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## **Socioeconomic factors, gender and smoking as determinants of COPD in a low income country of sub-Saharan Africa: FRESH AIR Uganda**

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## **Abstract**

In Uganda, biomass smoke seems to be the largest risk factor for the development of COPD, but socioeconomic factors and gender may play a role. Therefore, more in depth research is needed to understand the risk factors.

To investigate the impact of socioeconomic factors and gender differences on the COPD prevalence in Uganda.

The population comprised 588 randomly selected participants (> 30 years) who previously completed the FRESH AIR Uganda study. In this post-hoc analysis, the impact of several socioeconomic characteristics, gender and smoking on the prevalence of COPD was assessed using logistic regression model.

The main risk factors associated with COPD were non-Bantu ethnicity (OR 1.73, 95% CI 1.06-2.82, P=0.030), biomass fuel use for heating (OR 1.76, 95% CI 1.03-3.00, P=0.038), former smoker (OR 1.87, 95% CI 0.97-3.60, P=0.063), and being unmarried (OR 0.087, 95% CI 0.93-2.95, P=0.087).

A substantial difference in the prevalence of COPD was seen between the two ethnic groups: non-Bantu 20% and Bantu 12.9%. Additional analysis between these two groups showed significant differences in socioeconomic circumstances: non-Bantu smoked more (57.7% vs 10.7%), lived in tobacco-growing areas (72% vs 14.8%) and were less educated (28.5% vs 12.9% had no education). Within gender, men with COPD were unmarried (OR 3.09, 95% CI 1.25-7.61, P=0.015) and used more biomass fuel for heating (OR 2.15, 95% CI 1.02-4.54, P=0.045); women with COPD were former smokers (OR 3.35, 95% CI 1.22-9.22, P=0.019).

Only a few socioeconomic factors (i.e. smoking, biomass fuel use for heating, marital status and non-Bantu ethnicity) have been found to be associated with COPD. This applied for gender differences as well (i.e. for men marital status and biomass fuel for heating, and for women former smoker). More research is needed to clarify the complexity of the different risk factors.

## **Keywords**

COPD, sub-Saharan Africa, biomass fuel, socioeconomic factors, ethnicity

## **Introduction**

Chronic obstructive pulmonary disease (COPD) is a major health problem in low- and middle-income countries (LMICs).(1) In 2010, COPD was the fourth cause of death globally and it was expected to be the third by 2030.(2,3) Unfortunately, the prediction has been overtaken by reality: at this moment COPD is the third leading cause of mortality worldwide.(4,5) Approximately 90% of COPD deaths occur in LMICs.(6) Despite these high numbers, COPD is an unknown disease in most of the rural areas of sub-Saharan Africa, both in terms of public awareness and in public health planning. The people are unaware of the potential damage to respiratory and non-respiratory health caused by tobacco and biomass smoke.(7-9) Biomass fuel use is the third largest contributor to the global burden of disease.(10)

While the development of COPD is multifactorial, biomass smoke is probably the largest risk factor for COPD in LMICs.(11-13) Worldwide, around 3 billion people, most of them living in LMICs, rely on the use of open fires and burning of biomass fuels (wood, animal dung, crop residues, straw and charcoal) for cooking and heating in poorly ventilated conditions.(14) Solid fuel burning is incomplete and produces high levels of household air pollution with a range of more than 250 health-damaging pollutants, including carbon monoxide, nitrogen and sulphur oxides, as well as a variety of pollutants, irritants, carcinogens, co-carcinogens, and free radicals.(12,13,15)

Until recently, data on the prevalence of COPD, the risk factors and socioeconomic determinants in LMICs were scarce.(9,16,17) In 2012, a prospective cross-sectional observational study (FRESH AIR Uganda) was performed to assess the prevalence of COPD and its risk factors in a rural district of Uganda. Among adults above the age of 30 years, the prevalence of spirometry-based COPD was 16.2% (52.6% women) as defined according to the methods used in FRESH AIR Uganda.(18) The prevalence of COPD was remarkably high (39%) among adults aged 30-39 years, both for men (37%) and for women (40%). In addition to tobacco smoking, particularly by young men, more than 90% of the participants were exposed to smoke caused by biomass fuel use.(18)

