21, 22). In clinical practice, it is the convention to use a comparator that is typical of the local population that has no diagnosed disease and no obvious risk factors. In assessing local health, however, this may be less useful if the local "norm" is suboptimal. In this case, using a common reference standard may be more appropriate when looking across populations to compare prevalence. In

Table 3. Linear regression model of determinants of post-bronchodilator FVC

Variables	Categories	Univariate Model			Multivariate Model			*P* Value*
		Coefficient (*ml*)	95% CI		Coefficient (*ml*)	95% CI		
Age group, yr	40–49 (reference)	—	—	—	—	—	—	<0.001
	50–59	−207	−328	−85	−125	−201	−49	
	60–69	−542	−670	−414	−581	−472	−290	
	70+	−750	−871	−629	−543	−644	−442	
Sex	Women	−878	−968	−788	−445	−525	−365	<0.001
Height (cm)		63	59	68	38	34	43	<0.001
Education, yr of schooling	0–6	−464	−565	−364	−96	−172	−19	0.015
	7+ (reference)	—	—	—	—	—	—	
Body mass index, kg/m^2	Underweight (<18.5)	−432	−671	−192	−269	−464	−73	<0.001
	Normal (18.5–24.9) (reference)	—	—	—	—	—	—	
	Overweight (25.0–29.9)	−265	−396	−133	−132	−219	−46	
	Obese (⩾30)	−455	−582	−328	−222	−332	−112	
Farming†		158	67	249	−36	−99	27	0.260
Dusty Job‡		299	192	406	63	−3	129	0.060
Wood, coal, or crop residue§		−54	−160	53	58	−11	127	0.098

Definition of abbreviation: CI = confidence interval.
**P* value of the multivariate model.
†Ever worked as a farmer for at least 3 months.
‡Ever worked in a dusty job for at least 1 year.
§Ever used indoor open fire with wood, coal, or crop residue as primary means of cooking or heating home for at least 6 months.

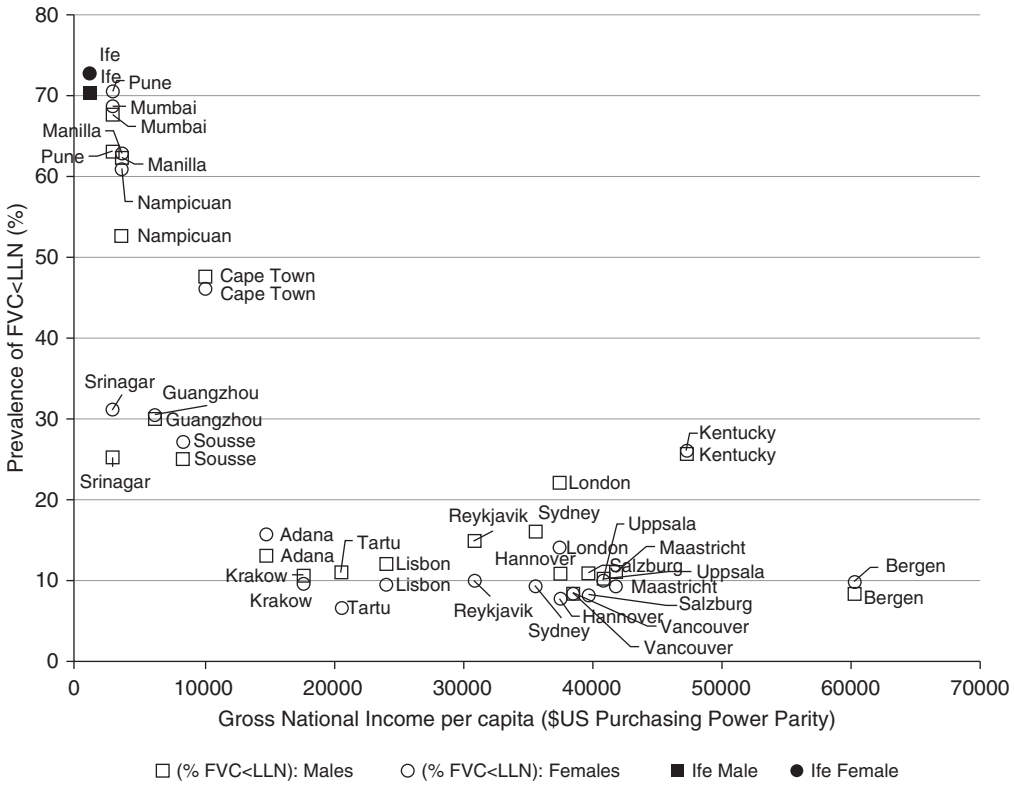

Figure 2. Ecological association of the prevalence of reduced forced vital capacity against gross national income by sex across Burden of Obstructive Lung Disease Study sites (15). LLN = lower limit of normal.

support of this, Burney and Hooper have shown that the reduced FVC in African Americans is associated with a commensurate reduction in life expectancy (1) and have argued against an assumption that locally determined standards are truly normative (23). This interpretation is supported by the observation that the mean FVC and the mortality rate for chronic obstructive pulmonary disease are both strongly correlated with the GNI in the BOLD Study (15).

