Published in final edited form as:

Sex Transm Dis. 2019 June ; 46(6): 416–421. doi:10.1097/OLQ.0000000000000989.

Who has yet to test? A risk score for predicting never having tested for HIV among women and men in rural Malawi

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Abstract

Background: HIV status awareness is important for preventing onward HIV transmission, and is one of the UNAIDS 90-90-90 goals. Efforts to scale up HIV testing have generally been successful, but identifying at risk individuals who have never tested for HIV - a population necessary to reach to improve HIV status awareness - remains challenging.

Methods: Using data from a community-based cohort of people living in rural central Malawi, we identified demographic, socioeconomic, and sexual health correlates of never having tested for HIV. Correlates were assigned values from the logistic regression model to develop a risk score that identified who had never tested for HIV.

Results: Among 1,310 ever sexually active participants, 7% of women and 13% of men had never tested for HIV. Of those who had tested for HIV, about 30% had tested more than 12 months ago. For women, younger age and poorer sexual health knowledge were correlated with never having tested for HIV, and the c-statistic for the risk score was 0.83. For men, their partner having not tested for HIV, low socioeconomic status, and poor sexual health knowledge were correlated with never testing for HIV (c-statistic 0.81). Among those with a score of 3, the sensitivity and specificity for never having tested for HIV were 81% and 77% for women, and 82% and 66% for men, respectively.

Conclusions: About 10% of participants had never tested for HIV. This risk score could help health professionals to identify never-testers to increase HIV status awareness in line with 90-90-90 goals.

Summary:

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No authors have conflicts of interest to declare.

About 10% of research participants in rural Malawi had never tested for HIV. A risk score using demographic and sexual health knowledge variables may help identify who has never tested.

Keywords

HIV testing; risk score; Malawi

Introduction

Malawi may be on target to reach the UNAIDS 90-90-90 goals by 2020,¹ in which 90% of people living with HIV (PLWH) know their status, 90% of those aware of their positive status receive sustained antiretroviral treatment (ART), and 90% of those on treatment are virally suppressed.² Between 2004 and 2015, Malawi increased the proportion of adults who have ever tested for HIV from 13% to 83% among women and 15% to 70% among men.^{3,4} Currently, an estimated 73% of PLWH in Malawi are aware of their HIV status, 89% of PLWH are on ART, and 91% of those on ART are virally suppressed.⁵ The largest gap in reaching the 90-90-90 goals is in the proportion of PLWH who are aware of their HIV status.

Adequate testing coverage is critical, particularly in a high HIV prevalence setting such as Malawi. Massive scale-up of rapid HIV testing has occurred globally,⁶ and testing can be cost-effective.⁷ HIV testing behavior in Malawi and worldwide varies by demographic, behavioral and other factors. Typically, a lower proportion of men are tested than women.^{3,8} Differences in testing prevalence exist by urban/rural status, education level,³ and HIV knowledge.⁹ Deterrents of HIV testing include low perceived risk for HIV,¹⁰ fear of status disclosure or being seen at the testing site, and gender norms.⁸

Given the recent HIV testing scale up in Malawi and the UNAIDS 90-90-90 targets, we sought to determine demographic and behavioral correlates for who has yet to test for HIV. While initiatives to increase testing have been generally successful, some populations remain untested, and in some instances, those who refuse HIV testing may have a higher prevalence of HIV.¹¹ Risk scores can efficiently identify susceptible individuals who could benefit most from targeted outreach for HIV testing.¹² We created a risk score that can be readily used as a screening tool for never having tested for HIV.

Materials and Methods

Study setting & population

We analyzed data from the baseline survey of the *Umooyo wa Thanzi* (UTHA, Health for the Future) longitudinal cohort study on sexual and reproductive health, conducted in 2014–2015 in the Lilongwe Rural District in central Malawi. The catchment area contains approximately 20,500 people residing in 5,500 households. Based on a geo-coded census of the catchment area, a sampling frame of village clusters was made, with each cluster containing between 40 and 252 households. Village clusters were randomly selected until the cluster sample (n=11) contained households with approximately 1,000 reproductive-aged women. All females aged 15–39 in all households in the selected village clusters were eligible for participation, as were all male partners of the selected women. Malawian

research assistants read the consent documentation aloud; those who wished to participate gave written consent. Survey responses were collected on tablet devices in Chichewa.