The FRESH AIR Uganda study was conducted in rural Masindi district (population 350,000) of Uganda, a low-income country with an average life expectancy of 52 years (men 48 and women 57).(19) Masindi district is one of the poorest districts of Uganda, where the poverty line (\$1.25 a day) is consistently above 40%.(19) Poverty is known to be a risk factor for COPD, but the socioeconomic factors that contribute to this, are unclear, particularly in LMICs.(3,20) The socioeconomic status (SES) is an important determinant of overall health status.(17) In contrast with poverty, which is often quantified as a minimum level of income to meet the basic needs of life, SES is defined as an individual overall position or standing, and can be indicated by a compilation of measurements including income as well as education, employment, location of residence, cooking tradition, biomass fuel use, and housing.(21) Using the data of FRESH AIR Uganda, we performed a post-hoc analysis to examine the association of socioeconomic factors, gender and smoking with COPD.

## **Results**

### **Patient characteristics**

Of the 588 participants, 95 (16.2%) were classified as having spirometry-based COPD and 493 (83.8%) as non-COPD (table 1). Wood as main domestic fuel was used by 558 (94.9%) participants; grass, used by 534 (91%) participants, and crop residues, used by 501 (85.2%) participants, were applied to

lit the fire. Concerning their cooking place, 490 (83.3%) participants cooked in a separate building as kitchen.

Participants with COPD coughed and wheezed more than without COPD, particularly among men (all P-values<0.007). There were no significant differences in age and gender between participants with and without COPD. More than 90% of the participants had at least one chest infection a year. More details are depicted in Table 1.

#### **Socioeconomic factors, ethnicity, and tobacco smoking as determinants of COPD**

Participants with COPD were more often active or former smokers compared to participants without COPD (P=0.046), used more biomass fuel for heating (P=0.035) and they were more often of non-Bantu ethnicity (P=0.020); a trend was shown for being unmarried (P=0.055). No other significant differences in socioeconomic factors were found between subjects with and without COPD (table 2). In the multivariable logistic regression model on the presence of COPD (table 3) significant associations were found with biomass fuel use for heating (OR 1.76, 95% CI 1.03-3.00, P=0.038), and non-Bantu ethnicity (OR 1.73, 95% CI 1.06-2.82, P=0.030). Borderline significant associations were found with being unmarried (OR 1.66, 95% CI 0.93-2.95, P=0.087) and being a former smoker (OR 1.87, 95% CI 0.97-3.60, P=0.063). No significant associations between the presence of COPD and educational level, employment, village in tobacco growing areas, time cooking indoors or outdoors, sleeping area, and cooking area, were found.

#### **Risk factors for COPD stratified by gender**

The logistic regression models on the presence of COPD stratified by gender, showed for men an association with being unmarried (OR 3.09, 95% CI 1.25-7.61, p=0.015) and biomass fuel use for heating (OR 2.15, 95% CI 1.02-4.54, p=0.045), and for women an association with former smoker (OR 3.35 (95% CI 1.22-9.22, p=0.019) (table 3).

#### **Cooking tradition as COPD determinant**

There were no significant differences between non-COPD and COPD participants concerning the cooking data, including exposure to biomass smoke (hours per day and number of years), and sleeping area. There were similarly no significant differences between cooking data as risk factors and COPD prevalence.

## **Discussion**

#### **Main findings of the study**

The main risk factors associated with the COPD found during the FRESH AIR survey were being of non-Bantu ethnicity and biomass fuel use for heating; a trend was found with former smokers and the marital status. An association with biomass fuel use for cooking, both indoors and outdoors, was not found as almost everybody used biomass fuel for cooking. The other tested socioeconomic factors also did not differ between subjects with and without COPD. Among men, a risk factor for COPD was being unmarried and the use of biomass fuel for heating; a borderline risk factor was being of non-Bantu ethnicity. Among women, being a former smoker was a risk factor for COPD.

