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Prevalence and determinants of chronic respiratory diseases in adults in Sudan

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SUMMARY

BACKGROUND: Chronic respiratory diseases (CRDs) are considered a significant cause of morbidity and mortality worldwide, although data from Africa are limited. This study aimed to determine the prevalence and determinants of CRDs in Khartoum, Sudan.

METHODS: Data were collected from 516 participants aged ≥40 years, who had completed a questionnaire and undertook pre- and post-bronchodilator spirometry testing. Trained field workers administered the questionnaires and conducted spirometry. Survey-weighted prevalence of respiratory symptoms and spirometric abnormalities were estimated. Regression analysis models were used to identify risk factors for chronic lung diseases.

RESULTS: Using the Third National Health and Nutrition Examination Survey, 1988–1994 (NHANES III) reference equations, the prevalence of chronic airflow obstruction (CAO) was 10%. The main risk factor was older age, 60–69 years (OR 3.16, 95% CI 1.20–8.31). Lower education, high body mass index and a history of TB were also identified as significant risk factors. The prevalence of a low forced vital capacity (FVC) using NHANES III was 62.7% (SE 2.2) and 11.3% (SE 1.4) using locally derived values.

CONCLUSION: The prevalence of spirometric abnormality, mainly low FVC, was high, suggesting that CRD is of substantial public health importance in urban Sudan. Strategies for the prevention and control of these problems are needed.

KEY WORDS: COPD; CAO; risk factors; low FVC; SSA

The Global Burden of Disease Study estimates 3.9 million deaths annually from chronic non-communicable respiratory diseases – mainly chronic obstructive pulmonary disease (COPD) and asthma.[1,2] The associated burden of deaths and morbidity is expected to increase over future decades, especially in low- and middle-income countries (LMICs).[3,4] Prevalence estimates for COPD in sub-Saharan Africa (SSA) are based on limited epidemiological data, which lack a standardised definition of COPD.[5,6] A recent systematic review reported a population prevalence of COPD in SSA ranging from 1.7% to 24.8%.[7] The prevalence and determinants of low FVC in SSA are barely understood; however, it is reported that Africans have reduced FVC compared with Caucasians.[8] Moreover, studies reported an association between lung restriction and mortality and a higher prevalence of chronic respiratory diseases (CRDs) in SSA that linked to numerous risk factors, including early childhood exposure, poverty, biomass fuel exposure, smoking and pulmonary TB.[9]

The Burden of Obstructive Lung Disease (BOLD) Initiative developed standardised methods for estimating the burden and determinants of chronic airflow obstruction (CAO) in populations aged ≥40 years.[10,11] We conducted a BOLD study in Khartoum, Sudan, to help fill the knowledge gap about CRDs in Africa.

METHODS

Setting

Khartoum, the capital of Sudan, consists of seven localities that encompass a diverse mix of urban, semi-urban, rural, and internally displaced populations.

Sampling

Three localities, with a total population of 661,617, were randomly selected for sampling in this study and divided into clusters. Respectively 280, 258 and 158 households were randomly selected from Jabelawlya, Shargalneel and Omdurman localities.

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Participants

Using the BOLD protocol,[11] we approached 998 participants, from which 600 individuals aged ≥40 years were included using a 3-stage stratified cluster sampling plan. Potential participants who were institutionalised or medically unfit to perform spirometry were excluded.

Data collection and management

All study participants completed a structured interview in the local Arabic language administered by trained interviewers. Anthropometric measurements, along with spirometry data obtained before and after bronchodilator (BD) use, were collected per American Thoracic Society (ATS) guidelines using the Easy One system (ndd Medizintechnik, Zurich, Switzerland) by three trained certified technicians.[11] A brief data or refusal questionnaire was filled out for those not willing to participate in the full study. The clinical data obtained included height, weight, pulse rate, and waist and hip circumference. Quality control was carried out at the BOLD coordinating centre. Usable spirometry was defined as two or more acceptable blows, with forced expiratory volume in 1 sec (FEV_1) and forced vital capacity (FVC) repeatability within 200 mL. Acceptable manoeuvres were defined as those with a rapid start (back-extrapolated volume, 150 mL or 5% of the FVC), lack of cough during the first second and a small end-of-test volume (<40 mL during the final second). The calibration of all spirometers was verified to be accurate within 3.0% using a 3.00 L syringe at the beginning of each day of testing. Spirometry traces were then classified according to $FEV_1/FVC <$ lower limit of normality (LLN).

