Prevalence of chronic respiratory disease in urban and rural Uganda

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Abstract

Objective To determine the prevalence of chronic respiratory diseases in urban and rural Uganda and to identify risk factors for these diseases.

Methods The population-based, cross-sectional study included adults aged 35 years or older. All participants were evaluated by spirometry according to standard guidelines and completed questionnaires on respiratory symptoms, functional status and demographic characteristics. The presence of four chronic respiratory conditions was monitored: chronic obstructive pulmonary disease (COPD), asthma, chronic bronchitis and a restrictive spirometry pattern.

Findings In total, 1502 participants (average age: 46.9 years) had acceptable, reproducible spirometry results: 837 (56%) in rural Nakaseke and 665 (44%) in urban Kampala. Overall, 46.5% (698/1502) were male. The age-adjusted prevalence of any chronic respiratory condition was 20.2%. The age-adjusted prevalence of COPD was significantly greater in rural than urban participants (6.1 versus 1.5%, respectively; \( P < 0.001 \)), whereas asthma was significantly more prevalent in urban participants: 9.7% versus 4.4% in rural participants (\( P < 0.001 \)). The age-adjusted prevalence of chronic bronchitis was similar in rural and urban participants (3.5 versus 2.2%, respectively; \( P = 0.62 \)), as was that of a restrictive spirometry pattern (10.9 versus 9.4%; \( P = 0.82 \)). For COPD, the population attributable risk was 51.5% for rural residence, 19.5% for tobacco smoking, 16.0% for a body mass index \( < 18.5 \) kg/m\(^2\) and 13.0% for a history of treatment for pulmonary tuberculosis.

Conclusion The prevalence of chronic respiratory disease was high in both rural and urban Uganda. Place of residence was the most important risk factor for COPD and asthma.
Introduction
Chronic respiratory disease affects one billion people worldwide and is a leading cause of death.\textsuperscript{1} Most forms of the disease are noncommunicable, such as chronic obstructive pulmonary disease (COPD), asthma, chronic bronchitis, occupational lung disease and pulmonary hypertension. Currently, the associated morbidity and mortality principally occur in low- and middle-income countries, where the disease burden is expected to rise as rapid economic gains lead to increases in longevity, industrialization and tobacco consumption.\textsuperscript{1–3} In addition to its impact on individuals, this epidemiological transition has substantial direct and indirect economic implications.\textsuperscript{4}

Urbanization has been associated with noncommunicable diseases, including chronic respiratory disease,\textsuperscript{5,6} and is expected to increase as virtually all future population growth will be concentrated in urban areas.\textsuperscript{7} There are particular concerns about sub-Saharan Africa, where rapid urbanization and population growth are coupled with an inadequate health infrastructure and poor urban planning.\textsuperscript{7} Little is known about the association between urbanization and the shifting burden of chronic respiratory disease in low- and middle-income countries, particularly those in sub-Saharan Africa. Previous studies have examined the prevalence of COPD in either rural or urban settings,\textsuperscript{8–10} but none has investigated how the pattern chronic respiratory disease varies across different residential settings with the aim of evaluating the impact of the urban environment. Moreover, understanding of the population attributable risk (PAR) for different chronic respiratory diseases in African populations is limited. Nevertheless, COPD has been closely linked to household air pollution in rural areas in low- and middle-income countries and the disease burden is expected to increase in urban areas with the growing prevalence of tobacco smoking.\textsuperscript{2}

The primary aim of this study was to examine variations in the prevalence of different chronic respiratory diseases and their attributable risk factors between urban and rural Uganda. In both settings, we assessed the respiratory symptoms and functional status of individuals with obstructive lung disease.

Methods
We conducted a cross-sectional, population-based cohort study in an urban centre and a rural district in Uganda. The urban sample was drawn from Kampala, the capital city, which had a
population of 1.5 million in an estimated 416,070 households in 2014. The rural sample was drawn from Nakaseke, a health district covering 43,167 households with an estimated population of 208,500. Nakaseke, which is located 50 km from downtown Kampala and 14 km from the nearest highway, has been defined as rural by the Uganda Bureau of Statistics (Fig. 1).