#### **Interpretation of findings in relation to previously published work**

Participants with COPD were more often active or former smokers compared to participants without COPD and used more biomass fuel for heating (P values 0.046 and 0.035 respectively). This is well-known from the literature.(3,12) However, it was striking to see in the multivariable analysis that

former smoking, and not active smoking, was borderline associated with a higher prevalence of COPD. This was particularly true for women, whereas in men no association was found at all. These findings were not confirmed by other studies. A possible explanation for this could be the so-called 'healthy smoker effect'.(28) This refers to the fact that people that quit smoking often do this motivated by smoking related symptoms, leaving the less suffering and relatively healthy group still smoking. In our study this was only seen in women. In Ugandan men, the decision to quit smoking is probably not related to health or smoking-related symptoms, but may be influenced by other factors (e.g. cultural factors) that need to be discovered.

In addition, tobacco smoke potentiates the detrimental effects of biomass smoke.(11,29,30); active smokers, who are also exposed to biomass smoke, have an increasing the risk of airflow obstruction.(31,32) Given that almost every participant in our study was exposed to biomass fuel used for cooking, this variable could not be investigated. However, the use of biomass fuel for heating was significantly associated with the prevalence of COPD, especially in men. This indicates that biomass fuel use is indeed an important risk factor for COPD.

For men, being unmarried seemed to increase the risk of developing COPD. This could be explained by the fact that married men are less exposed to biomass fuel for cooking, as women in Uganda, and probably other countries of sub-Saharan Africa, have the responsibility for domestic cooking.(7,33) Although women were more exposed to biomass smoke (both number of years and hours per day), no association with COPD was found. However, during cooking, women and perhaps unmarried men have several periods of intense exposure to biomass smoke each day, particularly when fires are started or stirred.(7,33) More research is needed to understand the individual exposure to household air pollution, as the exposure is spatially and temporally highly variable.(34) For men, the biomass fuel exposure for heating increased the chance of COPD: the context of this finding is not clear yet.

A substantial difference in the prevalence of COPD was seen between the two ethnic groups: the prevalence of COPD among non-Bantu was 20% (20.3% men and 19.7% women) and among Bantu 12.9% (10.5% men and 14.9% women). Interestingly, additional analyses showed substantial differences between the two ethnic groups in socioeconomic status. Bantu refers to a primarily large and complex linguistic grouping of people in Africa. Their cultural pattern is extremely diverse and are the most prosperous. They occupy the southern and western parts of Uganda.(19,25) In general, non-Bantu are the poorer ethnic group, and inhabit a geographical area stretching semi-arid eastern and northern parts of Uganda.(19,25) Compared to the Bantu, non-Bantu smoked more (57.7% vs 10.7%,  $P<0.001$ ) , were less educated (no education 28.5% vs 12.9%, particularly women: 51.6% vs 17.1%,  $P<0.001$ ), and lived more in tobacco-growing areas (72.0% vs 14.8%,  $P<0.001$ ). After adjustment for these socioeconomic factors in the multivariable model the association between ethnicity and COPD remained significant, in contrary to the single socioeconomic risk factors (tobacco smoking, education and living in tobacco-growing areas). An explanation for this could be that ethnicity was associated with a combination of all these socioeconomic factors and that this combination was more important than any single factor. As such, ethnicity could be seen as a variable indicating socioeconomic status. However, other unmeasured factors, such as lifestyle, cultural, or genetic factors, that differ between the ethnic groups could also explain this association between COPD and ethnicity. Further research is necessary to confirm this.

### **Strengths and limitations of this survey**

FRESH AIR Uganda was one of the first observational surveys on the prevalence of COPD performed in a rural area of sub-Saharan Africa. The survey used well-trained local healthcare workers and was performed in thirty villages, randomly selected with a probability proportional to their size.(18) The sample size was relative small, but had enough power to detect differences in COPD prevalence between men and women in Masindi district. However, it was not powered to detect significant differences in COPD prevalence among other sub-groups (e.g. ethnicity or occupational groups). In addition, it was not possible to detect a difference in COPD prevalence associated with exposure to biomass smoke, as the exposure was almost uniform in this rural area.(18) Finally, this study was a post hoc-analysis and the results need caution with interpretation. Further properly designed prospective studies are needed to confirm our findings.

