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Prevalence of atopy, asthma and COPD in an urban and a rural area of an African country

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Summary
The objectives of this study were to determine the prevalence of asthma, atopy and COPD in Rwanda and to identify risk factors. The survey was conducted in Kigali, the Capital of Rwanda, and in Huye District, a rural area located in southern Rwanda.
Methods: A total of 2138 subjects were invited to participate in the study.1920 individuals (90%) answered to questionnaires on respiratory symptoms and performed spirometry, 1824 had acceptable spirograms and performed skin-prick test. In case of airflow obstruction (defined as pre-bronchodilator ratio $FEV_1/FVC < LLN$) a post bronchodilator spirometry was performed. Reversibility was defined as an increase in FEV_1 of 200 ml and 12% above baseline FEV_1 after inhalation of 400 mcg of salbutamol.
Results: The mean age was 38.3 years; 48.1% of participants were males and 51.9% females. Airflow obstruction was found in 256 participants (14%); 163(8.9%) subjects were asthmatics and 82 (4.5%) had COPD. COPD was found in 9.6% of participants aged 45 years and above. 484 subjects had positive skin-prick tests (26.5%); house dust mite and grass pollen mix were the main allergens. Risk factors for asthma were allergy, female gender and living in Kigali. COPD was associated with cigarette smoking, age and male sex.
Conclusion: this is the first study which shows the prevalence of atopy, asthma and COPD in Rwanda. Asthma and COPD were respectively diagnosed in 8.9% and 4.5% of participants. COPD was diagnosed in 9.6% of subjects aged $\geq$45 years.The prevalence of asthma was higher in urban compared to rural area.

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Introduction

Chronic obstructive pulmonary disease (COPD) and asthma are major health problems worldwide and the number of patients with these diseases continues to rise.[1] It is predicted that by the year 2020, COPD will be the third leading cause of death and the fifth leading cause of disability adjusted life years worldwide.[2]

Most of available information of the disease burden of chronic lung diseases comes from industrialized countries. One of the more troubling aspects of COPD is that it is under-recognized by the patient, under diagnosed by the physicians, and arguably undertreated. This may cause an important role in the increase in mortality and morbidity as a result of asthma or COPD.[3] Tobacco smoking is by far the major risk factor for COPD and the prevalence of the disease in different countries is related to rate of smoking and time of introduction of cigarette smoking.[4] The use of biomass fuel has also been associated with the occurrence of obstructive airways disorders.[5]

In Africa, COPD rate is rising because of an increase of tobacco consumption. The prevalence of tobacco use in African countries is between 8 and 43% for men and 5—30% for women and there are intensive efforts by the Tobacco industry to expand African markets.[6] If nothing is done to stop this rate of growth, Africa will have one of the world highest levels of tobacco consumption.[7] In Rwanda, COPD is not known in general population; it is even sometimes ignored by some health care workers including medical doctors.

The prevalence of asthma throughout Africa has increased markedly in recent years, having previously been uncommon over most parts of the continent. Prevalence data are lacking for many countries in Africa including Rwanda, but it is estimated that nearly 50 millions of Africans currently have asthma. The prevalence of the disease is greatest, about 8% of the population in Southern Africa.[8] A clinical overlap between asthma and COPD often occur in patients who smoke.[4] Efforts to improve care of patients with asthma and allergic conditions is in some developing countries being overwhelmed by the burden of tuberculosis, HIV/AIDS and other infectious diseases.[9]

The overall objective of this cross-sectional observational study was to determine the prevalence of atopy, asthma and COPD in Huye District and Kigali town, to determine the risk factors and compare the city of Kigali (urban) and the District of Huye (rural)

Patients and methods

Between February 2008 and August 2009, a total of 2138 individuals have been randomly recruited in the rural district of Huye and in Kigali town localized respectively at 1568 m and 1768 m of altitude. In Kigali, the study was performed in Nyarugenge district considered as the gate of the country, based around the city centre of Kigali, more polluted and containing most of the city's businesses with an urban population of 193000 subjects.[10] Nyarugenge is known to be representative of the larger population of Kigali in terms of housing, socio economic status and air quality. Huye district is localized in southern Rwanda and was chosen because it is less polluted and it is the only rural district in the country that has a University Hospital where spirometers could be regularly maintained. The district has a population of 290000 subjects but recruitment was done among 150000 individuals living in the rural side of the district.[11]