CAO was defined by post-BD $FEV_1/FVC <$ LLN. Predicted values based on standardised values for age, sex and height were calculated based on the Third National Health and Nutrition Examination Survey 1988–1994 (NHANES III) of White Americans.[12] Local values were derived from spirometry of non-smoking Sudanese adults with no respiratory symptoms or diagnoses participating in this survey. CAO stages were categorised as follows: stage 1 or higher CAO (post-BD $FEV_1/FVC <$ LLN) and stage 2 or higher CAO (post-BD $FEV_1/FVC <$ LLN and post-BD FEV_1 <80% predicted).

Statistical analysis

Evaluation of selection bias and a comparison between groups was conducted using χ^2 test between participants who completed full data and basic information questionnaires with acceptable or unacceptable spirometry readings. Prevalence estimates of spirometric abnormalities stratified by age and sex were reported using NHANES III.[11] Prevalence estimates using locally derived spirometry were also reported.

Univariable and multivariable logistic regression analyses were used to test associations between spirometry abnormalities and several exposure variables, including age, sex, education level, self-reported history of TB, hypertension, diabetes, heart disease, body mass index, smoking status, smoking pack-years, exposure to indoor smoke from biomass fuel and occupational exposure. A wealth score was developed based on the Mokken Scale to differentiate between different levels of wealth using a count of owned assets.[13,14]

Multivariable logistic regression models that included sex, age and all variables from the univariable analysis with $P < 0.2$ were then developed. The prevalence of respiratory symptoms was reported and associations with the study variables were tested using regression analysis. A description of the associations between abnormal spirometry and respiratory symptoms was reported. The data were analysed using Stata IC v14 (StataCorp, College Station, TX, USA). Prevalence estimates and regression models were developed using survey weighting with the *Svy* package in Stata.[14]

Ethical considerations

Ethical approval was obtained from the Imperial College London, London, UK; and Khartoum State Ministry of Health, Khartoum, Sudan. Written informed consent was collected from study participants before data collection.

RESULTS

The flow chart for participant recruitment is shown in Figure 1. Of the 998 participants approached, 516 provided full questionnaire data and had approved spirometry results. Eleven of the 998 participants declined to participate fully in the study but completed the basic information data questionnaire. The final response rate was 85.5% ($n = 696$).

Participant characteristics

The mean age was 53.8 years (standard deviation [SD] 10.4); 59.3% were male. Overall, 35% completed primary school. Men had a higher level of education, as did the group aged 40–49 years compared to other age groups. The mean number of household members was 7.8 (SD 3.56) and the mean wealth score was 5.2 (SD 2.7).

Among respondents, 24% had smoked cigarettes and 50% of men were current smokers. About 24% of smokers had more than 20 pack-years of exposure. Exposure to indoor biomass fuel for ≥6 months was reported by 82% of participants. Overall, women had a higher mean number of hours of exposure to indoor biomass fuel per year than men (70% vs. 54%). Farming was the most frequently reported occupation (24%; Table 1).