### **Implications for future research, policy and practice**

Tobacco smoking is known to be a major cause of COPD, but recent literature has shown that the use of biomass fuels for cooking and heating is an important risk factor as well, particularly in LMICs.(12,13) A person living in a rural area of sub-Saharan Africa is exposed to a variety of other risk factors for the development of COPD during all stages of life: perinatal factors (maternal exposure to biomass smoke or tobacco smoke, low birth weight and pre-term birth), childhood exposure (respiratory tract infections, exposure to biomass smoke, childhood asthma, second-hand smoking, occupational exposure, poor nutrition and kerosene-based lamps) and adult exposure (occupational exposure, agricultural smoke, exposure to biomass smoke, cigarette smoking, second-hand smoking, kerosene-based lamps, and outdoor air pollution).(35-37) More information is needed to understand the full extent and influence of these risk factors. Low socioeconomic circumstances as poverty are associated with most of these risk factors, as well as poor access to health care, poor living conditions and water supply/sanitation. All these factors may cause health effects (intrauterine growth restriction, malnutrition, respiratory tract infections), and therefore increase the risk of developing COPD.(3,17,20,38-40) The influence of socioeconomic factors is therefore very complex: more research is needed to identify these partly modifiable risk factors on the development of COPD.(17,39,40)

The general lack of knowledge leads to failure to make simple steps in avoiding exposure to biomass smoke.(35,41) The nature of the communities also determines the health-seeking behaviour -both traditional (local herbs) and western (dispensaries and health centers)- most of the time with a lack of successful results and not addressing the problem of exposure.(7) Reduction of tobacco smoking and exposure of biomass smoke, as well as second-hand tobacco smoke, smoke from kerosene lamps, and occupational air pollution, are major controllable factors to tackle the burden of COPD. Public awareness and control of (household) environment are important steps in preventing respiratory and non-respiratory diseases.(41) More research is vital, with prospective studies and a larger sample size, to perform further comparisons among the sub-groups, and understand the impact of COPD and other (non)-respiratory diseases.

### **Conclusions**

The risk factors for the development of COPD in Masindi district of Uganda are complex. Although tobacco smoking remains an important cause of COPD, almost everybody in this district, and probably in many other rural areas of sub-Saharan Africa, is exposed to biomass smoke and other risk factors. Only a few socioeconomic factors have been found to be significantly associated with COPD (biomass fuel use for heating and non-Bantu ethnicity); for others a trend was found (former smoker

and marital status). This applied for gender differences as well (i.e. for men marital status and biomass fuel for heating, and for women former smoker). Between the two ethnic groups of Masindi district in Uganda, a difference in the prevalence of COPD was found, what could possibly be explained by the combination of several unfavourable socioeconomic circumstances in the non-Bantu people. Research is needed to elucidate the complexity of the different risk factors in the development of COPD. Any intervention to reduce the incidence of COPD must combine raising awareness about the damaging effects of biomass fuel use and tobacco smoking, with clean-cooking solutions and tobacco smoking cessation to support at risk communities. Researchers, policy-makers and government, stakeholders, health professionals and communities will have to work together to control the growing burden of COPD, and start prevention and intervention programmes.

## **Methods**

### **The FRESH AIR Uganda study**

The intended sample size of the FRESH AIR Uganda study, was 600 participants, determined to give an acceptable degree of reliability in estimating the prevalence of spirometry-based COPD.(22) Eventually, 588 randomly selected participants were asked about their living circumstances and exposure to risk factors.(18) A screening questionnaire assessed gender, tribal and ethnic origin, education, living conditions, occupation, biomass fuel use, tobacco smoking, symptoms, MRC dyspnoea score and chest infections.(18) A household air pollution questionnaire gave information on type and place of cook stoves, type of fuels, preparation of meals, time activity pattern, and cooking during pregnancy. Both questionnaires were developed from different validated questionnaires, and were pre-tested and completed during a face-to-face interview.(18) Subsequently, to assess COPD prevalence, pre- and post-bronchodilator spirometry was performed by well-trained local healthcare workers.(18) The study used the lower limit of normal threshold, i.e. participants below the fifth percentile of the predicted FEV<sub>1</sub>/FVC ratio, as the defining criterion of COPD to avoid under-diagnosis in young participants and over-diagnosis in older participants.(23,24)

The study was approved by the Makerere University School of Medicine Ethics Committee and the Uganda National Council for Science and Technology (HS 2012-1142). All participants signed an informed consent form, or in case of illiteracy, thumb-printed and signed by the village leader. More details about the study participants, study procedure and COPD diagnosis of FRESH AIR Uganda, are reported elsewhere.(18)

