Exploring the Association Between Adult Male Circumcision and Hepatitis B & C infection in the Tanzania Human Immunodeficiency Virus (HIV) Impact Survey 2016-2017 (THIS 2016-17)

Spring 2023

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Abstract

Viral Hepatitis infection is a major public health concern in Sub-Saharan Africa leading to a high mortality from hepatitis B and C infection as well as associated cancers. In Sub-Saharan Africa, male circumcision has been advocated as an important intervention tool for reducing the risk of HIV infection. Both hepatitis B and C are known to spread via sexual transmission, blood and bodily fluids amongst others and male circumcision has been explored as an intervention to help stop their transmission. In this study, we examine the associations between male circumcision and hepatitis B and hepatitis C infection, based on hepatitis B surface antigen (HBsAg) and hepatitis C antibody (anti-HCV) respectively among adult males 15 years and older using data from the Tanzania HIV Impact Survey 2016-2017. Among individuals tested for HBsAg, circumcision status was significantly associated with age group, urban vs rural, region, sexual intercourse history, and education status, respectively. Among individuals tested for anti-HCV, circumcision status was significantly associated with age group, urban vs rural, region, education status, and HIV status respectively. Univariate analysis between HBsAg and HIV status revealed a higher likelihood of HBsAg among HIV positive males compared to HIV negative males. There was no significant relationship between HBsAg and circumcision status. Univariate analysis between anti-HCV and circumcision status found that males in polygynous relationships had a higher likelihood of anti-HCV compared to males in other relationships. There was no significant relationship between anti-HCV and circumcision status. A main limitation of this study is the constraint of statistical power. As such, these results provide a push for further research into the effect of male circumcision on HBsAg and anti-HCV, respectively.

1. Introduction

Viral hepatitis is a major public health concern in sub-Saharan Africa and other parts of the world. According to the "*Global Hepatitis Report, 2017"* released by the World Health Organization (WH0) in 2017, viral hepatitis accounted for a staggering 1.34 million deaths in 2015 alone, a number that was higher than deaths caused by HIV in that year.[1] Furthermore, recent data from 2021 suggests that hepatitis B and C account for 1.1 million deaths and 3 million new infections every year.[2]

Africa faces one of the highest burdens of viral hepatitis with a high mortality rate (13.7 per 100,000) compared to the Americas (11.2 per 100,000) with deaths at a median age of 38.9 years among adults resulting from hepatitis B Virus (HBV) associated cancers, hepatitis C virus (HCV) chronic infection and other cancers.[1] The *"Global Hepatitis Report, 2017"* estimated that HBV prevalence in Africa (6.1%) was one of the highest in the world with 71% of all HIV-HBV co-infected persons living in Sub- Saharan Africa (1.96 million) .[1] Unlike HBV, HCV is heterogeneously distributed across the world. Prevalence of anti-HCV is more commonly found among individuals who inject drugs (8.0%) and HIV-infected persons (6.2%); among HIV infected individuals, the prevalence of anti-HCV was highest in individuals who inject drugs (82.4%) and men who have sex with men (6.4%).[1]

In Tanzania, recent data from the Tanzania HIV Impact Survey (THIS) 2016 – 2017 found that the prevalence of hepatitis B surface antigen (HBsAg) and hepatitis C antibody (anti-HCV) was 3.4% among adults 15 years and older, and 1% among adults 15 – 64 years, respectively.[3] The prevalence of HIV in this survey was 5% among adults.[3] Both HBV and HCV are known to be transmitted via perinatal transmission, exposure to infected blood and body fluids (sharing needles and syringes) and sexual contact, though this mode of transmission is less common for HCV infection.[4,5]. While other types of hepatitis viruses exist, there is a greater focus on HBV and HCV due to the enduring lifelong health consequences that result from their infection. The WHO estimates that 96% of all mortality from viral hepatitis are associated with HBV and HCV infection.[1]

