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HIV Incidence by Male Circumcision Status From the Population-Based HIV Impact Assessment Surveys—Eight Sub-Saharan African Countries, 2015–2017

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Abstract

Background: Male circumcision (MC) offers men lifelong partial protection from heterosexually acquired HIV infection. The impact of MC on HIV incidence has not been quantified in nationally representative samples. Data from the population-based HIV impact assessments were used to compare HIV incidence by MC status in countries implementing voluntary medical MC (VMMC) programs.

Methods: Data were pooled from population-based HIV impact assessments conducted in Eswatini, Lesotho, Malawi, Namibia, Tanzania, Uganda, Zambia, and Zimbabwe from 2015 to 2017. Incidence was measured using a recent infection testing algorithm and analyzed by self-reported MC status distinguishing between medical and nonmedical MC. Country, marital status, urban setting, sexual risk behaviors, and mean population HIV viral load among women as an indicator of treatment scale-up were included in a random-effects logistic regression model using pooled survey weights. Analyses were age stratified (15–34 and 35–59 years). Annualized incidence rates and 95% confidence intervals (CIs) and incidence differences were calculated between medically circumcised and uncircumcised men.

Results: Men 15–34 years reporting medical MC had lower HIV incidence than uncircumcised men [0.04% (95% CI: 0.00% to 0.10%) versus 0.34% (95% CI: 0.10% to 0.57%), respectively; *P* value = 0.01]; whereas among men 35–59 years, there was no significant incidence difference [1.36% (95% CI: 0.32% to 2.39%) versus 0.55% (95% CI: 0.14% to 0.67%), respectively; *P* value = 0.14].

Discussion: Medical MC was associated with lower HIV incidence in men aged 15–34 years in nationally representative surveys in Africa. These findings are consistent with the expected ongoing VMMC program impact and highlight the importance of VMMC for the HIV response in Africa.

Keywords

male circumcision; HIV; Africa; incidence

INTRODUCTION

Approximately 1.7 million people were newly infected with HIV worldwide in 2019, most of whom resided in southern and eastern Africa.1 Substantial scale-up of prevention and treatment programs over the past decade has made possible the goal of containing the epidemic and ultimately eliminating HIV. Male circumcision (MC) reduces the risk of heterosexually acquired HIV infection by approximately 60% among men[2–5] and is an essential component of the HIV prevention program in southern and eastern Africa, where HIV is transmitted primarily heterosexually and MC prevalence is relatively low. Since 2009, the US President's Emergency Plan for AIDS Relief (PEPFAR) has supported Ministries of Health and Defense to offer voluntary medical male circumcision (VMMC) services for HIV prevention in 15 southern and eastern African countries with generalized HIV epidemics and low MC prevalence. Through 2020, approximately 25 million (of 27 million total) VMMC services had been supported by PEPFAR.[6]

Following years of observational studies showing an association between MC and lower HIV prevalence, 3 randomized controlled trials published from 2005 to 2007 definitively established the HIV preventive benefit of MC[3–5]; the durability of effect has been demonstrated in longer-term follow-up of participants from these randomized controlled trials.[8–10] More recently, observational data from community cohorts where VMMC programs have been implemented have demonstrated greater HIV incidence reduction among circumcised men and, in some instances, their female sexual partners than among uncircumcised men.[11–15] These studies did not account for concomitant antiretroviral treatment (ART) scale-up, although modeling has shown that ART scale-up largely explains near-term declines in HIV incidence whereas MC explains longer-term declines.[16] Nationally representative data to quantify the decline in HIV incidence from the VMMC program, to determine its contribution toward regional epidemic control in the context of ART scale-up, have not previously been available.

The population-based HIV impact assessments (PHIAs) are nationally representative surveys conducted in several African countries with generalized HIV epidemics. The PHIA surveys were designed to directly estimate national HIV incidence among adults using HIV recency testing. This article describes the impact of the VMMC program on male HIV incidence after approximately 10 years of VMMC program scale-up in 8 countries with completed PHIA surveys.

METHODS

Study Design and Population

The PHIA surveys were cross-sectional, household-based surveys conducted on a nationally representative sample designed to measure subnational HIV prevalence, national incidence, and viral load suppression in adults in multiple countries across sub-Saharan Africa supported by PEPFAR.[17,18] These PHIAs enrolled participants aged 0 years and above, with varying upper-age limits (59 years to ≥65 years). Each survey used a 2-stage cluster sampling design to obtain representative samples of persons living in households within the country. All surveys used comparable questionnaires that included a set of core questions, as well as common specimen collection and HIV testing methods. Questionnaire data were collected through computer-assisted personal interviews conducted by trained staff in preselected households. Eligible participants first provided informed consent and then answered questions regarding household membership and characteristics; individual social, behavioral, and demographic characteristics; and HIV-related risk factors. Diagnostic data were collected by trained survey staff through in-home and laboratory-based testing. Venous blood was collected from consenting participants, followed by home-based rapid HIV testing following respective national algorithms and counseling. All HIV test results were returned to participants. Individuals who tested positive for HIV were referred to care and treatment. HIV infection recency testing was performed at the laboratory.

