Estimating the impact of identifying and treating HIV-infected male circumcision clients in Uganda, Zambia, and Swaziland: a mathematical modeling analysis

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Abstract

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Introduction: Men represent an underserved population in sub-Saharan Africa with respect to HIV testing and treatment. Identification and treatment of HIV-infected men are vital both to improve their health and prevent onward transmission to their partners, especially for men in sero-discordant partnerships. One means of identifying HIV-infected men is via HIV testing and counseling in conjunction with voluntary medical male circumcision (VMMC) programs. Men in discordant couples could be identified by offering at-home testing to their cohabiting partners.

Methods: This analysis utilizes a modified version of the UNAIDS Modes of Transmission (MoT) mathematical model to estimate the number of primary HIV transmissions that could be averted over one year in 2014 and on average from 2015-2025, under two scenarios: 1) identifying and treating HIV-infected VMMC clients in discordant couples as per World Health Organization recommendations; and 2) identifying and treating all HIV-infected VMMC clients. The analysis was applied to three countries with differing magnitudes of HIV prevalence: Uganda, Zambia, and Swaziland. Univariate sensitivity analyses were performed on key model parameters.

Results: To meet the WHO/UNAIDS target of 80% coverage of adult male circumcision by 2025, we estimate that each year from 2015 to 2025, an average of 390,945 circumcisions will need to be performed in Uganda, 189,387 in Zambia, and 20,486 in Swaziland.

On average over 2015-2025 we estimate that about 2% of men presenting for male circumcision will be HIV-positive and in a discordant couple and that about 40% of those men could be identified and successful treated with ART for at least one year. Using the MoT model we predict that in one year this intervention could successfully identify and treat 2,517 men, preventing 298 new HIV cases in Uganda; 2,232 men, preventing 210 cases in Zambia, and 195 men, preventing 19 cases in Swaziland.

Under a scenario in which all HIV-infected men, regardless of relationship status or CD4 count, were offered ART treatment we estimate that about 46% would start and stay on treatment for one year. In one year during 2015-2025, we predict this intervention could successfully identify and treat 9,089 men, preventing 537 new HIV cases in Uganda; 8,893 men, preventing 410 cases in Zambia, and 2,063 men, preventing 68 cases in Swaziland.

Discussion and Conclusions: VMMC programs are an important, relatively short-term opportunity to identify HIV-infected men that may not otherwise volunteer for HIV testing. A substantial proportion of the male national population in the 14 VMMC target countries will visit clinics between 2015 and 2025 and large numbers of HIV-infected men will be identified there. We predict that while circumcision programs to date have recruited mostly adolescents, as countries move toward the 80% coverage target, clients will be tend to be older and be more likely to be infected with HIV. If VMMC programs integrate HIV treatment as prevention, even if targeted only at men in discordant couples, thousands of transmissions to partners could be prevented each year.

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Introduction

Men represent an underserved population in sub-Saharan Africa with respect to HIV testing and treatment [5, 6]. Men are less likely to be tested compared to women in most African countries [7]. Once their status is known, men are less likely to seek care for HIV compared to women [8, 9] and when they do, it is at a more advanced stage of the disease [10]. Among those who do initiate treatment, men are more likely to be lost to follow-up [9]. In Uganda, women make up an estimated 56% of adults living with HIV, but outnumber men two to one at antiretroviral therapy (ART) clinics [11]. These disparities by gender may be a result of gender norms, stigma, or programmatic prioritization of women and children [12]. Pregnant HIV-infected women are routinely identified through testing for prevention of mother-to-child transmission. Even though couples testing is being promoted at these antenatal care visits, few men attend these clinics perhaps because they are viewed as “female” environments [6].

While it is vital to identify and treat HIV-infected men to improve their health, we now know that treatment is also an effective method of preventing onward transmission. A seminal randomized trial published in 2011 estimated a 96% decrease in HIV transmission for participants on ART (RR: 0.04, 95% CI: 0.00-0.27) [13].

Undiagnosed and untreated HIV-infected men are important drivers of the HIV epidemic. Sero-discordant (HIV-uninfected) partners of HIV-infected men are at particular risk of infection due to limited mutual knowledge of their HIV status and inadequate preventive measures to limit transmission. The discordant couple sub-population in many countries in sub-Saharan Africa is extremely large and is estimated to make up 11% of stable sexual partnerships in Zambia and more than 16% in Swaziland [14]. Models predict that in the course of an upcoming year, the majority of new infections in most sub-Saharan African countries will occur within stable couples that have been monogamous during the past year [15, 16]. HIV-infected men engaging in casual sex are another key population for HIV transmission, and are probable drivers of the surge of infections in young unmarried women and girls who may be more susceptible to infection [17].