Nyarugenge district is divided into 10 administrative sectors and Huye district has 14 administrative sectors. Each sector has a population register regularly updated. Using population registers systematic sampling was used to obtain probabilistic samples that are representative of the total population. The sample size was estimated at 2138 subjects aged 15—80 years (1184 in Kigali and 954 in Huye district). Participants were invited in Health centers where a structured interview was conducted by well trained health workers. Three health centers were available in Kigali and three others in Huye district.

Inclusion criteria were age $\geq$ 15 years, living in Kigali town or Huye District and being competent and willing to sign the informed consent form after being given all the details about the study.

Exclusion criteria for the study were age below 15 years or having any mental illness, recent myocardial infarction or history of admission for cardiac illness within the last 5 months, recent thoracic, abdominal or eye surgery (or retinal detachment) and pregnant women. Subjects with active tuberculosis or any acute lung infections were also excluded. Only those who signed the informed consent form participated in the study.

After height and weight were measured, a questionnaire on respiratory symptoms and history of respiratory diseases, smoking history, exposure to various chemical agents and dust was administrated to each participant. A stadiometer with a precision of 0.1 cm was used for measuring height while the subject standing without shoes. A weighing scale with a precision of 100 g was used for measuring weight. Body mass index was calculated as weight (in kilograms) divided by height (in meters) squared. For smoking history, non-smokers were defined as those who never had smoked; smokers were those who were currently smoking at least one cigarette per day, and ex-smokers those who reported having smoked on a regular basis until $\geq$ 5 months before the examination. Passive smokers were defined as subjects who were regularly (daily basis) exposed to environmental tobacco smoke at least during the last 12 months. The questionnaires used were a short version of the American Thoracic Society[12] and the European Community Respiratory Health Survey II questionnaires.[13]

Spirometry was performed using an ML 3535 microloop spirometer with a database storage capacity for over 1000 patients (Microloop 3535, SPIDA spirometry, Micromedical limited, UK). The spirometric parameters used were: FEV_1 (Forced Expiratory Volume in 1 s), FVC (Forced Vital Capacity), FEV_1/FVC ratio and PEF (Peak Expiratory Flow).

After explanation of the procedures and demonstration by the technician, using local language, participants were asked to perform up to 8 maneuvers to obtain 3 acceptable flow-volume curves. The spirometry with largest value of FVC and FEV was considered as the best and used for analysis. Equipments and procedures were in accordance

with the American Thoracic Society for spirometry.[14] Spirometers were daily calibrated using a 3 L's syringe.

The Global Initiative of Chronic Lung Disease (GOLD) guidelines define COPD in subjects with FEV_1/FVC of less than 70%.[2] Many authors showed that this fixed cut-off of 0.70 can lead to an overestimation of COPD prevalence in elderly subjects. Moreover as asthma is a disease of predominantly young people, the GOLD criterion may fail to diagnose many asthmatics as having obstruction.[15,16]

In this study, we used the ATS/ERS guidelines[17] on lung function testing proposing use of the lower limit of normality (LLN) instead of a fixed cut-off of 0.70. The lower limit of normal is the fifth percentile which is equivalent to 1.645 SD below predicted.[17]

The reference equations for LLN defined by the ratio FEV_1/FVC were:

$$e^{(FEV_1/FVC\ \ predicted)-(1.645\times 0.06)} \text{ for males } \quad \left(e^X : \mathrm{Exp}(X)\right)$$

$$e^{(FEV_1/FVC\ \ predicted)-(1.645\times 0.08)} \text{ for females}$$

where FEV_1/FVC predicted = Exp (7.1477−0.518 ln(H) − 0.001025A) for males and Exp (5.848 + 0.268 ln(H) − 0.000839 A) for females, age is expressed in years.(A: age, H: height, ln: natural logarithm)

Based on the reference equations generated from healthy non smoking subjects in this study, the lower limits of the normal were calculated for each subject and the presence of airflow limitation was defined as FEV_1/FVC less than the LLN.