Inclusion criteria for this analysis were being a man aged 15–59 years (because participants aged 0–14 years were not asked about MC and 59 years was the upper-age limit of adult participants in several countries), providing answers (not "refused" or "don't know") to MC status questions described below, having valid HIV test and recency results, and residing in a country implementing a VMMC program with a PHIA from 2015 to 2017. The countries included Eswatini (August 2016–March 2017), Lesotho (November 2016–May 2017), Malawi (November 2015–August 2016), Namibia (June–November 2017), Tanzania (October 2016–August 2017), Uganda (August 2016–March 2017), Zambia (March–August 2016), and Zimbabwe (October 2015–August 2016). Because there were few incident cases in any given PHIA, data were pooled across countries.

The PHIA protocols and data collection tools were approved by in-country ethics committees and the institutional review boards at Columbia University Medical Center and the US Centers for Disease Control and Prevention.

Study Definitions

HIV incidence can be measured from cross-sectional data with a laboratory assay that distinguishes between recent and long-term HIV infections based on avidity of anti-HIV antibodies for HIV antigens.[19] A recent infection testing algorithm was used using HIV-1 LAg-Avidity enzyme immunoassay (Sedia Biosciences Corporation, Portland, OR), viral load (VL), and residual antiretroviral (ARV) drugs in dried blood spot samples.[20] Specimens with a median normalized optical density ≤1.5 were classified as potentially recently HIV infected and then, for further classification, VL and ARV testing results from earlier in the study were analyzed for each specimen. Specimens with a VL of <1000 copies/mL or with detectable ARVs were classified as long-term infections. Specimens with VL ≥1000 copies/mL and without detectable ARVs were classified as recent infections.

MC status was self-reported in the PHIA surveys. Among circumcised men, we distinguished between MC type (ie, medical or nonmedical MC) based on the participant's report of the person who performed the procedure. Medical MC was defined as those reported to have been performed by a physician, clinical officer, nurse, or midwife; nonmedical MC was defined as MC performed by a traditional practitioner/circumciser, religious leader, initiation school personnel, family member/relative, or friend. This distinction was made because multiple studies document an association between nonmedical MC and incomplete circumcision,[21–24] and partial foreskin removal may not provide the same level of protection as complete foreskin removal.[25]

To assess for possible misclassification of MC type (medical versus nonmedical), a subanalysis of medical MC status was conducted, inspecting the reported age of men at MC. Men reporting medical MC were divided according to whether they reported undergoing the procedure before or after VMMC program scale-up began in their country based on national reports to the World Health Organization (2009: Zambia; 2010: Eswatini, Tanzania, Uganda, and Zimbabwe; 2011: Malawi; 2012: Lesotho; and 2015: Namibia).[7] A high proportion of men reporting medical MC before VMMC program scale-up could indicate possible self-misclassification of medical MC because it was not widespread in these countries before VMMC program scale-up.[26] Cases of recent HIV infection among men reporting medical circumcision were then analyzed for whether or not they reported undergoing the procedure before or after VMMC program scale-up in their country. Because of small cell size, we were unable to conduct a sensitivity analysis restricting medical circumcision to only men who reported circumcision after VMMC scale-up in their country.

ART coverage and viral load suppression (VLS) vary across communities where VMMC is supported by PEPFAR. Given the efficacy of VLS in preventing HIV transmission, controlling for the impact of ART was critical to isolate the association between VMMC and HIV incidence. A measure of population VL, which is associated with HIV incidence,[27,28] was used as a marker of ART program scale-up. Specifically, we calculated the population VL as the mean VL among all women aged 15–59 years at the first subnational unit level with HIV-negative women counted as having a VL of 0 copies/mL.

HIV risk from sexual behavior was defined by a composite score of risky behaviors in the past 12 months, including: any sexual intercourse; sexual intercourse with ≥2 partners; lack of condom use at last sexual intercourse with a nonregular partner (defined as friend/acquaintance, sex worker, sex worker client, ex-wife/ex-partner, stranger, or other); and any sexual partner with HIV-positive or unknown HIV status.[29–32] Previous studies have validated composite scores for quantifying individual risk of HIV infection.[30–32] Because not all country surveys were identical, only variables asked across all countries were included in the composite score. We selected sexual risk behaviors in this analysis that reflected risks in the past year, given HIV incidence was the outcome of interest. Other HIV transmission modes were not included because many PHIA questionnaires did not ask about injection drug use, there was expected under-reporting of homosexual intercourse in PHIAs, and no strong evidence exists for MC to reduce HIV infection through these transmission modes.

Additional covariables were included in this analysis because of potential association with HIV incidence and MC included residence in an urban or rural enumeration area, marital status, and country[29,32,33] (Figure 1).