In Sub-Saharan Africa and Tanzania, circumcision has been used as an effective tool to combat sexually transmitted diseases. Circumcision procedures involve the removal of "inner and outer foreskin tissues" of the penis, which contain CD4, T cell and dendritic cells susceptible to HIV

infection.[22] Among males aged 15 – 64 years old in Tanzania, approximately 78% self-reported being circumcised in the THIS 2016-17, although prevalence varied when stratified by regions, age, education, and wealth quintile.[3] The evidence base for this intervention comes from numerous studies that were conducted to examine the relationship between male circumcision and sexually transmitted diseases (STDs). For example, evidence from three randomized controlled studies in Africa found that male circumcision greatly reduced the risk of acquiring HIV among heterosexual men and prompted the WHO and UNAIDs in 2007 to recommend voluntary medical male circumcision as an intervention to help end the HIV epidemic.[6] Other studies have examined the relationship between male circumcision and other sexually transmitted diseases including hepatitis B and C, syphilis, gonorrhea, and HPV, albeit with mixed results.[7,8] In Sub-Saharan Africa, studies conducted in Kenya and South Africa suggested that male circumcision was protective of hepatitis B surface antigen status, while another study conducted in Buenos Aires among men who have sex with men found no significant association between HBV, HCV and male circumcision respectively.[9,10, 11] Nevertheless, to the best of our knowledge not many studies have specifically examined the association between male circumcision and hepatitis B or hepatitis C infection in the Sub-Saharan context. I propose to examine how male circumcision may be related to the prevalence of sexually transmitted diseases other than HIV, specifically, HBV and HCV infection based on hepatitis B surface antigen (HBsAg) and hepatitis C antibody (anti-HCV) respectively in adult males in Tanzania. Although this cross-sectional study will only examine associations instead of a causal relationship, results generated could spur further research.

1.1 Study Aims

The aims of this study are to examine whether in 2016 – 2017 there was an association between circumcision status and HBV and HCV infection among adult males aged 15 years and older in Tanzania.

1.2 Hypotheses

a. There is no significant association between circumcision status and HBV infection among adult males.
b. There is no significant association between circumcision status and HCV infection among adult males.

2. Methods

2.1 Data Source and Study Population

As previously described,[3] THIS 2016-2017 was a national, cross-sectional population-based survey of children and adults conducted between October 2016 and August 2017 to measure the national HIV incidence, prevalence of viral load suppression, progress towards UNAIDS 90-90-90 targets, collect information about health behaviors associated with HIV acquisition and transmission, syphilis, HBV, and HCV. The sampling frame consisted of all enumeration areas based on the 2012 Tanzania Population and Housing Census. Enumeration areas (Eas) are the smallest geographical units defined for a census.[21] The survey used a two-stage stratified cluster sample design. In the first stage, 526 census Eas were selected using a Probability Proportional to Size (PPS) method and stratified by the 31 geographical regions in Tanzania. In the second stage, an average of 30 households were randomly selected within each EA, using the PPS method. The survey population consisted of children aged 0 – 14 and adults aged 15 years and older. In households, the head of the household completed a household questionnaire form, including a roster of all individuals residing in the household. A total of 14,811 households were interviewed. Among 36,087 eligible survey participants in the surveyed households, 33,004 (91.5%) were interviewed and 31,579 (95.7%) of those interviewed provided blood for biomarker testing to determine HIV, syphilis, hepatitis B and hepatitis C status. Of those blood samples, 1,310 randomly selected adults aged 15 and older were tested for hepatitis B surface antigen (HBsAg) with positive results indicating current acute or chronic hepatitis B infection. Blood samples from a different subgroup of 5,300 adults, were tested for hepatitis C antibody (anti-HCV), with positive results indicating past infection that may have resolved on its own or through treatment, or current acute or chronic hepatitis C. Participants were provided the opportunity for active linkage to care and have their results returned to a health facility of their choice. Household and individual questionnaires were administered by staff via face-to-face interviews in confidential locations near each household. In this analysis, we included data from 556 adult males aged 15+ tested for HBsAg and with complete data on circumcision status, and 2,274 adult males aged 15+ tested for anti-HCV with complete data for circumcision status. Please refer to **Figure 1** for further details.

2.2 Variables

2.2.1 HBsAg status

As described above, a subset of the THIS survey participants provided blood samples that were tested for hepatitis B surface antigen (HBsAg) and the result of this test was recorded as a dichotomous outcome (positive for HBsAg or negative for HBsAg). Alere Determine (Abbott Molecular Inc., Chicago, Illinois, U.S., formerly Alere) was used to detect HBsAg in plasma specimens at the THIS central lab.