Healthy subjects for generating reference values were defined as those who did not smoke or report respiratory symptoms (cough, phlegm, dyspnea or wheezing); those who had no medical diagnosis of COPD, asthma, chronic bronchitis, emphysema, lung fibrosis and had no history of pulmonary tuberculosis, lung cancer or lung resection.

For subjects with airways obstruction as defined above, a short acting β2 agonist was administered by inhalation (salbutamol 400 μg) through a 500 ml spacer, to check the reversibility of the obstruction, and spirometry was repeated 15 min later with the same criteria. Reversibility was considered as significant if there was an FEV_1 increase of 200 ml and 12% above baseline FEV_1.[17] For the LLN, the cut-of value of the post-bronchodilator ratio was set at the fifth percentile of the normal distribution.

Asthma versus COPD

Asthma and COPD are two different respiratory chronic diseases characterized both by airflow limitation. Airflow limitation in asthma is by definition reversible either spontaneously or as a result of treatment, whereas in COPD airflow limitation is not fully reversible and is progressive.[18]

Diagnosis of asthma

Clinical diagnosis of asthma is difficult and many epidemiological studies have used symptom questionnaires to distinguish asthmatics and non asthmatics subjects. Diagnosis of asthma made by a health care provider still remains the most common approach used to define asthma in epidemiological studies.[19]

In our study, after excluding any cardiac disease, 2 conditions were taken into account for the diagnosis of asthma:

1. All participants whose diagnosis of asthma was confirmed by a medical doctor and who reported one of the following symptoms during the last 12 months[12,13]:
   - Episodic wheezes
   - episodic wheezes and attacks of shortness of breath
   - Nocturnal attacks of shortness of breath
   - Use of asthma medication
2. Subjects who presented with reversible airways obstruction as defined above at the time of recruitment in the study (pre-bronchodilator $FEV_1/FVC < LLN$ and a positive reversibility test meaning an increase in FEV_1 of 200 ml and 12% with respect to pre-bronchodilator FEV_1 after 400 mcg of salbutamol)

Diagnosis of COPD

In this study, chronic obstructive pulmonary disease (COPD) was defined as post bronchodilator FEV_1/FVC less than the LLN. Subjects with a doctor diagnosis of COPD were those who reported a physician's diagnosis of chronic bronchitis, emphysema or COPD.

Skin-prick testing

All the patients were skin-prick tested for six common allergen extracts (Laboratoire Stallergène, Waterloo, Belgium): house dust mite, grass pollen mix, cat dander, dog dander, aspergillus and cockroach plus a negative and positive control (Histamine). After cleaning the forearm of the participant, a drop of each allergen extract was placed on the anterior side of the forearm with an interval of 2 cm between 2 drops. A sterile lancet (stallerpoint) was used to prick the centre of the drop. Results were read 15 min later and sensitization was defined as wheal at least 3 mm greater than the negative control.

Ethical considerations

Ethical approval was obtained from both the Ghent University Hospital Ethics Committee (Belgium) and the Rwanda National Ethics Committee. Only subjects who signed the informed consent form participated in the study.

Statistical methods

Statistical analyses were performed using the statistical package SPSS 12.01 and statistical significance was viewed as *P* values lower than 0.05. Odds ratios (OR) and 95% confidence intervals (CI) were calculated, the data of height, age and lung function parameters were expressed as means ± SD (Standard deviation). Ratio FEV_1/FVC was expressed as a percentage. A logistic regression model was performed using age, gender, smoking, residential area as

independent variables and obstructive lung diseases as dependant variables.