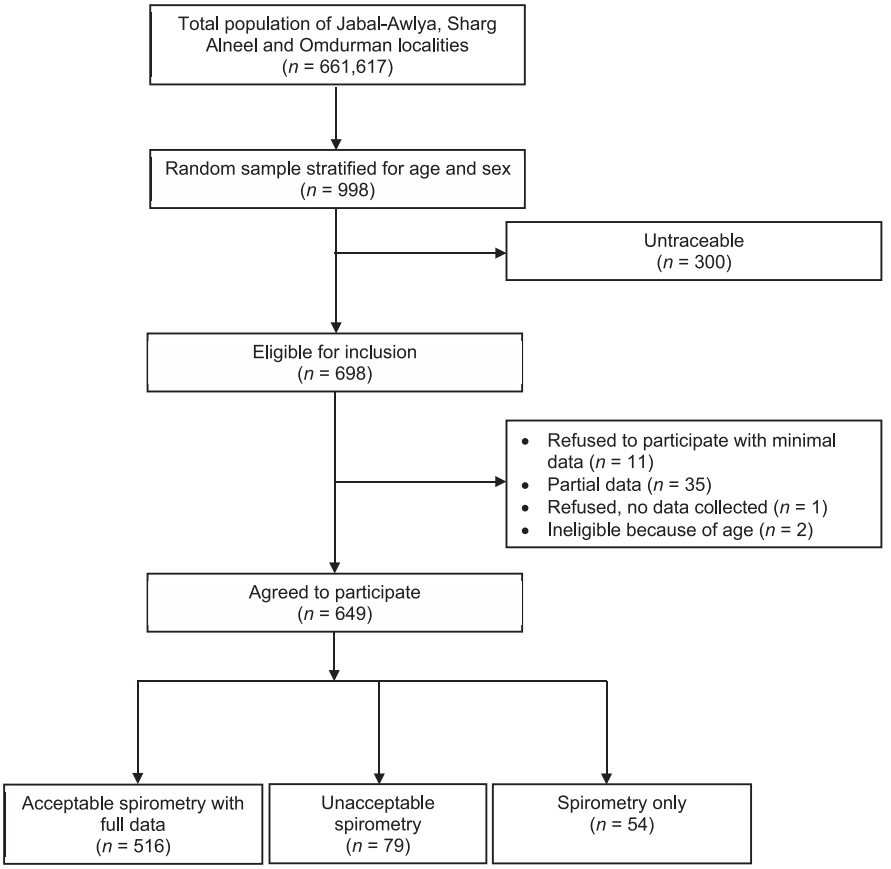


Figure 1 Participant flow diagram.

In total, 23% of participants were obese and 7% were underweight. Hypertension was self-reported by 20% of all participants, of whom 55% were women. Diabetes was reported by 9% (9.5% of women and 8.8% of men).

Respiratory symptoms

At least one respiratory symptom was reported by 23% (standard error [SE] 1.9) of participants; respiratory symptoms interfering with daily activities were reported by 1.9% (SE 0.5). Cough was reported by 10.4% (SE 1.3), with the highest prevalence recorded in participants aged ≥70 years (11.9%, SE 4.9). Chronic cough (lasting >3 months per year) was reported by 4.0% (SE 0.8). Production of sputum was reported by 11% (SE 1.3) and chronic production of sputum (for >3 months per year) was reported by 5% (SE 0.09). Shortness of breath was reported by 11% (SE 1.3), and 41% (SE 6.5) of this group reported that breathing problems made it difficult to walk more than 100 yards (91.4 m). Wheeze in the past 12 months in the absence of cold was reported by 3.0% (SE 0.7).

Spirometry

No statistically significant differences were found between the groups who did or did not complete the spirometry test. Based on NHANES III, stage 1 or higher CAO prevalence was 10.3% (overall: SE 1.4; men: 9.2, SE 1.7; women: 11.2, SE 2.4). Using the locally derived reference range, the prevalence was 5.7% (overall: SE 1.1; men: 5.2%, SE 1.3; women: 6.2, SE 1.9). Participants aged 60–69 years had the highest prevalence of stage 1 or higher CAO (13.4%, SE 3.8). Prevalence of stage 2 or higher CAO was 9.4% (overall: SE 1.4; men: 8.8%, SE 1.7; women: 10.1%, SE 2.2). Using the locally derived reference range, 3.0% (SE 0.8) of the study population had stage 2 or higher CAO (men: 2.9%, SE 0.9; women: 3.1%, SE 1.3). Similarly, participants aged 60–69 years had the highest prevalence of stage 2 or higher CAO using both the local and NHANES reference ranges (17.6%, SE 4.2 vs. 6.7%, SE 2.6).

Low FVC was observed in 62.7% (overall: SE 2.2; men: 65.2%, SE 2.8 vs. women: 59.8%, SE 3.5). Cough was less frequently reported in those with low FVC (odds ratio [OR] 0.48, 95% confidence interval [CI] 0.27–0.87). Airflow reversibility was found in 6.1% (SE 1.1) of the total study population and was more common in women than men (8%, SE 1.9 vs. 4.4%, SE 1.1). Airflow obstruction persisted after use of a BD in 8.4% (SE 4.7) of participants with reversibility (Figure 2).