Statistical Analysis

Survey data were weighted based on sampling design, nonresponse, and the age and sex distribution of each country's population. Incidence was estimated using the R package *inctools*.[34] The inputs for this package are prevalence of recent infection (number of recent infections as determined by the LAg-Avidity assay/number of HIV-positives), prevalence of HIV (number of HIV-positive participants/all participants), the relative standard errors for each prevalence estimate, and parameters related to the test characteristics. Kassanjee et al[35] provide the details of the estimation.

Random-effects logistic regression models were fit using SAS PROC GLIMMIX (version 9.4, SAS Institute, Cary, NC) to generate the prevalence estimates of recent infection and HIV and standard errors among men aged 15–59, for inputs into *inctools*. Both unadjusted models and models adjusted for covariates (mean VL among women aged 15–59, sexual risk behavior score, urban/rural residence, marital status, and country) were fit for each dichotomous outcome (prevalence of recent infection and prevalence of HIV) by MC status (medical MC, nonmedical MC, and uncircumcised). Because of a significant interaction between age and MC status, models were age stratified into 2 groups (15–34 and 35–59 years); stratifying into finer age bands was not possible because of few recent cases among participants in the PHIA surveys. (Finer age bands are presented for analyses where data were sufficient.) Country was included as a random effect.

Prevalence estimates of recent infection and HIV, relative standard errors (defined as standard errors/prevalence), and recency test characteristics including the mean duration of recent infection (132 days [mean duration of recent infection (MDRI) was 130 days on the HIV-1 LAg-Avidity enzyme immunoassay for HIV subtype A. However, in Uganda an MDRI of 153 days was used based on the weighted average of the MDRIs for HIV subtypes A and D. For this analysis, we used an MDRI of 132, a weighted average of country-specific estimates (weighting by number at risk for infection in each country)]), the false recency rate (0.01%), and the time cutoff for recent infection (730 days) were entered into *inctools* to generate HIV incidence estimates, differences between incidence estimates, confidence limits, and *P* values. For both medically and nonmedically circumcised men, we estimated incidence differences as compared to uncircumcised men, with *P* values <0.05 considered statistically significant. All comparisons were 2 sided.

RESULTS

From 2015 to 2017, among the 8 countries, 90,088 men aged 15–59 years were rostered, of whom 80,154 (89.0%) were deemed eligible for participation (see Figure, Supplemental Digital Content, http://links.lww.com/QAI/B621); 68,758 (85.8%) participated in the interview [range: 80.8% (Zambia)–93.7% (Uganda)], and 63,088 (91.8%) of those interviewed participated in the biomarker portion of the survey [range: 86.8% (Malawi)–98.5% (Uganda)]. Overall, 62,344 (98.8%) men with blood results reported their MC status, and among circumcised men, 25,786 (96.6%) reported their MC provider type. Overall, MC prevalence was 32.3% [95% confidence interval (CI): 31.8% to 32.7%] medically circumcised; 19.4% (95% CI: 19.0% to 19.8%) nonmedically circumcised; and 48.3% (95% CI: 47.9% to 48.7%) uncircumcised. Recency testing was performed in 99.9% of specimens of men with positive HIV test results (n = 6089). There were a total of 75 recent HIV infections among men with known MC status: 12 in men who reported medical MC, 17 in men who reported nonmedical MC, and 46 in uncircumcised men.

Medically circumcised men were more likely to be younger, single, and have higher levels of education than uncircumcised men [15–24 years: 47.4% (95% CI: 46.3% to 48.5%) versus 38.6% (95% CI: 37.9 to 39.2) (Table 1); single 50.3% (95% CI: 49.2% to 51.3%) versus 38.4% (95% CI: 37.7% to 39.0%); and higher education 8.4% (95% CI: 7.9% to 9.0%) versus 7.1% (95% CI: 6.8% to 7.5%), respectively]. They were also more likely to live in urban areas than uncircumcised men [44.9% (95% CI: 44.1% to 45.7%) versus rural 26.6% (95% CI: 26.2% to 27.0%), respectively]. Tanzania contributed the largest proportion of men (weighted) to the analysis [39.4% (95% CI: 39.3% to 39.5%)].

Similar proportions of medically circumcised and uncircumcised men reported having sex in the past 12 months [83.9% (95% CI: 83.0% to 84.8%) and 84.6% (95% CI: 84.1% to 85.1%), respectively] (Table 1). Medically circumcised men more frequently had ≥2 sex partners in the past 12 months than uncircumcised men [34.8% (95% CI: 33.6% to 36.1%) versus 26.8% (95% CI: 26.1% to 27.5%), respectively,] and were less likely to know the HIV status of their last sex partner(s) than uncircumcised men [50.2% (95% CI: 48.9% to 51.5%) versus 41.0% (95% CI: 40.2% to 41.7%), respectively]. Men aged 25–34 years had the highest mean risk score among all groups, and for each age group, medically circumcised men had higher mean risk scores than uncircumcised men (see Table 1, Supplemental Digital Content, http://links.lww.com/QAI/B622). HIV prevalence was 6.2% (95% CI: 3.9% to 9.5%) among medically circumcised men, 7.9% (95% CI: 5.1% to 12.1%) among nonmedically circumcised men, and 11.4% (95% CI: 7.5% to 17.1%) among uncircumcised men (Table 2).