Twenty-five enumeration areas each were selected for the urban and rural setting, with the probability of selection proportional to the population size of the enumeration area, and 1000 adults were randomly sampled in each setting. Fieldworkers conducted home visits between November 2015 and June 2016 to assess eligibility and obtain informed consent. Inclusion criteria included: (i) age 35 years or older; (ii) full-time residency in either Kampala or Nakaseke; and (iii) capacity to consent to the study. Exclusion criteria included having active pulmonary tuberculosis or a current respiratory infection and pregnancy. The study was approved by the institutional review boards of Mulago Hospital and the Uganda National Council of Science and Technology in Kampala, Uganda and the Johns Hopkins School of Medicine in Baltimore, United States of America.

Anthropometric measurements were taken in triplicate. Spirometry was carried out using an Easy on-PC spirometer (ndd, Zürich, Switzerland) and participants with low-quality results were asked to repeat the test on another day for up to three attempts. Those with evidence of pulmonary obstruction were tested again after administration of a bronchodilator (i.e. 400 µg of inhaled salbutamol). As there were no established reference parameters for lung function among Ugandans, we used the reference for African American individuals in the United States’ National Health and Nutrition Examination Survey. We defined pulmonary obstruction as a pre-bronchodilator ratio of forced expiratory volume in 1 second (FEV1) to forced vital capacity (FVC) below the lower limit of normal (i.e. a z-score ≤−1.64).

We investigated four chronic respiratory conditions: (i) COPD, defined as a post-bronchodilator FEV1/FVC ratio z-score ≤−1.64; (ii) a restrictive spirometry pattern, defined as a pre-bronchodilator FVC z-score ≤−1.64 with a post-bronchodilator FEV1/FVC ratio z-score >−1.64; (iii) asthma, defined as a self-reported wheeze, use of asthma medication in the previous 12 months or a physician’s diagnosis of asthma; and (iv) chronic bronchitis, defined as self-reported phlegm production for at least 3 months each year in two successive years. In addition, we examined airflow-limitation reversibility, defined as a post-bronchodilator increase
in FEV\textsubscript{1} of 12\% or more from baseline or an increase in FVC of 200 mL or more.\textsuperscript{16} Respiratory symptoms and functional status were evaluated using the St. George’s Respiratory Questionnaire, version 1 of the 36-item short-form health survey (SF-36) and a modified BOLD (Burden of Obstructive Lung Disease) questionnaire,\textsuperscript{10,20,21} all adapted to the local language (i.e. Luganda).

Demographic questionnaires asked for details of biomass fuel smoke exposure, human immunodeficiency virus (HIV) infection and history of treatment for pulmonary tuberculosis. Individuals in households that used wood or charcoal for cooking or heating were regarded as being exposed to biomass fuel smoke. Daily smoking was defined as self-reported smoking of one or more cigarettes per day, underweight, as a body mass index (BMI) \(<18.5 \text{ kg/m}^2\) and obesity, as a BMI \(\geq 30 \text{ kg/m}^2\).

**Biostatistical methods**

Our primary aims were to determine how the age- and sex-adjusted prevalence of chronic respiratory diseases varied according to place of residence (i.e. urban or rural) and to estimate the fraction of chronic respiratory disease that could be attributed to urbanization. Risk factors for chronic respiratory conditions were identified using single variable and multivariable logistic regression models; as risk factors, we included sex, age, place of residence, daily smoking, use of biomass fuels, history of treatment for pulmonary tuberculosis, history of HIV infection and BMI. The adjusted odds ratios from these models were used to calculate attributable fractions for different risk factors in our study population and represent the proportional reduction in morbidity that would result if exposure to a particular risk factor were removed.\textsuperscript{22} Associations between these risk factors, FEV\textsubscript{1}, FVC and FEV\textsubscript{1}/FVC ratio z-scores were evaluated using multivariable linear regression models. In addition, multivariable logistic regression was used to analyse the association between reversibility and these risk factors. For other analyses, a \(\chi^2\) or Fisher’s exact test was used to compare proportions between groups and a \(t\) test, analysis of variance or Wilcoxon rank–sum test was used to compare continuous variables between subgroups, as appropriate. All analyses were carried out in R (The R Foundation, Vienna, Austria) and we used the epitools package to perform direct standardization by age using population structure data for 2015 from the Uganda Bureau of Statistics.\textsuperscript{11,23,24}
Results
Of the 2000 individuals originally identified for enrolment in the study, 1772 met inclusion criteria, consented and agreed to undergo spirometry. Ultimately, 84.8% (1502/1772) had acceptable and reproducible spirometry results (Table 1): their average age was 46.9 years (standard deviation, SD: 10.6) and 46.5% (689/1502) were male. Self-reported biomass fuel smoke exposure was high in both rural and urban settings; in rural settings, 99.6% (832/837) of individuals reported using biomass fuels for cooking. The type of biomass fuel varied: 92.3% (771/837) of rural participants reported using wood, whereas 86.0% (564/665) of urban participants reported using charcoal. We did not find any difference between the settings in self-reported history of HIV infection or treatment for pulmonary tuberculosis or in household size. However, a significantly greater percentage of participants in the urban setting had had a secondary education (P < 0.001).

