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HIV Infection, Pulmonary Tuberculosis, and COPD in Rural Uganda: A Cross-Sectional Study

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Abstract

Purpose HIV is associated with chronic obstructive pulmonary disease (COPD) in high resource settings. Similar relationships are less understood in low resource settings. We aimed to estimate the association between HIV infection, tuberculosis, and COPD in rural Uganda.

Methods The Uganda Non-communicable Diseases and Aging Cohort study observes people 40 years and older living with HIV (PLWH) on antiretroviral therapy, and population-based HIV-uninfected controls in rural Uganda. Participants completed respiratory questionnaires and post-bronchodilator spirometry.

Results Among 269 participants with spirometry, median age was 52 (IQR 48–55), 48% ($n = 130$) were ever-smokers, and few (3%, $n = 9$) reported a history of COPD or asthma. All participants with prior tuberculosis (7%, $n = 18$) were PLWH. Among 143 (53%) PLWH, median CD4 count was 477 cells/mm^3 and 131 (92%) were virologically suppressed. FEV1 was lower among older individuals (-0.5%pred/year, 95% CI 0.2–0.8, $p < 0.01$) and those with a history of tuberculosis (-14.4%pred, 95% CI -23.5 to -5.3, $p < 0.01$). COPD was diagnosed in 9 (4%) participants, eight of whom (89%) were PLWH, six of whom (67%) had a history of tuberculosis, and all of whom (100%) were men. Among 287 participants with complete symptom questionnaires, respiratory symptoms were more likely among women (AOR 3.9, 95% CI 2.0–7.7, $p < 0.001$) and those in homes cooking with charcoal (AOR 3.2, 95% CI 1.4–7.4, $p = 0.008$).

Conclusion In rural Uganda, COPD may be more prevalent among PLWH, men, and those with prior tuberculosis. Future research is needed to confirm these findings and evaluate their broader impacts on health.

Keywords Spirometry · Africa · Lung function · AIDS · Tuberculosis

Introduction

Chronic obstructive pulmonary disease (COPD) affects over 200 million people and is the third leading cause of death globally [1]. An estimated 90% of COPD-related deaths occur in low- and middle-income countries (LMIC) [2], where COPD epidemiology is incompletely understood. For instance, although tobacco is the primary cause of COPD in

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much of the world, the estimated fraction of tobacco-associated COPD mortality in LMICs is only 12% in women and 45% in men [3]. In sub-Saharan Africa (SSA), air pollution, recurrent pulmonary infections, and malnutrition additionally coalesce to increase the COPD burden [4].

HIV infection increases COPD risk. Compared to HIV-uninfected individuals, COPD is more prevalent, presents earlier, and progresses more rapidly among PLWH [5–8]. Though data are conflicting on associations with antiretroviral therapy [5, 9], virologic failure and lower CD4 T-cell counts are associated with increased odds of COPD [10, 11]. Tuberculosis, a well-documented risk among PLWH, also increases risk for subsequent COPD [12]. Data on the relationships between HIV, tuberculosis, and COPD in SSA are sparse. Since SSA is home to over 75% of the global population of PLWH, the magnitude of undiagnosed COPD may significantly impact regional morbidity and mortality. To address this gap in knowledge, we measured associations between chronic HIV infection, prior tuberculosis, and lung function within a mixed cohort of PLWH and population-based, HIV-uninfected controls in rural Uganda.

Study Population and Methods

The Uganda Non-communicable Diseases and Aging Cohort (UGANDAC, NCT02445079) is an observational cohort study of PLWH and population-based controls. PLWH were recruited from Mbarara Regional Referral Hospital's HIV clinic using convenience sampling, provided they were at least 40 years of age and on antiretroviral therapy (ART) for at least 3 years. There were no exclusion criteria. The HIV-uninfected population was recruited from a parish about 20 km from the clinic, using census data to recruit people matched by age (quartile) and sex to the PLWH cohort. HIV serostatus was confirmed prior to yearly study visits for the HIV-uninfected population. Yearly study visits gathered data on demographics, medical history, respiratory symptoms [13], socioeconomic status [14], smoking history [15], and cooking practices. ART regimens, HIV viral load, and CD4 + T-cell counts within 1 year of pulmonary function testing were obtained through clinical record abstraction for PLWH. We defined virologic suppression as a viral load below the limit of assay detection (plasma specimens: < 40 copies/µL; dried blood spots: < 550 copies/µL; Cobas® assays, Roche Molecular Systems Inc; detection limit changed due to change in clinic protocol during study enrollment period).