2.2.2 anti-HCV status

As described above, a different subset of the THIS survey participants provided blood samples that were tested for hepatitis C (anti-HCV antibody) and the result of this test was recorded as a dichotomous outcome (positive for anti-HCV or negative for anti-HCV antibody). Murex HCV Antigen/Antibody (Ab) Combination EIA (DiaSorin, Saluggia, Italy) was used to detect anti-HCV in plasma specimens at the THIS central lab.

2.2.3 Circumcision status

Male participants responded to the question about their circumcision status, "Are you circumcised?" after being shown a picture of a completely circumcised penis, by answering "Yes", "No", "Don't Know", or "Refused". Circumcision status was recorded as circumcised for individuals who answered, "Yes and as uncircumcised for individuals who answered "No". The inclusion criteria for circumcision status included any circumcision method such as medical, traditional, midwife and other methods. Individuals who answered "Don't Know" or "Refused" were excluded from the study. Those excluded were more likely to be between 15 – 34 years and have missing data for other survey questions.

2.2.4 HIV status

Final HIV status was determined from a combination of lab test results from the national HIV rapid test algorithm- SD Bioline (Abbott Molecular Inc., Chicago, Illinois, U.S., formerly Alere), Uni-Gold (Trinity Biotech Manufacturing, Ltd., County Wicklow, Ireland), Geenius HIV ½ Supplemental Assay (Bio-Rad Laboratories, Hercules, CA, U.S.) , and HIV polymerase chain

reaction (TNA PCR) .[3] The final result of their test was recorded as a dichotomous outcome (positive for HIV and negative for HIV).

2.2.5 Sexual intercourse history

Participants were questioned about their sexual history, "Have you ever had sexual intercourse?", by answering "Yes", "No", "Don't Know", or "Refused". Sexual intercourse history was recorded as "Yes" for individuals who reported ever having sexual intercourse and recorded as "No" for individuals who reported never having sexual intercourse.

2.2.6 Anal sex intercourse history

Participants were questioned about anal sex intercourse history with the question "Have you ever had anal sex?", by answering "Yes", "No", "Don't Know", or "Refused". Anal sex intercourse history was recorded as ever had anal sex for individuals who answered "Yes", as never Had anal sex for individuals who answered "No" and unknown for individuals who answered, "Don't Know" or "Refused".

2.2.7 Demographic variables

Participants self-reported their age. Because of the small number of outcomes, age was categorized into 2 categories: *15 to 34 years old and 35+ years.* To obtain a balance in the age distribution of participants, a cutoff of 34 years was used despite the median age of the population being 32 years.

Participants were questioned about their relationship status defined as "union type" in the survey with the questions "What is your marital status now: are you married, living together with someone as if married, widowed, divorced or separated?", "How many wives or live-in partners does your husband or partner have?", and "Does your husband or partner have other wives or does he live with other women as if married?". Due to the small number of outcomes and to obtain a balance in the marital status distribution of participants, marital status was categorized into 2 categories: *In polygynous union* for participants in polygynous unions (participants with more than wife) *and Other* for individuals not in polygynous union, not currently in union and don't know or missing.

Participants reported their education level attainment by stating whether they had no education, pre-primary, primary, post-primary training, secondary, post-secondary, university and missing for individuals with no data. Due to the small number of outcomes, education was categorized into 2 categories: *attained some level of education* for participants with pre-primary, primary, post primary, secondary, post-secondary, and university education and *Limited education* for participants with no education and missing data.

Participants were grouped into geographic locations if they lived in urban areas on Mainland Tanzania or Zanzibar and rural if they lived in rural areas on Mainland Tanzania or Zanzibar. Rural vs Urban was categorized as *Rural vs Urban*. From the 31 regions in Tanzania, region was categorized into 7 categories based on geographic zones: *Central zone; Coastal zone; Lake zone; Northern Highlands; Southern Highlands; Western; and Zanzibar.*

2.3 Statistical Analysis

All statistical analyses were conducted using SAS version 9.4. Participants were excluded from specific analyses if data was missing for either the covariates of interest and/or outcomes of interest. We performed a chi-square test of independence and Fisher's exact test where appropriate to examine the association between covariates and male circumcision status for each study population, respectively. A p-value of < 0.05 was considered statistically significant. We performed univariate analyses to assess the association between covariates and the outcomes of interest, HBsAg and anti-HCV, separately. Anal sex intercourse history and marital status were excluded from the univariate analysis with HBsAg status due to lack of model convergence. HIV status was also excluded from the univariate analysis with hepatitis C antibody status due to the same reason. The odds ratios (OR) and corresponding 95% confidence intervals (CI) were calculated to estimate the direction and strength of the association between our outcomes of interest and independent variables.