Table 1 Characteristics of all subjects who completed a full BOLD core questionnaire, including those with and without spirometry results

Variable	*n* (%)
Age group, years ($n = 595$)	
40–49	226 (38.0)
50–59	200 (33.6)
60–69	108 (18.2)
≥70	61 (10.3)
Sex ($n = 595$)	
Male	353 (59.3)
Female	242 (40.7)
Level of education ($n = 593$)	
None	125 (21.1)
Primary school	207 (34.9)
Middle school	69 (11.6)
High school or above	192 (32.4)
Mean years of education ($n = 595$)	6.49 (5.5)
Smoking status ($n = 595$)	
Current smoker	55 (9.2)
Ex-smoker	86 (14.5)
Never smoked	454 (76.3)
Pack-years of smoking ($n = 595$)	
Never smoked	454 (76.3)
0–10	71 (11.9)
10–20	36(6.1)
≥20	34(5.7)
Biomass exposure ($n = 532$)	
Yes	422 (82.4)
No	90 (17.6)
Farm work for ≥3 months ($n = 527$)	
Yes	126 (23.9)
No	401 (76.1)
Body mass index, kg/m^2 ($n = 588$)	
Underweight (<18.5)	39 (6.6)
Normal (18.5–24.9)	226 (38.4)
Overweight (25.0–29.9)	189 (32.1)
Obese (≥30)	134 (22.8)
Reported history of TB ($n = 595$)	
Yes	5 (0.8)
No	590 (99.2)
Reported history of hypertension ($n = 595$)	
Yes	118 (19.8)
No	477 (80.2)
Reported history of diabetes ($n = 595$)	
Yes	54 (9.1)
No	541 (90.9)
Reported history of heart disease ($n = 595$)	
Yes	12 (2.0)
No	583 (98.0)

BOLD = Burden of Obstructive Lung Disease.

Factors associated with respiratory symptoms

In both univariable and multivariable analyses, chronic production of sputum was negatively associated with age. Participants aged 60–69 years were less likely to report chronic sputum production (OR 0.39, 95% CI 0.16–0.93) than those aged 40–49 years. There was a significantly increased likelihood of regular sputum production with being an ex-smoker (OR 2.66, 95% CI 1.09–6.50) and having diabetes (OR 4.04, 95% CI 1.82–8.96). Participants with lower socio-economic status who had a wealth score of 2 tended to have higher odds of sputum production than those with zero score (OR 7.18, 95% CI 1.16–44.53).

In multivariable analysis, having shortness of breath was significantly greater in participants exposed to indoor biomass fuel (OR 4.56, 95% CI 1.44–14.43). The presence of wheeze was only associated with being a current smoker (OR 3.49, 95% CI 1.02–11.96). There were no significant associations between CAO and respiratory symptoms.

Factors associated with post-bronchodilator airway obstruction

Participants aged 60–69 years had the highest risk of stage 1 or higher CAO (OR 3.16, 95% CI 1.20–8.31) and stage 2 or higher (OR 3.39, 95% CI 1.04–6.93) than those aged 40–49 years. In contrast, having higher education level was protective against any obstruction in bivariate analysis (OR 0.31, 95% CI 0.13–0.76); however, no association was found after adjustment. Similarly, being overweight or obese was protective against any obstruction (OR 0.38, 95% CI 0.17–0.82 and OR 0.34, 95% CI 0.13–0.99, respectively). Those with a history of TB were less likely to have any obstruction (OR 0.08, 95% CI 0.01–0.59). There was no observed trend in Mokken Scale points and CAO. However, participants with a low socio-economic position who scored >2 in wealth score had the highest odds of developing stage 1 or higher and stage 2 or higher CAO (OR 6.00, 95% CI 1.03–34.94). No other factor was significantly associated with airway obstruction (Table 2).

Using the local reference range, participants aged 60–69 years were more likely to have stage 1 or higher CAO than their younger counterparts (OR 3.10, 95% CI 1.01–9.57), and being obese were negatively associated with obstruction (OR 0.29, 95% CI 0.09–0.97) in multivariable analysis. A higher education level was protective against CAO in the bivariate analysis (OR 0.23, 95% CI 0.063–0.83); however, no association was identified after adjustment.

Factors associated with low forced vital capacity

Low FVC was associated with smoking history of 10–20 packs-year, having primary or higher-level education, having more people in the house and being obese (OR 2.79, 95% CI 1.11–7.00; OR 2.42, 95% CI 1.43–4.09; OR 0.94, 95% CI 0.89–0.99 and OR 1.73, 95% CI 1.04–2.86 respectively) in bivariate analysis. In multivariate analysis, those aged 50–59 were less likely to have low FVC than those aged 40–49 years (OR 0.50, 95% CI 0.31–0.81). No other factors were associated with low FVC in multivariate analysis (Table 3).