One means of identifying HIV-infected men is in conjunction with voluntary medical male circumcision (VMMC) programs. HIV testing and counseling is routinely offered as part of a minimum service package the World Health Organization (WHO) recommends offering alongside VMMC [18]. Men are generally offered circumcision regardless of their HIV status. In 2007, male circumcision was recognized by the WHO and the Joint United Nations Programme on HIV/AIDS (UNAIDS) as an effective intervention to decrease transmission. In 2011, together with other stakeholders, they set a goal of 80% coverage of VMMC in 14 priority countries by 2016 [19]. While several countries have made good progress toward this goal – Kenya in particular with 90.7% coverage in 2013 [7] – most countries are not on track to meet the 80% coverage target and will likely continue mass circumcision programs through 2020 to 2025 [20].

Acceptance of HIV testing and counseling in VMMC programs has been high at 86.5% [1]. While the HIV prevalence in the early years of VMMC scale-up was relatively low (2.4%) [1], this was largely due to the young age of clients, as countries near the 80% coverage goal, the age of clients and the proportion infected with HIV will both increase substantially. In the countries that consistently reported the number of clients by age (Mozambique, South Africa, Tanzania, and Zambia) the percentage of VMMC clients over age 24 has increased from 8.8% in 2011, to 11.3% in 2012, to 17.2% in 2014 [1, 20]. We can expect a large number of HIV-positive men to be identified at VMMC clinics by 2025.

While the maximum benefit of treatment as prevention would be attained by treating all identified HIV-positive men, the WHO currently recommends initiation of ART only once a patient's CD4 count drops below 500 cells/μL [18]. For HIV-positive partners in discordant couples however, they recommend immediate initiation to prevent transmission to their uninfected partners [21]. Identifying these discordant couples is a challenge to intervening, but offering in-home HIV counseling and testing to cohabiting partners of HIV-infected clients (index testing) could be an acceptable, cost-effective method of finding them. Index testing has been successfully implemented as a more efficient alternative to untargeted door-to-door testing [22]. While most couples are concordantly negative, nearly one in two couples with an HIV-positive male are discordant in Uganda and Zambia [23, 24]. A systematic review of various HIV testing strategies estimates acceptance of index testing at 88% (95% CI: 81-96) [2].

This analysis aims to estimate the number of direct transmissions over the short-term (one year) that could be prevented via programs that provide HIV testing and ART treatment to VMMC clients. We first estimate the number of HIV-infected men that could be identified at VMMC clinics with special attention to discordant couples and other high risk groups. We then use a modified version of the UNAIDS Modes of Transmission (MoT) model [25] to estimate the number of cases averted under two scenarios: 1) offering treatment as prevention to men in discordant couples, identified using index testing of their partners; and 2) offering treatment as prevention to all identified HIV-positive men. The generalizability of the impact is explored by applying the analysis to three countries with differing magnitudes of HIV prevalence, specifically Uganda, Zambia, and Swaziland.

Methods

Modeling Approach

The following modeling approach was applied separately for each country. First, estimates of the number of HIV-infected men presenting at VMMC clinics in 2014 were produced based on the number and age of men presenting at circumcision clinics funded by the US President's Emergency Plan for AIDS Relief (PEPFAR) [20], combined with Demographic and Health Survey (DHS) [23, 26] and AIDS Indicator Survey (AIS) [24] estimates of HIV prevalence among uncircumcised men by five-year age group. These estimates were disaggregated into four risk groups for inclusion in the MoT model: i) HIV-infected men who are sexually active, but not in a cohabiting partnership, ii) HIV-infected men reporting no recent sex, iii) HIV-infected men with concordantly infected cohabiting partners, and iv) HIV-infected men in discordant cohabiting couples. DHS and AIS data on demographics, self-reported sexual behavior in the past 12 months, rates of HIV prevalence and rates of HIV discordancy within couples by age group were used for these estimates. The proportion of cohabiting couples by age group that were discordant with the male positive were gathered from DHS and AIS couples surveys.