Among men aged 15–34 years, medically circumcised men had lower annualized HIV incidence than uncircumcised men [0.04% (95% CI: 0.00% to 0.10%) versus 0.34% (95% CI: 0.10% to 0.57%), respectively; adjusted incidence difference: 0.23% (95% CI: 0.06% to 0.40%); *P* value = 0.01] (Table 3). Among men aged 35–59 years, the incidence difference was not statistically significant between medically circumcised men and uncircumcised men [1.36% (95% CI: 0.32% to 2.39%) versus 0.55% (95% CI: 0.14% to 0.97%), respectively; adjusted incidence difference: −0.34% (95% CI: −0.79% to 0.11%); *P*-value = 0.14]. For men aged 15–34 and 35–59 years reporting nonmedical MC, the incidence differences were not statistically significant versus uncircumcised men.

A majority (56.5% [range: 12.0% in Zimbabwe to 71.9% in Tanzania]) of medically circumcised men reported undergoing the MC procedure before VMMC program implementation in their country (see Table 2, Supplemental Digital Content, http://links.lww.com/QAI/B622). As expected, this was more common among men aged 35–59 years than 15–34 years (84.1% versus 47.2%, respectively). Among the 12 recent HIV infections in medically circumcised men, 8 occurred in those reporting to be circumcised before VMMC program scale-up and 4 in those circumcised afterward.

DISCUSSION

In this large, multicountry analysis, medical MC was associated with reduced HIV incidence among men aged 15–34 years compared with uncircumcised men, even though medically circumcised men in this age group had higher sexual risk scores. This finding demonstrates the effectiveness of the VMMC program in a nationally representative setting, lending strong support for continued VMMC scale-up in countries with generalized HIV epidemics and low MC prevalence. No such country has yet reached the fast-track target MC prevalence of 90% in men 10–29 years.[36] Although the HIV prevalence pattern in the PHIA surveys was consistent with numerous cohort and controlled studies and demographic and health surveys showing the protective effect of MC on HIV acquisition among men, prevalence associations alone cannot exclude the possibility of reverse causality (ie, HIV-negative men self-selecting to undergo MC). The lower HIV incidence among medically circumcised men aged 15–34 years found in this study helps address this issue.

The incidence difference was nonsignificant for 35–59-year-olds. This could be a consequence of few recent cases occurring in the PHIAs resulting in large variance estimates, or the short amount of time elapsed between when MCs scale-up began and the PHIAs were conducted, as the lifelong benefits (and population-level effect) of this one-time intervention are expected to accrue with time.16 A risk concentrating phenomenon —wherein as a result of the HIV preventive benefit of MC, among all men at high risk for HIV, uncircumcised men differentially move out of the HIV-negative category more quickly than circumcised men, leaving a substantial risk discrepancy at older ages—could also be a factor. Spurious waning—wherein as a result of the partial preventive benefit of MC, among men at high risk for HIV, the uncircumcised ones become infected more quickly than the circumcised ones, leaving a substantial risk differential at older ages—could also bias this analysis.[37] True spontaneous biological mitigation of the protective effect of MC seems unlikely given the strong evidence for MC.[3–5] Offsetting of the protective effect by other factors (eg, herpes simplex virus infection and development of high-risk behaviors later in life) are other possible explanations. As discussed below, a lack of significance could also result in part from MC-type misclassification, which our findings suggest was more frequent in this age group.

HIV incidence in men with nonmedical MC was not different from incidence in uncircumcised men. This could be due to heterogeneity in the treatment effect, given this is a nonstandardized practice for amount of foreskin removed, unlike medical MC. It could also result from the observed higher prevalence of high-risk behaviors and/or differences in adoption of other HIV prevention and treatment interventions among these groups.

The findings of this study also suggest that relying on self-reported provider type to distinguish medical and nonmedical MC may be unreliable. Many men reporting medical MC said it occurred well before the VMMC program in their country was implemented. Although some amount of medical MC is likely to have been performed before the VMMC program, absence of widespread availability of medical MC was a prerequisite for implementing VMMC programs[26]; thus, such a large proportion reporting medical MC before VMMC program scale-up is unlikely. This finding could result from a combination of recall bias for men circumcised many years before and social desirability response bias because of potentially stigmatizing characterization for some men of nonmedical MC (eg, “traditional”). Possible misclassification of MC status and type has implications for future PHIAs (as well as other surveys) that draw distinctions between self-reported medical and nonmedical MC, especially because these measures are used as benchmarks for progress of MC programming in respective countries. Including a question that asks about MC setting (ie, clinic versus “traditional”) and providing graphical depictions of partial versus complete MC could potentially improve differentiation of medical and nonmedical MC, although this, too, would need to be validated.