Participants were defined as having respiratory symptoms if they reported any of the following: cough, phlegm production, dyspnea, or wheezing. Chronic cough was defined as a cough on most days for at least 3 months, chronic bronchitis was defined as a chronic cough for at least two consecutive

years, dyspnea was defined as shortness of breath when hurrying on flat ground or walking up a slight hill, and wheezing was defined as ever having a 'wheezy or whistling' chest. Dyspnea severity was categorized from mild (needing to walk more slowly than other people of a similar age due to breathlessness) to severe (too breathless to leave the house or breathlessness on dressing or undressing).

Our primary outcome of interest was pulmonary function (forced expiratory volume in one second (FEV1), forced vital capacity (FVC)). Study staff performed pre-bronchodilator spirometry with EasyOne® Plus spirometers (nDD Medical Technologies; Andover, MA) on all study participants, and post-bronchodilator spirometry on those meeting criteria for obstruction (defined below), in accordance with American Thoracic Society/European Respiratory Society (ATS/ERS) guidelines [16]. Spirometers were factory-calibrated prior to use, and calibration was confirmed each morning using a 3-L syringe (nDD Medical Technologies, Andover, MA). Spirometry was interpreted using National Health and Nutrition Examination Survey III (NHANES III) prediction equations and African American correction factors [17], based on similarities with East African prediction equations [18]. ATS/ERS guidelines were used to define acceptability and reproducibility [19]. Tests with only two acceptable trials were included if the best values were within 200 mL of one another. Participants with FEV1:FVC < 0.7 received 4 puffs of albuterol (Ventolin, GlaxoSmithKline, Philadelphia PA) and spirometry was repeated after 10 min. We defined COPD as a post-bronchodilator FEV1:FVC < 0.7 and graded severity according to the global initiative for chronic obstructive lung disease (GOLD) criteria [20].

Study procedures were approved by the Partners Healthcare and Mbarara University of Science and Technology human studies ethics committees, and all participants gave written informed consent.

Statistical Analysis

We compared participant characteristics by HIV serostatus using Student's t tests, Wilcoxon rank sum testing, χ^2, or Fisher's exact testing. To assess for selection bias, we compared characteristics between study participants who completed and declined spirometry, and those with and without ATS/ERS-acceptable results. We identified predictors of impaired FEV1 using a modified forward selection process by fitting multivariable linear regression models that included HIV, tuberculosis, and other covariates with a p value < 0.2 in unadjusted analyses. We identified predictors of respiratory symptoms using logistic regression equations that included smoking status and other covariates with a p value < 0.2 in unadjusted analyses. Candidate covariates were selected based on scientific plausibility and included age, gender, smoking, prior tuberculosis, cooking fuel type,

socioeconomic status (as measured by the asset ownership index [14]), education, occupation, and body mass index (BMI). We compared COPD prevalence by covariates of interest, and evaluated differences in lung function by CD4 count, viral load, and ART duration among PLWH. Data were analyzed with Stata 13 (StataCorp, College Station, Texas).