3. Results

3.1 Study Population

3.1.1 Hepatitis BsAg Study Population

Table 1 shows the descriptive statistics of the study population of individuals with complete data on male circumcision and HBsAg. The prevalence of circumcision among males in this population was 73%, which was slightly lower than the reported overall circumcision prevalence in THIS, where approximately 78% of males self-reported being circumcised.[3] Circumcision was more prevalent among males aged 15 to 34 years compared to males aged 35 years and above (55% vs 45%), statistical analysis using the chi-squared test showed a significant relationship between age group and circumcision status ($p = 0.026$).

Among circumcised males, most (44%) commonly reported being circumcised between 8-16 years old. Medical circumcision was the most prevalent method of circumcision (62%). Majority of uncircumcised males lived in rural Tanzania compared to urban Tanzania (91% vs 9%). Overall, most men in this population lived in rural Tanzania (73% vs 27%) and statistical analysis using the chi-squared test revealed a significant relationship between circumcision status and urban vs rural ($p < 0.001$). Furthermore, region was also significantly associated with circumcision status ($p < 0.001$).

Most reported having ever had sexual intercourse compared to never (83% versus 17%), and sexual intercourse history was significantly associated with circumcision status ($p = 0.038$).

Majority of the males in this population reported to have attainment of some level of education (89% vs 11%) and statistical analysis using the chi-squared test showed a significant association between education status and circumcision status (p-value = 0.0008).

In this population, the prevalence of HBsAg was 3%. There was no significant association between HBsAg and circumcision status ($p = 0.57$). Similarly, the prevalence of HIV in this population was 3% and no significant association was found between HIV and circumcision status ($p = 1.00$).

3.1.2 Anti-HCV Study Population

Table 2 shows the descriptive statistics of the study population of individuals with complete data on male circumcision and anti-HCV. The prevalence of circumcision among males in this population was 79%, which was very similar to the reported overall circumcision prevalence in THIS, where approximately 78% of males self-reported being circumcised.[3] Circumcision was

more prevalent among males aged 15-24 years compared to males aged 35 years and above (54% vs 46%) and statistical analysis using the chi-squared test showed a significant relationship between age group and circumcision status ($p < 0.001$). Among circumcised males, most (41%) commonly reported being circumcised between 8 -16 years old. Medical circumcision was the most prevalent method of circumcision (61%).

A greater proportion of the males in this population reported to have attained some level of education (88% vs 12%), and statistical analysis using the chi-squared test showed a significant association between education status and circumcision status ($p < 0.0001$).

Majority of uncircumcised males lived in rural Tanzania compared to urban Tanzania (89% vs 11%). Overall, most men in this population lived in rural Tanzania (73% vs 27%) and statistical analysis using the chi-squared test revealed a significant relationship between circumcision status and urban vs rural ($p < 0.0001$). In addition, region was also significantly associated with circumcision status (p-value < 0.0001).

Among males in this population, the prevalence of anti-HCV was found to be 1%. No significant association was found between anti-HCV and circumcision status ($p = 1.00$). However, the prevalence of HIV was 3% among circumcised males and 5% among uncircumcised males in this population. Statistical analysis using the chi-squared test revealed a significant association between HIV status and circumcision status indicating that circumcision was associated with HIV prevalence ($p = 0.0026$).

3.2 Univariate analysis

Based on univariate analysis, HIV positive males had 8.8 times the odds of having a positive Hepatitis BsAg test compared to HIV negative males (95% CI: 2.2, 34.3; see Table 3). In addition, males in polygynous unions were 4 times more likely to test positive for anti-HCV compared to males in other types of marital unions (95% CI: 1.4, 11.2, see Table 4). These results were statistically significant at a 5% level of significance.