A unique strength of this analysis was inclusion of the impact of ART scale-up in the adjusted analysis given the efficacy of VLS in preventing HIV transmission. Although several observational studies have shown declining HIV incidence in the presence of ART and VMMC scale-up, they did not isolate the contribution of VMMC.[11–13] Our study indicates that VMMC scale-up in sub-Saharan African countries with low baseline MC prevalence is already yielding population health benefits.

There were several limitations to this study. First, there were few recent cases among participants in the PHIAs, which resulted in wide confidence intervals with lower precision on estimates. This potentially impacted our ability to detect incidence differences between groups of men by MC status. In addition, data had to be pooled across countries because of these few recent HIV cases. Thus, although the adjusted model controlled for country, important differences in the drivers of HIV infection between countries may have been unaccounted for. Because of the imbalance in national population sizes, almost 40% of the study population is Tanzanian, from Tanzania where HIV incidence is relatively low and circumcision status relatively high. Residual confounding by age also cannot be discounted as a contributor to the protective association of MC with HIV incidence. However, the few recent cases did not permit finer age disaggregation.

Misclassification of MC status (circumcised versus uncircumcised) and MC type (medical versus nonmedical) is possible with self-reported outcomes.[21] In both instances, we expect that misclassification would be pre-dominantly one way, related to social desirability bias resulting from a perception of alignment between PHIA survey staff and the VMMC program (ie, both are PEPFAR-supported activities). Furthermore, the observed incidence differences between medically circumcised and uncircumcised men would not be expected if bidirectional misclassification dissociated true and self-reported MC status or MC type. Thus, misclassification from nonmedical to medical MC would likely bias our findings toward the null. No studies have assessed the validity of self-report for MC type (ie, medical or nonmedical MC), whereas this has been studied for MC status—with mixed results—elsewhere; some have found a high level of agreement between self-report and physical examination,[38–42] typically in areas where nonmedical MC is not a local cultural practice, whereas others have indicated substantial self-misclassification.[14,23,43,44] Importantly, Lissouba et al[14] found that the protective association of MC (measured using an HIV recency test) was obscured when relying only on self-reported as opposed to clinically assessed MC status. In surveys as large as PHIAs, the feasibility of clinical examination for MC status is low. Including the timing of medical MC and geographic information about where VMMC scale-up occurred might further refine self-reported MC designations. However, such an approach in this analysis was not possible as a larger sample size would be needed to ensure sufficient values in all cells given the rarity of recent HIV infections in PHIAs.

This multicountry, nationally representative analysis found significantly lower HIV incidence among medically circumcised men aged 15–34 years compared with uncircumcised men. Additional rounds of PHIAs will provide the opportunity to analyze the trend in incidence to further explore the impact of the VMMC program, as well as permit more refined age groups than were possible in this study. Given that many VMMC program clients to date have been 10–14 years old, compounding benefits are expected over time as these boys who are mostly presexual age into higher incidence groups. The findings from this analysis are consistent with the expected ongoing VMMC program impact and highlight the independent importance of VMMC as part of the HIV response in sub-Saharan Africa, including in the context of ART scale-up.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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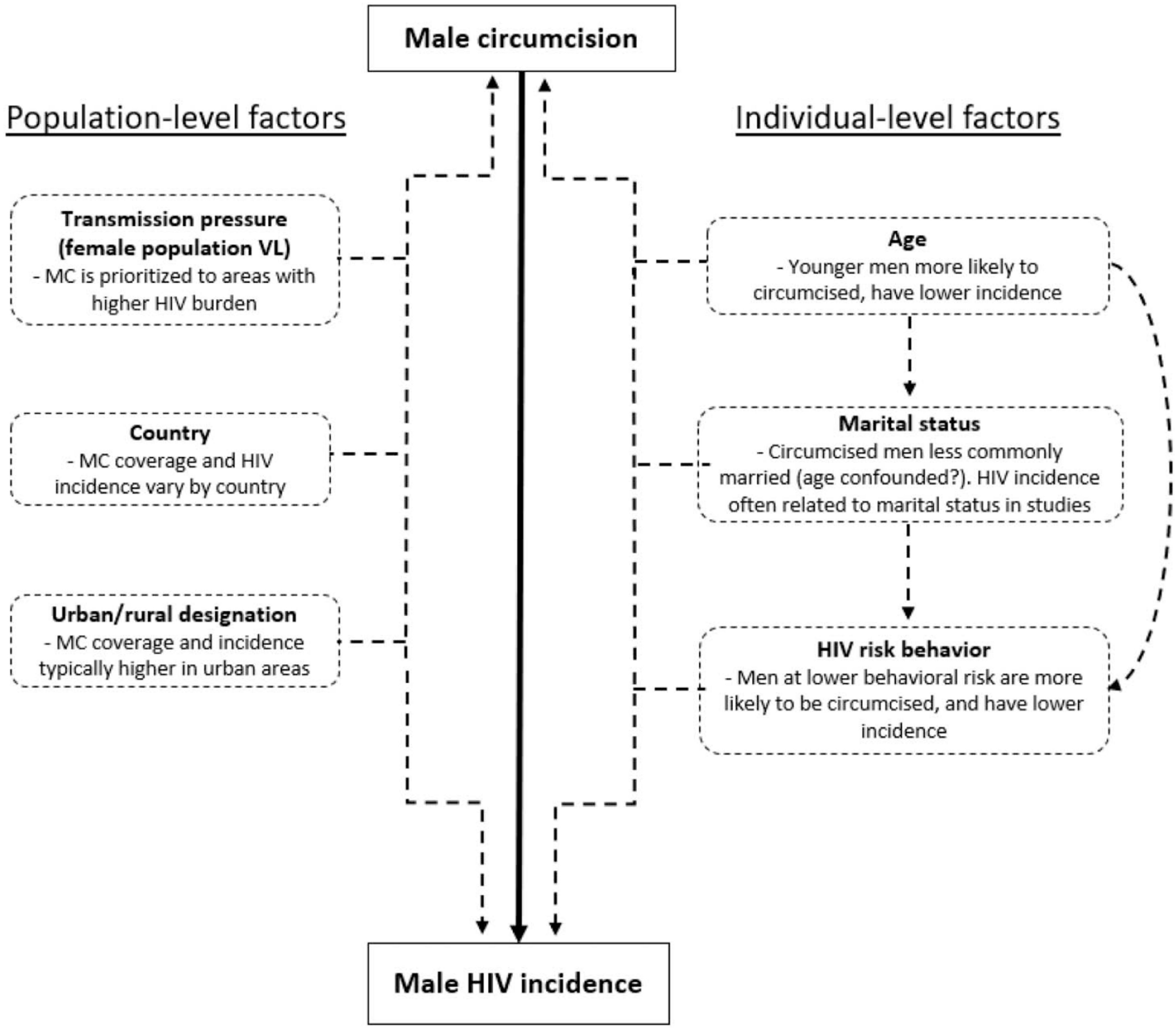