Results

All 287 study participants completed respiratory questionnaires and 269 (94%) also completed spirometry. Among those with spirometry, PLWH comprised 53% (n = 143) of

the cohort, 46% (n = 125) were women, and the median age was 52 years (Table 1). Fewer PLWH were currently smoking compared to HIV-uninfected participants (9% vs. 22%, p = 0.01). Participants were mostly farmers (67%, n = 179) and generally had completed at most a primary school education (89%, n = 239). All households used either firewood (86%, n = 229) or charcoal (14%, n = 38) for cooking. Few reported a history of COPD (1%, n = 4) or asthma (2%, n = 5); while 9% (n = 23) had prior pneumonia and 7% (n = 18) had prior tuberculosis. All participants with prior tuberculosis were PLWH, and 94% (n = 17) were men (p < 0.001).

Most PLWH were virologically suppressed at last measurement (92%, n = 131), and most (82%, n = 117) had a

Table 1 Baseline characteristics, including those with and without ATS acceptable spirometry, n (%), or median [IQR]

Characteristic	Total cohort (n = 269)	HIV + (n = 143)	HIV − (n = 126)	p value
Age (years)	52 [48, 55]	52 [49, 56]	52 [48, 55]	NS
Women	125 (46)	66 (46)	59 (47)	NS
Body mass index (kg/m^2)				0.02
Underweight (< 18.5)	31 (12)	9 (6)	22 (17)	
Normal (18.5–25)	153 (57)	89 (62)	64 (51)	
Overweight (25.1–30)	52 (19)	30 (21)	22 (17)	
Obese (≥ 30)	33 (12)	15 (10)	18 (14)	
Smoking history				0.01
Never	139 (52)	82 (57)	57 (45)	
Former	89 (33)	48 (34)	41 (33)	
Current	41 (15)	13 (9)	28 (22)	
Years smoked[a]	18 [10, 32]	17 [10, 26]	24 [11, 35]	NS
Pack-years[a]	4 [1, 7]	3 [1, 8]	4 [1, 7]	NS
Farmer	179 (67)	76 (53)	103 (82)	< 0.001
Medical history[b]				
COPD	4 (1)	3 (2)	1 (1)	NS
Asthma	5 (2)	4 (3)	1 (1)	NS
Pneumonia	23 (9)	18 (13)	5 (4)	0.01
Tuberculosis	18 (7)	18 (13)	0 (0)	< 0.001
Biomass exposure				< 0.001
Charcoal	38 (14)	37 (26)	1 (1)	
Firewood	229 (86)	104 (74)	125 (99)	
Education				0.06
Did not complete primary school	148 (55)	69 (48)	79 (63)	
Completed primary school	91 (34)	55 (38)	36 (29)	
Completed secondary school	30 (11)	19 (13)	11 (9)	
Asset ownership index[c]				< 0.001
Poorest	61 (23)	28 (20)	33 (26)	
Poorer	71 (26)	27 (19)	44 (35)	
Richer	65 (24)	34 (24)	31 (25)	
Richest	71 (26)	54 (38)	17 (14)	

[a]Current or former smokers only

[b]Self-reported history

[c]Filmer and Pritchett [14]

CD4 count ≥ 350 cells/mm^3 (median 477, IQR 368–633) (Table 2). Median time on antiretroviral therapy was 9 years [IQR 8–10]. First line, non-nucleoside reverse transcriptase inhibitor-based ART was the most common regimen (92%, $n = 131$). The remaining 8% ($n = 12$) were taking protease inhibitor-based regimens.

Respiratory Symptoms

Respiratory symptoms were reported by 72 (25%) study participants (Fig. 1). Among those who reported any respiratory symptoms, 49 (68%) endorsed dyspnea on exertion. Of participants reporting dyspnea, most PLWH (70%, $n = 19$) reported severe/very severe dyspnea and most HIV-uninfected participants (67%, $n = 14$) reported mild/moderate dyspnea ($p = 0.04$). Any history of wheezing was endorsed by 31 (43%) of the cohort. Chronic cough was prevalent among 7 (10%), and 6 (8%) met criteria for chronic bronchitis. All participants with chronic bronchitis were PLWH.