4. Discussion

Male circumcision has been advocated as an effective tool for reducing the transmission of HIV and other sexually transmitted diseases in Sub-Saharan Africa.[17] In this study, while there was no significant relationship between hepatitis B surface antigen and circumcision status, the findings suggested that circumcised males had a lower likelihood of hepatitis B surface antigen compared to uncircumcised males. This was consistent with our hypothesis of observing no significant association between hepatitis B surface antigen and circumcision status. However, previous studies examining this relationship do not align with the results obtained in this study.

A cross-sectional study conducted among 2,850 males in the HIV Incidence Provincial Surveillance System (HIPSS) in the Kwa-Zulu-Natal province in South Africa found evidence that "medical male circumcision" was protective against Hepatitis B surface antigen (OR 0.53, 95% CI: 0.30 to 0.95)[9]. Even after adjusting for age alone and adjusting for age, education, income, relationship status, in addition to other covariates in that study, the association remained significant (aOR 0.49, 95% CI: 0.29 to 0.85; aOR 0.53, 95% CI: 0.30 to 0.95).[9] That study provided some evidence that circumcision could be used as an effective tool to prevent Hepatitis B infection in the Sub-Saharan context, albeit only voluntary medical male circumcision was examined. To the best of our knowledge, this is one of very few studies conducted in Sub-Saharan Africa to examine the association between circumcision status and hepatitis B.

Notably, in this current study, HIV positive males were more likely than HIV negative males to test positive for hepatitis B surface antigen. Both HIV and HBV are known to be transmitted sexually and via percutaneous routes so it's not uncommon to observe co-infections.[12] These findings suggest that males with HIV-HBV co-infections may exhibit more similarities in terms of behavior and characteristics; this population may be worth exploring in subsequent studies.

This study found no significant association between male circumcision and anti-HCV infection. This conclusion further supports our hypothesis of not observing a significant association, although previous studies revealed otherwise. A few studies have suggested that sexual transmission of HCV may not be the most efficient mode of transmission as the most prominent routes of transmission are via injection drug use, body piercings, organ transplants and unsafe medical procedures and practices especially among health care workers. [15] Nevertheless, it is important to recognize that although the risk of sexual transmission is low, transmission through this route is still possible, particularly among high-risk groups such as men who have sex with men.[15]

Furthermore, the circumcision method performed could play a pivotal role in how HCV and HBV infection occurs. A cross-sectional study in Southern Cameroon among circumcised males 60 years and older found that males who underwent traditional circumcision were more likely than males who underwent medical circumcision to have anti-HCV antibodies (OR 2.05, 95% CI: 1.09 – 3.84).[18] But after adjusting for age, and past intravenous treatment history, the results were not significant (aOR 1.83, 95% CI: 0.95 -3.54).[18] Another cross-sectional study conducted in Egypt found that among males 30 years or younger, those circumcised by an informal heath care provider had a higher likelihood of anti-HCV compared to those who had been circumcised by a formal health care provider or had not been circumcised at all (OR 2.0, 95% CI: 1.1 – 3.6).[13] An additional cross-sectional study, also conducted in Egypt, found that circumcision by informal health care personnel was significantly associated with HCV infection (OR 2.6 95% CI: 1.0 - 6.73).[14] These findings suggest that examining a specific circumcision method could influence the relationship we observe.

Univariate analyses between anti-HCV and marital status suggested that males in polygynous relationships were more likely to test positive for anti-HCV compared to those in other types of relationships. This may be explained by the fact that males in this type of relationship may engage in sexual activities with multiple sexual partners, which is a risk factor for HCV transmission.[16] Furthermore, numerous studies have linked acute HCV transmission to sexual risk behaviors, HIV positive status and unprotected anal sex.[19] Behavioral characteristics among various high-risk subgroups and potential associations with anti-HCV could be worth further exploration in the Sub-Saharan context.

This study has several limitations. A main limitation is the relatively small sample size of both hepatitis BsAg and anti-HCV populations. This limitation reduced our statistical power and ability to ascertain meaningful relationships. Moreover, the Tanzania HIV Impact Survey was primarily designed to determine HIV incidence, HIV viral load suppression and other HIV related indicators within the Tanzanian population. As a result, performing secondary data analysis with the sample of individuals tested for our targeted proved to be challenging. The Tanzania HIV Impact Survey 2022-2023 may provide a better opportunity to explore this topic further with a larger sample when the data becomes available because all survey participants will be tested for HBsAg and anti-HCV.[20]

Another significant limitation in this study was the inability to control for potential confounders and create multivariate models. The limited number of events of our targeted outcomes of interest contributed to this constraint. Variables were collapsed into smaller categories and circumcision was analyzed as a whole, instead of specific methods. Considering that data was self-reported, recall bias posed an additional concern that must be considered in this study.