Results

Of the 2138 subjects initially invited, 48 (2.2%) refused to participate and 170 (7.9%) were excluded because they did not meet the inclusion criteria (26% were under tuberculosis treatment, 18% were pregnant, 15% were in heart failure, 7% had mental diseases, 34% had a recent abdominal/thoracic/eye surgical history). A total of 1920 individuals aged 15—80 years responded to questionnaires and underwent spirometry. Subjects performed at least three spirometry measurements acceptable by the ATS criteria. 96 individuals were excluded from the analysis due to the inability to perform acceptable spirograms. We remained with 1824 subjects composed of 946 women and 878 men, mean age was 38.3 years. (Fig. 1)

65.2% of participants were below age 45 years and 34.8% above 45 years; this reflects the Rwandan general population distribution where more than 60% of the population is under 40 years and where women are overrepresented (88 males for every 100 females in the general population).[20] 67.8% of subjects had a normal BMI, 17.1% were overweighted and 5.9% had obesity. 26.7% have never been at school. The characteristics of participants are shown in Table 1

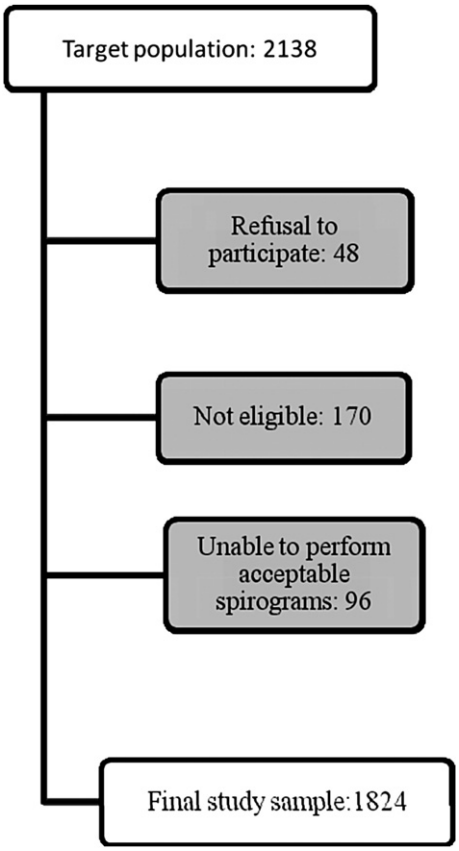

Figure 1 Flow diagram of the study population.

Prevalence of smokers

56.8% of subjects were living in Kigali and 43.2% in Huye district. More than the half of participants had never-smoked cigarettes, 15.8% were ex-smokers (19.8% of men and 11.8% of women) and 16.7% were current smokers (20.9% of men and 12.6% of women). Passive smoking was found in 542 patients (29.7%). 26.5% participants reported an exposure to smoke from wood stoves and 28.2% were exposed to smoke from charcoal stoves. Occupational exposure to dust was reported by 20.5% of participants. The prevalence of current smokers was significantly higher in men than in women ($p < 0.05$). (Table 2)

Respiratory symptoms

228 (12.5%) participants reported episodes of wheezes, among them 24 (10.5%) had a history of tuberculosis. Cough with phlegm was reported by 96 participants. 121 (6.6%) subjects reported a doctor's diagnosis of asthma (Table 3).

Spirometry

Of the 1824 subjects who performed spirometry, 256 (14%) were classified as having airflow obstruction with a ratio $FEV_1/FVC < LLN$. All participants with airflow limitation underwent a post bronchodilator spirometry, among them, 174 out of 256 subjects (94 females and 80 males) had a significant improvement of FEV_1 which was greater or equal to 12% predicted and 200 ml.

Asthma was diagnosed in 163 (8.9%) individuals (Table 4). 11 subjects who had a good reversibility after administration of a bronchodilator were not considered as asthmatics since they reported a history of tuberculosis and mentioned that asthma-like symptoms started after tuberculosis treatment. With regard to doctor's diagnosis of asthma, 121 (74.2%) out of 163 individuals who met our criteria for asthma had a doctor's diagnosis of asthma.