Prevalence and risk factors
The overall age- and sex-adjusted prevalence of the four chronic respiratory conditions studied was 20.2%: 20.8% in the rural and 19.4% in the urban setting (P = 0.54). For COPD, the adjusted prevalence was 6.1% in rural participants versus 1.5% in urban participants (P < 0.001). In contrast, asthma was more prevalent in urban participants, in whom the adjusted prevalence was 9.7% compared with 4.4% in rural participants (P < 0.001; Fig. 2). The adjusted prevalence of chronic bronchitis was similar in rural and urban participants (3.5% versus 2.2%, respectively; P = 0.62), as was that of a restrictive spirometry pattern (10.9% versus 9.4%, respectively; P = 0.82).

The most important factor associated with COPD was living in a rural environment, followed by daily smoking, a BMI < 18.5 kg/m² and a history of treatment for pulmonary tuberculosis. Specifically, 51.5% (95% confidence interval, CI: 13.5–75.8) of the prevalence of COPD was attributable to living in a rural environment, 19.5% (95% CI: 3.1–45.2) was attributable to daily smoking, 16.0% (95% CI: 4.3–35.1) was attributable to a BMI < 18.5 kg/m² and 13.0% (95% CI: 3.5–30.8) was attributable to a history of treatment for pulmonary tuberculosis (Fig. 3). For asthma, urban residence was the principal risk factor, with a PAR of 41.4% (95% CI: 14.2–63.1). The PAR of a history of treatment for pulmonary tuberculosis was
9.5% (95% CI: 0.8–29.8) for chronic bronchitis and 5.4% (95% CI: 0.2–16.4) for a restrictive spirometry pattern.

**Symptoms and functional status**

Although the reported rate of wheezing in the past 12 months was similar in urban and rural participants, the rate of asthma-related medication use and of a previous diagnosis of asthma were significantly higher in urban participants (Table 2). In addition, the reported number of days of work missed due to respiratory disease and the rate of shortness of breath were both higher in the urban setting. There was no significant difference between the groups in respiratory symptoms, as assessed using the St. George’s Respiratory Questionnaire (Table 3). Participants from the urban setting reported fewer impairments in emotional well-being than those from the rural setting: the mean SF-36 score was 57.2 and 77.3 points, respectively (P = 0.001). There was no difference in physical functioning, social functioning, role limitation because of emotional problems, or overall health between the groups.

**Lung function**

In all participants, the mean ± SD pre-bronchodilator FEV₁, FVC and FEV₁/FVC ratio was 2.53 ± 0.66 L, 3.18 ± 0.75 L and 0.79 ± 0.08, respectively. Fig. 4 presents the distribution of the pre-bronchodilator FEV₁/FVC ratio z-score, stratified by place of residence and sex. Both female and male participants in the rural setting had a lower FEV₁/FVC ratio than their urban counterparts. Among participants found to have pulmonary obstruction on pre-bronchodilator spirometry, the proportion with a post-bronchodilator FEV₁ less than 50% of predicted was higher in the rural than the urban setting: 18.9% (10/53) versus 8.3% (1/12), respectively. However, the difference was not significant (P = 0.67). Fig. 5 shows the estimated effect of sociodemographic and clinical variables on the pre-bronchodilator FEV₁, FVC and FEV₁/FVC ratio, as determined by multivariable regression analysis. A history of treatment for pulmonary tuberculosis was significantly associated with a low adjusted pre-bronchodilator FEV₁ (p<0.001) FVC (P < 0.001) and FEV₁/FVC ratio (P < 0.001); living in a rural environment was significantly associated with a low adjusted pre-bronchodilator FEV₁ (P = 0.009) and FEV₁/FVC ratio (P < 0.001); and self-reported daily tobacco smoking was significantly associated with a low adjusted pre-bronchodilator FEV₁/FVC ratio (P = 0.001). Among participants with obstruction, 26.2% (17/65) exhibited reversibility on post-bronchodilator spirometry – the
proportion was 50.0% (6/12) in the urban setting and 20.8% (11/53) in the rural setting (P = 0.065).

