

Manuscript

Title

No Association of Male Circumcision and Sexual Risk Behaviors Found in the Prioritized Sub-Saharan Countries After the WHO's Medical Male Circumcision Promotion

Authors

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Guidelines

Avoid using the backslash or brace characters. Use a single underscore for *emphasis* and double for **bold**

Abstract

Context

Objective

Design, Setting, and Participants

Main Outcome Measures

Results

Conclusions

Funding

Keywords

male circumcision, HIV, sexual risk behaviors, risk compensation, generalized linear mixed models (?), DHS

Introduction

The idea of a possible connection between male circumcision (MC) and HIV risk reduction has been suggested for a few decades [**Acle86**, **CameSimo89**, **Lind88**, **HalpBail99**]. In 2007, the World Health Organization (WHO) and the Joint United Nation Programme on HIV/AIDS (UNAIDS) recommended a medical male circumcision (MMC) scale-up as part of biomedical HIV prevention interventions [**WHO07a**] after the results of three randomized clinical trials (RCT) [**AuveTalj05**, **BailMose07**, **GrayKigo07**] found MC reducing female-to-male HIV transmission by up to 60%. WHO subsequently prioritized 14 eastern and southern African countries with high HIV and low MC prevalence for a MMC scale-up, with a goal of 80% coverage of uncircumcised males aged 15-49 by 2015 [**WHO11a**]. By 2014, Kenya and Tanzania had reached the goal with 108% and 89% targets implemented, compared to nations like Namibia (6%) and Malawi (8%) lagging behind [**WHO15**] (see

table of MC progress in appendix). Since not all the governments and medical communities were able to satisfy MMC demands with sufficient resources and planning [CurrNjeu11], people aware of the MC benefit were likely to seek the services at clinics or traditional healers where proper medical guidelines were not likely provided, and the need of safe sex less likely emphasized [GreeMaha13].

There have been concerns of MMC possibly hinting sexual risk compensation (SRC) [1, AndeCock12, BrooEtze10, CassHalp06, EatoKali09, EatoCain11, GreeMaha13, GrunHenn12, GustKres11, HeweHall12, HogbLidd08, KaliEato07, L_EnLanh14, MattCamp10, PadiBuve08, RiesAchi10, SACE09, WestAgot12] because of the partial protection of MC. Risk compensation is a cognitive-behavioral process searching for a balance between risk-taking (e.g., intercourse without condoms) and potential benefits of risky behaviours (e.g., sexual pleasure) responding to health intervention [Chen13, HogbLidd08, KaliEato07, KatzSchw02, SheeChu01, Unde13, WilsGore04]. Although most studies showed no significant sexual risk behaviour changes [AgotKiar07, AuveTalj05, BailMose07, GrayKigo07, GrayKigo12, KongKigo12, MattCamp08, WestAgot14, ConfirmCites, MoreCites], other findings showed some signs of SRC [GrunHenn12, KibiNans14, KongSsek14, MaugVenk12, MaugGodl14, RiesAchi10, ZungSimb16]. A comparison of before and after the UN’s MMC recommendation in Uganda found a significant change of reduction of condom use among circumcision men [KibiSand16]. It was also found that risky sexual behaviours were more common among the circumcised groups [KibiNans14, KibiSand16], and the riskier behaviours were found to associate with willingness to be circumcised after the UN’s MMC recommendation [KibiMaku15]. Qualitative studies observed mixed messages [RiesAchi10, GrunHenn12]: most respondents described no behavioral changes, but some reported increased sexual risk behaviors [GrunHenn12, RiesAchi10].

Here, we look at population-level survey data from ten of the fourteen countries prioritized by the UN for the African MMC scale-up. Our primary analysis compares the *difference* in sexual risk behaviours (SRB) between circumcised and uncircumcised men before and after the UN’s official MMC promotion. We also compared SRB after the promotion in: uncircumcised men; men circumcised before the promotion; and men circumcised after the promotion started. Analyzing survey data provides a useful complement to RCT data,

because it is not subject to biases that may occur in RCTs due to intense HIV counselling and education [MatoSsem07].

Research Questions

Our main analysis focuses on changes in risk behaviour between post-2007 and pre-2008 (i.e., before and after the UN MMC recommendation). We analyze the *interaction* between survey year and circumcision status in predicting sexual behaviour and whether the *difference* between the behavior of circumcised and uncircumcised men changes. We called this the “MC status” analysis.