COPD was diagnosed in 82 (4.5%) subjects who presented a ratio FEV_1/FVC less than the LLN and was more frequently diagnosed in men than in women the difference was statistically significant. The prevalence of COPD was higher among current (11.2%) and ex-smokers (8.6%) compared to non-smokers (1.9%). 59 (71.9%) subjects with COPD were current smokers or ex-smokers and about one third (28%) were non-smokers. Among 635 individuals aged 45 years and above, COPD was diagnoses in 9.6% of subjects. With regard to doctor's diagnosis of COPD, only 5 (6.1%) out of 82 individuals who met our criteria for COPD had a doctor's diagnosis of COPD. Spirometry baseline information is given in Table 5.

FEV_1, FVC and ratio FEV_1/FVC were lower in current smokers and ex-smokers over 45 years than in never-smoked subjects. Airflow obstruction was classified as mild, moderate, severe and very severe according to the GOLD classification[21]; we had only 4 COPD patients with severe obstruction. Although the use of LLN criterion was preferred in this study an effort was made to compute prevalence rates of the airflow limitation by the Gold criteria (Fixed ratio: $FEV_1/FVC < 0.70$) for comparison. Using this criterion, a total of 212 (11.6%) subjects were

Table 1 Description of the sample according to socio-demographic variables and anthropometric measures.

Variables	Kigali	Huye	N
Gender			
Men	502	376	878 (48.1%)
Women	534	412	946 (51.9%)
Age (years)			
15–29	396	308	704 (38.6%)
Male	200	158	358 (40.7%)
Female	196	150	346 (36.5%)
30–44	286	199	485 (26.6%)
Male	134	96	230 (26.2%)
Female	152	103	255 (27.0%)
45–60	249	212	461 (25.3%)
Male	120	96	216 (24.6%)
Female	129	116	245 (25.9%)
>60	105	69	174 (9.6%)
Male	41	33	74 (8.5%)
Female	66	34	100 (10.6%)
Marital status			
Never married	420	378	798 (43.8%)
Married	348	336	684 (37.5%)
Divorced/separated	46	50	96 (5.3%)
Widowed	134	112	246 (13.5%)
Level of education			
None	284	204	488 (26.7%)
Primary school	398	314	712 (39%)
Secondary school	290	151	441 (24.1%)
More than secondary school	112	71	183 (10%)
Body Mass Index (Kg/m^2)			
<18.5	42	66	108 (5.9%)
18.5–24.9	640	596	1236 (67.7%)
25–29.9	201	111	312 (17.1%)
>30	76	32	108 (5.9%)

classified as having airflow obstruction (men : 14.9%, women: 8.4%) andCOPD was diagnosed in 113 (15.8%) subjects aged 40 years and above. The number of subjects with airflow limitation by fixed ratio increased as the subjects' age increased. For the subjects aged 45 years and above, airflow limitation was found in 61 (9.6%) subjects when we used the LLN criterion and in 91 (14.4%) subjects when we used the fixed ratio criterion.

Skin prick test

484 participants (26.5%) had a positive skin-prick test meaning a wheal at least 3 mm greater than the negative control. House dust mites and grass pollen were the main allergens found with respectively 10.7% (13.2% in Kigali versus 7.6% in Huye) and 7.2% (5.8% in Kigali versus 9.1% in Huye) sensitized participants. The other sensitizations were as follow: cat dander 3.2%, dog dander 2.3%, cockroach 1.8% and Aspergillus 1.3%. (Table 6)

Sensitisation by site

Sensitization to House dust mites was mainly seen in Kigali compared to Huye District ($P < 0.001$).

Risk factors

The prevalence of COPD was higher among smokers than non-smokers. By bivariate analysis male sex, old age and smoking were risk factors for COPD. We did not find any correlations between COPD and the level of education, residence and other types of exposures (smoke from wood and charcoal stoves, biomass, exposure at work) or BMI.