DISCUSSION

This study aimed to investigate the prevalence and determinants of CRDs in a population aged ≥40

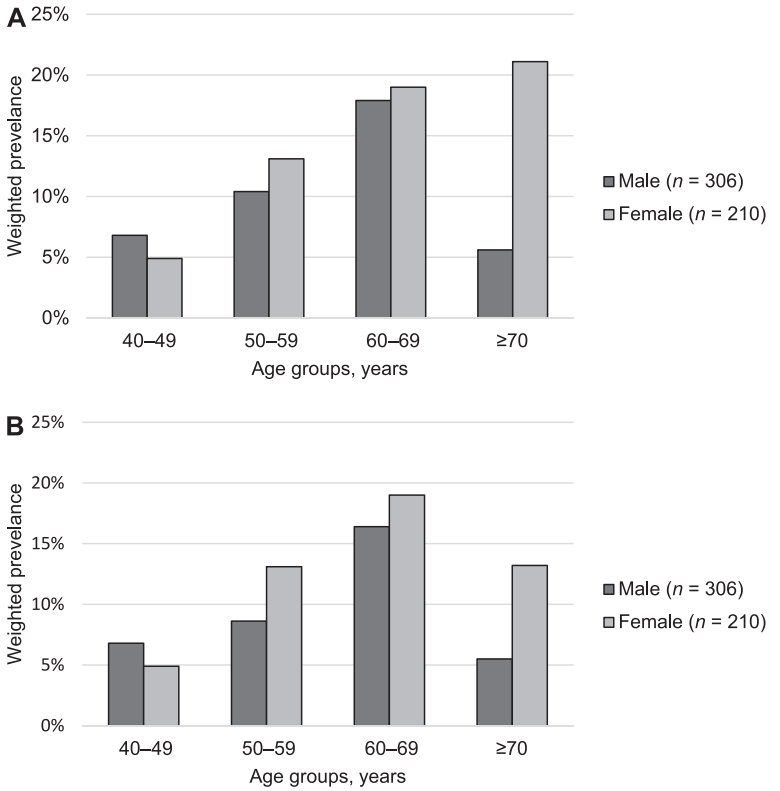


Figure 2 Estimated population prevalence of chronic airflow obstruction by age and sex using NHANES III reference ranges for the Sudanese population in participants completing standard American Thoracic Society spirometry ($n = 516$). **A)** Prevalence of stage 1 or higher CAO (post-BD $FEV_1/FVC <$ LLN); **B)** prevalence of stage 2 or higher CAO (post-BD $FEV_1/FVC <$ LLN and post-BD $FEV_1 < 80\%$ predicted). NHANES III = Third National Health and Nutrition Examination Survey; CAO = chronic airflow obstruction; BD = bronchodilator; FEV_1 = forced expiratory volume in 1 sec; FVC = forced vital capacity; LLN = lower limit of normal.

years in urban Sudan. Our main finding was that 10% of people in this age group had CAO. Stage II or higher CAO was detected in 9.4% of the overall population using the same reference range; however, this decreased to 3.0% when the local reference range was used. A higher prevalence of obstruction when using the NHANES III compared to the local reference range has been reported previously.[9] In spite of being the only available data, local estimations might be more ethnically suitable than the NHANES III. However, varying exposures in this setting may constrain its use.[9,15]

The prevalence of spirometric obstruction determined in this study is consistent with that in similar studies from sub-Saharan Africa where the prevalence of smoking is high.[16] Previous BOLD studies reported a COPD prevalence of 23% in men and 16.9% in women in South Africa,[17] and 7.7% in Nigeria.[7,18,19] CAO prevalence reported from a multinational BOLD study was 11.5% in men and 8.8% in women, which is consistent with our findings.[20] Compared to studies from the MENA (Middle East and North Africa) region, our findings are higher than those in Saudi Arabia,[21] Tunisia,[22,23] Morocco,[24] Algeria[25] and Lebanon.[26]

Older age was the main risk factor for CAO in our study, which is consistent with both regional and global findings.[7,9,16,18] The absence of an association with CAO and cigarette smoking might be due to the fact that 50% of the smokers in our study reported a smoking history of $\leq$10 pack-years. Countries with lower smoking rates, such as Malawi and Rwanda, have a lower reported prevalence of COPD.[9,27] However, the 60–69 years age group who reported the highest smoking rates in this study had the highest prevalence of spirometric obstruction and higher prevalence of both chronic cough and chronic phlegm. The high prevalence of CAO might be due to exposure to air pollutants coming from the large number of factories and cars in the State.