In addition, we also analyzed data from after 2007 to study the differences of SRB among MC category (uncircumcised, previously circumcised -circumcised before 2008, and newly circumcised men -circumcised after 2007). This analysis focused on the variable-level effect of circumcision category on risk behaviors at the overall effect of circumcision category as the main predictor. We call this the “MC recency” analysis.

Methods

Data and Samples

We used nationally representative surveys from the Demographic and Health Surveys (DHS) in this study. Countries with DHS data met the following criteria were selected: first, one of the 14 MMC prioritized nations by WHO with national engagement in MMC programs either in implementing or pilot stage [WHO11, WHO11a, WHO15] (also, see table of MC progress in appendix); second, availability of DHS data both before and after 2007; third, survey modules of the selected SRB data. That resulted in ten nations: Kenya, Lesotho, Malawi, Mozambique, Namibia, Rwanda, Tanzania, Uganda, Zambia and Zimbabwe (see TABLE in Appendix).

Each nation has two datasets, and it summed up to 20 datasets in total. The datasets were grouped into pre-MC surveys (i.e., pre-2007 and 2007), and post MC surveys (i.e., after 2007). Male samples aged from 15-49 were selected in consistence with the WHO’s scale-up targets [WHO11a].

(see [tab:Status_characteristics] and [tab:Recency_characteristics, Recency] [CF: we can put this in Appendix: nation by variables, one pre-2008 and one post-2007.]

The following samples were excluded from this study: never heard of AIDS, never had sexual intercourse prior to the surveys, unaware of their circumcision status, or had NA answers to any of the variables. [Maybe move this to the table descriptions]

The sample population was not proportionally representative of the countries because the survey sampling weights were not considered in this study. Instead, we tried to make inferences about behaviour in the surveyed population.

Measurements and Concepts

There was no agreement on how to evaluate sexual risk behaviours (SRB) when analyzing intervention in association of HIV reduction [Unde13]. Our selection of SRB was based on DHS data availability and other related studies [AuveTal05, BailMose07, GrayKigo07, GrayKigo12, KongSsek14]. Our main predictors were MC status, defined as circumcised vs. uncircumcised, in the MC status analysis, and MC category, defined as uncircumcised, newly circumcised and previously circumcised (i.e., pre and post UN's MMC campaign) in the recency model. The main responses were condom use at last sex and number of non-marital sexual partners in the last 12 months in the status model. Number of non-marital sexual partners in lifetime was analyzed only in the recency model because many of the pre 2008 surveys did not include this module.

The co-variables in the two models included age, education, work status, religion, wealth, residence (rural vs. urban), marital status, media use and HIV knowledge. (see [tab:Status_characteristics, tab:Status_Sample_Characteristics] and [tab:Recency_characteristics]). Lesotho was excluded in the status model because it missed the condom data in the pre-2007 DHS. Clusters and country were treated as random factors in order to control for correlations between individuals from the same geographic area and background. We also control for media slopes in the random effect based on the presumption that media content in each country was likely to be different.

- insert TABLE Sample_Selection: sample size, method of selection (by per how many household), age, etc. A raw index of wealth was used and coded as a three-knot spline based on a priori decision, and age four-knot spline. Marital status was recoded into four categories that did not distinguish between formal and informal marriage, and religion also into four categories. Because Tanzania missed religion data, we therefore coded it separately along the code for religion. Number of non-marital sexual partners within the last 12 months was recoded from zero to three; and number of non martial sexual partners in lifetime from zero to six. Numbers exceeded the maximum was truncated as the maximum. The media use refers to the amount spend on newspapers, radio and TV. The basic HIV knowledge was based on three questions: “Reduce chances of AIDS by always using condoms during sex,” “Reduce chance of AIDS: have 1 sex partner with no other partner,” and “Can a healthy person have AIDS.” Both of media use and HIV knowledge were constructed into scores. (Please confirm if this is correct)

Statistical Model

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We used cumulative link mixed models (CLMMs) in the statistics package R [**Rstats**] in this study. The CLMM framework allows us to model a binary or ordinal response variable, while treating clusters and country as random effects.