The number of HIV-infected men that will be presenting at VMMC clinics from 2015-2025 was also calculated. These estimates were based on the number of circumcisions needed during 2011-2025 to reach the WHO / UNAIDS target of 80% coverage of males between the ages of 15-49 [27]. A linear scale-up was assumed and the total number of circumcisions needed was distributed equally among the eleven years. Since the model only accounts for short-term primary transmission, not onward transmission, the number of cases prevented is based directly on the number of men presenting for circumcision. The number of HIV-infected men was again based on DHS data for each age group, but the proportion in each group was based on the national age distribution for males [28]. The number of expected HIV-infected men was disaggregated into the four risk groups as above.

A base-case MoT model for 2015 was fit using parameters from previous published analyses [29-31]. Parameters were updated for Uganda and Zambia MoT models as new DHS and AIS reports had been released for those countries since previous analyses were done. The model predicts one-year national incidence, disaggregated across risk groups, in the absence of testing at VMMC clinics and referral of HIV-infected men to care.

The base-case model output was validated using independent data and modeling sources. Per the MoT guidelines, the average adult prevalence of HIV was compared with a 10% range around the UNAIDS estimates [7] and the HIV incidence estimates were compared with the 2013 Spectrum model 95% uncertainty intervals, revised by the Institute for Health Metrics and Evaluation [32].

A pair of alternative MoT models was fit for 2015 and compared with the base-case model to produce estimates of the number of incident cases averted in one year if a) only HIV-infected men in cohabiting discordant couples (identified at VMMC clinics in the previous year) were invited to start ART treatment or b) all HIV-infected men (identified at VMMC clinics in the previous year) were invited to start treatment regardless of their relationship status or CD4 count.

A second pair of alternative models was fit predicting the potential average annual impact from 2015 to 2025 if the 80% coverage target is met. Again, the number of incident cases that could be averted in one year was estimated under scenarios where a) only HIV-infected men in discordant cohabiting couples presenting at VMMC clinics were invited to start treatment or b) all identified HIV-infected men were invited to start treatment regardless of their relationship status or CD4 count.

Univariate sensitivity analyses were performed on key parameters including HIV prevalence, uptake of HIV testing and counseling for VMMC clients, uptake of HIV testing and counseling for partners of clients, uptake of ART, and retention on ART. Each parameter was varied within plausible limits while holding all other parameters at their base values. The upper value for HIV prevalence is the national HIV prevalence in adults and the lower value is half of the expected prevalence in VMMC clients. The upper and lower values for other parameters were chosen as plausible values.

Modes of Transmission Model Structure

This analysis utilized a modified form of the 2012 version of the UNAIDS Modes of Transmission model. The model was created as part of the UNAIDS “know your epidemic, know your response” initiative to help countries prioritize HIV interventions by estimating the fraction of new cases attributable to various risk factors [33]. Between 2008 and 2012 analyses using the MoT model were completed or begun in over 40 countries [16].

The MoT model is a Microsoft Excel-based, deterministic, static, compartmental model that estimates a country’s one-year HIV incidence and distribution among several key groups with varying levels of risk. The national population is broken up into groups based on their highest risk behavior in the past 12 months (Figure 1). One limitation of the standard version of the MoT model is that it did not account for concordance and thus probably overestimated the number of infections in stables couples. To correct for this we discretely defined a discordant couples group.

Predicted incidence for the coming year is calculated within each risk group according to the following equation [25]:

$$I = S[1 - \{p(B(1 - \beta'(1 - v))^{a} + (1 - B)(1 - \beta)^{a(1 - v)}) + (1 - p)\}^{n}]$$

Where I is the HIV incidence in the risk group, which is a function of the number susceptible, S; the HIV prevalence in the partner population, p; the prevalence of sexually transmitted infections (STIs) in the target or partner population (whichever is higher), B; the probability of transmission of HIV during a single contact in the presence or absence of an STI, β' and β; the proportion of acts protected by condom use or sterile needles, v; the number of partners, n; and the number of risk acts per partner, a. The incidence derived separately for each risk group can be summed to estimate national incidence. The distribution of the national population among MoT risk groups is presented in Figure 1 of the Appendix.

Data Sources

The base parameters for Uganda, Zambia, and Swaziland were drawn from the most recent published reports of the results of the MoT model fit for each country [29-31]. When possible, parameters were updated according to UNAIDS recommendations. Additional parameters required for this modified 2011 version of the model were attained from the most recent DHS and AIS publications and UNAIDS Global AIDS Response Progress Reporting [7, 23, 24, 26].

PEPFAR-funded male circumcision program data for 2014 was acquired from Appendix V of PEPFAR's Eleventh Annual Report to Congress [20]. HIV prevalence, rates of cohabitation, and recent sexual behavior for each sex and age group were also available in DHS and AIS reports.