Discussion

Although previous studies in Uganda and sub-Saharan Africa have examined the prevalence of, and risk factors for, single respiratory diseases,\(^8\)-\(^10\) few have examined the effect of urbanization on a range of chronic respiratory diseases and none has assessed the PAR. We found that one in every five adults in our study had a chronic respiratory condition and that place of residence was the single most important PAR factor. Specifically, 40% of people with asthma were attributable to urban residence and 50% of people with COPD were attributable to rural residence (a proxy for daily wood smoke exposure), which was a more important factor than tobacco smoking.

Many participants in both urban and rural settings had a low lung volumes – this was associated with a history of treatment for pulmonary tuberculosis and being underweight, both of which are common in low- and middle-income countries.

Published data on the prevalence of chronic respiratory diseases in low- and middle-income countries cover a wide range. In the BOLD study, the prevalence of COPD in primarily urban environments ranged from 11.4 to 23.8% and that of a restrictive spirometry pattern ranged from 4.2 to 48.7%.\(^{10,26}\) In Uganda, a FRESH AIR study found a COPD prevalence of 16.2% in a rural setting.\(^8\) The prevalence in our study was lower: 6.1% in rural and 1.5% in urban participants. There are several possible reasons for the varying estimates: (i) there may have been differences between the studies in the spirometry criteria used to diagnose COPD;\(^{27}\) (ii) the proportion of tobacco smokers was higher in the FRESH AIR study, which covered a tobacco-growing region, than in our study (36% versus 9%, respectively) or in other parts of Uganda;\(^8,28\) and (iii) the average age of participants was lower in our study than in the BOLD study: 47 versus 56 years, respectively.\(^{10}\) The difference in estimates is unlikely to have been due to differences in the proportion of participants with acceptable spirometry between our study (84.8%) and either BOLD (93%) or FRESH AIR (97%).\(^8,10\)

The prevalence of chronic bronchitis in our study was 3.3%, which was similar to that in the BOLD study (i.e. 3.1%) and in a population-based study in South Africa (i.e. 2.3 to 2.8%).\(^{29,30}\) We found no difference between urban and rural settings, possibly because both ambient air pollution exposure in urban Kampala and household air pollution exposure in rural...
Nakaseke were high. The prevalence of wheezing and of a physician's diagnosis of asthma were similar in our study and in a population-based study in sub-Saharan Africa. Further, the overall prevalence of asthma was higher in our urban sample than our rural sample, which is consistent with findings in both high- and low-income regions, including sub-Saharan Africa.

Urban populations, particularly in low- and middle-income countries, are exposed to several risk factors that predispose to smaller lungs and accelerated lung function decline. Early life events, such as childhood respiratory infection, micronutrient deficiency and both ambient and household air pollution, can influence lung size and function, thereby predisposing individuals to obstructive pulmonary disease in adulthood. High cortisol and inflammatory biomarker levels due to urban stressors have been linked to lung injury. Exposure to indoor and outdoor allergens, pollutants and irritants during the early years of life may tip a child's immune system's response from a non-asthma to an asthma phenotype, thereby leading to adult asthma. Diminished early exposure to parasites (exposure results in parasite-induced immunoglobulin-E) may lead to the development of atopic disease. Greater exposure to additives and synthetic foods may influence nutrition, which has been associated with asthma. A higher risk of communicable diseases such as tuberculosis and recurrent pulmonary infection can predispose to chronic respiratory diseases such as COPD, restrictive lung disease, asthma, chronic bronchitis and bronchiectasis. Our findings reflect the effect of exposure to these risk factors on airway and parenchymal injury and disease and are consistent with previous data on the distribution of chronic respiratory disease in urban and rural environments in low- and middle-income countries.