In multivariable logistic regression models adjusted for predicted confounders, the odds of any respiratory symptoms were higher among women (AOR 3.9, 95% CI 2.0–7.7, $p < 0.001$), and those in households cooking with charcoal [AOR 3.2 (vs firewood), 95% CI 1.4–7.4, $p = 0.008$)]. There
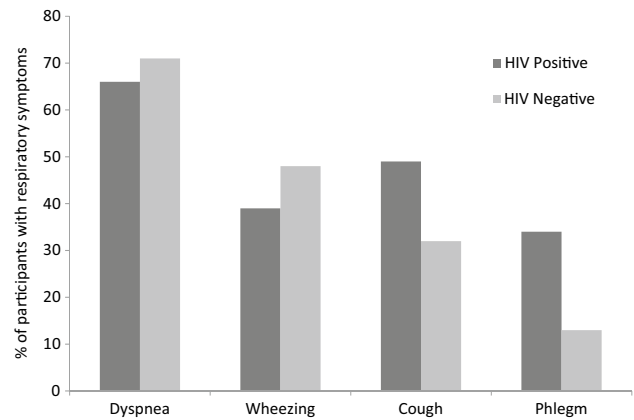

Fig. 1 Self-reported respiratory symptoms

were no associations between odds of respiratory symptoms and smoking history, prior tuberculosis or HIV (Table 3).

Pulmonary Function

Among the 269 study participants with spirometry, 89% ($n = 239$) met ATS/ERS interpretation criteria. Only four of the 18 who declined spirometry were PLWH (22%) compared to 143 of the 269 ($n = 53$%) who completed spirometry

Table 2 HIV-related clinical characteristics ($n = 143$), n (%)

	Total cohort ($n = 143$)	COPD ($n = 8$)	No COPD ($n = 135$)	p value
CD4 cell count, current (cells/m^3)				NS
< 100	0 (0)	0 (0)	0 (0)	
100–349	26 (18)	3 (38)	23 (17)	
350–499	54 (38)	2 (25)	52 (39)	
≥ 500	63 (44)	3 (38)	60 (44)	
CD4 cell count, nadir[a] (cells/m^3)				NS
< 100	50 (35)	3 (38)	47 (35)	
100–349	90 (63)	5 (63)	85 (63)	
350–499	2 (1)	0 (0)	2 (1)	
≥ 500	1 (1)	0 (0)	1 (1)	
Viral load (copies/μL)				NS
Undetectable	131 (92)	8 (100)	123 (91)	
Detectable, < 10,000	6 (4)	0 (0)	6 (4)	
≥ 10,000	1 (1)	0 (0)	1 (1)	
Years on antiretroviral therapy	9 [8, 10]	8 [8, 10]	9 [8, 10]	NS
Current antiretroviral regimen[b]				NS
AZT/3TC/NVP or EFV	112 (78)	6 (75)	106 (79)	
TDF/3TC/NVP or EFV	18 (13)	1 (13)	17 (13)	
TDF/3TC/LPV/r	12 (8)	1 (13)	11 (8)	
AZT/3TC/ABC	1 (1)	0 (0)	1 (1)	

[a]Measured prior to antiretroviral therapy initiation

[b]*AZT* zidovudine, *3TC* lamivudine, *NVP* nevirapine, *TDF* tenofovir, *EFV* efavirenz, *LPV/r* lopinavir/ritonavir, *ABC* abacavir

Table 3 Predictors of decreased FEV1 (percent predicted) and respiratory symptoms