This analysis includes all ever sexually active female participants and their male partner if he participated. At the time of data collection, routine opt-out HIV testing was offered in antenatal care settings throughout the study area. Child Legacy Hospital (CLH), located centrally within the study area, provided voluntary counseling and testing for HIV. Health extension workers from CLH held periodic mass testing outreach in the nearby communities. The study was approved by the Institutional Review Board at Ohio State University (2013B0172) and the Malawi College of Medicine Research Ethics Committee (P.04/13/1280).

Measures

The primary outcome was self-report of ever having tested for HIV (yes/no). Those who had tested noted when their most recent test occurred. We evaluated demographic, socioeconomic, health status, and sexual health predictors of ever having tested for HIV. Demographic variables included age; education; and for women, current relationship status, cohabitation with her male partner, and ever pregnant. Socioeconomic variables included a set of household material possessions. Health status variables included self-rated health and a screening tool for depressive symptoms (PHQ-2).¹³ Sexual health variables included the number of lifetime sexual partners; condom use behaviors and knowledge; partner dynamics; HIV knowledge; and whether the participant's partner had ever tested for HIV.

Statistical analyses

We developed a predictive model for never having tested for HIV, then used the beta coefficients from the model to create a risk score. Given that all men who participated were spouses of women participants, whereas some women participants were single or not currently in a relationship, we ran separate models for men and women. We excluded the small number of participants with missing covariate data (6%, $n=78/1,388$) for a complete case analysis. We first used unadjusted logistic regression models to identify candidate predictors that were associated with never having tested for HIV. Variables whose prevalence odds ratios (POR) had a p-value of ≤ 0.25 were considered for inclusion in the multivariable model.¹⁴ Collinearity was evaluated prior to manual backward elimination.

We simplified the fully adjusted model by manual backward elimination. We eliminated variables one at a time until there were only 5 predictor variables in the model, regardless of p-value. A maximum of 5 predictors was set to balance predictive ability with ease of use for the risk score.¹⁵ We compared the area under the curve (c-statistic) between the simplified and full models to see how the two models' predictive ability differed.

To create risk scores, the five beta coefficients from the simplified adjusted models were doubled and rounded to the nearest whole integer for ease of interpretability and to preserve differences between the betas with manageable integer values.¹⁶ A person's total risk score equaled the sum of the manipulated beta point values for each predictor variable. *A priori*, we deemed a risk score with sensitivity of at least 80% and specificity of at least 60% to indicate reasonable performance. We prioritized sensitivity over specificity because

recommending HIV testing to someone who has previously tested is less detrimental than not recommending testing to someone who has never tested for HIV, and high sensitivity would maximize identifying who had never tested. Sensitivity and specificity were calculated for each potential risk score cut point, separately for men and women. We used bootstrapping with replacement (n=1000) to internally validate the risk score and used the 2.5 and 97.5 percentile values to estimate the 95% confidence intervals on the sensitivity and specificity for each possible risk score cut point.¹⁷

All analyses were conducted in SAS version 9.4 (SAS Institute, Cary, NC, USA).

Results

Participant characteristics

The baseline UTHA study enrolled 1,034 female participants from 930 households (4% refusal). Of the 842 male spouses identified, 441 agreed to participate. Most men who did not participate were not seen at all by the research team due to being away from the home for travel or work. From the baseline data, 951 women and 437 men reported ever being sexually active, and of those, 905 women (95%) and 405 men (93%) were included in this analysis due to missing covariates. Most women were 20 years or older (87%), had not completed primary school (< Standard 7) (65%), had ever been married (94%), were currently living with their partner (86%), had ever been pregnant (93%), and had ever tested for HIV (93%) (Table 1). Most women were comfortable buying or requesting a condom (76%), and knew that a person who appears in good health can have HIV (70%), but less than half knew how to put on a condom (46%).

Most men were 25 years or older (76%), had not completed primary school (< Standard 7) (58%), and had ever tested for HIV (87%). Most men knew how to put on a condom (79%), knew that a person who appears in good health can have HIV (81%), and reported that their partner had ever tested for HIV (90%).

Few women (7%, n=67) and men (13%, n=51) reported never having tested for HIV. Among participants who had tested for HIV, nearly one in three women (28%) and men (33%) most recently tested for HIV more than 12 months ago.

