Population-Level Prevalence, Determinants, and Barriers to HIV Testing Among Refugees in Uganda: Evidence from the 2021 Refugee Uganda Population-Based HIV Impact Assessment (RUPHIA)

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Running head: Lifetime HIV non-testing among Ugandan refugees

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Abstract

Background

HIV testing is the essential first step in the treatment cascade and a prerequisite for the UNAIDS 95-95-95 targets. However, data on lifetime testing non-uptake are almost entirely absent among refugees, a historically underserved group in national HIV surveillance and population. The 2021 Refugee Uganda Population-Based HIV Impact Assessment (RUPHIA) is the first population-representative bio-behavioural survey of Uganda's gazetted refugee settlements, offering an opportunity to quantify the prevalence, determinants, and barriers associated with never having tested for HIV at the population level.

Methods

We conducted a cross-sectional secondary analysis of RUPHIA 2021, a nationally representative multi-stage cluster survey of adults aged 15+ in Uganda's formally recognised refugee settlements. Survey-weighted multivariable logistic regression guided by a directed acyclic graph (DAG) identified independent predictors of lifetime non-testing. Barriers were characterised using weighted prevalence estimates, multinomial regression, and a classification and regression tree (CART). A supply-side analysis quantified HIV test offer at health facility visits. Firth's penalised regression served as a sensitivity analysis.

Results

Of 2,770 eligible adults, 805 (weighted prevalence 31.0%) had never tested for HIV. The strongest adjusted predictors of lifetime non-testing were current marriage (aOR 7.16; 95% CI 5.09–10.1), absence of a health facility visit (aOR 3.44; 95% CI 2.50–4.73), widowhood (aOR 3.38; 95% CI 2.33–4.91), and Southwestern region residence (aOR 2.40; 95% CI 1.72–3.36). Youth aged 15–24 had 56% greater adjusted odds (aOR 1.56; 95% CI 1.08–2.25); secondary education was independently protective (aOR 0.54; 95% CI 0.37–0.78). Of 237 never-tested health facility visitors, only 7 (weighted 3.0%; 95% CI 0.5–5.5%) were offered an HIV test. Low perceived personal risk was the dominant self-reported barrier (46.4%; 95% CI 39.6–53.1%), followed by not knowing where to test (25.3%; 95% CI 17.8–32.8%). Barrier profiles differed significantly by gender, age group, and country of origin. Among those citing low perceived risk, 75.4% (95% CI: 67.5–83.2%) met author-defined behavioural criteria for actual HIV risk (sexually active with multiple partners or no condom), indicating substantial risk misperception.

Conclusions

Nearly one third of adult refugees in Uganda's settlements have never tested for HIV. Provider-initiated testing at health facility contacts is almost completely absent. Among those who cited low perceived personal risk, the majority met objective behavioural criteria for HIV risk. This combination of missed clinical opportunities and widespread risk misperception underscores the urgent need for differentiated, proactive, and community-embedded testing strategies. Risk

communication must also address cognitive gaps, not simply improve access to services. These findings provide the first population-representative evidence base for targeted interventions to close the HIV testing gap in this historically invisible population.

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1. Introduction

HIV testing is the critical gateway to the care cascade: without knowledge of serostatus, linkage to antiretroviral therapy (ART), viral suppression, and transmission interruption remain impossible. The UNAIDS 95-95-95 strategy places universal status awareness as the foundational first step in epidemic control [1,2]. Despite substantial global progress, structurally marginalised populations remain disproportionately untested, a critical gap in the first 95 target[35].

The global forced displacement crisis has produced an estimated 108 million displaced persons, with sub-Saharan Africa disproportionately affected [3,4]. Forced displacement amplifies HIV risk through population mixing during flight, disruption of protective networks, elevated exposure to sexual violence, post-traumatic psychological distress, and collapse of health-seeking behaviour [5,6]. Yet population-representative epidemiological evidence on HIV testing uptake in refugee settings remains strikingly sparse [7]. Most available data derive from facility-based surveillance which are subject to severe selection bias or from small-scale, single-settlement studies with limited generalisability. Refugee populations are frequently excluded from national HIV Impact Assessments, making them systematically invisible to the data systems that drive policy and resource allocation.

Uganda hosts over 1.5 million refugees, the largest refugee population in Africa [8]. Most of these refugees come from South Sudan and the Democratic Republic of Congo (DRC). Uganda's legal framework enshrines refugees' right to access public health services on a non-discriminatory basis [9], yet in practice access is constrained by limited facility density, health personnel shortages, HIV test kit stock-outs, language barriers, and cultural misalignment between standardised health communication and diverse refugee communities [10,11]. The extent to which these barriers translate into a substantial never-tested population has not previously been quantifiable in the absence of representative survey data[36].

The 2021 Refugee Uganda Population-Based HIV Impact Assessment (RUPHIA) is the first bio-behavioural survey to sample Uganda's formally gazetted refugee settlements using a multi-stage cluster design. It provides the first opportunity to address this evidence gap. This study aimed to: (i) estimate the weighted prevalence of lifetime HIV non-testing; (ii) identify independent predictors using multivariable logistic regression; (iii) quantify the proportion of never-tested health facility visitors that weren’t offered an HIV test; (iv) characterise self-reported barriers; and (v) develop a classification-based typology to support differentiated intervention design.

2. Methods

2.1 Study Design and Data Source

We conducted a cross-sectional secondary analysis of RUPHIA 2021, a nationally representative population-based bio-behavioural survey of adults aged ≥15 years in Uganda's formally recognised refugee settlements, implemented by the Uganda Ministry of Health, the U.S. Center for Disease Control and Prevention (CDC), and the PHIA Project, with PEPFAR support (cooperative agreement U2GGH002173). RUPHIA employed multi-stage stratified cluster sampling: enumeration areas (EAs) within gazetted settlements were selected with probability proportional to size; households within selected EAs were systematically sampled; all consenting adults within sampled households were eligible. Detailed methodology is described in the RUPHIA 2021 Final Report [12]. This analysis adhered to all conditions of the RUPHIA data use agreement.

2.2 Analytical Sample

The full RUPHIA dataset comprised 2,777 records. Following listwise deletion of records with missing outcome or key predictor values (n = 7), the final analytical sample comprised 2,770 adults. The never-tested subgroup comprised 805 individuals, of whom 716 (89.0%) provided valid barrier responses; 689 (96.2%) cited exactly one barrier. A total of 237 (29.4% of never tested) reported a health facility visit in the preceding 12 months. The complete sample flow is presented in Table 1.

2.3 Variables

The primary outcome was a binary variable indicating lifetime HIV testing status (never tested = 1; ever tested = 0). Socio-demographic predictors included: age group (Youth 15-24 vs. Adult 25+, per WHO/UNAIDS definitions [13]); gender; educational attainment (primary or below vs. secondary or above); household wealth quintile (principal components analysis-based index, dichotomised lower [Q1-Q3] vs. higher [Q4-Q5]); marital status (never married; currently married; widowed; divorced/separated); and employment status. Health system access variables included health facility visit in the preceding 12 months and among visitors, whether an HIV test was offered. Refugee-specific contextual variables included country of origin (South Sudan [reference]; DRC/Congo; Rwanda/Burundi; other) and settlement region (West Nile [Region 1, reference]; Southwestern [Region 2]). Mental health screening used the PHQ-2 for depression and the GAD-2 for anxiety, each dichotomised at ≥3, the validated clinical screening threshold [14,15]. Among never-tested individuals, eight binary barrier items were grouped into three categories: attitudinal (low perceived risk; not wanting to know result), informational (not knowing where to test), and structural or social (facility distance; cost; stigma; permission refusal; other).

2.4 Statistical Analysis

All analyses accounted for the RUPHIA complex sampling design using the function “svydesign()” in R's survey package (version 4.1.1) [16], specifying primary sampling units, stratification, and interview weights. The quasi-binomial family with Taylor Series Linearisation

variance estimation was applied to accommodate clustered overdispersion [16]. Stratified comparisons used the Rao-Scott chi-square test [17]. Variable selection for the multivariable model was guided by a DAG (Supplementary Figure S3) encoding substantive causal assumptions [18,19], distinguishing distal causes (age, gender, education, wealth, country of origin), proximal mediators (marital status, employment, health facility visit), and structural context (settlement region). Unmeasured confounders including HIV knowledge, stigma attitudes, partner communication are acknowledged in the DAG; all associations are adjusted, not unconfounded causal effects. Adjusted odds ratios (aOR) with 95% CI are reported; $\alpha = 0.05$. Barrier frequencies were estimated with 95% CIs; exploratory multinomial logistic regression and CART characterised barrier-type predictors (Supplementary Tables S4-S6; Supplementary Figures S4-S8). Firth's penalised regression on unweighted data [20,21] assessed directional robustness (Supplementary Table S2). The study was reported in accordance with STROBE guidelines [22]. Ethical approval details are provided in Supplementary Methods.