Results

The 2014 base-case total national HIV incidence for men and women aged 15-49 from the modified MoT models are 88,483; 48,636; and 5,722 for Uganda, Zambia, and Swaziland, respectively and each fall within the 2013 incidence ranges estimated by IHME [32].

Extremely large numbers of men (more than 5.5% of the total adult male population) are currently presenting each year for male circumcision in Uganda and Zambia. The first row in Table 1 shows the number of adult clients in 2014[*], and the average number required each year from 2015 through 2025 to reach the 80% coverage target. The following five rows show the estimated number of HIV-positive men among these clients: total and disaggregated into four risk groups by relationship status and sexual behavior. Substantial numbers of HIV-positive men were estimated to have presented at VMMC clinics in 2014.

As demographics of VMMC clients shift toward the demographic distribution of the general population, we predict the proportion of clients that are older, sexually active, and in cohabiting partnerships will increase (Figure 2). Due to this shift in demographics, we expect the number and proportion of HIV-positive men to likewise increase (Table 1). The proportion of those HIV-positive men that are sexually active and in discordant couples will be higher, thus raising their likelihood of transmission to their partners (Figure 3).

The actual prevalence of HIV among VMMC clients may be lower than the average prevalence based solely on their demographics, as HIV-infected men who are already aware of their status

[*] VMMC client counts for Uganda are from 2013 as 2014 data was not available

may be less likely to present for circumcision. Table 2 presents the number of men that would be identified at VMMC clinics given varying HIV prevalences.

Scenario 1 – Identifying and treating HIV-infected VMMC clients in discordant couples

We estimate that nearly 6,500 HIV-infected men in discordant couples visited VMMC clinics in these three countries in 2014, roughly one percent of all clients. As the average client age increases over 2015-2025, we expect that number to double to over two percent of clients being HIV-positive and in a discordant couple. These men are eligible for immediate treatment under current WHO guidelines and we estimate that about 40% would be identified, start treatment, and continue therapy for at least one year. The national incidence in the presence of an intervention to identify and treat discordant couples and the resulting number of primary transmissions averted for each country is presented in Table 1. We expect that almost all of the roughly 550 infections that would occur in one year in these 4,944 discordant couples in the absence of an intervention, would be prevented: 298 in Uganda, 210 in Zambia, and 19 in Swaziland (2015-2025).

The sensitivity of the number of cases averted to changes in various parameters while holding the others constant at their base values is presented in Table 3. We also calculated the number of cases that would be averted in a "best-case scenario," assuming the base HIV prevalence and that 77% of HIV-infected clients in discordant couples are identified, started, and retained on treatment for one year, (i.e. the upper parameter is assumed at each step). In the best-case scenario, the number of cases averted in one year during 2015-2025 would be: 571 among 6,248 HIV-positive men in discordant couples in Uganda, 402 among 5,539 in Zambia, and 35 among 483 in Swaziland.

Scenario 2 – Identifying and treating all HIV-infected VMMC clients

We estimate that roughly 29,000 HIV-infected men presented at VMMC clinics in these three countries in 2014, and nearly 44,000 will present annually on average from 2015-2025. Since partners of clients do not need to be tested to determine eligibility for treatment, we estimate a slightly higher ART uptake and one-year retention compared to discordant couples (46% vs 40%). The national incidence and number of direct infections that the MoT model predicts would be prevented in the following year due to an intervention testing and treating all VMMC clients is presented in Table 1. We predict that with successful treatment of 20,045 HIV-positive men across the three countries, about twice as many cases will be prevented in one year during 2015-2025, compared to Scenario 1: 537 in Uganda, 410 in Zambia, and 68 in Swaziland.

Table 3 presents the sensitivity of the number of cases averted to changes in various parameters holding the others constant for Scenario 2. As in Scenario 1, we calculated the number of cases that would be averted in a best-case scenario, assuming the base HIV prevalence and that 81% of HIV-infected clients are identified, started, and retained on treatment for one year, (again, the upper parameter is assumed at each step). In the best-case scenario, the number of cases averted in one year during 2015-2025 would be: 954 among 19,851 HIV-positive men in Uganda, 728 among 19,423 in Zambia, and 121 among 4,506 in Swaziland.

The distribution of HIV infections across MoT risk groups for each country is presented in Figure 2 of the Appendix.