FIGURE 1.

Diagram explaining relationship between male circumcision and HIV incidence and rationale for including covariables in an adjusted model.

TABLE 1.

Sociodemographic Characteristics and Sexual Risk Behaviors Among Men Aged 15–59 Years by Male Circumcision Status in Eight Sub-Saharan African Countries,* 2015–2017

Variable	Options	Uncircumcised, (95% CI)	Medically Circumcised,† % (95% CI)	Nonmedically Circumcised,† % (95% CI)	All Men, % (95% CI)	Male PHIA Particiapnts, N (Unweighted)
Age group	15–24	38.6 (37.9 to 39.2)	47.4 (46.3 to 48.5)	34.6 (33.2 to 36.0)	40.6 (40.1 to 41.2)	25,937
	25–34	26.3 (25.7 to 26.9)	27.2 (26.2 to 28.1)	27.0 (25.7 to 28.3)	26.8 (26.3 to 27.3)	17,659
	35–44	19.4 (18.9 to 19.9)	15.4 (14.6 to 16.2)	19.8 (18.7 to 21.0)	18.2 (17.8 to 18.6)	13,102
	45–59	15.7 (15.3 to 16.2)	10.1 (9.4 to 10.7)	18.6 (17.5 to 19.7)	14.4 (14.0 to 14.7)	11,199
Marital status	Single	38.4 (37.7 to 39.0)	50.3 (49.2 to 51.3)	32.9 (31.5 to 34.2)	41.2 (40.7 to 41.7)	29,433
	Married or cohabitating	55.8 (55.2 to 56.4)	44.1 (43.0 to 45.2)	59.4 (58.0 to 60.8)	52.6 (52.1 to 53.2)	33,952
	Divorced or separated	5.1 (4.9 to 5.4)	5.2 (4.8 to 5.7)	6.8 (6.2 to 7.5)	5.5 (5.3 to 5.8)	3642
	Widowed	0.7 (0.6 to 0.8)	0.4 (0.3 to 0.5)	0.9 (0.7 to 1.1)	0.7 (0.6 to 0.7)	639
Country	Eswatini	1.3 (1.2 to 1.3)	0.8 (0.7 to 0.8)	0.0 (0.0 to 0.0)	0.8 (0.8 to 0.8)	4340
	Lesotho	1.1 (1.0 to 1.1)	1.9 (1.8 to 2.0)	2.8 (2.7 to 2.9)	1.7 (1.6 to 1.7)	5295
	Malawi	16.6 (16.3 to 16.8)	3.3 (3.1 to 3.5)	9.3 (8.9 to 9.8)	10.7 (10.7 to 10.8)	7660
	Namibia	2.3 (2.2 to 2.4)	1.4 (1.4 to 1.5)	1.3 (1.3 to 1.4)	1.8 (1.8 to 1.8)	7933
	Tanzania	16.0 (15.5 to 16.4)	64.2 (63.5 to 64.9)	55.5 (54.6 to 56.5)	39.4 (39.3 to 39.5)	12,876
	Uganda	28.2 (27.8 to 28.6)	17.2 (16.6 to 17.8)	26.4 (25.6 to 27.2)	24.6 (24.5 to 24.7)	12,074
	Zambia	16.4 (16.2 to 16.6)	7.3 (7.0 to 7.6)	3.4 (3.2 to 3.6)	10.8 (10.7 to 10.8)	9080
	Zimbabwe	18.3 (18.1 to 18.5)	4.0 (3.8 to 4.2)	1.2 (1.0 to 1.3)	10.2 (10.2 to 10.3)	8639
Primary residence	Urban	26.6 (26.2 to 27.0)	44.9 (44.1 to 45.7)	31.5 (30.4 to 32.5)	33.7 (33.5 to 33.9)	22,997
	Rural	73.5 (73.1 to 73.8)	55.1 (54.3 to 55.9)	68.5 (67.5 to 69.6)	66.3 (66.1 to 66.5)	44,900
Educational level	Primary	53.8 (53.2 to 54.4)	47.8 (46.7 to 48.8)	68.9 (67.6 to 70.1)	54.5 (54.0 to 55.0)	30,375
	Secondary	39.1 (38.5 to 39.7)	43.8 (42.7 to 44.9)	27.8 (26.6 to 29.1)	38.6 (38.1 to 39.1)	28,315
	Higher	7.1 (6.8 to 7.5)	8.4 (7.9 to 9.0)	3.3 (2.9 to 3.7)	6.9 (6.6 to 7.1)	5160
Wealth quintiles	1st	23.0 (22.6 to 23.5)	12.6 (12.0 to 13.3)	18.0 (16.9 to 19.1)	18.5 (18.2 to 18.9)	14,238
	2nd	22.0 (21.5 to 22.5)	16.0 (15.2 to 16.7)	22.4 (21.3 to 23.5)	20.0 (19.6 to 20.4)	13,950
	3rd	20.4 (20.0 to 20.9)	19.0 (18.2 to 19.9)	21.7 (20.6 to 22.9)	20.3 (19.9 to 20.7)	13,828
	4th	18.1 (17.6 to 18.5)	22.9 (22.0 to 23.8)	19.9 (18.7 to 21.0)	20.0 (19.6 to 20.4)	12,263