Asthma was clearly associated with atopy. Living in Kigali town was also a risk factor for having asthma ($p < 0.05$). Wheezing was associated significantly to asthma (OR :7.02; CI 3.12–9.68, $P < 0.001$). (Table.7) Female gender and the low level of education is also associated with asthma: we found more asthmatics in subjects who had never been to school or had only a basic education in basic schools.(Table 7)

By multiple logistic regression, smoking (OR: 3.9; CI: 2.12–5.71), higher age (above 45 years OR: 8.22, CI : 3.08–53.1) and male sex (OR: 2.97; CI: 1.96–4.22) remained independent predictors for COPD. For asthma risk factors were, atopy (OR: 4.01; CI: 2.86–5.13), female sex (OR: 1.99; CI: 1.18–3.69), living in Kigali (OR: 3.62; CI: 2.12–5.78), and low level of education (OR: 1.71; CI: 1.23–3.31)

Table 2 Description of the population according to smoking history and other type of exposures.

Variables	Kigali	Huye	N
Smoking history			
Never smoked	612	622	1234 (67.7%)
Male	218	302	520 (59.2%)
Female	394	320	714 (75.5%)
Ex-smokers	163	123	286 (15.7%)
Male	102	72	174 (19.8%)
Female	61	51	112 (11.8%)
Current smokers	189	115	304 (16.7%)
Male	98	86	184 (20.9%)
Female	91	29	120 (12.6%)
Lifetime cigarettes smoked			
<1 pack-year	126	91	217 (11.8%)
1–10 pack-years	124	109	233 (12.7%)
>10 pack-years	84	56	140 (7.6%)
Passive smoking			
Yes	298	244	542 (29.7%)
No	714	568	1282 (70.2%)
Exposure at work			
None	698	658	1356 (74.3%)
Dust	202	172	374 (20.5%)
Chemical fume	36	6.0	42 (2.3%)
Gas	44	8.0	52 (2.8%)
Do you cook?			
Yes	418	680	1098 (60.1%)
No	388	338	726 (39.8%)
Exposure to biomass	50	48	98 (5.3%)
Exposure to charcoal	412	104	516 (28.2%)
Exposure to wood stove	210	276	486 (26.6%)

Discussion

In developing countries, chronic respiratory diseases represent a challenge to public health because of their frequency, severity, projected trends and economic impact.[7] The aim of this study was to determine the prevalence of asthma, atopy and COPD in Rwanda using questionnaires, spirometry and allergy skin-prick tests. Spirometry in Rwanda is not done routinely in medical practice due to lack of specialized technicians, doctors and equipments. Asthma was diagnosed in 8.9% of subjects and was significantly associated with atopy.

Few studies on asthma have been conducted in Africa and an increase in asthma prevalence has been noted by other authors who also reported allergy as an important risk factor for asthma.[7,22,23] Westernization of lifestyle plays an important role in the development of asthma and allergic diseases.[24] A study carried out by Sunyer J.et al.[25] in Tanzania, one of the neighbouring countries to Rwanda reported a complexity in the association between asthma

Table 3 Frequency of respiratory symptoms of chronic airways diseases.

Variables	Kigali	Huye	N
Wheezing	124	104	228 (12.5%)
Cough	196	132	328 (17.9%)
Breathlessness	61	77	138 (7.6%)
Phlegm	70	61	131 (7.2%)
Cough + phlegm	44	52	96 (5.2%)
Family history of CPD	59	51	110 (6.0%)
Asthma diagnosed by Physician	76	45	121 (6.6%)
COPD diagnosed by Physician	9.0	12	21 (1.2%)
Self reported chronic bronchitis	79	75	154 (8.4%)
History of tuberculosis	22	15	37 (2.0%)
History of tuberculosis + Wheezes	12	12	24 (1.3%)

CPD: chronic pulmonary disease.

Table 4 Prevalence of atopy, asthma and COPD.

	Total	Age group	Men	Women	*P*-value
Atopy	290	<45	137	153	NS
	194	≥45	91	103	NS
Asthma	113	<45	54	59	NS
	50	≥45	22	28	NS
COPD	22	<45	10	12	NS
	60	≥45	50	10	<0.001

NS: not significant.

and atopy in tropical regions arguing that specific IgE reactivity to environmental allergens may not be related to asthma. One of our study limitations is that we did not take sera for specific IgE antibodies analysis.