The associations with FVC when analyzed as a continuous variable (Table 3) are independent of any arbitrary norms. In younger populations, it has been shown that reduced FVC in the general population correlates with low lung volume (24), but the risk factors for low lung volume in adulthood are still unclear.

Low levels of education are recognized as a proxy for poor socioeconomic status, a compound risk factor that encapsulates exposure to several agents that can affect lung development *in utero* and subsequent postnatal lung growth and development. These early-life exposures are known to influence anthropometry and adult ventilatory function and include intrauterine growth restriction; childhood respiratory tract infections; environmental pollution, including tobacco smoke; housing conditions; household income; and diet (25–28). If these factors are important in the causal chain, they are potentially amenable to interventions focused on maternal and early childhood health.

There is a significant body of literature showing that low socioeconomic status, poverty, low birth weight, and little or no education are risk factors for reduced maximal ventilatory function and chronic lung disease in adults (29–31). The very high prevalence of reduced FVC seen in Ile-Ife, Nigeria, fits well with data from other BOLD Study sites (32) and is consistent with the low economic status of Nigeria (Figure 2). In addition, this estimate is similar to estimates from countries with similar economies in South Asia (33) and with BOLD Study data from an Aboriginal site in Australia (34). The causal pathways linking poverty with reduced FVC are still unclear and require further elucidation. The implications of reduced FVC for health and mortality in these low-income settings is still unknown because, so far, estimates have had to rely on extrapolation from U.S. data.

We also observed that those with abnormal BMI have lower FVC compared with those with normal BMI. The interpretation of this observation is not clear in the absence of information on body fat distribution and fat-free mass. However, findings of previous studies suggest that the relationship between FVC and BMI may be nonlinear and influenced predominantly by the percentage of body fat (35, 36). These studies show that whereas there is a negative association between body fat and FVC, the relationship between FVC and fat-free mass is generally positive, and FVC tends to improve when young, previously underweight individuals gain weight (16). On one hand, underweight individuals in our study may have shown a lower age- and sex-adjusted maximal FVC for various reasons, including poor

nutritional status and predisposition to respiratory infections, leading to lower FVC. On the other hand, our report also corroborates previous reports showing that obesity is a determinant of reduced FVC as a consequence of the restrictive effect of additional body fat accumulation (16, 35).

Strengths and Limitations

The strength of this study is that it provides information on lung function in a West African population through rigorous sampling and data collection with high quality control. We attained a good response rate (76%), and 97% of respondents interviewed were cooperative and provided full spirometry and questionnaire data.

The study was limited by the fact that all associations with risk factors are cross-sectional and rely on questionnaire data alone without external validation. Cross-sectional studies examining lung function against risk factors for which there is an element of choice may underestimate the risk for decline in lung function, particularly in younger age groups, because of selection bias toward the "healthy" population (37). Reliance on questionnaire responses without objective measurements of exposure is also likely to introduce errors that may under- or overestimate risks.

Conclusions

In a population-based study of adults living in a West African city, we found a high prevalence of reduced FVC similar to the prevalence found in South Asia and in an Aboriginal study in Australia conducted where the economic conditions were similarly poor. Reduced FVC was independently associated with poor education and being underweight, overweight, or obese. We cannot tell the origins of this condition, but we regard it as an important target for better understanding because it is common in deprived populations, is inadequately understood, and carries a poor prognosis. Longitudinal studies are required to quantify the additional risk, if any, associated with the reduced FVC described in the present study. Further studies of more diverse populations, including more affluent Nigerian populations, would increase the power to identify individual risk factors for poor ventilatory function in adult life. ■

Author disclosures are available with the text of this article at www.atsjournals.org.

Acknowledgment: The authors thank the BOLD Study coordinating center at Imperial College London for assistance with spirometry training and quality control during the study. The authors also thank William Vollmer of the Kaiser Permanente Center for Health Research, Portland, OR; Ben Nemery of the Department of Public Health and Primary Care, KU Leuven, Leuven, Belgium; and Douglas Von Korff for providing useful input into the writing of the manuscript. The authors are also highly indebted to the ATS's Methods in Epidemiologic, Clinical and Operations Research program for training in the fundamentals of research that initiated this work.

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