3. Results

3.1 Analytical Sample and Descriptive Profiles

Of 2,770 eligible adults, 805 (weighted prevalence 31.0%) had never tested for HIV (Table 1). The never-tested group had a pronounced youth bulge: the 15 - 24 age band contained 68.9% of never-tested individuals, compared with 33.9% of ever-tested individuals. Currently married individuals constituted 66.3% of never-tested individuals vs. 20.1% of ever-tested. Never-tested individuals were substantially less likely to have visited a health facility in the preceding year (29.2% vs. 60.2%; $p < 0.001$). Full sub-group prevalence estimates are presented in Supplementary Figure S1. Pairwise Cramér's V analysis (Supplementary Figure S2) confirmed strong association between country of origin and settlement region ($V > 0.5$), as expected from geographic settlement patterns; both were retained in the regression model as they encode conceptually distinct causal pathways i.e., cultural/linguistic background vs. settlement-level service infrastructure.

Table 1: Analytical Sample (RUPHIA 2021)

Step	Group / Description	N	Notes
1	Full RUPHIA 2021 individual dataset (all adults aged 15+ in gazetted settlements)	2,777	Multi-stage cluster sample
2	Applied survey weights; listwise deletion of records missing outcome or key predictors	2,770	Final analytic sample
3a	Ever tested for HIV (lifetime) - reference group	1,965	69.0% weighted prevalence
3b	Never tested for HIV (lifetime) - primary analytical group	805	31.0% weighted prevalence
4a	Never tested with valid barrier data	716	89.0% of never tested
4b	Never-tested citing exactly one barrier (analytical barrier sample)	689	96.2% of never tested with valid barrier data
5	Never tested who visited a health facility in preceding 12 months (supply-side sub-sample)	237	29.4% of never tested

Survey-weighted population estimates. N = unweighted counts. Listwise deletion applied for missing outcome or key predictor values (7 records excluded from N = 2,777).

3.2 Socio-Demographic Profile by Testing Status (Table 2)

Table 2 presents the weighted socio-demographic profile stratified by HIV testing status. The never-tested group was significantly younger (68.9% aged 15–24; $p < 0.001$), more likely to be currently married (66.3% vs. 20.1%; $p < 0.001$), less educated (21.0% vs 24.6%; $p < 0.001$), less employed (15.3% vs. 27.8%; $p < 0.001$), and less likely to have accessed a health facility (29.2% vs. 60.2%; $p < 0.001$). Women were proportionally less represented among the never tested (47.2% vs. 57.0%; $p < 0.001$), suggesting some reproductive health testing pathway even in the refugee context. Wealth quintile distribution did not differ significantly ($p = 0.6$), indicating that HIV testing was not associated with socio-economic status. Depression and anxiety screening positivity did not differ significantly between groups in bivariate analysis ($p = 0.9$ and 0.2, respectively). Figure 1 illustrates the magnitude of the testing gap by age and sex across all strata.

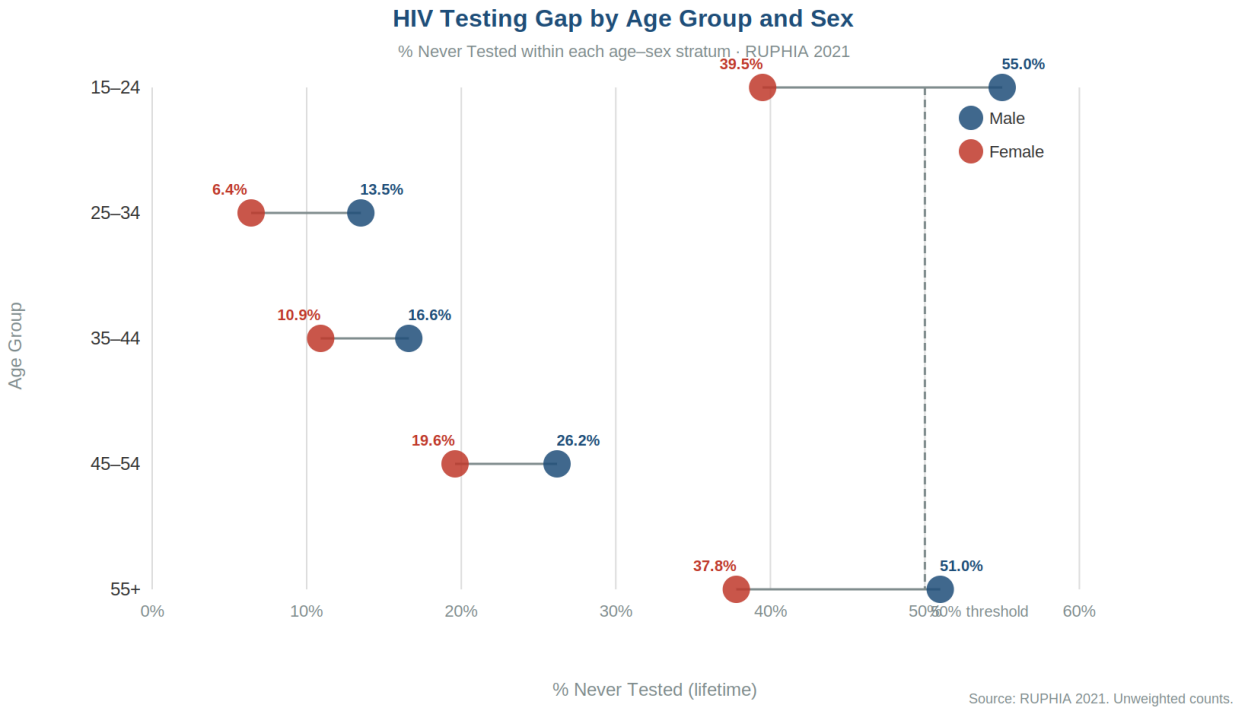

Figure 1: HIV Testing Gap by Age Group and Sex (RUPHIA 2021). Percentage never-tested (lifetime) within each age-sex stratum. Lines span the male-female gap; dashed line = 50% threshold. Red = female; blue = male.

Table 2: Weighted Socio-Demographic Profile of RUPHIA 2021 Adults by HIV Testing Status

Characteristic	Overall N=2,770	Ever Tested N=1,965	Never-tested N=805	p-value
Gender				**<0.001**
Male	46.1% (1,035)	43.0% (672)	52.8% (363)	
Female	53.9% (1,735)	57.0% (1,293)	47.2% (442)	
Age Group				**<0.001**
Youth 15–24 years	44.7% (1,118)	33.9% (607)	68.9% (511)	
25–34 years	25.5% (710)	33.4% (648)	8.0% (62)	
35–44 years	14.2% (436)	17.9% (380)	6.1% (56)	
45–54 years	8.1% (246)	9.0% (188)	5.9% (58)	
55+ years	7.4% (260)	5.8% (142)	11.1% (118)	
Education Level				**<0.001**
No education	23.2% (692)	24.1% (505)	21.0% (187)	
Primary	54.7% (1,497)	51.5% (1,010)	61.7% (487)	
Secondary	20.3% (513)	21.9% (388)	16.7% (125)	
Higher	1.9% (47)	2.5% (44)	0.5% (3)	
Wealth Quintile				**0.6**
Poorest (Q1)	20.5% (555)	20.3% (398)	20.9% (157)	
Poor (Q2)	20.3% (577)	21.4% (439)	18.0% (138)	
Middle (Q3)	19.5% (563)	18.6% (382)	21.4% (181)	
Rich (Q4)	19.4% (514)	19.3% (363)	19.5% (151)	
Richest (Q5)	20.4% (559)	20.5% (382)	20.1% (177)	
Marital Status				**<0.001**
Never married	51.3% (1,480)	64.3% (1,279)	22.3% (201)	
Currently married	34.4% (823)	20.1% (329)	66.3% (494)	
Divorced/Separated	7.8% (234)	9.4% (202)	4.2% (32)	
Widowed	6.5% (222)	6.2% (148)	7.1% (74)	
Employed (past 12 months)				**<0.001**
Yes	23.9% (617)	27.8% (500)	15.3% (117)	

Characteristic	Overall N=2,770	Ever Tested N=1,965	Never-tested N=805	p-value
No	76.1% (2,153)	72.2% (1,465)	84.7% (688)	
Health Facility Visit (past 12 months)				**<0.001**
Yes	50.6% (1,439)	60.2% (1,202)	29.2% (237)	
No	49.4% (1,331)	39.8% (763)	70.8% (568)	
Country of Origin				**0.11**
South Sudan	61.4% (1,690)	62.7% (1,234)	58.5% (456)	
DRC/Congo	31.9% (863)	29.9% (563)	36.3% (300)	
Rwanda/Burundi	5.9% (183)	6.6% (142)	4.2% (41)	
Other	0.8% (20)	0.8% (15)	0.9% (5)	
Settlement Region				**0.2**
Region 1 — West Nile	60.1% (1,595)	62.1% (1,192)	55.6% (403)	
Region 2 — Southwestern	39.9% (1,175)	37.9% (773)	44.4% (402)	
Depression Screen (PHQ-2)				**0.9**
Negative (PHQ-2 <3)	91.7% (2,466)	91.6% (1,745)	91.9% (721)	
Positive (PHQ-2 ≥3)	8.3% (277)	8.4% (205)	8.1% (72)	
Anxiety Screen (GAD-2)				**0.2**
Negative (GAD-2 <3)	90.0% (2,416)	89.3% (1,699)	91.6% (717)	
Positive (GAD-2 ≥3)	10.0% (316)	10.7% (240)	8.4% (76)	

N = weighted population estimates. Cells show weighted % (unweighted n). Rao-Scott adjusted Pearson chi-square. Unadjusted odds ratios for each predictor in Supplementary Table S1.