The leading risk factor for several chronic respiratory diseases in both urban and rural settings remains chronic inflammation due to exposure to environmental substances. Although cigarette exposure is low in many African countries, it is expected to rise with growing urbanization over the next two decades, thereby increasing the prevalence of chronic respiratory disease. Today, household air pollution remains the leading cause of COPD. In our study, biomass fuel was commonly used for cooking at both rural and urban sites though the type of fuel was different: the primary fuel was wood at rural sites and charcoal at urban sites. We were unable to assess differences in the relative risk of different types of fuel. However, burning wood emits more particulate matter than burning charcoal or liquefied petroleum gas and there have
been reports that respiratory symptoms are more common in individuals in low- and middle-income countries who use wood than in those who use charcoal or liquefied petroleum gas.38

Our study has several strengths. First, it had a large population-based design and comprehensive spirometry and respiratory data were collected. Second, we used the lower limit of normal for African American individuals in the National Health and Nutrition Examination Survey to identify COPD and a restrictive spirometry pattern – this helped prevent overdiagnosis of obstruction and restriction, particularly in elderly people.27 Third, by calculating PARs, we were able to gain a better understanding of the risk factors for chronic respiratory diseases. Our study also has some potential shortcomings. First, we were unable to recruit 15.2% (270/1772) of individuals who met inclusion criteria after two follow-up visits; nevertheless, our non-response rate was lower than in many other studies. Second, participants who had incomplete spirometry results were predominantly elderly or had severe respiratory disease, which highlights the difficulty of spirometry in those with reduced pulmonary function. The disease burden may, therefore, have been underestimated. Third, urban participants were younger than rural participants, which may have affected the crude disease prevalence; however, we calculated age- and sex-adjusted prevalences to reduce the risk of bias. Fourth, we defined asthma as a self-reported wheeze, use of asthma medications or a physician’s diagnosis. The last two criteria are closely linked to health-care access and utilization, which may be influenced by socioeconomic status. Consequently, the higher rates we observed for these two criteria among urban participants may reflect better access to health care. However, post-bronchodilator reversibility, which indicates greater airway reactivity, was significantly more common in urban residents with obstruction. Fifth, we did not assess individual exposure to air pollution. Better understanding of the association between urbanization and chronic respiratory disease requires longitudinal assessment of individual exposure to air pollution.

The increase in urbanization over the next two decades is expected to occur almost exclusively in low- and middle-income countries and, by 2030, half of sub-Saharan Africa’s population will reside in an urban area.7 However, poor infrastructure and a lack of policy interventions aimed at sustainable urban growth will have severe health implications for many countries in Africa, Asia and Latin America. Future public health interventions will depend on a good understanding of the evolving disease burden. Currently, chronic respiratory disease is associated with chronic inflammation throughout life, whether due to household air pollution, the
urban microenvironment (e.g. allergens and outdoor air pollution) or recurrent pulmonary infection. As urban dwellers transition to cleaner fuels for cooking and heating, cigarette exposure and outdoor air pollution will become increasingly important risk factors.

In summary, we found a high burden of chronic respiratory disease in both rural and urban Uganda. Place of residence was the single most important risk factor: urban residence was the principal risk factor for asthma and rural residence was the principal risk factor for COPD. As urbanization continues in sub-Saharan Africa, the profile and burden of chronic respiratory disease are likely to change in parallel.

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**Competing interests:**
None declared.