	FEV1 (% predicted), $n=239$				Respiratory symptoms, $n=287$			
	Unadjusted		Adjusted		Unadjusted		Adjusted	
	Estimate	95% CI	Estimate	95% CI	OR	95% CI	AOR	95% CI
Age, per year	0.5**	0.2, 0.9	0.5**	0.2, 0.8	1.03	0.99, 1.07	1.04	0.99, 1.09
Female	0.1	− 4.5, 4.6			4.09***	2.28, 7.34	3.88***	1.96, 7.66
Ever-smoker	0.5	− 4.1, 5.0	0.3	− 4.2, 4.7	1.05	0.61, 1.79	1.74	0.89, 3.41
Asset index								
Poorer	− 3.5	− 9.9, 2.8			0.65	0.31, 1.35	0.61	0.27, 1.35
Richer	− 2.9	− 9.4, 3.6			0.37*	0.16, 0.85	0.31*	0.12, 0.77
Richest	− 4.6	− 11.0, 1.8			0.77	0.38, 1.59	0.44	0.17, 1.13
BMI								
< 18.5	− 5.2	− 12.7, 2.3			0.77	0.30, 2.01	0.74	0.26, 2.10
≥ 25	− 2.2	− 7.2, 2.8			1.81*	1.01, 3.22	1.36	0.67, 2.76
HIV	− 3.2	− 7.7, 1.3	− 1.8	− 6.3, 2.8	1.42	0.83, 2.44		
TB	− 16.1***	− 24.9, − 7.2	− 14.4**	− 23.5, − 5.3	1.86	0.70, 4.92		
Biomass (charcoal)	1.9	− 4.7, 8.5			2.68**	1.33, 5.37	3.17*	1.36, 7.41
Farmer	1.8	− 3.0, 6.6			1.04	0.59, 1.85		
HIV characteristics, $n=143$								
CD4 count								
350–499	3.7	− 3.4 to 10.8	5.4	− 1.7 to 12.5				
< 350	− 10.6*	− 19.5 to − 1.7	− 9.0*	− 17.8 to − 0.1				
Viral load ≥ 10,000 copies	− 25.9**	− 40.9 to − 10.8	− 26.7***	− 41.4 to − 12.0				
ART duration, per year	− 0.3	− 2.1 to 1.5	− 0.7	− 2.5 to 1.1				
ART regimen (AZT-based)	1.9	− 6.5 to 10.3	1.7	− 6.8 to 10.2				

Reference categories—*BMI* 18.5–24.9, *Asset index* poorest, *CD4 count* > 500 cells, *viral load* < 10,000 copies, *ART regimen* non-AZT-based therapy

% predicted based on NHANESIII prediction equations (Ref. [15] in text)

*$p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

($p = 0.01$). Otherwise, demographic characteristics were similar in comparing those who completed or declined spirometry (eTable 1), and in comparing those who did or did not have interpretable spirometry (eTable 2).

Among those with ATS/ERS-acceptable spirometry, mean FEV1, FVC, and FEV1:FVC percent predicted were 103 (± 18), 104 (± 16), and 98 (± 8), respectively, none of which differed by HIV serostatus. In multivariable regression models adjusted for predicted confounders, FEV1%predicted was lower among older-age individuals (− 0.5%predicted per year, 95% CI 0.2–0.8, $p < 0.01$) and those with prior tuberculosis (− 14.4%predicted, 95% CI − 23.5 to − 5.3, $p < 0.01$). There was no association between FEV1%predicted and HIV serostatus or smoking history. Among PLWH, FEV1%predicted was lower among those with detectable viral loads (− 26.7%predicted, 95%CI − 41.4 to − 12.0, $p < 0.001$) and those with lower CD4 counts (< 350 vs > 500: − 9%predicted, 95%CI − 17.8 to − 0.1, $p < 0.05$) (Table 3).

COPD prevalence was 4% ($n=9$), and was six times as high among PLWH (6%, $n=8$) compared to HIV-uninfected participants (1%, $n=1$; $p=0.04$) (Table 4). Most obstruction was Stage I or II in severity (89%, $n=8$). Prevalence estimates were unchanged when defining COPD as FEV1:FVC < lower limit of normal. All participants with COPD were men, and 6 (67%) had a history of tuberculosis ($p < 0.001$). COPD prevalence did not differ by CD4 count, viral load, or ART duration (Table 2).

Discussion

In summary, we found that COPD prevalence was lower than expected in rural Uganda, but more common among men, PLWH, and those with a history of tuberculosis.