3.3 Multivariable Predictors of Lifetime Non-Testing

The multivariable model was fitted among 2,694 individuals with complete covariate data (Table 3; forest plot in Supplementary Figure S9).

Current marriage was the single strongest predictor: currently married individuals had over seven-fold greater adjusted odds of lifetime non-testing compared with never-married individuals (aOR 7.16; 95% CI 5.09–10.1; $p < 0.001$), and widowed individuals had over three-fold greater odds (aOR 3.38; 95% CI 2.33–4.91; $p < 0.001$).

Absence of a health facility visit was one of the strongest predictors of non-testing (aOR 3.44; 95% CI 2.50–4.73; $p < 0.001$), suggesting that women who do not engage with health services represent a highly underserved population at risk of undiagnosed HIV. Southwestern region

residence conferred more than double the odds of non-testing compared with West Nile (aOR 2.40; 95% CI 1.72–3.36; p < 0.001), highlighting substantial geographic disparities in HIV testing uptake. Regional comparisons are detailed in Supplementary Table S3.

Youth aged 15–24 had 56% greater adjusted odds of non-testing compared with adults (aOR 1.56; 95% CI 1.08–2.25; p = 0.019), an independent effect persisting after full covariate adjustment. Secondary educational attainment was independently protective (aOR 0.54; 95% CI 0.37–0.78; p = 0.002), with the effect remaining significant after wealth adjustment, indicating that education may operate through mechanisms that are independent of economic advantage. Unemployment was independently associated with 90% higher odds of never testing for HIV (aOR 1.90; 95% CI 1.38–2.62; p < 0.001). Rwanda/Burundi-origin refugees had 64% lower odds of non-testing compared with South Sudanese refugees (aOR 0.36; 95% CI 0.22–0.60; p < 0.001). Neither depression nor anxiety screening positivity was significant in the adjusted model.

Sensitivity analysis (Supplementary Table S2) using Firth's penalised regression on unweighted data was directionally concordant across all predictors, strengthening confidence in the main findings.

Table 3: Adjusted Odds Ratios for Lifetime HIV Non-Testing - Survey-Weighted Multivariable Logistic Regression (RUPHIA 2021, N = 2,694)

Characteristic	aOR	95% CI	p-value
Age Group (ref: Adult 25+)			
Youth (15–24 years)	1.56	1.08–2.25	0.019
Gender (ref: Male)			
Female	0.79	0.61–1.01	0.061
Education (ref: Primary or below)			
Secondary or above	0.54	0.37–0.78	0.002
Wealth (ref: Lower Q1–Q3)			
Higher (Q4–Q5)	0.84	0.65–1.08	0.2
Marital Status (ref: Never married)			
Currently married	7.16	5.09–10.1	<0.001
Divorced/Separated	1.21	0.78–1.88	0.4
Widowed	3.38	2.33–4.91	<0.001
Employment (ref: Employed)			
Not employed	1.90	1.38–2.62	<0.001
Health Facility Visit (ref: Yes)			
No visit in past 12 months	3.44	2.50–4.73	<0.001

Characteristic	aOR	95% CI	p-value
Country of Origin (ref: South Sudan)			
DRC/Congo	0.77	0.48–1.24	0.3
Rwanda/Burundi	0.36	0.22–0.60	<0.001
Other	1.11	0.43–2.83	0.8
Settlement Region (ref: West Nile)			
Southwestern (Region 2)	2.40	1.72–3.36	<0.001
Depression Screen (ref: Negative)			
PHQ-2 ≥3 (positive)	1.59	0.91–2.78	0.10
Anxiety Screen (ref: Negative)			
GAD-2 ≥3 (positive)	1.03	0.65–1.63	>0.9

aOR = adjusted odds ratio; CI = 95% confidence interval. svyglm, quasibinomial family, Taylor Series Linearisation. All predictors entered simultaneously. Reference categories in parentheses. Unadjusted ORs: Supplementary Table S1. Firth sensitivity: Supplementary Table S2. Forest plot: Supplementary Figure S9.

3.4 Supply-Side Missed Opportunity

Among the 237 never-tested individuals who visited a health facility in the preceding 12 months, only 7 (weighted 3.0%; 95% CI 0.5–5.5%) were offered an HIV test; the remaining 97.0% (n = 227; 95% CI 94.5–99.5%) left without a testing offer. While 5.4% of male visitors and 1.2% of female visitors were offered a test, small cell sizes preclude precise sub-group estimation.

3.5 Barriers to HIV Testing (Figure 2)

Low perceived personal risk dominated the barrier landscape, cited by 46.4% (95% CI 39.6–53.1%) of never-tested respondents with valid barrier data. Not knowing where to obtain a test was cited by 25.3% (95% CI 17.8–32.8%), an informational gap reflecting limited awareness of testing locations. Structural access barriers were each cited by smaller proportions (Supplementary Table S4). Social and stigma barriers were less prevalent overall but showed important gender patterning: partner or family permission refusal was cited by 5.8% of female never-tested individuals vs. 2.1% of males, quantifying a gender-specific barrier rooted in diminished health decision-making autonomy. Among youth aged 15–24, informational barriers were proportionally more common (31.1%) than among adults 25+ (13.4%), consistent with lower cumulative exposure to community testing outreach. South Sudanese refugees reported higher attitudinal risk misperception (63.0%) relative to DRC/Congolese refugees (36.2%), who reported higher informational and structural barriers. Gender, age, and country-of-origin-stratified barrier profiles are presented in Supplementary Figures S4–S6. The CART typology (Supplementary Figure S7) and multinomial regression (Supplementary Table S6) confirmed country of origin and settlement region as the primary discriminators of barrier type.

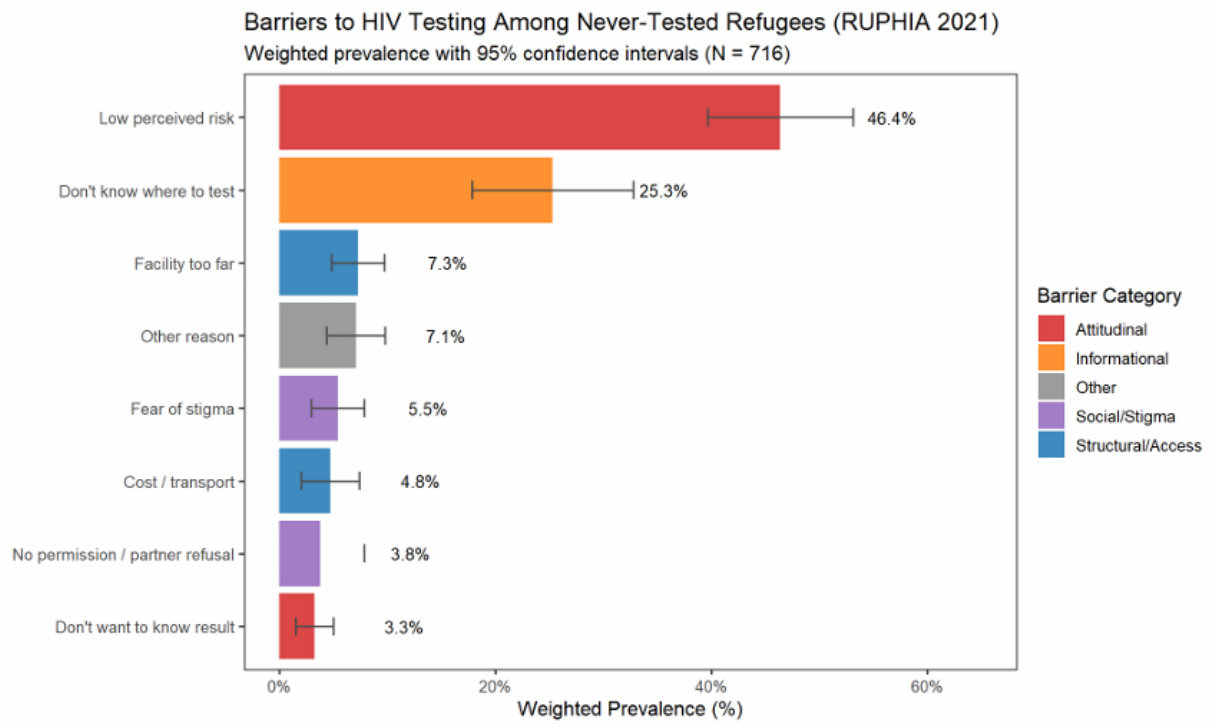

Figure 2: Barriers to HIV Testing Among Never-Tested Refugees (RUPHIA 2021, N = 716). Weighted prevalence of each self-reported barrier with 95% CIs

3.5.1 Sexual Behaviour Among Those Citing Low Perceived Risk

Among never-tested refugees who cited "low perceived risk" as their primary barrier to HIV testing (n = 349), the majority were behaviourally at risk for HIV despite their self-perception. While only 26.6% (95% CI: 19.1–34.1%) reported sexual activity in the past 12 months, among those who were sexually active, 84.7% (95% CI: 72.1–97.3%) had two or more sexual partners (Table S5). Condom use at last sex was low, with 11.3% (95% CI: 0.6–22.1%) of sexually active individuals reporting no condom use. By our author-defined composite measure (sexually active with multiple partners or no condom at last sex), 75.4% (95% CI: 67.5–83.2%) of low-risk perceivers had objective HIV risk. These findings demonstrate that low perceived personal risk among never-tested refugees is predominantly a misperception rather than an accurate assessment of behavioural risk.