### **Socioeconomic status, ethnicity and tobacco smoking**

FRESH AIR Uganda measured the SES using education, employment, location of residence, exposure to household air pollution, cooking tradition, sleeping and cooking areas as variables. Furthermore, we also included variables as gender, ethnicity and tobacco smoking to capture possible inequalities within communities. Ethnicity was defined as Bantu speaking vs non-Bantu speaking based on linguistic grouping of the 55 tribes living in Masindi district.(25-27)

### **Statistical methods**

Demographic and socioeconomic characteristics of subjects with and without COPD were compared using chi-square tests for categorical variables, Student's t-test for normally distributed continuous variables, and Mann-Whitney U-tests for non-normally distributed variables.

The association between socioeconomic factors and COPD was assessed using a multivariable logistic regression model adjusted for age, gender, and smoking habits. Socioeconomic factors were selected



using backward selection and the final model retained all socioeconomic variables with a P-value < 0.1). The socioeconomic factors tested were marital status, biomass fuel use for cooking (indoors and outdoors), biomass fuel use for heating, ethnicity, education, employment, village in tobacco-growing area and sleeping area. The analyses were also stratified for gender to assess risk factors for COPD in males and females separately. P-values < 0.05 were considered as statistically significant, and P-values of 0.05-0.10 as trends. We did the statistical analyses with the Statistical Package for the Social Science SPSS 20 (IBM® SPSS, New York, USA).

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### **Contribution**

FvG, NC, BK, IT, RJ, SW, CdJ and TvdM designed the survey. FvG, BK, CdJ, RJ and TvdM analysed and interpreted the data. FvG and CdJ did the statistical analysis and prepared the results. The manuscript was written by FvG and commented by CdJ, BK, RJ, JWK and TvdM. JV adapted and finalized the epidemiological aspect. All the authors contribute to the editing of the manuscript and giving input for the final version.

### **Competing interests**

The authors declare there were no conflicts of interest in relation to this manuscript.

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	non-COPD			COPD			p value		
	total	men	women	total	men	women	total	men	women
<b>Population</b>	493 (83.8%)	246 (49.9%)	247 (50.1%)	95 (16.2%)	45 (47.4%)	50 (52.6%)			
<b>Age</b>	44.9 (13.5)	44.9 (13.1)	44.9 (14.0)	46.6 (13.9)	45.5 (11.5)	47.7 (15.5)	0.258	0.793	0.211
<b>Cough</b>	89 (18.1%)	40 (16.3%)	49 (19.8%)	29 (30.5%)	15 (33.3%)	14 (28.0%)	0.005	0.007	0.198
<b>Phlegm</b>	102 (20.7%)	48 (19.5%)	54 (21.9%)	21 (22.1%)	13 (28.9%)	8 (16.0%)	0.756	0.155	0.352
<b>Wheeze</b>	32 (6.5%)	16 (6.5%)	16 (6.5%)	16 (16.8%)	9 (20.0%)	7 (14.0%)	0.001	0.003	0.070
<b>Chest infections</b>							0.381	0.007	0.541
<i>none</i>	50 (10.1%)	30 (12.2%)	20 (8.1%)	9 (9.5%)	4 (8.9%)	5 (10.0%)			
<i>1-2 per year</i>	272 (55.2%)	134 (54.5%)	138 (55.9%)	46 (48.4%)	15 (33.3%)	31 (62.0%)			
<i>&gt;2 per year</i>	171 (34.7%)	82 (33.3%)	89 (36.0%)	40 (42.1%)	26 (57.8%)	14 (28.0%)			

Data are N (%) or mean (SD)

Table 1: Comparison of symptoms between non-COPD and COPD participants and within gender