In conclusion, although no statistically significant associations were observed between male circumcision and hepatitis B surface antigen and anti-HCV respectively, this study provides an impetus for further research. In addition, the associations observed in this study could be further explored in future studies for validation. In Sub-Saharan Africa, circumcision is widely implemented as a tool for preventing HIV and could prove to be useful in combating hepatitis infection along with other interventions.

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Figure 1. Inclusion flow chart for males in the THIS 2016-17 survey included in the analyses between covariates of interest and Hepatitis BsAg status & Hepatitis C antibody status.

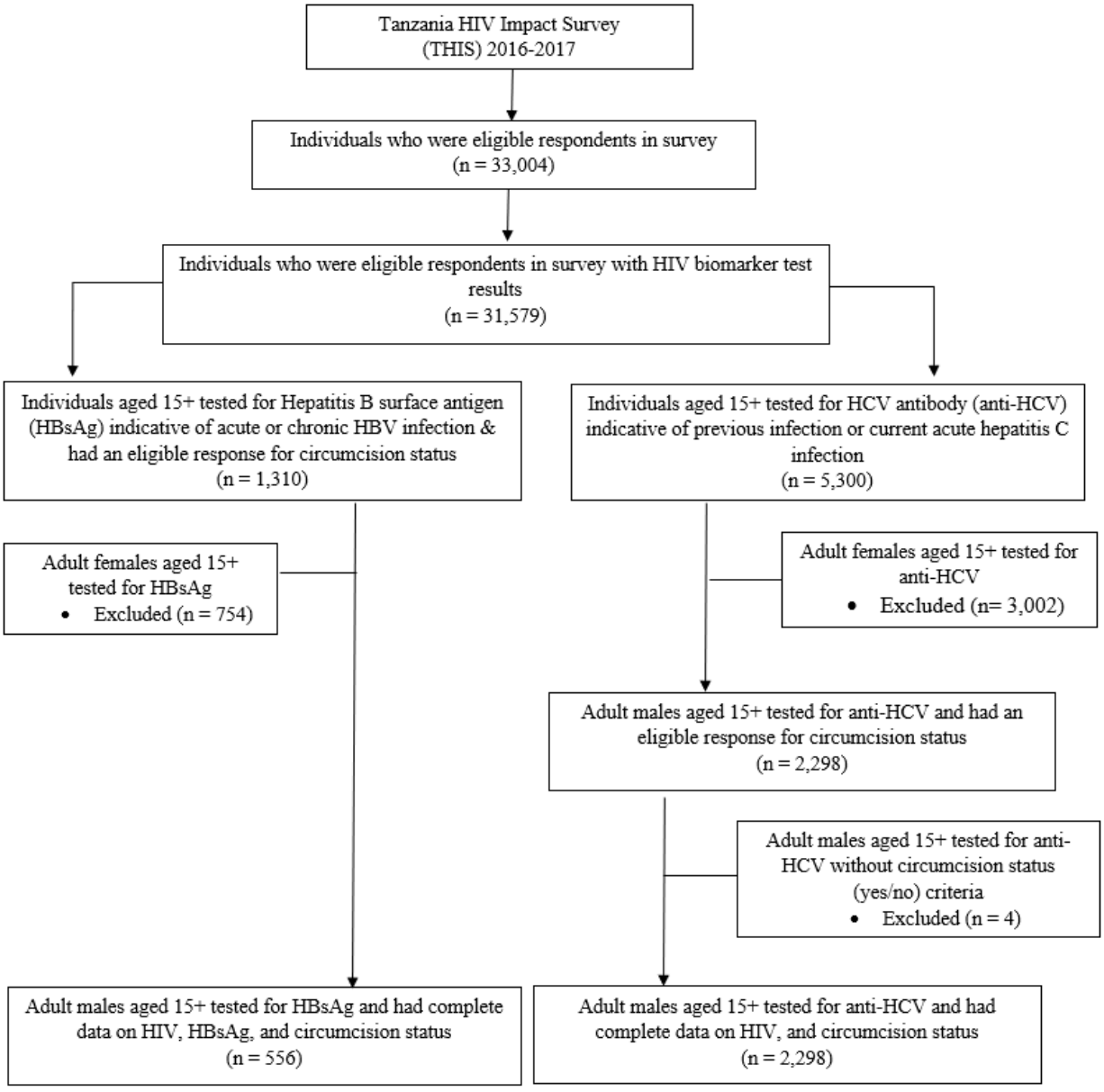

Table 1. Characteristics of adult male population by circumcision status in the THIS 2016-2017 Survey (HBsAg population, N = 556)