3.6 Mental Health and HIV Testing

Among never-tested individuals, depression (PHQ-2 $\geq$ 3) was present in 8.1% and anxiety (GAD-2 $\geq$ 3) in 8.4%. Both were significantly associated with barrier type (PHQ-2: $p = 0.005$; GAD-2: $p = 0.016$) and health facility contact: depression was positive in 12% of never-tested health facility visitors vs. 6.4% of non-visitors ($p = 0.005$), and anxiety in 12% vs. 6.9% ($p = 0.020$; Supplementary Table S6). These findings imply that never-tested individuals who attend health facilities are a higher-risk subgroup for common mental disorders.

4. Discussion

This study presents the first population-representative characterisation of lifetime HIV testing non-uptake among refugees in Uganda, drawn from RUPHIA 2021. This is the first bio-behavioural survey to sample Uganda's refugee settlement population using a representative multi-stage cluster design. Three overarching findings emerge with direct programmatic implications.

First, 31.0% of adult refugees have never tested, a substantial proportion concentrated in identifiable subpopulations. The exceptionally strong association of current marriage with non-testing (aOR 7.16) is a novel finding, likely reflecting the high proportion of young, married individuals not captured by ANC-based testing pathways in the refugee context. In stable sub-Saharan African settings, marriage typically facilitates testing through ANC and couples testing [23]. The reversal reflects structural constraints and uneven service coverage in refugee settlements, where ANC access is limited. The independent effect of youth (aOR 1.56), which remained significant after full adjustment, reflects multiple co-occurring mechanisms: disrupted schooling limiting HIV information access, economic dependence constraining mobility, and absence of the reproductive health testing pathway most commonly reaching women of reproductive age in stable settings [23,24].

Second, a near-complete supply-side failure: 97.0% of never-tested individuals who visited a health facility were not offered an HIV test. This demonstrates that even those who overcome structural barriers to attend a facility left without a testing opportunity, a gap that can be addressed without a demand-side behaviour change. Routine opt-out HIV testing at all facility contacts is a minimum standard that is clearly not being met in this setting. The finding that distressed never-tested individuals were more likely to attend health facilities creates an opportunity for integrated HIV and mental health screening.

Third, low perceived personal risk dominates the demand-side barrier landscape (46.4%). In a country with 5.1% adult HIV prevalence, and in a humanitarian context known to amplify risk [5], this magnitude of risk misperception represents a profound communications failure. Importantly, barrier profiles are heterogeneous: South Sudanese refugees exhibit predominantly attitudinal barriers, while DRC/Congolese refugees report relatively more informational and structural barriers and younger individuals report informational barriers at higher rates than older adults. The CART typology (Supplementary Figure S7) operationalises this heterogeneity into a decision framework for differentiated programming: for older South Sudanese refugees in West Nile, targeted risk communication; for younger South Sudanese refugees, location-specific informational outreach and HIVST(HIV Self-Testing Kits) distribution [25]; for Congolese refugees in the Southwestern region, facility integration improvements and gender-sensitive outreach.

The gender-specific permission barrier, cited by 5.8% of female never-tested individuals vs. 2.1% of males, is qualitatively distinct from supply-side or informational barriers. It is not amenable to facility-level or informational interventions but may require community-level, gender-

transformative approaches [26] addressing household power dynamics reinforced by economic dependency and limited legal protection in the displacement context.

The finding that low perceived personal risk dominates the demand-side barrier landscape warrants deeper examination. Taken at face value, a high prevalence of low-risk perception might reflect accurate self-assessment among genuinely low-risk individuals. The behavioural data presented in Supplementary Table S5 suggest otherwise. Among the 349 never-tested refugees who cited low perceived personal risk, 75.4% (95% CI 67.5–83.2%) met the composite behavioural criterion for HIV risk: sexual activity in the past year with two or more partners, or no condom at last sex. This gap between perceived and objective risk is consistent with evidence from comparable displaced and migrant populations. Low perceived risk has been identified as a central determinant of HIV non-testing among sub-Saharan African migrants in precarious conditions in Europe [31]. In rural Malawi, individuals with ongoing risk behaviours frequently failed to recognise their continued exposure, particularly when they perceived their own behaviour to have changed relative to community norms [32]. These findings have clear implications for programme design. Risk communication for never-tested refugees cannot rely on information provision alone; it must address the affective and cognitive dimensions of risk appraisal. Critically, the 97.0% PITC (Provider-Initiated HIV Testing and Counselling) failure rate at health facilities demonstrates that routine opt-out testing, which bypasses risk-based eligibility assessment entirely, is the structural intervention most directly matched to this gap.

The youth testing gap merits specific discussion. Youth aged 15–24 accounted for 68.9% of never-tested individuals and had 56% greater adjusted odds of lifetime non-testing compared with adults, an effect that persisted after adjustment for marital status, employment, and health facility contact. This independent youth effect likely reflects at least three intersecting mechanisms. First, shorter time since potential HIV exposure reduces the probability of ever having been captured by any testing programme. Second, young refugees are less likely to have been reached by the ANC(Antenatal Care)-based testing pathway that, in stable sub-Saharan African settings, constitutes the primary route to testing for women of reproductive age [23]. Third, the barrier data add specificity: among youth, informational barriers (not knowing where to test) were substantially more prevalent (31.1%) than among adults (13.4%; Supplementary Figure S5), suggesting that location-specific outreach is the primary response needed for this age group. The demographic concentration of non-testing among youth also has epidemiological implications: if young people with unrecognised HIV risk remain untested throughout their peak sexual activity years, this represents a sustained transmission risk that compounds annually. HIVST (HIV Self-Testing Kits), which enables testing without a facility contact and has demonstrated efficacy in comparable East African settings [25], is the approach most directly matched to the informational and access barriers documented here among youth.

The regional finding deserves attention beyond its statistical significance. Residence in the Southwestern settlement region (Region 2) was independently associated with more than double the odds of lifetime non-testing compared with West Nile (aOR 2.40), after adjustment for country

of origin, individual demographics, and health facility contact. This regional effect, net of individual-level factors, points to settlement-level programmatic variation in HIV testing coverage that is not attributable to compositional differences between the two populations. The Southwestern region hosts predominantly DRC/Congolese refugees, and the barrier data show that this group reports a meaningfully different barrier profile from South Sudanese refugees: lower rates of attitudinal risk misperception (36.2% vs. 63.0%) but higher rates of informational barriers (not knowing where to test: 32.4% vs. 11.4%) and structural barriers (facility too far: 10.8% vs. 2.4%; Supplementary Figure S6). This suggests that the regional disparity in HIV testing uptake may in part reflect lower community awareness of testing locations and greater geographic access barriers in Southwestern settlements, which warrants targeted investment in community-level testing promotion, HIVST (HIV Self-Testing Kits) distribution, and facility outreach in that region.

The intersection of mental health and HIV testing in this population has not previously been examined in a representative refugee survey. Two findings are notable. First, depression and anxiety screening positivity were each significantly associated with barrier type: psychologically distressed individuals were disproportionately concentrated among those reporting structural and social barriers (Supplementary Table S7), suggesting that common mental disorders compound the access constraints that prevent testing. Second, depression and anxiety rates were significantly higher among never-tested individuals who did visit a health facility (12% each) than among those who did not (6.4% and 6.9% respectively). This indicates that the subset of never-tested refugees who do access health care carry a higher burden of psychological distress and yet were almost never offered an HIV test. Integrating HIV testing into mental health service contacts at health facilities and integrating psychosocial support into community-based HIV testing outreach, would address both gaps simultaneously. These findings support the case for integrated HIV and mental health services in refugee settlement health facilities, a model consistent with WHO guidance on integrated health service delivery in humanitarian settings.