Variable-level P values were calculated by sequentially dropping each variable and comparing the resulting restricted models to the full model. “Prediction” plots were made by calculating the effect of each level or value of a predictor variable on the linear predictor of the CLMM, using the model center as a reference point. Any sample with missing data for a given variable was adaptively dropped from analyses involving that variable.

(A sentence why this is a good/more sensible tool?)

Scripts

Permission for using the DHS was authorized by USAID and is available upon registration at The DHS program. All of the R scripts used to analyze the data and produce the figures will be made available on the web when the paper is published.

Results

-figures and tables

- (insert TABLE Status_characteristics Status Sample Characteristics) (We can put this in Appendix. The sociodemographic and sexual risk behaviour profile was presented in table XX in appendix. Can refer to <https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3626062/> table one format)
- (insert TABLE Recency_characteristics Recency Sample Characteristics) (ditto)
- (insert FIGURE of condomStatus: the *interaction* plot showing the mean effect of MC Status on condom use, and the interaction with DHS survey year. The relative odds ratio (ROR) is 0.83 (95% CI, 0.74-0.92; interaction P=?) figdrop/condomStatus_intplots.pdf)
- (insert FIGURE of partnerYearStatus: the *interaction* between survey year and circumcision status on numbers of non-martial sexual partners within the previous year. The ROR is 0.006 (95% CI, -0.008-0.021; P=?) figdrop/partnerYearStatus_intplots.pdf)
- (insert FIGURE of condomRecency: the comparison of condom use during the last sexual intercourse by circumcision category. $P < 0.001$). Men circumcised after the UN's MMC promotion started were xx times more likely to use condom than uncircumcised men; and men circumcised before the MMC promotion were least likely to use condom.
- (insert FIGURE of partnerYearRecency: the comparison of numbers of non-martial sexual partners within the previous year by circumcision category. $P = 0.142$). Although men circumcised after the UN's MMC promotion started had more non-martial sexual partners within the

previous year than men circumcised before the promotion and than uncircumcised men. The difference was not significant.

- (insert FIGURE of partnerLifeRecency: the comparison of numbers of non-marital sexual partners in lifetime by circumcision category. $P < 0.001$). Men circumcised before the UN's MMC promotion had an average of xx sexual partners compared to xx in men circumcised newly circumcised after the UN's campaign started and to xx to men not circumcised; and the difference was significant.

(Let's put these three recency results into one figure)

[To do: Combine the above recency figure descriptions into one P (to match one figure)]

[To do: Combine the pages from the below recency figures descriptions into one figure]

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- figdrop/partnerLifeRecency_MCcat.pdf
- figdrop/partnerYearRecency_MCcat.pdf

(need a sentence on how many samples in total and by nation or by data.)

The results of the condom MC status model showed a significant difference of condom use between pre-2008 and post 2007 surveys (See Figure of interaction of condomStatus_intPlots.pdf). The gap of condom use between circumcised men and non circumcised men post 2007 was significantly smaller than pre-2008 (The relative odds ratio (ROR) is 0.83 (95% CI, 0.74-0.92; $P=?$)). Before the UN's MMC promotion started in 2007, circumcised men were less likely to use condom in their last intercourse compared to uncircumcised men, but MORE likely to use condom after the promotion started. The likelihood of condom use among circumcised men increased significantly (How to transfer ROR (0.83) into words?)

A non-significant finding was found in numbers of non-marital sexual partners within the last 12 months between men the pre-2008 data and post 2007 data (See the interaction of prediction in Figure of partnerYearStatus_intPlots.pdf). The findings showed an increases of numbers of non-marital sexual partners by year in circumcised men in the pre-2008 surveys to post 2007 surveys, and

a decrease for non circumcised men. But the gap of the differences between circumcised men and non circumcised men between post-2007 and pre-2008 surveys was not significant (the relative odds ratio (ROR) is 0.006 (95% CI, -0.008-0.021; P=?).