Sensitisation to house dust mites is the most common allergy detected in our study especially in Kigali. Previous studies conducted in Europe showed that house dust mites were uncommon in high altitudes,[26,27] Kigali and Huye are localized respectively at 1568 and 1768 m of altitude. Valdivieso et al.[28] reported recently the presence of mites at an altitude of 4800 m in Ecuador. Earlier in 2006, the same author reported the presence of frequent and abundant mites and their allergens in dust samples at an altitude between 2500 and 2800 m.[29] Climatic differences in particular differences in ambient humidity may explain the situation. Other African studies also revealed house dust mites as the most common allergens.[30,31]

We showed an association between the low level of education with asthma. Even if we did not find a significant association between asthma and various exposures at work, we speculate that this can be partly explained by the fact that subjects with low level of education are the same who have low income and who live in poor condition, thus more exposed to allergens and various irritants.

Living in Kigali was associated with asthma (OR: 2.21 CI (2.32−4.54). Kigali is the capital of Rwanda, more urbanized and more polluted than Huye district which is mainly rural. Outdoor air pollution has been studied as a risk factor for asthma and high levels of traffic related emissions have been correlated to increased prevalence of respiratory allergies.[32,33]

Among subjects aged 45 years and above, COPD was diagnosed in 9.6% participants. Not all subjects with COPD were smokers, about one third of subjects with COPD were non-smokers. Although exposure to passive smoking, biomass, smoke from wood and charcoal stoves did not show a statistically significant effect, we believe that they may be the possible causes of COPD in non-smokers. An association between exposure to indoor air pollution and the development of COPD has been reported previously.[34]

The overall prevalence of COPD for all participants (1824 individuals) was 4.5% and association with tobacco smoking, male sex and older age was observed. For subjects aged ≥45 years, the prevalence is fairly similar to results from other studies from Europe, Asia or America.,[35,36,37,38] Furthermore, our prevalence of COPD among smokers (11.2% in current smokers and 8.6% in ex-smokers) is similar to previous findings.[35,39,40] The overall prevalence in our study is low because of the low mean age in our study sample with two thirds of subjects being below the age of 45 years. In Africa, there is very limited published data on COPD, studies on selected populations showed highly variable prevalence rates ranging from 5.3% to 47%.[40]

Considering both ex-smokers and current smokers in our study, we have in total 32.3% of subjects who had a smoking history. However, though this number seems to be high, few were heavy smokers; moreover, during interviews we noted a tendency of quitting smoking due to new regulatory measures against tobacco consumption in Rwanda. Smoking for women is still a taboo in the country, it is more tolerated for old women than younger ones.

Table 5 Spirometry baseline information by gender.[a]

Characteristics	Men (n = 878)	Women (n = 946)
Mean age	38.1	38.6
Height	172.2 ± 6.60	161.4 ± 5.4
Weight	72.2 ± 11.8	60.2 ± 8.3
BMI	24.6 ± 3.123	4 ± 3.2
FEV_1(L)	3.34 ± 0.60	2.42 ± 0.44
FEV_1 (%)	88.3 ± 11.1	82.1 ± 7.4
FVC (L)	3.98 ± 0.61	2.87 ± 0.54
FVC%	94 ± 13.2	89 ± 11,8
FEV_1/FVC (%)	82.6 ± 6.6	84.4 ± 5.1
PEFR Ls^{-1}	8.9 ± 1.68	6.2 ± 1.48

[a] Value are given as mean ± standard deviation (SD).

Table 6 Frequency of sensitisation determined by skin-prick testing.

Allergen extract	Site		Positive skin reactivity N (%)	*P*-value
	Kigali	Huye		
Dermatophagoides Pteronyssinus	136 (13.2%)	60 (7.6%)	196 (10.7%)	$P < 0.001$
Grass pollen	60 (5.8%)	72 (9.1%)	132 (7.2%)	NS
Cat dander	39 (3.8%)	21 (2.7%)	60 (3.2%)	NS
Dog dander	13 (1.2%)	29 (3.7%)	42 (2.3%)	NS
Cockroach	10 (1.0%)	22 (2.8%)	32 (1.9%)	NS
Aspergillus	22 (2.2%)	1.0 (0.2%)	23 (1.3%)	NS

NS: not significant.