Strengths and Limitations

RUPHIA 2021 is the first population-representative bio-behavioural survey of Uganda's refugee settlement population, enabling generalisable findings beyond what facility-based or convenience samples permit. Application of survey weights, stratification, and clustering adjustments throughout ensures valid population-level inference. DAG-guided variable selection makes causal assumptions transparent; Firth's penalised sensitivity analysis and the transparent characterisation of the barrier instrument's single-endorsement structure strengthen methodological rigour.

Limitations include the cross-sectional design, which precludes causal inference. Self-reported testing status may be subject to recall and social desirability bias. Dichotomisation of continuous variables reduces statistical precision. Listwise deletion of 76 records may introduce selection bias if data are not missing at random. The multinomial barrier regression does not propagate survey clustering; those results are presented as exploratory. Refugees outside formally gazetted settlements (potentially the most marginalised group) were not in the sampling frame, suggesting that our estimates may be conservative. Acknowledged unmeasured confounders such as HIV

knowledge, stigma attitudes, and partner communication were not captured at the individual level in RUPHIA 2021.

5. Conclusions

Nearly one third of adult refugees in Uganda's gazetted settlements have never tested for HIV. Standard facility-based and ANC-linked testing pathways are failing to reach the most affected groups, that is, youth, currently married individuals, those not accessing facilities, and residents of Southwestern settlements. School-integrated, community-embedded, and peer-driven HIV testing models including HIVST (HIV Self-Testing Kits) are evidence-based approaches that should be urgently scaled [25]. A near-complete failure of provider-initiated testing at health facility contacts is an immediately addressable supply-side gap requiring routine opt-out HIV testing at all encounters. Low perceived risk, the dominant barrier, demands targeted, culturally adapted, and demographically differentiated risk communication. These findings provide the first population-representative evidence base for designing targeted interventions to close the HIV testing gap among Uganda's refugee population and contribute to the UNAIDS 95-95-95 targets.

Acknowledgements

The authors acknowledge RUPHIA 2021 study participants, the Uganda Ministry of Health, CDC Uganda, and the PHIA Project for making survey data available.

Conflict of Interest

The authors declare no conflicts of interest.

Funding

Data Availability

The RUPHIA 2021 dataset is available upon request through the PHIA Project data access process at phia.icap.columbia.edu.

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Supplementary Material

This document contains six supplementary tables (Tables S1–S6) and nine supplementary figures (Figures S1–S9) referenced in the main manuscript. All estimates are survey-weighted unless otherwise stated. All figure legends are provided immediately below each figure.

Ethical Approval

RUPHIA 2021 received ethical approval from the Uganda National Council for Science and Technology, the Makerere University School of Public Health Institutional Review Board, and the U.S. CDC's National Center for HIV/AIDS, Viral Hepatitis, STD, and TB Prevention. All participants provided written informed consent prior to interview. This secondary analysis used fully anonymised data under the terms of the RUPHIA data use agreement and did not require separate ethical review.

Supplementary Tables

Table S1: Unadjusted (Bivariate) Odds Ratios for Lifetime HIV Non-Testing - RUPHIA 2021

Unadjusted ORs from separate survey-weighted logistic regression models for each predictor, presented to permit assessment of confounding relative to Table 3 in the main manuscript. The large crude OR for youth (4.32) vs. adjusted OR (1.56) illustrates substantial mediation through marital status and health facility contact.

Characteristic	OR	95% CI	p-value	Direction
Age Group (ref: Adult 25+)				
Youth (15–24 years)	4.32	3.03–6.14	<0.001	Higher non-testing
Gender (ref: Male)				
Female	0.67	0.57–0.80	<0.001	Lower non-testing
Education (ref: Primary/below)				
Secondary or above	0.65	0.49–0.87	0.004	Lower non-testing
Wealth (ref: Lower Q1–Q3)				
Higher (Q4–Q5)	1.00	0.77–1.29	>0.9	Not significant
Marital Status (ref: Never married)				
Currently married	9.48	6.45–13.9	<0.001	Higher non-testing
Divorced/Separated	1.28	0.85–1.93	0.2	Not significant
Widowed	3.32	2.40–4.58	<0.001	Higher non-testing
Employment (ref: Employed)				

Characteristic	OR	95% CI	p-value	Direction
Not employed	2.12	1.70–2.65	<0.001	Higher non-testing
HF Visit (ref: Yes)				
No visit in past 12 months	3.67	2.82–4.77	<0.001	Higher non-testing
Country of Origin (ref: South Sudan)				
DRC/Congo	1.30	0.87–1.96	0.2	Not significant
Rwanda/Burundi	0.68	0.46–1.03	0.065	Borderline lower
Other	1.25	0.65–2.41	0.5	Not significant
Settlement Region (ref: West Nile)				
Southwestern (Region 2)	1.31	0.89–1.92	0.2	Not significant (unadjusted)
Depression (ref: Negative)				
PHQ-2 ≥3	0.96	0.57–1.64	0.9	Not significant
Anxiety (ref: Negative)				
GAD-2 ≥3	0.76	0.51–1.15	0.2	Not significant

OR = unadjusted odds ratio from separate bivariate models. CI = 95% confidence interval. Each row represents an independent model. Compare with adjusted estimates in main Table 3.

Table S2: Sensitivity Analysis: Firth's Penalised Logistic Regression for Lifetime HIV Non-Testing (Unweighted Data, N = 2,770)

Firth's penalised logistic regression (logistf package) applied to unweighted data to assess directional robustness to small-sample bias from sparse cross-classified cells. Results do not account for the survey design and should not be used as primary population-level estimates. Concordance with the primary model (Table 3) strengthens confidence in the main findings.

Predictor	OR (Firth)	95% CI	p-value
Age: Youth 15–24 years	4.13	3.43–4.99	<0.001
Gender: Female	0.64	0.53–0.78	<0.001
Education: Secondary or above	0.51	0.39–0.65	<0.001
Wealth: Higher (Q4–Q5)	0.91	0.74–1.11	0.33
HF Visit: No	3.60	2.99–4.35	<0.001
Origin: DRC/Congo	0.54	0.36–0.81	0.003
Origin: Rwanda/Burundi	0.27	0.15–0.46	<0.001
Origin: Other	1.05	0.32–3.10	0.93
Region: Southwestern	3.10	2.05–4.68	<0.001

OR = Firth penalised logistic regression estimate on unweighted data. 95% profile likelihood CI. Survey design not propagated; interpret as robustness check only.

Table S3: Regional Comparison: Socio-Demographic Composition and HIV Testing Status by Settlement Region (RUPHIA 2021)

West Nile (Region 1, predominantly South Sudanese refugees) and Southwestern (Region 2, predominantly DRC/Congolese refugees) differ substantially in demographic composition and wealth distribution, motivating the inclusion of settlement region as a structural-level predictor independent of country of origin.

Characteristic	West Nile (Region 1) N=451,300	Southwestern (Region 2) N=300,032	p-value
Gender			**0.14**
Male	44.8% (541)	47.9% (494)	
Female	55.2% (1,054)	52.1% (681)	
Age Group			**0.048**
Youth (15–24 years)	47.9% (675)	40.1% (443)	
Adult (25+ years)	52.1% (920)	59.9% (732)	
Education			**0.8**
Primary or below	77.6% (1,269)	78.7% (941)	
Secondary or above	22.4% (326)	21.3% (234)	
Household Wealth			**0.004**
Lower (Q1–Q3)	70.0% (1,154)	45.6% (543)	
Higher (Q4–Q5)	30.0% (441)	54.4% (632)	
HIV Testing Status			**0.2**
Ever tested	71.4% (1,192)	65.6% (773)	
Never tested	28.6% (403)	34.4% (402)	

N = weighted population estimates in column headers. Cells show weighted % (unweighted n). Rao-Scott adjusted chi-square. Region 1 (West Nile) is the reference in the multivariable model.

Table S4: Weighted Prevalence of Self-Reported Barriers to HIV Testing Among Never-Tested Adults (RUPHIA 2021, N = 716)

Complete barrier frequency table. The near-exclusive single-endorsement structure (96.2% of respondents citing exactly one barrier) reflects the survey instrument's primary-reason design and motivated treatment of barrier type as a nominal categorical variable in all analyses.

Category	Barrier	Weighted % (N=716)	95% CI
Attitudinal			
	Low perceived personal risk	46.4%	39.6–53.1
	Does not want to know result	3.3%	1.5–5.0
Informational			
	Does not know where to test	25.3%	17.8–32.8
Structural/Access			
	Health facility too far	7.3%	4.8–9.8
	Cost or transport difficulties	4.8%	2.0–7.5
Social/Stigma			
	Fear of stigma	5.5%	3.0–7.9
	No permission / partner refusal	3.8%	-0.2–7.9
Other			
	Other reason	7.1%	4.4–9.8

Estimates are survey weighted. Analysis restricted to 716 respondents with valid barrier data. Negative lower CI for 'No permission/partner refusal' reflects small cell counts. Barrier frequencies displayed graphically in main Figure 2.