The results of the three recency analyses (e.g., post-2007 surveys) were mixed. The condom recency results showed a significant difference among those newly circumcised, previously circumcised and non circumcised men. The newly circumcised men were most likely to use condom, followed by non circumcised ones. The previously circumcised men were least likely to use condom ($P < 0.001$. See Figure condomRecency_MCcat.pdf). Regarding numbers of non-marital sexual partners in lifetime, the results showed that previously circumcised men had significantly higher numbers, followed by the newly circumcised, then the non circumcised ones ($P < 0.001$. See Figure partnerLifeRecency_MCcat.pdf). In the case of yearly number, although newly circumcised men had most non-marital sexual partners followed by previously circumcised ones, then the non circumcised, the result was not significant ($P = 0.143$. See Figure partnerLifeRecency_MCcat.pdf)

The variable-level significance of co-factors and the patterns of how each risk behavior responds to these co-variates were shown in Figures of co-variates XXX in the Appendix. Of all the co-variates, except wealth, education and residence (Mike, can you change area to residence on the figures? So it will match with DHS surveys), age, religion, job, marital status, media use and knowledge were all found with significant levels of differences in associating with all the indice of SRB in our models (See Figures of co-variates XXX). For example, HIV knowledge was found positively associated with condom use, and it also positively associated with numbers of non-marital sexual partners by lifetime and by year. It showed that the more aware of the HIV knowledge one had, the more non-marital sexual partners they had, and, at the same time, the more likely to use condom during sex. Similar finding was found in media use: the more one spent on media, the more likely they would use condom and have more sexual partners.

Because religion and location (e.g., clusters) were controlled, we believe our findings were not biased due to background of religious and geographical background.

(A few words on how we decided to use “less conventional” statistical presentation. I.e., without relying on P values, and why. - BE BRAVE -)

Discussion

Overall, there was no signs of SRB in association of circumcision found in our study. The result was similar to the three main clinical trials [**AuveTalj05**, **BailMose07**, **GrayKigo07**], and some follow-up prospect studies in Kenya [**WestAgot14**] and in Uganda [**GrayKigo12**, **KongKigo12**], yet different from the others [**GrunHenn12**, **KatzSchw02**, **KirbSand15**, **SheeChu01**, **WilsGore04**, **ZungSimb16**, to]. The cross-sectional studies did observe some significant behaviour change [a], for examples, in Uganda [**KibiSand15**] and in South Africa [**ZungSimb16**] [CF: {more cites, see who cites Katz and Wils}]

Furthermore, we found a clear increase of safe sex behaviours in condom use during their last sexual intercourse as presented above (See Figure of interaction of condomStatus_intPlots.pdf). First, despite of their circumcision status, men in the post UN's MMC campaign were more likely to use condom than those before the campaign. Second, circumcised men were more likely to use condom than the uncircumcised men in the post-campaign period compared to the pre-campaign era when circumcised men were less likely to use condom than uncircumcised men. The results were rather consistent compared to the results of WHEN men were circumcised (see condom recency figure): men who circumcised after the UN's MMC promotion were more likely to use condom than those who had already circumcised before the promotion initiated. Such an increase in condom use was similar to findings in a prospect cohort study [**WestAgot14**] in Kenya but different from the post trial follow up in Uganda [**KongSsek14**] where condom use declined despite MC status and others [**ChikMaha15**, **KirbSand15**, **EatoCain11**] [CF: confirm and update]. **For example, traditionally circumcised men were found more likely to have unprotected sex in xxx** [**EatoCain11**] [CF: update].

In terms of how many non-marital sexual partners men had during the previous year, we found no clear differences by their circumcision status (see partner year status figure) or by when they were circumcised (see partner year recency); and the results were similar to previous results [**KibiSand15**]. Although there was an increase of numbers of non-marital sexual partners in circumcised men and a decrease in the uncircumcised in the post MMC campaign compared to the pre-campaign time (see partner year status figure),

newly circumcised men were more likely to have more sexual partners (see partner year recency). In the case of numbers in lifetime, we noted that men circumcised before the MMC promotion clearly had more sexual partners than those newly circumcised after the campaign initiated (see partnerLife recency). The fact that men sought for circumcision after the MMC campaign were less likely to perform risky sex than those who already circumcised in the comparison of total numbers of non-marital sexual partners suggested that previously circumcised men might falsely believe in MC protection against HIV infection and perform a riskier sex [**EatoCain11**, **GrunHenn12**] ____ [CF: update].