Variable	Options	Uncircumcised, (95% CI)	Medically Circumcised,[†] % (95% CI)	Nonmedically Circumcised,[†] % (95% CI)	All Men, % (95% CI)	Male PHIA Particiapnts, N (Unweighted)
	5th	16.4 (16.0 to 16.8)	29.5 (28.7 to 30.4)	18.0 (17.0 to 19.0)	21.3 (20.9 to 21.6)	13,556
Had sex in the past 12 mo	Yes	84.6 (84.1 to 85.1)	83.9 (83.0 to 84.8)	86.6 (85.6 to 87.7)	84.9 (84.4 to 85.3)	46,849
	No	15.4 (14.9 to 15.9)	16.1 (15.2 to 17.0)	13.4 (12.3 to 14.4)	15.2 (14.7 to 15.6)	8233
No. of sexual partners in the past 12 mo	1 partner	73.2 (72.5 to 73.9)	65.2 (63.9 to 66.4)	62.3 (60.7 to 63.9)	68.3 (67.7 to 68.9)	33,104
	≥2 partner	26.8 (26.1 to 27.5)	34.8 (33.6 to 36.1)	37.7 (36.1 to 39.3)	31.7 (31.1 to 32.3)	13,567
Last sex was condomless sex with a nonregular partner[‡]	Yes	61.2 (59.8 to 62.6)	61.9 (60.0 to 63.8)	68.6 (66.2 to 71.0)	63.4 (62.3 to 64.4)	7679
	No	38.8 (37.4 to 40.3)	38.1 (36.2 to 40.0)	31.4 (29.0 to 33.8)	36.7 (35.6 to 37.7)	6204
Last sex partner was HIV-positive or unknown[‡]	HIV-negative	53.1 (52.3 to 53.8)	47.0 (45.7 to 48.3)	45.0 (43.4 to 46.6)	49.4 (48.8 to 50.0)	23,127
	HIV status unknown	41.0 (40.2 to 41.7)	50.2 (48.9 to 51.5)	51.9 (50.3 to 53.5)	46.2 (45.6 to 46.9)	20,224
	HIV-positive	6.0 (5.6 to 6.3)	2.9 (2.5 to 3.2)	3.1 (2.7 to 3.5)	4.4 (4.2 to 4.6)	3265
Risk score[§]	0	31.4 (30.8 to 32.0)	33.2 (32.2 to 34.2)	23.6 (22.4 to 24.9)	30.5 (30.0 to 31.0)	21,048
	1	30.4 (29.8 to 31.0)	24.3 (23.4 to 25.2)	25.5 (24.3 to 26.7)	27.4 (26.9 to 27.8)	19,111
	2	20.6 (20.1 to 21.2)	18.3 (17.4 to 19.1)	22.7 (21.6 to 23.9)	20.3 (19.9 to 20.7)	14,858
	3	11.8 (11.4 to 12.2)	13.6 (12.8 to 14.3)	16.2 (15.1 to 17.2)	13.2 (12.8 to 13.6)	8763
	4	5.8 (5.5 to 6.2)	10.7 (10.0 to 11.4)	11.9 (11.0 to 12.9)	8.6 (8.3 to 9.0)	4117

[*] Eswatini, Lesotho, Malawi, Namibia, Tanzania, Uganda, Zambia, and Zimbabwe.