Women's predictors and risk score

In adjusted analysis, the final risk score model included: younger age (adjusted POR (aPOR) 12.07; 95% confidence interval (CI) 6.70–21.75), uncomfortable buying a condom (aPOR 2.30; 95% CI 1.29–4.11), not cohabitating with a male partner (aPOR 2.21; 95% CI 1.17–4.16), not having knowledge of how to put on a condom (aPOR 1.93; 95% CI 1.06–3.53), and not having knowledge that a healthy appearing person could have HIV (aPOR 1.70; 95% CI 0.96–3.03) (Table 2). Women's risk scores ranged from 0 to 11 (c-statistic 0.83) (Figures 1a and 2). A cut-point of 3 met our *a priori* criteria with a sensitivity of 81% (95% CI 70%–89%) and a specificity of 70% (95% CI 67%–73%) for identifying women who had never tested for HIV (Figure 1a). Using a cut-point of 3, 34% (n=306/905) of women were categorized as never having tested for HIV, of which 18% (54/306) had truly never tested. False negative (score 3 and categorized as tested but had actually never tested for HIV)

proportion was 1%, and false positive (score 3 and categorized as never tested but had truly ever tested) proportion was 28%.

Men's predictors and risk score

In adjusted analysis, the final risk score model included not reporting that his partner had ever tested for HIV (aPOR 10.90; 95% CI 5.07–23.42), not knowing how to put on a condom (aPOR 3.66; 95% CI 1.75–7.63), not knowing that a healthy appearing person could have HIV (aPOR 2.49; 95% CI 1.17–5.27), not having a bicycle in the household (aPOR 2.32; 95% CI 1.17–4.61), and reporting that his partner would suspect he was accusing her of infidelity if he asked to use a condom (aPOR 1.98; 95% CI 0.98–4.01) (Table 2). The male risk score ranged from 0 to 13 (c-statistic 0.81) (Figures 1b and 2). A cut-point of 3 met our *a priori* criteria with a sensitivity of 82% (95% CI 72–93%) and specificity of 66% (95% CI 62–71%) (Figure 1b). Using a cut-point of 3, 40% (n=162/405) of men were categorized as never tested for HIV, of which 26% (n=42/162) had truly never tested. The false negative and false positive proportions (2% and 30%, respectively) were comparable to the women's model.

Overall risk score performance

Of those scoring 3, 18% of women and 26% of men had never tested for HIV, which was approximately twice the proportion of people who had never tested in the overall participant population (7% women, 13% men). In contrast, a low proportion of those who scored between 0 and 2 had never tested for HIV (2% of women and 4% of men). While a higher proportion of people with scores 7 or higher (41% women, 59% men) had never tested for HIV, the higher specificity (94% for women, 96% for men) of this cut-point reduces the sensitivity (49% for women, 43% for men) and did not meet our *a priori* criteria.

Discussion

Among reproductive-aged women and their male partners in rural central Malawi, about one in ten participants had never tested for HIV. Low sexual health knowledge was relevant in identifying both men and women who had never tested. For women, young age and non cohabitation with a male partner were also prominent correlates in never having tested. For men, having a partner who had not tested and low socioeconomic status were also correlated with never having tested for HIV. With these findings we developed risk scores for women and men that could be used to help identify who has never tested for HIV. With cut-points of 3, each risk score identified over 80% of participants who had never tested for HIV. To our knowledge, no other risk scores exist to identify individuals who have never tested for HIV.

Risk scores have been developed previously for different applications in HIV prevention and care: to identify people with acute HIV infection,¹⁸ and those at risk of HIV virologic failure¹⁹ or development of antiretroviral treatment (ART) resistance.¹⁶ While others have documented correlates of HIV testing history, these have not been described using a risk score approach.^{20–22} In sub-Saharan Africa, correlates for never testing include being a man,²² being younger,^{21,22} having completed less formal schooling,²² having less HIV knowledge,²¹ and having a lower perceived risk for HIV.²⁰

Malawi's largest gap in meeting the UNAIDS 90-90-90 goals is HIV status awareness: 73% of people living with HIV know their status, compared with nearly 90% each for ART use and viral suppression.⁵ To increase the proportion of people who have tested for HIV, public health programs have made HIV testing easier to access, less stigmatized, and less invasive.²³ The Malawi Ministry of Health (MOH) recommends HIV testing for all persons attending health services, whenever there is new HIV risk, and again three months after a negative HIV test that followed risky behavior.²⁴ Options for improving HIV status awareness include more consistent use of the electronic medical record and established health passports to document testing history, as well as programmed alerts for a lapse of >12 months since the person's last HIV test.²⁴

Risk for HIV can vary over time, and people may have valid reasons for having never tested, or not tested recently. Thus we posit that ever having tested for HIV may be a proxy measure of HIV risk perception. Of study participants who had tested for HIV, about 30% had a test more than 12 months ago, which was lower than among 2015 Demographic Health Survey (DHS) respondents (58%).³ Even testing within the past 12 months may be inadequate: per 2010 DHS data, 20% of HIV seropositive respondents had a negative HIV test within the past 12 months.^{4,25} People at low risk for HIV acquisition could be those with no new sexual partners, who are not sexually active, or do not practice risky behaviors such as injection drug use.