Table S5: Sexual Behaviour and Actual HIV Risk Among Never-Tested Refugees Citing Low Perceived Risk

Indicator	% (95% CI)
Sexually active (past 12 months)	26.6 (19.1–34.1)
Among sexually active:	
• Two or more sexual partners	84.7 (72.1–97.3)
• No condom use at last sex	11.3 (0.6–22.1)
Composite at-risk indicator†	75.4 (67.5–83.2)

†Author-defined composite indicator for this analysis: sexually active AND (≥2 partners OR no condom at last sex). Not a validated scale.

Table S6: Exploratory Multinomial Logistic Regression: Predictors of Barrier Type Among Never-Tested Adults (RUPHIA 2021, N = 689)

Relative risk ratios (RRR) from multinomial logistic regression with barrier group (attitudinal / informational / structural-social) as the outcome. Reference outcome: attitudinal barriers. Survey weights applied as case weights (nnet::multinom). Variance estimates do not propagate survey clustering and may be anti-conservative; results are exploratory.

Outcome (ref: Attitudinal)	Predictor	RRR (95% CI)	p-value		
Informational barrier					
	Youth (15–24)	2.86 (2.78–2.94)	<0.001	↑	Higher vs attitudinal
	Female	1.42 (1.38–1.45)	<0.001	↑	Higher vs attitudinal
	Secondary+ education	0.74 (0.72–0.77)	<0.001	↓	Lower vs attitudinal
	Higher wealth	1.22 (1.19–1.26)	<0.001	↑	Higher vs attitudinal
	DRC/Congo origin	0.64 (0.60–0.69)	<0.001	↓	Lower vs attitudinal
	Rwanda/Burundi origin	1.41 (1.29–1.54)	<0.001	↑	Higher vs attitudinal
	Southwestern region	0.32 (0.30–0.34)	<0.001	↓	Lower vs attitudinal
Structural/Social barrier					
	Youth (15–24)	0.88 (0.86–0.90)	<0.001	↓	Lower vs attitudinal
	Female	1.14 (1.12–1.17)	<0.001	↑	Higher vs attitudinal
	Secondary+ education	1.58 (1.54–1.63)	<0.001	↑	Higher vs attitudinal

Outcome (ref: Attitudinal)	Predictor	RRR (95% CI)	p-value		
	Higher wealth	1.04 (1.02–1.07)	0.001	↑	Higher vs attitudinal
	DRC/Congo origin	0.22 (0.21–0.23)	<0.001	↓	Lower vs attitudinal
	Rwanda/Burundi origin	0.22 (0.21–0.24)	<0.001	↓	Lower vs attitudinal
	Southwestern region	1.72 (1.63–1.80)	<0.001	↑	Higher vs attitudinal

RRR = relative risk ratio vs. attitudinal barrier reference. Wald 95% CI (case-weighted, clustering not propagated). Reference for origin: South Sudan; region: West Nile. Results are exploratory only.

Table S7: Mental Health Screening by Health Facility Visit Status Among Never-Tested Individuals (RUPHIA 2021)

Depression and anxiety screening positivity are both significantly higher among never-tested individuals who visited a health facility than non-visitors, identifying a psychosocially vulnerable subgroup within the never-tested population that may benefit from integrated HIV testing and mental health care.

Characteristic	Overall (N=805)	HF Visitor (N=237)	Non-Visitor (N=568)	p-value
Depression Screen (PHQ-2)				**0.005**
Negative (PHQ-2 <3)	91.9% (721)	88.0% (203)	94.0% (518)	
Positive (PHQ-2 ≥3)	8.1% (72)	12.0% (32)	6.4% (40)	
Anxiety Screen (GAD-2)				**0.020**
Negative (GAD-2 <3)	91.6% (717)	88.0% (203)	93.0% (514)	
Positive (GAD-2 ≥3)	8.4% (76)	12.0% (32)	6.9% (44)	

Survey-weighted estimates. N = 805 never-tested total; 237 HF visitors; 568 non-visitors. Rao-Scott adjusted chi-square. PHQ-2 ≥3 = probable depression; GAD-2 ≥3 = probable anxiety disorder.

Supplementary Figures

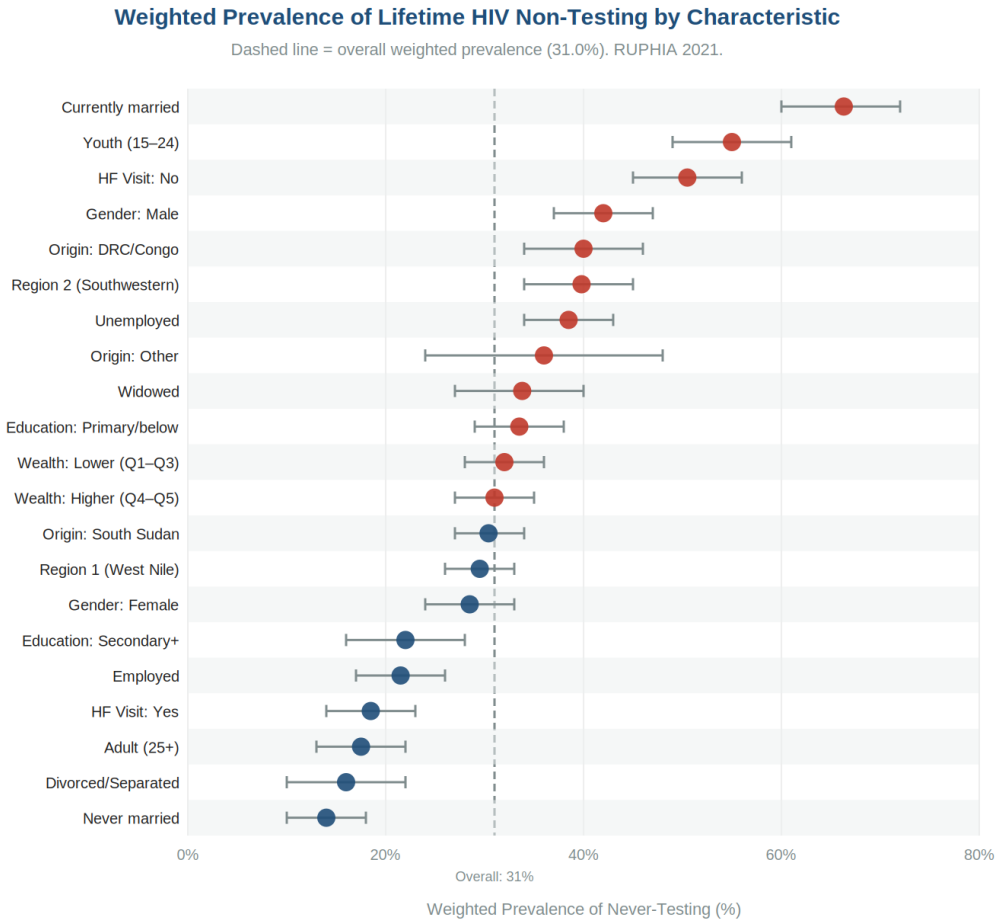

Figure S1: *Weighted Prevalence of Lifetime HIV Non-Testing by Socio-Demographic Subgroup (RUPHIA 2021). Dot plot with approximate 95% confidence intervals. Dashed vertical line = overall weighted prevalence (31.0%). Red = subgroups above the overall prevalence; blue = below. Source: RUPHIA 2021.*

Figure S2: *Bivariate Association Heatmap (Cramér's V) Among Candidate Predictors and Outcome (RUPHIA 2021). Values range from 0 (independence) to 1 (perfect association). Country of Origin and Region show the strongest pairwise association (V = 0.90), reflecting geographic settlement patterns. No other pair exceeds V = 0.3. Both variables retained in the multivariable model as they encode distinct causal pathways.*