Discussion

In order to meet the 80% male circumcision coverage target, even by 2025, Uganda and Zambia will need to continue similar annual numbers of circumcisions and Swaziland will need to increase the annual number of adult circumcisions approximately six-fold. We estimate that in Uganda, for example, more than 17,000 HIV-infected men presented at VMMC clinics in 2013. Based on our projections, we expect this number to increase on average over the next 11 years as adolescents that currently predominate VMMC clinics are replaced by men over age 25 (Table 1). Clients will tend to be older, and the prevalence of HIV will increase, especially in countries with high overall prevalence (Figure 2).

We predict that a large number of discordant couples can be identified at VMMC clinics and nearly all transmissions to their partners can be prevented for those who undergo treatment. The total number of primary cases averted in one year in each country may seem small relative to the total number of annual incident infections; in Zambia for instance, we predict that 210 primary cases would be averted out of more than 48,000. This number represents a significant proportion of the number of transmissions within the roughly 4-6% of the male population coming in to VMMC clinics each year.

The number of cases prevented is proportional to the size of the epidemic, but is also sensitive to the distribution among risk groups, especially when focusing on discordant couples. Swaziland has one of the highest HIV prevalences in the world, so while the HIV prevalence in clients over 2015-2025 on average is expected to be more than twice as high compared to Uganda (22.0% vs 10.3%), a smaller proportion of the clients overall are in cohabiting couples, thus fewer discordant couples will be identified (2.4% vs 2.9%). The smaller proportion of discordant couples leaves fewer couples in which to intervene and therefore, a smaller proportion of transmissions averted per identified case. Countries that would most benefit from an intervention that specifically targets discordant couples are those with broad epidemics and more adults in cohabiting couples.

As expected, substantially more transmissions are prevented in Scenario 2 when offering treatment to all identified cases, compared to Scenario 1 that targets only men in discordant couples. However, the relative efficiency (i.e. the number of cases averted per HIV-infected client put on treatment) is roughly halved, since many of those receiving treatment are either not sexually active or in concordantly positive partnerships. This lower efficiency is probably overemphasized by the short-term one-year outlook of the model, as many if not most of the clients that are not sexually active are likely to become so after a few years and men who are not in stable partnerships are likely to expose multiple partners in a several year period.

This analysis has several limitations. A primary limitation is the simplicity and short-term structure of the MoT model structure, which can only predict primary HIV transmission over a single year, ignoring any secondary transmissions arising from onward transmission. Each modeled risk group is assumed to have a homogeneous, static risk of infection. Temporal patterns of sexual contacts, such as partner concurrency, are ignored and for participants with multiple risk factors, transmissions are considered for the highest risk category only.

A second major limitation of this analysis is that many of the included parameters are based on self-report. There is likely to be substantial social desirability bias, among other survey biases, when collecting information on sexual behaviors, some of which may be taboo. Many parameters borrowed from previous country teams that fit the MoT model were not available in the literature and were assumed.

A third limitation of this analysis is that it does not include a cost component to compare the cost effectiveness of the two scenarios and other potential means of identifying HIV-positive men, such as door-to-door community-based HIV testing. Nor are potential social harms included, such as breaches of confidentiality that result in inadvertent identification of HIV-positive men.

Conclusions

VMMC programs are an important, relatively short-term opportunity to identify HIV-infected men that may not otherwise volunteer for HIV testing. A substantial proportion of the male national population in the 14 VMMC target countries will visit clinics between 2015 and 2025 and large numbers of HIV-infected men will be identified there. If VMMC programs integrate HIV treatment as prevention, even if targeted only at men in discordant couples, thousands of transmissions to partners could be prevented each year.

Tables

Table 1 – Estimated number of HIV-infected VMMC clients in 2014 and projected average for 2015-2025 to meet 80% coverage target and cases averted by linking them to care