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Table 1. **Study participants, chronic respiratory disease in rural and urban Uganda, 2015–2016**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Rural sample (n=637)</th>
<th>Urban sample (n=665)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age in years, mean (SD)</strong></td>
<td>49.1 (11.2)</td>
<td>44.1 (8.9)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Male sex, no. (%)</strong></td>
<td>380 (45.4)</td>
<td>318 (47.8)</td>
<td>0.40</td>
</tr>
<tr>
<td><strong>Height in m, mean (SD)</strong></td>
<td>1.60 (0.1)</td>
<td>1.62 (0.1)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>BMI, mean (SD)</strong></td>
<td>24.0 (4.5)</td>
<td>25.9 (5.4)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Secondary education, no. (%)</strong></td>
<td>173 (21)</td>
<td>328 (50)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Household size, median (IQR)</strong></td>
<td>5 (3–7)</td>
<td>5 (3–7)</td>
<td>0.50</td>
</tr>
<tr>
<td><strong>Biomass fuel smoke exposure, no. (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Daily biomass fuel use</td>
<td>832 (99.6)</td>
<td>614 (93.6)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td><strong>Fuel type</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wood</td>
<td>771 (92.3)</td>
<td>50 (7.6)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Charcoal</td>
<td>61 (7.3)</td>
<td>564 (86.0)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Kerosene</td>
<td>1 (0.1)</td>
<td>22 (3.4)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Propane</td>
<td>0 (0.0)</td>
<td>12 (1.8)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Electricity</td>
<td>2 (0.2)</td>
<td>6 (0.9)</td>
<td>0.16</td>
</tr>
<tr>
<td>Other</td>
<td>0 (0.0)</td>
<td>2 (0.3)</td>
<td>0.38</td>
</tr>
<tr>
<td><strong>Daily tobacco smoking, no. (%)</strong></td>
<td>66 (7.9)</td>
<td>65 (9.8)</td>
<td>0.20</td>
</tr>
<tr>
<td><strong>Clinical history, no. (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Personal history of treatment for pulmonary tuberculosis</td>
<td>22 (3.0)</td>
<td>22 (3.6)</td>
<td>0.70</td>
</tr>
<tr>
<td>Personal history of hypertension</td>
<td>80 (9.8)</td>
<td>77 (13.3)</td>
<td>0.05</td>
</tr>
<tr>
<td>Personal history of diabetes</td>
<td>5 (0.7)</td>
<td>22 (4.5)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Personal history of HIV infection</td>
<td>68 (8.1)</td>
<td>65 (9.8)</td>
<td>0.67</td>
</tr>
<tr>
<td>Family history of asthma or COPD</td>
<td>6 (1.0)</td>
<td>137 (33.6)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

BMI: body mass index; COPD: chronic obstructive pulmonary disease; HIV: human immunodeficiency virus; IQR: interquartile range; SD: standard deviation.
Table 2. **Chronic respiratory disease symptoms, by rural or urban residence, Uganda, 2015-2016**

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Rural sample (n=637)</th>
<th>Urban sample (n=665)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Asthma</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-reported wheezing or whistling in the chest in the past 12 months</td>
<td>47 (5.6)</td>
<td>39 (5.9)</td>
<td>0.99</td>
</tr>
<tr>
<td>Self-reported medication use to aid breathing in the past 12 months</td>
<td>17 (2.0)</td>
<td>51 (7.7)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Previous diagnosis of asthma</td>
<td>7 (0.8)</td>
<td>16 (2.4)</td>
<td>0.04</td>
</tr>
<tr>
<td><strong>Chronic bronchitis</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-reported coughing up sputum for at least 3 months in each of two successive years</td>
<td>27 (3.2)</td>
<td>16 (2.4)</td>
<td>0.41</td>
</tr>
<tr>
<td><strong>Functional status</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-reported experience of missing work due to, or having daily activities impeded by, respiratory problems in the past 12 months</td>
<td>7 (0.8)</td>
<td>26 (3.9)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Self-reported shortness of breath on physical exertion</td>
<td>73 (8.7)</td>
<td>154 (23.2)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>
Table 3. **Disease severity and health-related quality of life, study participants with chronic obstructive pulmonary disease in rural and urban Uganda, 2015-2016**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Rural participants with COPD&lt;sup&gt;a&lt;/sup&gt; (&lt;i&gt;n&lt;/i&gt; = 53)</th>
<th>Urban participants with COPD&lt;sup&gt;a&lt;/sup&gt; (&lt;i&gt;n&lt;/i&gt; = 12)</th>
<th>&lt;i&gt;P&lt;/i&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>COPD severity,&lt;sup&gt;b&lt;/sup&gt; no. (%)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mild</td>
<td>20 (37.7)</td>
<td>3 (25.0)</td>
<td>ND</td>
</tr>
<tr>
<td>Moderate</td>
<td>23 (43.4)</td>
<td>8 (66.7)</td>
<td>ND</td>
</tr>
<tr>
<td>Severe</td>
<td>10 (18.9)</td>
<td>0 (0.0)</td>
<td>ND</td>
</tr>
<tr>
<td>Very severe</td>
<td>0 (0.0)</td>
<td>1 (8.3)</td>
<td>ND</td>
</tr>
<tr>
<td><strong>St. George's Respiratory Questionnaire score,&lt;sup&gt;20&lt;/sup&gt; mean (95% CI)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Symptoms domain</td>
<td>48.3 (40.5–56.1)</td>
<td>63.2 (51.6–74.8)</td>
<td>0.07</td>
</tr>
<tr>
<td>Activity domain</td>
<td>37.4 (26.8–48.0)</td>
<td>34.1 (17.8–50.5)</td>
<td>0.76</td>
</tr>
<tr>
<td>Psychosocial impact domain</td>
<td>27.4 (19.0–35.9)</td>
<td>32.0 (21.4–42.7)</td>
<td>0.59</td>
</tr>
<tr>
<td>Total</td>
<td>34.6 (25.5–43.6)</td>
<td>38.1 (27.4–48.7)</td>
<td>0.70</td>
</tr>
<tr>
<td><strong>MRC dyspnoea scale score, median (IQR)</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>2 (1–2)</td>
<td>2 (2–3)</td>
<td>0.12</td>
</tr>
</tbody>
</table>