Among participants who met our criteria for COPD, only 6.1% had a doctor diagnosis of the disease, confirming the fact that COPD is under diagnosed.[41] The absence of spirometry in most hospitals in Rwanda is a major handicap to the diagnosis of COPD and there is a frequent overlap of asthma and COPD. The case definition for COPD is problematic in developing countries where the prevalence of lung infections including tuberculosis is still high and a fraction of patients develop chronic irreversible airflow obstruction as a result of these conditions or from both smoking and sequelae of lung infection.[42]

More than 50% of participants reported exposure to charcoal and wood stoves, but we did not find any association with COPD. Woods and charcoal are used in all the

Table 7 Risk factors for Asthma and COPD.

Variables	N	Asthma		*p* value	COPD		*p* value
		%	OR: CI 95%		%	OR: CI 95%	
Overall	1824	8.9	—		4.5	—	
Sex							
Female	946	9.1	1		2.3	1	
Male	878	8.7	0.22 (0.36—0.79)	$p < 0.05$	6.8	3.21 (2.44—6.32)	$p < 0.001$
Age							
<45 years	1189	9.5	1		1.8	1	
≥45 years	635	7.8	0.92 (0.65—2.21)	$p = 0.601$	9.6	9.56 (3.12—60.9)	$p < 0.001$
Smoking							
Never	1234	9.4	1		1.9	1	
Ex-smokers	286	7.3	0.70 (0.33—2.92)		8.6	2.02 (1.27—4.92)	
Current smokers	304	8.6	0.92 (0.55—2.61)	$p = 0.612$	11.2	3.22 (1.53—4.31)	$p < 0.05$
Atopy							
No	1340	3.8	1		3.2	1	
Yes	484	23.1	5.24 (3.15—8.22)	$p < 0.05$	7.2	0.24 (0.09—1.32)	$p = 0.964$
Wheezing							
No	1596	1.5	1		3.2	1	
Yes	228	60.9	5.24 (3.15—8.22)	$p < 0.05$	7.2	0.24 (0.09—1.32)	$p = 0.661$
Residence							
Huye	788	8.3	1		5.6	1	
Kigali	1036	9.3	2.21 (1.32—4.54)	$p < 0.05$	3.6	0.72 (0.58—2.28)	$p = 0.667$
Level of education							
None	488	12.2	2.71 (1.53—6.22)	$p = 0.010$	5.1	0.23 (0.09—0.95)	$p = 0.923$
Primary school	712	9.5	2.12 (1.32—4.26)		2.9	0.26 (0.12—1.03)	
Secondary	441	5.2	1.35 (0.68—2.31)		5.5	0.51 (0.32—1.90)	
More than secondary	183	6.5	1		6.2	1	
Exposure to dust at work							
No	1450	8.8	1		4.3	1	
Yes	374	9.3	0.68 (0.39—2.14)	$p = 0.672$	5.2	0.92 (0.51—1.88)	$p = 0.611$
Exposure to wood stoves							
No	1336	9.7	1		4.0	1	
Yes	486	6.7	0.52 (0.41—1.89)	$p = 0.714$	5.7	0.31 (0.22—1.48)	$p = 0.701$

OR, Odds ratio (Adjusted for age and sex); CI, Confidence interval.

country for cooking, but the exposure is minor since many Rwandans cook outdoor.

Conclusion

This is the first study which shows the prevalence of atopy, asthma and COPD in Rwanda. Asthma and COPD were respectively diagnosed in 8.9% and 4.5% of participants. COPD was diagnosed in 9.6% of subjects aged ≥45 years and was higher among current smokers (11.2%). The prevalence of asthma was higher in urban compared to rural area and a quarter of subjects were sensitized to various allergens.

Conflict of interest

All authors report no conflict of interest and have agreed for publication of this study to which they all contributed.

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