		Uganda		Zambia		Swaziland	
		2013*	**2015-2025**	**2014**	**2015-2025**	**2014**	**2015-2025**
Number of VMMC clients (age 15-49)		465,305†	390,945	147,933	189,387	3,309	20,486
Estimated number HIV+		17,330 (3.7%)	19,851 (5.1%)	11,360 (7.7%)	19,423 (10.3%)	381 (11.5%)	4,506 (22.0%)
Not cohabiting, not sexually active		4,253	2,004	2,052	1,640	50	307
Not cohabiting, sexually active		4,502	4,414	3,736	4,817	172	1,992
Cohabiting, concordant		4,651	7,186	3,140	7,427	124	1,724
Cohabiting, discordant		3,924	6,248	2,433	5,539	34	483
SCENARIO 1 – IDENTIFYING AND TREATING MEN IN DISCORDANT COUPLES							
Number HIV+ in cohabiting discordant partnerships		3,924	6,248	2,433	5,539	34	483
Number accepting testing, identified as discordant, and starting ART	50.2%‡	1,971	3,139	1,222	2,783	17	243
Number retained on ART after 1 year	80.2%§	1,581	2,517	980	2,232	14	195
Base case national one-year incidence (MoT Model)		88,483	88,483	48,636	48,636	5,722	5,722
Intervention national one-year incidence (MoT Model)		88,296	88,185	48,544	48,426	5,721	5,703
Cases averted in one year (MoT Model)		**187**	**298**	**92**	**210**	**1**	**19**
SCENARIO 2 – IDENTIFYING AND TREATING ALL HIV+ MEN							
Total number HIV+		17,330	19,851	11,360	19,423	381	4,506
Number accepting testing and starting ART	57.1%‡	9,894	11,333	6,486	11,088	217	2,572
Number retained on ART after 1 year	80.2%§	7,935	9,089	5,201	8,893	174	2,063
Base case national one-year incidence (MoT Model)		88,483	88,483	48,636	48,636	5,722	5,722
Intervention national one-year incidence (MoT Model)		88,068	87,946	48,398	48,226	5,716	5,654
Cases averted in one year (MoT Model)		**415**	**537**	**238**	**410**	**6**	**68**

* 2014 VMMC clinic data was not available for Uganda

† 2013 data for Uganda was not partitioned by age range. The proportion of clients aged 15-49 was estimated using the proportion in that age range for all other countries [1].

‡ MC client HIV testing and counseling acceptance: 86.5% [1], index testing acceptance: 88% [2] (to identify discordant couples), likelihood of ART initiation: 66% [3]

§ [4]

Table 2 – Sensitivity analyses exploring the impact of VMMC client HIV prevalence on the number of men that could be identified in one year on average during 2015-2025

				Uganda			Zambia			Swaziland		
Number of VMMC clients (2015-2025)				**390,945**			**189,387**			**20,486**		
	HIV Prevalence			**HIV+ men identified in one year**								
	Lower	**Base**	**Upper**	**Lower**	**Base**	**Upper**	**Lower**	**Base**	**Upper**	**Lower**	**Base**	**Upper**
DISCORDANT COUPLES												
VMMC client HIV prevalence (Uganda)	2.5%	5.1%	7.3%	3,124	6,248	8,978						
VMMC client HIV prevalence (Zambia)	5.1%	10.3%	13.3%				2,770	5,539	7,180			
VMMC client HIV prevalence (Swaziland)	11.0%	22.0%	27.4%							242	483	601
ALL HIV+ MEN												
VMMC client HIV prevalence (Uganda)	2.5%	5.1%	7.3%	9,926	19,851	28,526						
VMMC client HIV prevalence (Zambia)	5.1%	10.3%	13.3%				9,711	19,423	25,178			
VMMC client HIV prevalence (Swaziland)	11.0%	22.0%	27.4%							2,253	4,506	5,604

Table 3 – Sensitivity analyses exploring the impact of client prevalence and the HIV treatment cascade on the number of cases averted in one year on average during 2015-2025

				Uganda			Zambia			Swaziland		
Number of VMMC clients (2015-2025)				**390,945**			**189,387**			**20,486**		
	Parameter			**Cases averted in one year**								
	Lower	**Base**	**Upper**	**Lower**	**Base**	**Upper**	**Lower**	**Base**	**Upper**	**Lower**	**Base**	**Upper**
SCENARIO 1 – IDENTIFYING AND TREATING MEN IN DISCORDANT COUPLES												
VMMC client HIV prevalence (Uganda)	2.5%	5.1%	7.3%	149	298	429						
VMMC client HIV prevalence (Zambia)	5.1%	10.3%	13.3%				105	210	272			
VMMC client HIV prevalence (Swaziland)	11.0%	22.0%	27.4%							9	19	23
% client uptake of testing and counseling	70.0%	86.5%	95.0%	241	298	327	170	210	230	14	19	20
% partner uptake of testing and counseling	70.0%	88.0%	95.0%	237	298	322	167	210	226	15	19	20
% initiating ART	50.0%	66.0%	90.0%	226	298	407	159	210	286	14	19	25
% retained on ART for one year	65.0%	80.2%	95.0%	242	298	353	170	210	248	15	19	22
SCENARIO 2 – IDENTIFYING AND TREATING ALL HIV+ MEN												
VMMC client HIV prevalence (Uganda)	2.5%	5.1%	7.3%	268	537	772						
VMMC client HIV prevalence (Zambia)	5.1%	10.3%	13.3%				205	410	531			
VMMC client HIV prevalence (Swaziland)	11.0%	22.0%	27.4%							34	68	85
% client uptake of testing and counseling	70.0%	86.5%	95.0%	435	537	590	332	410	450	55	68	75
% initiating ART	50.0%	66.0%	90.0%	407	537	733	310	410	559	52	68	93
% retained on ART for one year	65.0%	80.2%	95.0%	435	537	637	332	410	486	55	68	81