CI: confidence interval; COPD: chronic obstructive pulmonary disease; IQR: interquartile range; MRC: Medical Research Council; ND: not determined.

<sup>a</sup> Chronic obstructive pulmonary disease (COPD) was defined as a post-bronchodilator ratio of forced expiratory volume in 1 second (FEV<sub>1</sub>) to forced vital capacity (FVC) below the lower limit of normal (i.e. z-score ≤1.64) of the African American reference population in the United States National Health and Nutrition Examination Survey (NHANES).

<sup>b</sup> COPD severity was defined by the GOLD criteria as mild (i.e. FEV<sub>1</sub> ≥80% predicted), moderate (i.e. 50% ≤ FEV<sub>1</sub> < 80% predicted), severe (i.e. 30% ≤ FEV<sub>1</sub> < 50% predicted) and very severe (FEV<sub>1</sub> < 30% predicted).<sup>25</sup>
Fig. 1. Kampala and Nakaseke enumeration areas, study of chronic respiratory disease in rural and urban Uganda, 2015–2016

Note: In each image, the highlighted area represents one of the 25 enumeration areas selected randomly in each setting with the probability of selection proportional to the population size of the enumeration area. Maps obtained from Google Earth version 9.0 (2017 Apr 8). Kampala, Uganda: 0°20'51"N, 32°35'15"E, Eye alt 1,176m. CNES/Airbus 2018. Nakaseke, Uganda: 0°41'59"N, 32°24'42"E, Eye alt 1,176m. DigitalGlobe 2018.
Fig. 2. **Crude and age- and sex-adjusted prevalence of chronic respiratory disease in rural and urban Uganda, 2015-2016**

CI: confidence interval; COPD: chronic obstructive pulmonary disease.

Note: Age- and sex-adjusted values were calculated using mid-year estimates for 2015 from the Uganda Bureau of Statistics.
Fig. 3. Risk factors for chronic respiratory conditions, Uganda, 2015-2016

BMI: body mass index; CI: confidence interval; COPD: chronic obstructive pulmonary disease; HIV: human immunodeficiency virus; PAR: population attributable risk.

Notes: The four chronic respiratory conditions considered were chronic obstructive pulmonary disease (COPD), a restrictive spirometry pattern, asthma and chronic bronchitis.
Fig. 4. **Lung function, by sex and place of residence, Uganda, 2015–2016**

FEV₁: forced expiratory volume in 1 second; FVC: forced vital capacity.

Notes: The figure shows pre-bronchodilator FEV₁/FVC ratio z-score distribution. Each bar represents a 0.2 increment in z-score. Bars that include the 5th, 10th, 25th, 50th, 75th, 90th or 95th percentile in each distribution are labelled accordingly. The z-scores were calculated using data for the African American reference population in the United States’ National Health and Nutrition Examination Survey (NHANES).
Fig. 5. Estimated effect of sociodemographic and clinical variables on lung function, Uganda, 2015–2016

BMI: body mass index; CI: confidence interval; FEV₁: forced expiratory volume in 1 second; FVC: forced vital capacity; HIV: human immunodeficiency virus.

Notes: Mean absolute differences in z-scores and corresponding 95% CI were obtained from multivariable regression analysis. A normal BMI was in the range 20–25 kg/m².