A risk score to identify who has a greater likelihood of no prior tests may help the established lay cadre of HIV diagnostic assistants augment their established HIV testing promotion success.¹

Multiple initiatives exist to increase HIV testing among men,^{8, 26} yet some men perceive health services as female spaces,⁸ view testing as an accusation of infidelity,²⁷ or believe that they have tested "by proxy" if their wives have tested for HIV.²⁸ However, we observed higher testing among men whose partners had ever tested for HIV, which may point to partner notification and other testing initiatives, or to shared values and health-seeking behaviors among our participants compared to previous studies. Social norms are important: men in Tanzania who had never tested for HIV tended to assume that their closest friends had also never tested,²⁹ and gender norms that discourage health-seeking behaviors contribute to lower participation in HIV testing among men in Kenya and Uganda.²⁸ In Malawi, female partners who have tested for HIV could be important bridges to increase male HIV testing given that men noted their wives influenced their opinions about healthcare.⁸

Our risk score illuminates the ways in which both demographics and knowledge relate to HIV testing. Among Malawian women, the association of younger age with never having tested for HIV is logical: younger women may perceive themselves to be at lower risk for HIV, or may not yet have accessed antenatal care where HIV testing is routine. Of note, in the capital city of Lilongwe, about half of young women with multiple risk factors for HIV did not perceive themselves to be at high risk for HIV.¹⁰ We hypothesize that lack of sexual health knowledge is associated with not having tested because condoms and HIV knowledge are addressed during HIV testing and counseling.

While our risk scores met our *a priori* sensitivity and specificity criteria to identify who had never tested for HIV, additional validation should occur in other settings to address generalizability concerns. All males in our sample were married to female participants, so our male risk score may not be generalizable to men who do not have current female partners. Malawi DHS data show differences in HIV testing and knowledge by gender, age, education level and urban/rural status.³ If the risk scores were used in a population with a meaningfully different distribution of the risk score variables with respect to HIV testing status, we would expect the risk score performance to be different from what our analysis showed. If a different sensitivity or specificity threshold were desirable, our risk score may not have optimal performance.

The variables in the risk scores were dichotomized for simplicity, yet more nuanced categorizations may improve identification of who has never tested for HIV. Like in most sexual health research, the risk score was developed using variables that were self-reported, and the outcome, HIV testing history, was also self-reported. Despite extensive interviewer training in non-judgmental techniques, social desirability bias may be present in participants' self-reported answers. Health workers may prefer asking directly about HIV testing history rather than the risk score questions for efficiency. However, the set of questions a health worker would ask while using the risk score may facilitate a discussion about sexual health and improve HIV testing history disclosure, and ultimately, HIV testing coverage. Our analysis could have bias due to excluding 6% of respondents (5% n=46 of women and 7% n=32 of men) who had incomplete covariate data if the reasons for missing covariate data were related to their HIV testing response. The small number of participants who reported a prior positive HIV test (1.5%, n=18) were included in the analysis because they could be asked the risk score questions in a clinic or outreach setting if they did not disclose their HIV status upfront, and would be eligible for ART if not already on it. However, exact performance of the risk score among persons known to be living with HIV is not established.

Conclusions

About 10% of men and women participants in rural Malawi reported never having tested for HIV. A rich set of variables beyond common demographic information can identify who has never tested for HIV, and can provide guidance to prioritize offering HIV tests to people with risk scores. To optimize HIV testing coverage, new approaches are needed to reach those who have never tested.

Acknowledgments

A version of this analysis was presented at the International Society for Sexually Transmitted Diseases Research Meeting in Brisbane, Australia, and we are grateful for insightful comments from participants of that meeting. We also gratefully acknowledge Dr. John Phuka's contributions to the study's design. The authors acknowledge the following research funding: Institute for Population Research [NICHD P2C-HD058484], the OSU Center for Clinical and Translational Science [NCATS UL1TR001070, KL2TR001068, and TL1TR001069], the OSU Public Health Preparedness for Infectious Diseases program; the UNC Medical Scientist Training Program [grant T32GM008719], the NIMH individual fellowship [F30MH111370], and the NIH Fogarty International Center Grant [R25TW009340]. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health. The funding sources had no role in the study design, data collection and analysis, interpretation of results, or preparation of the manuscript for publication.