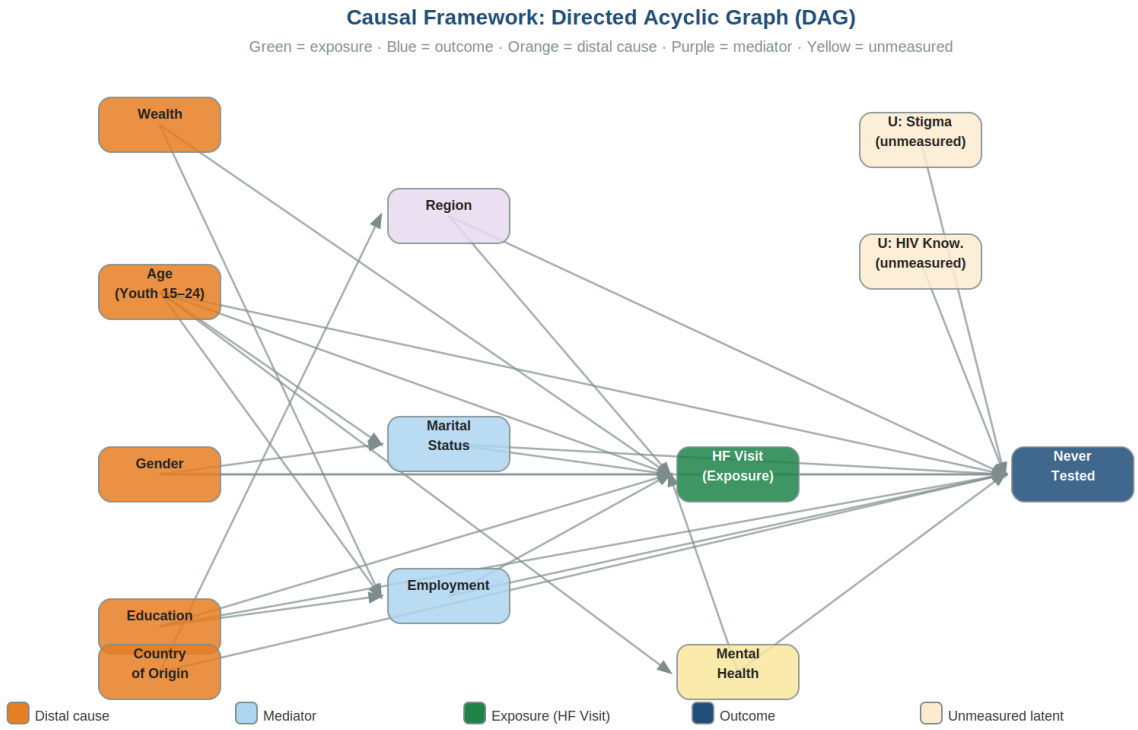

Figure S3: *Directed Acyclic Graph (DAG): Causal Framework for HIV Testing Non-Uptake (RUPHIA 2021). Orange = distal causes; light blue = proximal mediators; green = key exposure (health facility visit); blue = outcome (never tested); yellow = unmeasured latent variables (stigma, HIV knowledge). All estimated associations are adjusted, not unconfounded causal effects, due to unmeasured confounders.*

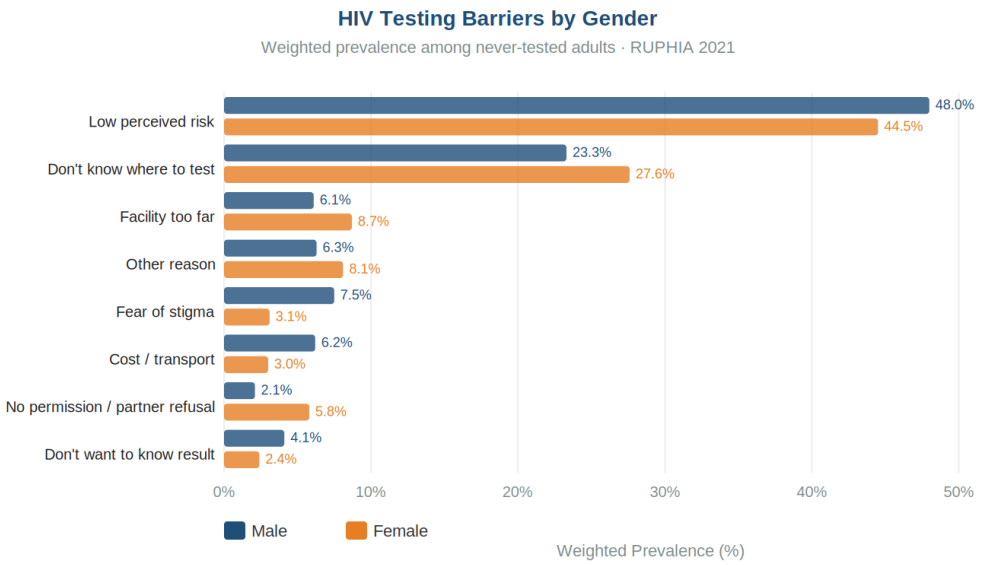

Figure S4: *HIV Testing Barriers by Gender Among Never-Tested Adults (RUPHIA 2021, N = 716). Blue = male; orange = female. Notable gender differences: partner/family permission refusal higher among women (5.8% vs. 2.1%); fear of stigma higher among men (7.5% vs. 3.1%).*

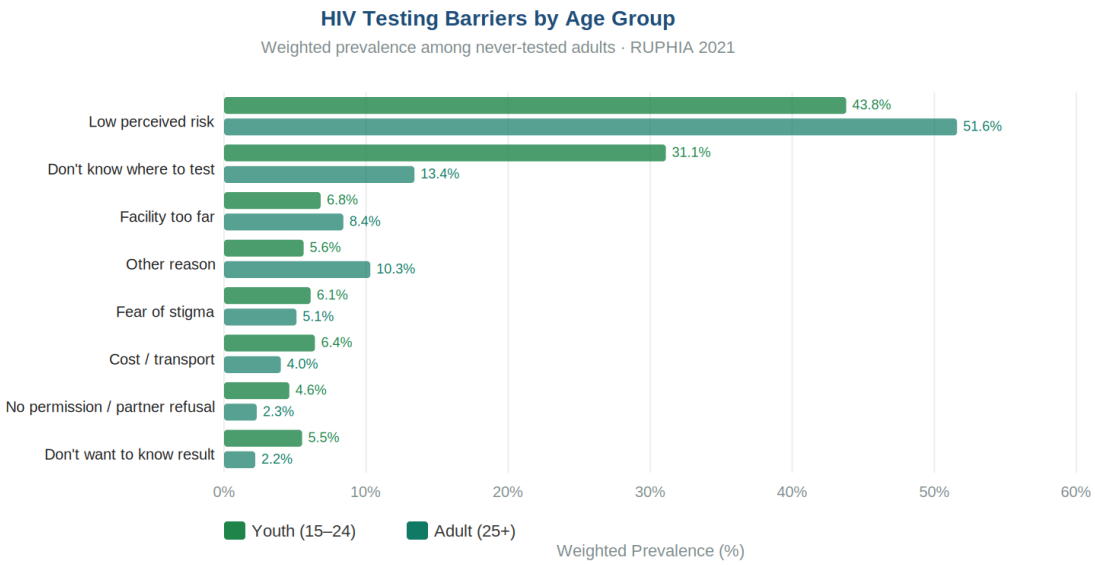

Figure S5: *HIV Testing Barriers by Age Group Among Never-Tested Adults (RUPHIA 2021, N = 716). Green = Youth 15–24; teal = Adult 25+. Informational barriers (not knowing where to test) are more prevalent among youth (31.1% vs. 13.4% among adults). Attitudinal risk misperception dominates across all age groups.*

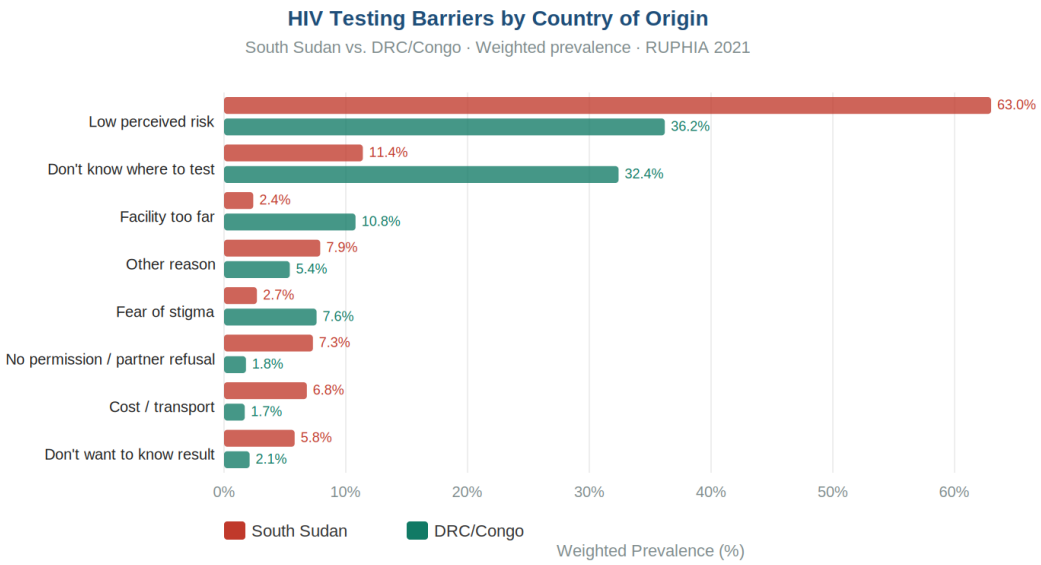

Figure S6: *HIV Testing Barriers by Country of Origin Among Never-Tested Adults (RUPHIA 2021, N = 716). Red = South Sudan; teal = DRC/Congo. South Sudanese refugees report higher attitudinal risk misperception (63.0% vs. 36.2%); DRC/Congolese refugees report higher informational (32.4% vs. 11.4%) and structural barriers.*