This is the first study in Uganda to investigate associations between HIV, tuberculosis, and COPD, joining three other spirometry-based studies in SSA. Cameroon investigators measured lower COPD prevalence among PLWH (2.2%) but describe similar associations between HIV, tuberculosis, and COPD [21]. Their lower prevalence may be explained by a comparatively younger population with a lower smoking

Table 4 Differences in COPD prevalence by covariates of interest

	COPD (n=9)	No COPD (n=230)	p value
HIV positive	8 (89)	135 (52)	0.04
Age			NS
<50 years	2 (22)	91 (35)	
50–53 years	5 (56)	83 (32)	
≥54 years	2 (22)	86 (33)	
Male gender	9 (100)	135 (52)	<0.01
Prior tuberculosis	6 (67)	12 (5)	<0.001
BMI (kg/m^3)			NS
<18.5	2 (22)	29 (11)	
18.5–24.9	6 (67)	147 (57)	
≥25	1 (11)	84 (32)	
Ever-smoker	7 (78)	123 (47)	NS
Asset ownership index			NS
Poorest	2 (22)	59 (23)	
Poorer	2 (22)	69 (27)	
Richer	1 (11)	64 (25)	
Richest	4 (44)	67 (26)	
Education			NS
Did not complete primary school	5 (56)	143 (55)	
Completed primary school	4 (44)	87 (33)	
Completed at least some secondary school	0 (0)	30 (12)	
Farmer	6 (67)	173 (66)	NS
CD4 count			NS
<350	3 (38)	60 (44)	
350–499	2 (25)	52 (39)	
≥500	3 (38)	23 (17)	
Undetectable viral load	8 (100)	123 (95)	NS
ART duration			NS
<8 years	1 (14)	32 (24)	
8–9.9 years	5 (71)	72 (54)	

prevalence. Conversely, Nigerian investigators measured 15.4% prevalence of COPD among PLWH in urban Nigeria, although no association was found between COPD and tuberculosis [22]. Importantly, viral control was less common in the Nigerian cohort. Finally, a population-based study in Malawi found no association between HIV and COPD [23]. Of note, these investigators included PLWH at various disease stages. In North American HIV cohorts, by comparison, COPD prevalence has been moderately higher, ranging from 9 to 27% [5, 24], possibly related to the higher smoking prevalence among PLWH in North America. Associations between lung function, high viral load, and low CD4 count are consistent with published literature [10, 11].

Prior tuberculosis may be largely responsible for the observed associations between HIV and COPD in SSA. PLWH are more susceptible to mycobacterial infection, particularly in TB-endemic regions such as SSA [12]. Tuberculosis increases the risk of COPD through several mechanisms, including infection-related parenchymal scarring and chronic airway inflammation from latently infected pulmonary macrophages [25–27]. HIV itself may also directly cause COPD through the consequences of HIV-infected pulmonary macrophages, which lead to alveolar inflammation, epithelial barrier dysfunction, altered pulmonary oxidant–antioxidant balance, increased cellular apoptosis and altered respiratory tract microbial colonization, all of which are implicated in COPD pathogenesis [28–31]. Indeed, HIV-associated systemic biomarkers of inflammation and immune activation, which persist despite viral suppression, have been associated with pulmonary dysfunction [26, 27]. Associations between tuberculosis and COPD among PLWH in North American cohorts have not been described, possibly related to lower tuberculosis prevalence. Discerning the relative contributions of tuberculosis-mediated structural lung damage and HIV-mediated chronic inflammation to COPD risk in SSA is an important area of future study.

The relationship between ART and COPD risk remains unclear. We did not find an association between lung

function and ART duration, but our sample was limited to individuals on longer-term ART. Some investigators have described a potentially protective effect of ART therapy on odds of COPD [7, 32], which may be from ART-related reduction in pulmonary HIV viral load and inflammation. In contrast, others have found increased COPD risk among PLWH on ART [9, 33], hypothesized to be from either direct pulmonary toxic effects of ART regimens or restoration of immune activity against latent pulmonary infections. Importantly, the above studies do not include data on ART duration. Of further interest, the START study of immediate versus delayed ART initiation in newly diagnosed PLWH followed for a median of 2 years showed that very early ART initiation (CD4 > 500) had no effect on lung function trajectory [34]. Unfortunately, because late presentation to HIV care remains common in SSA [35], these findings might not be generalizable to the regional population. Larger, locally conducted longitudinal studies are necessary to help clarify these associations.