Figures

Figure 1 – Modes of Transmission model risk groups and model structure

[*] Distinct risk groups added to the standard MoT model for this analysis

Figure 2 – Estimated changes in the percent of all VMMC clients in cohabiting partnerships; sexually active, but not cohabiting; or not sexually active, from 2014 to the 2015-2025 average, due to increased average age of clients

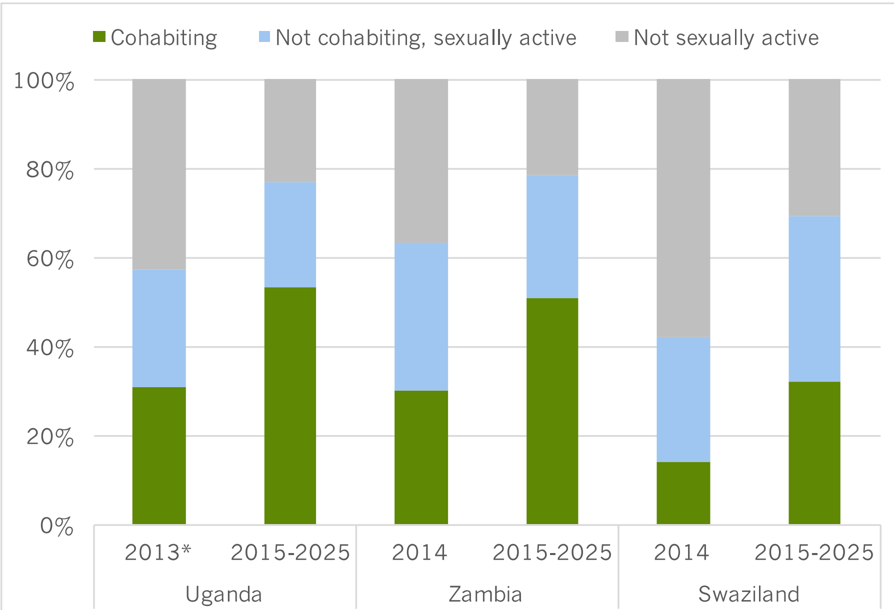
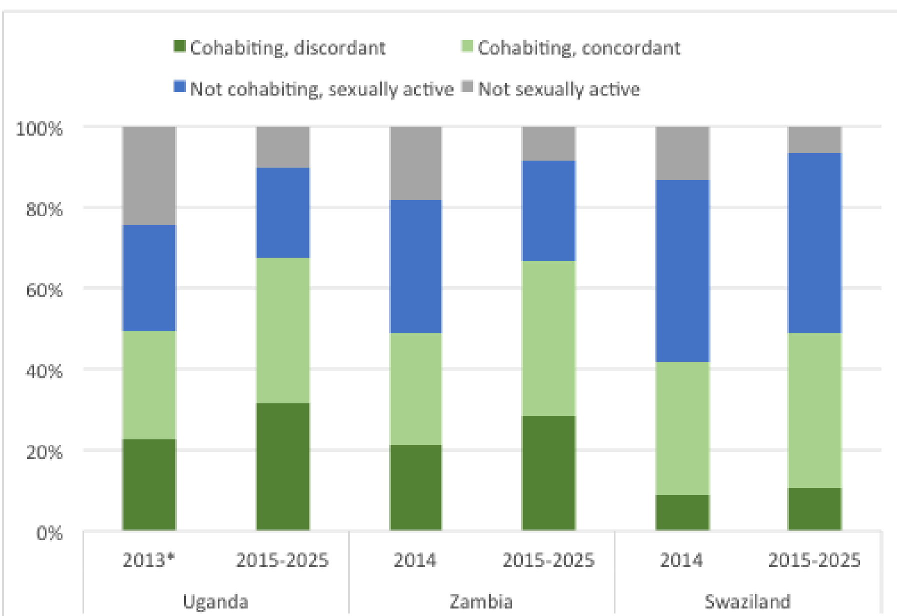