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Figure 1. Sensitivity, specificity and 95% confidence intervals at each risk score point for (a) women, and (b) men

RISK SCORE FOR WOMEN

Are you 20 or older?	No → + 5	
Do you live with your partner?	No → + 2	
Do you know where to buy a condom?	No → + 2	
Do you know how to put on a condom?	No → + 1	
Can a healthy appearing person have HIV?	No → + 1	
Total¹		

¹If total ≥ 3 , prioritize offering an HIV test

RISK SCORE FOR MEN

Has your partner ever had an HIV test?	No → + 5	
Do you know how to put on a condom?	No → + 3	
Can a healthy appearing person have HIV?	No → + 2	
Does your household have a bicycle?	No → + 2	
If you asked your partner to use a condom, would she suspect you were accusing her of infidelity?	Yes → + 1	
Total¹		

¹If total ≥ 3 , prioritize offering an HIV test

Figure 2.
Risk score tillable card

Table 1.

Participant characteristics

Variable		Women		Men	
		N	%	N	%
Ever tested for HIV					
	Yes	838	93	354	87
	No	67	7	51	13
Tested for HIV within the past 12 months					
	Yes	600	72	237	67
	No	238	28	117	33
Age					
	female <20; male <25	122	13	97	24
	female 20; male 25	783	87	308	76
Education					
	None or some primary school (Standard 6)	587	65	235	58
	Completed more than primary school (Standard 7)	318	35	170	42
Marital status					
	Single never married	55	6	0	
	Ever married	850	94	405	100
Cohabitation with partner					
	Yes	778	86	405	100
	No	127	14	0	
Ever pregnant					
	Yes	841	93	N/A	
	No	64	7	N/A	
Bicycle in household					
	Yes	511	56	260	64
	No	394	44	145	36
Cell phone in household					
	Yes	357	39	158	39
	No	548	61	247	61
General self-rated health					
	Very good	320	35	178	44
	Good/fair/poor	585	65	111	56
PHQ-2 score					
	0	373	41	162	40
	1	532	59	243	60
Number of lifetime sexual partners					
	Women <2; men <3	465	51	153	38
	Women 2; men 3	440	49	252	62
Knows where to buy or request a condom					
	Yes	686	76	353	87

Variable		Women		Men	
		N	%	N	%
Knows how to put on a condom	No	219	24	52	13
	Yes	416	46	319	79
	No	489	54	86	21
If ask partner to use a condom, would partner think the participant was accusing him/her of infidelity	Yes	314	36	111	27
	No	549	64	294	73
Knows a person who appears to be in good health can have the virus that causes AIDS	Yes	636	70	328	81
	No	269	30	77	19
Partner ever tested for HIV	Yes	649	75	363	90
	No/I don't know	111	25	42	10

Table 2.

Predictors of never having tested for HIV among women and men in rural central Malawi

Variable	Unadjusted POR (95%CI)	Final model adjusted POR (95%CI)	Predictor score ^a
WOMEN			
Age <20	14.74 (8.57–25.35)	12.07 (6.70–21.75)	5
Does not live with partner	4.63 (2.71–7.89)	2.21 (1.17–4.16)	2
Does not know where to buy a condom	2.79 (1.68–4.63)	2.30 (1.29–4.11)	2
Does not know how to put on a condom	1.82 (1.07–3.08)	1.93 (1.06–3.53)	1
Does not know that a person who appears healthy may have the virus that causes AIDS	1.90 (1.15–3.15)	1.70 (0.96–3.03)	1
MEN			
Partner never tested for HIV	11.10 (5.45–22.60)	10.90 (5.07–23.42)	5
Does not know how to put on a condom	3.11 (1.68–5.78)	3.66 (1.75–7.63)	3
Does not know that a person who appears healthy may have the virus that causes AIDS	2.45 (1.29–4.67)	2.49 (1.17–5.27)	2
Does not own a bicycle	1.88 (1.04–3.39)	2.32 (1.17–4.61)	2
If man asked to use a condom, his partner would think he was accusing her of infidelity	2.26 (1.24–4.13)	1.98 (0.98–4.01)	1

POR Prevalence Odds Ratio; CI confidence interval

^aPredictor score is the natural log of the adjusted prevalence odds ratio in the final model, multiplied by 2 and rounded to the nearest integer