All participants with COPD were men. Tuberculosis is twice as likely in men versus women in SSA [36–38], and while the pathophysiology of this differential susceptibility is yet to be determined, candidate mechanisms include sex-hormone effects on the immune system and/or differences in genetic susceptibility to infection by intracellular organisms [39]. Almost all participants with prior tuberculosis in our cohort were also men, thus we cannot differentiate whether a difference in COPD prevalence observed in our study was due to sex, prior tuberculosis, or some interaction between them. Our findings stand in contrast to other studies from Uganda [40] and other SSA cohorts [41, 42] that identify COPD risk among women, hypothesized to be related to higher biomass smoke exposure from gender-based meal preparation roles [43], although sex-based differences in genetic susceptibility to inhaled toxins may also contribute [44–46].

Finally, we did not find an association between smoking history and respiratory symptoms or lung function. This may be related to misclassification bias introduced by self-report, which has been previously reported in this study population [47]. Alternatively, smoking quantity is lower in resource-limited settings [48]. In this cohort, 83% smoked less than 10 pack-years, with no difference by HIV serostatus, so the overall smoking exposure may have been insufficient to cause respiratory symptoms or impact lung function.

A major strength of this analysis is the inclusion of a population-based, HIV-uninfected comparison group, allowing estimation of HIV-specific effects. Moreover, our methods included rigorous quality control procedures. For example, spirometry was conducted using bronchodilators in accordance with international standards, and automated quality control and interpretation algorithms were evaluated by two pulmonologists. Lastly, respiratory symptoms were collected using a standardized questionnaire, facilitating comparison across other cohorts.

We also acknowledge several limitations. Pulmonary function was measured once per participant, thus the timing of HIV or tuberculosis infection in relation to the onset of COPD is unknown. To better assess the latter, we will be conducting repeat testing in this study population to investigate associations between HIV infection and pulmonary function trajectories. We do not have chest imaging on study participants, so we cannot exclude non-COPD etiologies of irreversible obstruction such as bronchiectasis. DLCO measurements are unavailable locally due to infrastructure limitations, thus we cannot comment on differences in interstitial or pulmonary vascular abnormalities by HIV serostatus. The measured COPD prevalence was lower than anticipated based on other studies in the region [40], so we were underpowered to identify independent correlates of COPD. Although a larger proportion of HIV-uninfected participants declined spirometry, there were no detectable differences in demographics, respiratory symptoms, or smoking history between those who accepted and those who declined testing. Lastly, the study was conducted among older-aged people living in rural Uganda, so generalization to a younger or urban Ugandan population will require additional data.

Widespread availability of antiretroviral therapy, broadening inclusion criteria for therapy initiation, and improved clinical care infrastructure throughout SSA have improved life expectancy for PLWH [49–51] and shifted the health priorities to include diagnosis and management of non-communicable diseases. In this study we add to the evidence base for the importance of non-communicable disease screening among PLWH by demonstrating that, in rural Uganda, COPD prevalence seems to be higher among PLWH, as well as in those with a history of tuberculosis. Future work is needed to understand the relative contributions of HIV-mediated inflammation, tuberculosis, and environmental risks such as biomass smoke, tobacco smoke, and air pollution, and to better delineate the impact of lung disease on health and quality of life in this population. If our findings are confirmed, the vast investment in health care infrastructure made possible by the response to the HIV epidemic would allow an important opportunity to implement screening, diagnostic, and therapeutic services for lung disease.

Compliance with Ethical Standards

Conflict of interest None.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional an/or national research committee and with the 1964 Helsinki declation and its later amendemnts or comparable ethical standards.

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