[†] Medically circumcised = physician, clinical officer, nurse, or midwife; nonmedically circumcised = traditional practitioner/circumciser, religious leader, initiation school personnel, family member/relative, or friend.

[‡] Up to 3 different sex partners.

[§] Risk score was the sum of past 12 months (1 point each): any sexual intercourse; sexual intercourse with 2 or more partners; lack of condom use at last sexual intercourse with a nonregular partner (defined as friend/acquaintance, sex worker, sex worker client, ex-wife/ex-partner, stranger, or other); and any sexual partner with HIV-positive or unknown HIV status.

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TABLE 2.

HIV Prevalence Among Men Aged 15–59 Years by Male Circumcision Status in Eight Sub-Saharan African Countries,* 2015–2017

	Uncircumcised,	**Medically Circumcised,† %**	**Nonmedically Circumcised,† %**	**All Men, %**	**Men With HIV,**
Age Group (yr)	(95% CI)	(95% CI)	(95% CI)	(95% CI)	N
15–34	5.5 (3.4 to 8.7)	3.4 (2.1 to 5.5)	3.5 (2.1 to 5.8)	4.6 (2.8 to 7.5)	1802
35–59	22.3 (14.8 to 32.0)	15.9 (10.3 to 23.9)	15.3 (9.8 to 23.1)	19.8 (12.9 to 29.2)	4291
15–59	11.4 (7.5 to 17.1)	6.2 (3.9 to 9.5)	7.9 (5.1 to 12.1)	9.5 (5.5 to 15.8)	6093

* Eswatini, Lesotho, Malawi, Namibia, Tanzania, Uganda, Zambia, and Zimbabwe.

† Medically circumcised = physician, clinical officer, nurse, or midwife; nonmedically circumcised = traditional practitioner/circumciser, religious leader, initiation school personnel, family member/relative, or friend.

TABLE 3.

HIV Incidence and Incidence Difference Among Men Aged 15–34 Years and 35–59 Years by Male Circumcision Status in Eight Sub-Saharan African Countries,* 2015–2017

Age Group (yr)	Male Circumcision Status	No. of Recent Infections	Annualized HIV Incidence (95% CI) (Unadjusted†)	Incidence Difference (95% CI) (Unadjusted†)	Incidence Difference (95% CI) (Adjusted‡)	*P* for Incidence Difference (Adjusted‡)
15–34	Uncircumcised	27	0.34 (0.10 to 0.57)	N/A	N/A	N/A
	Medically circumcised	3	0.04 (−0.02 to 0.10)	0.30 (0.05 to 0.54)	0.23 (0.06 to 0.40)	0.01
	Nonmedically circumcised	9	0.40 (0.05 to 0.74)	−0.06 (−0.48 to 0.36)	0.00 (−0.26 to 0.27)	0.98
	All men	39	0.25 (0.08 to 0.42)	N/A	N/A	N/A
35–59	Uncircumcised	19	0.55 (0.14 to 0.97)	N/A	N/A	N/A
	Medically circumcised	9	1.36 (0.32 to 2.39)	−0.80 (−1.90 to 0.31)	−0.34 (−0.79 to 0.11)	0.14
	Nonmedically circumcised	8	0.42 (0.01 to 0.83)	0.14 (−0.44 to 0.72)	0.05 (−0.20 to 0.30)	0.68
	All men	38§	0.70 (0.22 to 1.18)	N/A	N/A	N/A

*Eswatini, Lesotho, Malawi, Namibia, Tanzania, Uganda, Zambia, and Zimbabwe.

†Annualized HIV incidence is before adjusting for covariables.

‡Result is for model adjusted for the following covariables: mean VL among women aged 15–59, sexual risk behavior score [past 12 month: any sexual intercourse; sexual intercourse with ≥2 partners; no condom use at last sexual intercourse with a nonregular partner (defined as friend/acquaintance, sex worker, sex worker client, ex-wife/ex-partner, stranger, or other); and any sexual partner with HIV-positive or unknown HIV status], urban/rural setting, marital status, and country.

‡Medically circumcised = physician, clinical officer, nurse, or midwife; nonmedically circumcised = traditional practitioner/circumciser, religious leader, initiation school personnel, family member/relative, or friend.

§Two men in 35–59-year-old age group did not have a recorded circumcision status. These men were excluded from the incidence analysis by male circumcision status but were included in the overall incidence estimate for men aged 35–59 years.