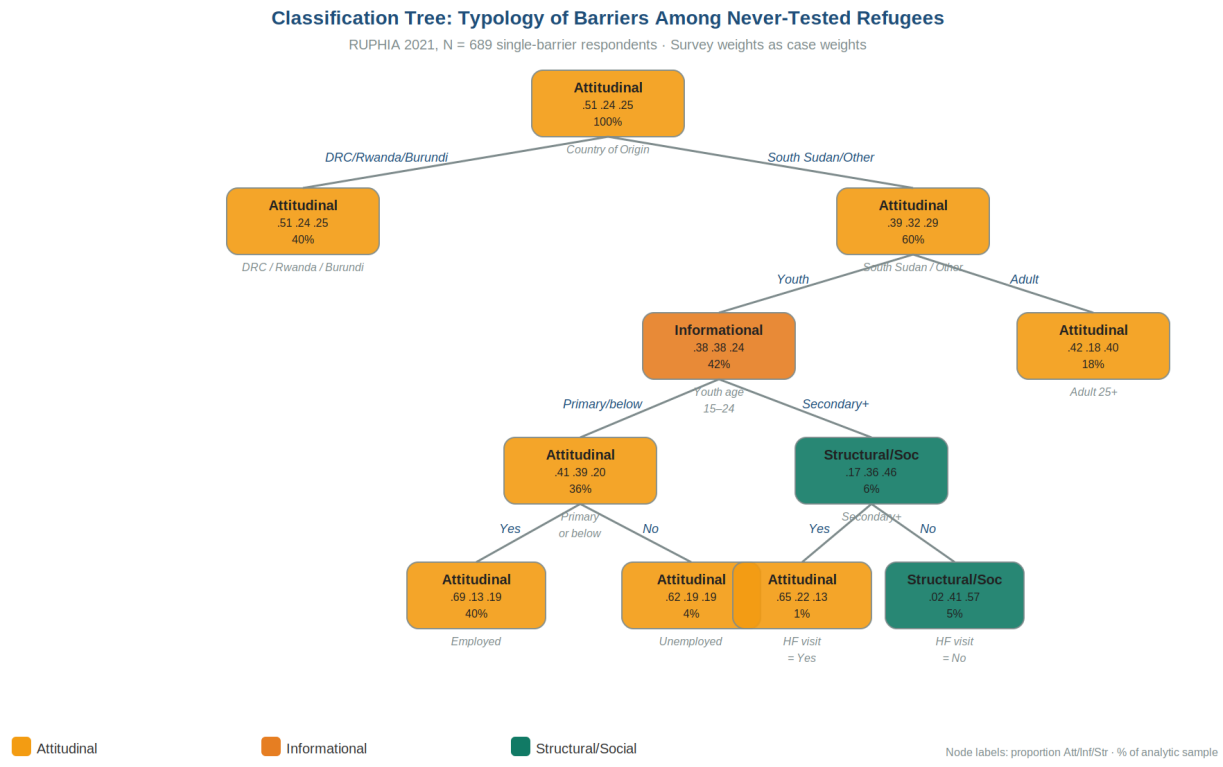

Figure S7: *Classification Tree (CART): Typology of Barriers Among Never-Tested Refugees (RUPHIA 2021, N = 689 single-barrier respondents). Primary splits on country of origin and settlement region; secondary splits on age, education, employment, and health facility visit. Node labels: dominant barrier type, proportions of attitudinal/informational/structural-social, and % of analytic sample. Gold = Attitudinal dominant; orange = Informational dominant; teal = Structural/Social dominant.*

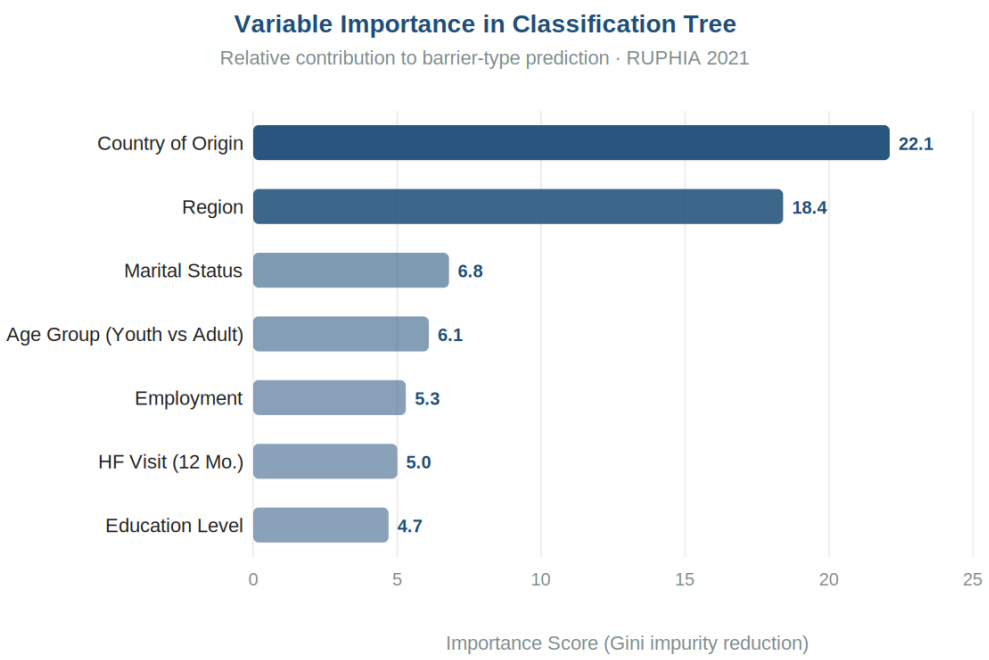

Figure S8: *Variable Importance in Classification Tree (RUPHIA 2021). Relative contribution of each predictor to barrier-type discrimination, measured by total reduction in Gini impurity. Country of origin and settlement region are dominant discriminating variables. Scores are unitless and comparative within this model only.*

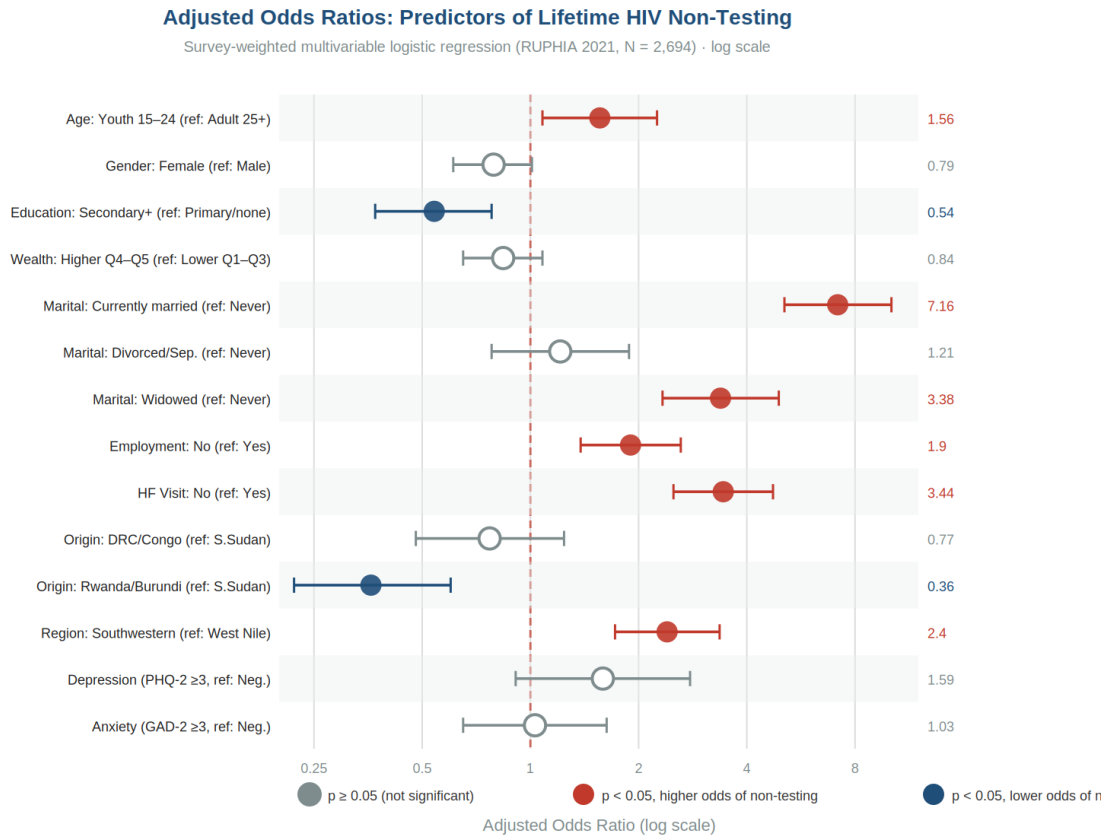

Figure S9: *Adjusted Odds Ratios Forest Plot: Predictors of Lifetime HIV Non-Testing - Survey-Weighted Multivariable Logistic Regression (RUPHIA 2021, N = 2,694). Log scale. Filled circles = $p < 0.05$ (red = higher odds of non-testing; blue = lower odds); open circles = $p \geq 0.05$. Horizontal lines = 95% confidence intervals. Values to the right are the aORs.*