Figure 3 – Estimated changes in the percent of HIV-infected VMMC clients in discordant and concordant cohabiting partnerships; sexually active, but not cohabiting; or not sexually active, from 2014 to the 2015-2025 average, due to increased average age of clients



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Appendix

Figure 1 – Distribution of adult population among MoT risk groups for Uganda, Zambia, and Swaziland, 2015

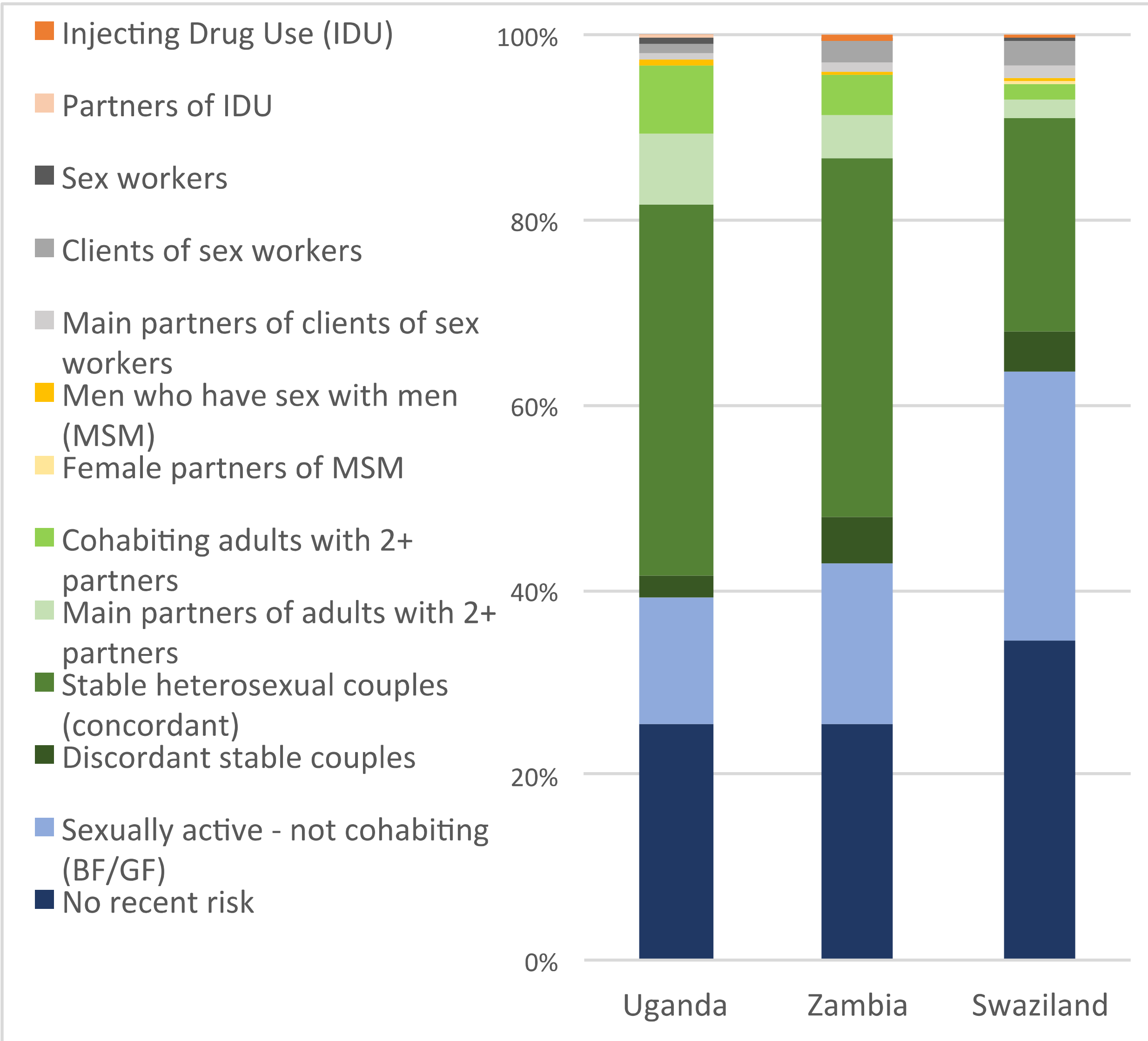

Figure 2 – Distribution of new HIV infections among MoT risk groups in Uganda, Zambia, and Swaziland in 2015