A higher educational level was protective against CAO, which is compatible with other studies.[10,18,28] Conversely, a significant association between low socio-economic status and developing CAO was found in this study, consistent with studies suggesting that low socio-economic status may be associated with a progression of airflow limitation.[16,29] The association between poverty, lung abnormality and COPD was previously reported in several studies.[14,17] Townend et al. reported that airflow obstruction is

Table 2 Multivariable associations of risk factors with stage 1 or higher CAO defined using NHANES III (post-BD $FEV_1/FVC < LLN$; $n = 53/516$) and stage 2 or higher CAO defined using NHANES III (post-BD FEV1/FVC < LLN and post-BD FEV_1 <80% predicted; $n = 49/516$)

	Multivariable association with CAO stage 1 or higher		Multivariable association with CAO stage 2 or higher	
Variable	OR	95% CI	OR	95% CI
Age group, years				
40–49	1.0	—	1.0	—
50–59	2.13	0.84–5.41	1.86	0.73–4.77
60–69	3.16*	1.20–8.32	2.78*	1.07–7.26
≥70	1.91	0.60–6.10	0.91	0.21–3.92
Sex				
Male	1.0	—	1.0	—
Female	1.31	0.61–2.84	1.67	0.76–3.66
Level of education				
None	1.0	—	1.0	—
Primary school	0.61	0.27–1.34	0.62	0.27–1.44
Middle school	1.23	0.40–3.81	1.03	0.32–3.36
High school or above	0.71	0.28–1.78	0.69	0.26–1.86
Body mass index, kg/m^2				
Underweight (<18.5)	1.87	0.66–5.30	1.16	0.33–4.07
Normal (18.5–24.9)	1.0	—	—	
Overweight (25.0–29.9)	0.43	0.18–1.01	0.37*	0.15–0.92
Obese (≥30)	0.35	0.11–1.17	0.29*	0.08–1.07
Self-reported TB				
No	1.0	—	1.0	0
Yes	0.08*	0.01–0.59	0.07*	0.01–0.48
Number of people living in household	†	†	1.05	0.96–1.16
Used firewood				
No	†	†	1.0	—
Yes	†	†	0.58	0.29–1.19
Wealth score/Mokken Scale	†	†	0.96	0.83–1.11

* $P < 0.05$.
† Not included in multivariable analysis.
CAO = chronic airflow obstruction; NHANES = National Health and Nutrition Examination Survey; BD = bronchodilator; FEV_1 = forced expiratory volume in 1 sec; FVC = forced vital capacity; LLN = lower limit of normal; OR = odds ratio; CI = confidence interval.

Table 3 Multivariable associations of risk factors with low FVC, defined using NHANES III reference range (FVC < LLN) ($n = 315/516$)

	Multivariable association	
Variable	OR	95% CI
Age group, years		
40–49	1	—
50–59	0.50*	0.31–0.81
60–69	0.29*	0.17–0.51
≥70	0.25*	0.12–0.53
Sex		
Male	1	—
Female	0.78	0.48–1.24
Body mass index, kg/m^2		
Underweight (<18.5)	0.95	0.43–2.07
Normal (18–25)	1	—
Overweight (25–30)	1.39	0.85–2.27
Obese (>30)	1.55	0.87–2.80
Packs-year of smoking		
Never	1	—
0–10	1.09	0.59–2.02
10–20	2.45	0.88–6.86
≥20	1.00	0.47–2.11
Wealth score/Mokken Scale	0.97	0.90 -1.04

* $P < 0.05$.
FVC = forced vital capacity; NHANES = National Health and Nutrition Examination Survey; LLN = lower limit of normal; OR = odds ratio; CI = confidence interval.

always associated with poverty at both individual and community levels.[14] Low access to high-quality healthcare, harmful early life and environmental exposures, and difficult social and political environments, which are poverty-related factors, are among the challenges that people face in LMICs.[4,17] It is therefore likely that poverty and low socio-economic status contributed to the prevalence of CAO in our study.

We did not observe any association between exposure to biomass fuel and obstruction. This is consistent with the study that included 25 BOLD sites,[30] and findings in other large studies in China.[31,32] A recent review of studies on COPD and household air pollution concluded that it was not possible to establish clear causal links between the two.[33] Shortness of breath, one of the most common symptoms of CAO, was significantly higher in those who used biomass fuel for ≥6 months. It is possible that this latter group suffer from chronic bronchitis or similar non-obstructive lung diseases.