Most of the co-factors, including social demographic factors (i.e., Age, religion, job, marital status), media use and HIV knowledge, also clearly associated with the risk behaviours (see the patterns at Figure- in appendix). In the case of media use, the findings suggested that the more time men spent on media, the more likely they would use a condom during sex and at the same time, the more likely to have more sexual partners overall, the positive media association was different from a previous finding in Kenya [**MuzyLaur12**]. Our findings of increases in both condom use and numbers of non-marital sexual partners suggested that an environment of more condom use and more casual sex. One interpretation is that people who consume more media content tend to have a freer style of sex in terms having more casual sexual partners under protection (i.e., using condoms). The similar implication applies to HIV knowledge and age: the better knowledge of HIV infection one has, the more likely they will perform safe sex by using condom, yet more likely to have multiple sexual partners than those with less HIV knowledge. We also found that younger men (aged 20-30) were more likely to use condom and to have more sexual partners within the previous years than the others.

This was the first cross-sectional study analyzing the differences of MC association with SRB by data before and after the UN's MMC campaign off set and by WHEN men were circumcised. Against common anticipation of SRB [**Acle86**, **CameSimo89**, **Lind88**, **HalpBail99**, 1, **AndeCock12**, **BrooEtze10**, **CassHalp06**, **EatoKali09**, **EatoCain11**, **GreeMaha13**, **GrunHenn12**, **GustKres11**, **HeweHall12**, **KaliEato07**, **L_EnLanh14**, **MattCamp10**, **PadiBuve08**, **RiesAchi10**, **SACE09**, **WestAgot12**], our findings found no clear signs of SRB. In summary, our findings disclosed an increase of condom use with their last sexual partners overall, especially among those newly circumcised after the UN's MMC recommendation; and also an

increase of numbers of sexual partners by lifetime among those circumcised before the campaign, with relatively low condom use. The results proposed that newly circumcised men were likely more aware of the partial protection of MC compared to those who were circumcised before the UN promotion. By identifying types of risk compensation, we can expect a more effective and focused campaign strategies.

Limits and Suggestions

This is the first big scale analysis of cross-sectional data across SSA on associations of MMC and SRB. We are unable to exclude all the possible confounding factors, including.. Associations concluded from secondary data can almost never draw causality and this limits must be recognized.

There are two groups of targets need to be understood in order to reach a maximum effect of MC curtailing HIV infection: women and high risk group. This study did not tear apart SRB of high risk groups from the general population, nor did we include women's perception of MC reducing HIV infection and their SRB engaging a circumcised man. Their behaviours can impact the efficiency of the goals of MC reducing HIV [**AlsaCash09**, 2, **HallSing08**, **WaweMaku09**, **WeisHank09**]. It is also important to reach out to the traditionally circumcised men because they were less likely to receive counselling on MC's partial protection against HIV infection. Least but not last, analyses of media (traditional, and social) promotion of the MMC campaign can further optimize the accuracy of media coverage.

(A sentence on why there are difference findings in the studies, due to statistics?)

Conclusion

This study of 10 nations (Kenya, Lesotho, Malawi, Mozambique, Namibia, Rwanda, Tanzania, Uganda, Zambia and Zimbabwe) comparing data before and after the UN's MMC campaign suggests no clear changes of SRB despite the circumcision status and when the circumcision was received. It is noted that the samples analyzed in this study were collected for DHS, and received no special consultation on safe sex regarding MC's partial protection, hence

was able to mitigate some concerns about safe education and counselling during RCTs. It is important that a safe sex education shall reach out to the general population and not focus only on the potential targets [EatoCain11].

Author Information

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Author contributions

Financial Disclosures

None reported

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Disclaimer

The findings and conclusions of this article are those of the authors and do not necessarily represent the views of the funding agency.

Additional Contributions

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Appendix

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Appendix

- table of MC progress: annual numbers of voluntary medical circumcision in east and southern Africa, 2008-2014/<http://apps.who.int/iris/bitstream/10665/179933/1/W>
- five figures of effects of co-factors.

References

- [1] S. A. Abbott et al. “Female sex workers, male circumcision and HIV: a qualitative study of their understanding, experience, and HIV risk in Zambia.” In: *PLoS One* 8 (2013), e53809.
- [2] J. Dushoff, A. Patocs, and C. F. Shi. “Modeling the population-level effects of male circumcision as an HIV-preventive measure: a gendered perspective.” In: *PLoS One* 6 (2011), e28608.