Characteristic	Total N (%) [b]	Circumcised Males n (%) [a]	Uncircumcised Males n (%) [a]	p-value
Gender				
Male	556 (100 %)	404 (73%)	152 (27%)	-
Age Group				
15-34 yrs.	306 (55 %)	234 (58 %)	72 (47%)	**0.026[c]**
35+ yrs.	250 (45%)	170 (42 %)	80 (53 %)	
Age at Circumcision				
0-7 yrs.	-	129 (32%)	-	-
8-16 yrs.	-	176 (44%)	-	
17-30 yrs.	-	92 (23%)	-	
Unknown	-	7 (1%)	-	
Circumcision Method				
Medical circumcision	-	250 (62 %)	-	-
Traditional circumcision	-	139 (34 %)	-	
Other	-	15 (4%)	-	
Marital Status				
In polygynous union	44 (8%)	27 (7%)	17 (11%)	**0.08[c]**
Other	512 (92%)	377 (93%)	135 (89%)	
Anal Sexual intercourse history				
Ever had anal sex intercourse	9 (2%)	6 (1%)	3 (2%)	**0.50[d]**
Never had anal sex intercourse	540 (97%)	394 (98%)	146 (96%)	
Unknown	7 (1%)	4 (1%)	3 (2%)	
Sexual intercourse history				
Ever had sexual intercourse	460 (83 %)	326 (81%)	134 (88 %)	**0.038[c]**

Never had sexual intercourse	96 (17 %)	78 (19%)	18 (12%)	
Education status				
Limited education	62 (11%)	34 (8%)	28 (18 %)	**0.0008**[c]
Attained some level of education	494 (89%)	370 (92%)	124 (82 %)	
Urban vs Rural				
Urban Tanzania (Mainland & Zanzibar)	152 (27%)	139 (34%)	13 (9%)	**< 0.0001**[c]
Rural Tanzania (Mainland & Zanzibar)	404 (73%)	265 (66%)	139 (91%)	
Region				
Central zone	67 (12%)	52 (13%)	15 (10%)	**< 0.001**[c]
Coastal zone	91 (16%)	88 (22%)	3 (2%)	
Lake zone	126 (23%)	77 (19%)	49 (32%)	
Northern Highlands	44 (8%)	40 (10%)	4 (3%)	
Southern Highlands	158 (28%)	95 (24%)	63 (41%)	
Western	47 (8%)	29 (7%)	18 (12%)	
Zanzibar*	23 (5%)	23 (5%)	-	
HIV Status				
HIV +	18 (3%)	13 (3%)	5 (3%)	**1.00**[d]
HIV -	538 (97%)	391 (97%)	147 (97%)	
Hepatitis BsAg Status				
Hepatitis BsAg+	15 (3%)	10 (2%)	5 (3%)	**0.5671**[d]
Hepatitis BsAg-	541 (97%)	394 (98%)	147 (97%)	

[a] Column percentages
[b] Row percentages
[c] Chi-square Test for Independence
[d] Fisher's Exact Test
*Excluded from chi-square test of independence analysis

Table 2. Characteristics of adult male population by circumcision status in the THIS 2016-2017 Survey (anti-HCV population)