The finding that only 0.2% reported TB might account for the significant negative association between TB and obstruction, which is in conflict with published literature.[34] Identification of TB was

based on self-reporting and many factors might affect the validity of the answers provided, given that TB is a highly stigmatised clinical condition so the proportion reported here may be an underestimate.[35]

A high prevalence of low FVC (62.7%) was identified in this study. BOLD studies in SSA and other studies in resource-poor settings reported similar findings.[9,17] That 55% of the study population was overweight might partly explain the high level of low FVC.[8]

Although we did not observe an any other associations between CAO, low FVC and other factors, early life exposures to indoor air pollution, in utero exposure, pre-term birth, malnutrition and childhood respiratory infections, TB and chronic HIV infection might affect lung development and lead to lung damage or abnormal lung functions in such settings.[4,9,17] Studies suggested that African populations might have smaller lungs[9] and reduced FVC[8] than Caucasians. Nonetheless, it is still unclear if there is a linear relationship between exposure to indoor air pollution and lung development in African children. Some studies found that early exposure during the early weeks of birth affects rates of lung growth; however, this was not statistically significant.[4] Other studies reported that excessive exposure to indoor air pollution and biomass consumption cause repeated respiratory tract infections in children, which have been indicated to be an associated risk factor for reduced lung function by 1 year of age.[4]

To our knowledge, this is the first study to provide detailed prevalence estimates of CAO in Sudanese adults using internationally standardised methods and procedures, as well as an appropriate sampling technique. We acknowledge our study had limitations. The cluster-weighted analysis was limited as information for some study participants was missing. Furthermore, the grounds for exclusion were not documented; therefore, it was impossible to distinguish between individuals who were eliminated for medical reasons and those who were excluded for other reasons. The sample size and study power were reduced because 54 participants had unacceptable spirometry readings and 79 participants had spirometry readings but no matching questionnaire data.

In conclusion, this study found evidence that CRD is a major problem in Sudan and needs to be considered in future public health policies and research. The overall prevalence of CAO in urban Sudan is similar to that found by other BOLD studies in countries with similar smoking rates. However, it is relatively high when compared to other countries in SSA and the MENA region. A high prevalence of low FVC was also identified, the aetiology and pathophysiology of which are unknown and require further investigation. These findings suggest the need for strengthening CRD programmes and the provision of improved diagnostic and treatment options for CRDs to address underestimation and diagnosis.

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RÉSUMÉ

CONTEXTE : Les maladies respiratoires chroniques (CRD) sont considérées comme une cause importante de morbidité et de mortalité dans le monde, bien que les données provenant de l'Afrique soient limitées. Cette étude visait à déterminer la prévalence et les déterminants des CRD à Khartoum, au Soudan.

MÉTHODES : Les données ont été collectées auprès de 516 participants âgés de ≥40 ans, qui avaient rempli un questionnaire et effectué des tests de spirométrie avant et après l'utilisation d'un bronchodilatateur. Des travailleurs de terrain formés ont administré les questionnaires et effectué les spirométries. La prévalence pondérée par enquête des symptômes respiratoires et des anomalies spirométriques a été estimée. Des modèles d'analyse de régression ont été utilisés pour identifier les facteurs de risque de maladies pulmonaires chroniques.

RÉSULTATS : En utilisant les équations de référence de la troisième Enquête nationale sur la santé et la nutrition, 1988–1994 (NHANES III), la prévalence de l'obstruction chronique des voies respiratoires était de 10%. Le principal facteur de risque était l'âge avancé, 60–69 ans (OR 3,16 ; IC 95% 1,20–8,31). Un faible niveau d'éducation, un indice de masse corporelle élevé et des antécédents de TB ont également été identifiés comme des facteurs de risque significatifs. La prévalence d'une capacité vitale forcée (FVC) basse utilisant NHANES III était de 62,7% (SE 2,2) et de 11,3% (SE 1,4) en utilisant des valeurs obtenues localement.

CONCLUSION : La prévalence d'anomalies spirométriques, principalement une FVC basse, était élevée, ce qui suggère que les CRD revêtent une importance considérable pour la santé publique dans les zones urbaines du Soudan. Des stratégies de prévention et de contrôle de ces problèmes sont nécessaires.