		<b>total</b>	<b>non-COPD</b>	<b>COPD</b>	<b>P-value</b>
<b>Gender</b>					0.652
	<i>men</i>	291 (49.5%)	246 (49.9%)	45 (47.4%)	
	<i>women</i>	297 (50.5%)	247 (50.1%)	50 (52.6%)	
<b>Unmarried</b>	<i>yes</i>	113 (19.2%)	88 (17.8%)	25 (26.3%)	0.055
<b>Biomass fuel use indoors</b>	<i>yes</i>	546 (92.9%)	460 (93.3%)	86 (90.5%)	0.335
<b>Biomass fuel use outdoors</b>	<i>yes</i>	544 (92.5%)	457 (92.7%)	87 (91.6%)	0.704
<b>Biomass fuel for heating</b>	<i>yes</i>	104 (17.7%)	80 (16.2%)	24 (25.5%)	0.035
<b>Smoking</b>					0.046
	<i>active</i>	122 (20.7%)	98 (19.9%)	24 (25.3%)	
	<i>former</i>	87 (14.8%)	67 (13.6%)	20 (21.1%)	
	<i>none</i>	379 (64.5%)	328 (66.5%)	51 (53.7%)	
<b>Ethnicity</b>					0.020
	<i>non-Bantu</i>	270 (45.9%)	216 (43.8%)	54 (56.8%)	
	<i>Bantu</i>	318 (54.1%)	277 (56.2%)	41 (43.2%)	
<b>Education</b>					0.433
	<i>none</i>	118 (20.1%)	97 (19.7%)	21 (22.1%)	
	<i>primary</i>	358 (60.9%)	302 (61.3%)	56 (58.9%)	
	<i>secondary</i>	91 (15.5%)	74 (15.0%)	17 (17.9%)	
	<i>tertiary</i>	21 (3.6%)	20 (4.1%)	1 (1.1%)	
<b>Employment</b>					0.585
	<i>farmers</i>	441 (75.0%)	370 (75.1%)	71 (74.7%)	
	<i>business</i>	43 (7.3%)	37 (7.5%)	6 (6.3%)	
	<i>teachers</i>	16 (2.7%)	15 (3.0%)	1 (1.1%)	
	<i>others</i>	69 (11.7%)	57 (11.6%)	12 (12.6%)	
	<i>unemployed</i>	19 (3.2%)	14 (2.8%)	5 (5.3%)	
<b>Village tobacco-growing area</b>					0.249
	<i>yes</i>	241 (41.0%)	197 (40.0%)	44 (46.3%)	
<b>Sleeping area</b>					0.711
	<i>same room as kitchen</i>	44 (7.5%)	35 (7.1%)	9 (9.5%)	
	<i>separate room</i>	54 (9.2%)	45 (9.1%)	9 (9.5%)	
	<i>separate house</i>	490 (83.3%)	413 (83.8%)	77 (81.1%)	

Data are N (%)

Table 2: Comparison of socioeconomic and risk factors between non-COPD and COPD participants

		All Subjects		Men		Women	
		OR (95% CI)	P value	OR (95% CI)	P value	OR (95% CI)	P Value
<b>Age (years)</b>		1.01 (0.99-1.02)	0.485	1.01 (0.98-1.04)	0.559	1.00 (0.98-1.03)	0.886
<b>Gender</b>	<i>women</i>	1 (reference)					
	<i>men</i>	0.74 (0.44-1.26)	0.269				
<b>Unmarried</b>	<i>no</i>	1 (reference)		1 (reference)			
	<i>yes</i>	1.66 (0.93-2.95)	0.087	3.09 (1.25-7.61)	0.015		
<b>Biomass fuel for heating</b>	<i>no</i>	1 (reference)		1 (reference)			
	<i>yes</i>	1.76 (1.03-3.00)	0.038	2.15 (1.02-4.54)	0.045		
<b>Smoking</b>	<i>never</i>	1 (reference)		1 (reference)		1 (reference)	
	<i>active</i>	1.57 (0.84-2.92)	0.156	1.53 (0.68-3.45)	0.310	1.27 (0.40-4.04)	0.692
	<i>former</i>	1.87 (0.97-3.60)	0.063	1.51 (0.61-3.72)	0.375	3.35 (1.22-9.22)	0.019
<b>Ethnicity</b>	<i>Bantu</i>	1 (reference)		1 (reference)			
	<i>non-Bantu</i>	1.73 (1.06-2.82)	0.030	1.94 (0.94-4.03)	0.075		

OR: odds ratio; 95% CI: 95% confidence interval

Table 3: Results of multivariable analysis of risk factors for COPD for all subjects and stratified by gender