Characteristic	Total N (%) [b]	Circumcised Males n (%) [a]	Uncircumcised Males n (%) [a]	p-value
Gender				
Male	2294 (100%)	1807 (79%)	487 (21%)	-
Age Group				
15-24 yrs.	1237 (54%)	1012 (56%)	225 (46%)	**< 0.0001[c]**
35+ yrs.	1057 (46%)	795 (44%)	262 (54%)	
Age at Circumcision				
0-7 yrs.	-	576 (32%)	-	-
8-16 yrs.	-	736 (41%)	-	
17-30 yrs.	-	406 (22%)	-	
Unknown	-	89 (5%)	-	
Circumcision Method				
Medical circumcision	-	1095 (61%)	-	-
Traditional circumcision	-	604 (33%)	-	
Other	-	108 (6%)	-	
Marital Status				
In polygynous union	179 (7%)	132 (7%)	47 (10%)	**0.09[c]**
Other	2115 (93%)	1675 (93%)	440 (90%)	
Anal Sexual intercourse history				
Ever had anal sex intercourse	36 (2%)	27 (1%)	9 (2%)	**0.24[c]**
Never had anal sex intercourse	2235 (97%)	1765 (98%)	470 (97%)	
Unknown	23 (1%)	15 (1%)	8 (1%)	
Sexual intercourse history				
Ever had sexual intercourse	1905 (83%)	1500 (83%)	405 (83%)	**0.94[c]**
Never had sexual intercourse	389 (17%)	307 (17%)	82 (17%)	
Education status				
Limited education	275 (12%)	171 (9%)	104 (21%)	**< 0.0001[c]**

Attained some level of education	2019 (88%)	1636 (91%)	383 (79%)	
Urban vs Rural				
Urban Tanzania (Mainland & Zanzibar)	623 (27%)	568 (31%)	55 (11%)	**< 0.0001[c]**
Rural Tanzania (Mainland & Zanzibar)	1671 (73%)	1239 (69%)	432 (89%)	
Region				
Central zone	242 (11%)	198 (11%)	44 (9%)	**< 0.0001[c]**
Coastal zone	364 (16%)	353 (20%)	11 (2%)	
Lake zone	470 (20%)	287 (16%)	183 (38%)	
Northern Highlands	301 (13%)	292 (16%)	9 (2%)	
Southern Highlands	419 (18%)	241 (13%)	178 (37%)	
Western	160 (7%)	100 (5%)	60 (12%)	
Zanzibar	338 (15%)	336 (19%)	2	
HIV Status				
HIV +	70 (3%)	45 (2%)	25 (5%)	**0.0026[c]**
HIV -	2224 (97%)	1762 (98%)	462 (95%)	
Hepatitis C Antibody Status				
Hepatitis C Antibody +	20 (1%)	16 (1%)	4 (1%)	**1.00[d]**
Hepatitis C Antibody -	2274 (99%)	1791 (99%)	483 (99%)	

[a] Column percentages
[b] Row percentages
[c] Chi-square Test for Independence
[d] Fisher's Exact Test

Table 3. Univariate analysis for HBsAg status

	Odds Ratio (95% C.I.)	p-value
Characteristic		
Male Circumcision Status		
Circumcised vs Uncircumcised	0.75 (0.25, 2.22)	0.60
Age		
15 - 24 vs 35+ yrs.	0.71 (0.25, 1.98)	0.51
Education Status		
Attained some level of education vs Limited education	0.49 (0.13, 1.79)	0.28
Rural vs Urban		
Rural Tanzania vs Urban Tanzania (Mainland + Zanzibar)	0.75 (0.25, 2.22)	0.60
Sexual Intercourse History		
Ever had sexual intercourse vs Never had sexual intercourse	1.37 (0.30, 6.15)	0.68
HIV status		
HIV positive vs HIV negative	8.77 (2.23, 34.34)	0.0018

Table 4. Univariate analysis for anti-HCV

	Odds ratio (95% C.I.)	p-value
Characteristics		
Circumcision Status		
Circumcised vs Uncircumcised	1.01 (0.34, 3.24)	0.89
Age Group		
15 - 34 vs 35+ yrs.	0.85 (0.35, 2.06)	0.72
Marital Status		
In polygynous union vs Other	4.02 (1.4, 11.2)	0.008
Education Status		
Attained some level of education vs Limited education	0.40 (0.15, 1.12)	0.08
Rural vs Urban		

Rural Tanzania vs Urban Tanzania (Mainland + Zanzibar)	2.12 (0.62, 7.27)	0.23
Sexual Intercourse History		
Ever had sexual intercourse vs Never had sexual intercourse	1.85 (0.43, 7.99)	0.41
Anal Sex History		
Ever had anal sex vs Unknown	0.63 (0.04, 10.57)	0.75
Never had anal sex vs Unknown	0.18 (0.02, 1.40)	0.10