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Effect of comprehensive knowledge of HIV on risky sexual behaviours associated with HIV transmission among adult Ugandans: a propensity score-matched analysis

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ABSTRACT

Objective To evaluate the effect of comprehensive knowledge of HIV on extramarital sexual relationships and consistent condom use.

Design Quasi-experimental study.

Setting 20 880 households, Uganda.

Participants Married/cohabiting men and women, aged 15–54 years.

Methods We applied propensity score-matched analysis and defined comprehensive knowledge of HIV as knowing that consistent use of condoms during sexual intercourse and having just one faithful partner without HIV reduces the chance of getting HIV, knowing that a healthy-looking person can have HIV and rejecting two local misconceptions (HIV can be transmitted by mosquito bites and by sharing food with a person who has HIV). The primary outcome was extramarital sexual relationship defined as involvement in a sexual relationship with a partner other than a spouse or cohabiting partner, within 12 months preceding the survey. The secondary outcome was consistent condom use, defined as using a condom at every sexual intercourse with any non-spouse/non-cohabiting partner over the past 12 months.

Results Among 18 504 participants matched in a 1:1 ratio, comprehensive knowledge of HIV showed no effect on extramarital sexual relationships (OR 1.03, 95% CI 0.96 to 1.11) but improved consistent condom use among married/cohabiting couples in extramarital sexual relationships (OR 1.18, 95% CI 1.02 to 1.37). Among married/cohabiting men, comprehensive knowledge of HIV had no effect on extramarital sexual relationships (OR 0.95, 95% CI 0.83 to 1.08) but improved consistent use of condoms in extramarital sexual relationships (OR 1.31, 95% CI 1.04 to 1.66). However, among married/cohabiting females, there was no effect on both outcomes.

Conclusions Comprehensive knowledge of HIV has no effect on extramarital sexual relationships but increases consistent condom use among those in extramarital sexual relationships. There is a need to consistently provide correct HIV prevention messages among sexually active married/cohabiting couples in Uganda.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ The study used a nationally representative data.
⇒ Large sample size.
⇒ Findings are robust to unmeasured confounders and the analytic approach.
⇒ The study is limited by a lack of qualitative data to contextualise the quantitative findings.
⇒ Outcome measure is limited by social desirability bias.

BACKGROUND

The majority of HIV transmissions in Uganda occur through heterosexual vaginal intercourse with a person living with HIV.[1] Currently, an estimated 1.4 million people are living with HIV in Uganda.[2] The 2020 Uganda Population-Based HIV Impact Assessment[3] reports a 5.5% HIV prevalence among people aged 15–49 years (7.1% females, 3.8% males). However, new HIV infections among adults (≥15 years) progressively declined from 71 000 in 2010 to 48 000 in 2020, a 32% drop. Having a comprehensive knowledge of HIV can prevent HIV acquisition by helping individuals to assess their own risk of HIV acquisition and adopting safer sexual practices.[3] Comprehensive knowledge of HIV is defined as knowing that consistent use of condoms during sexual intercourse and having just one faithful partner without HIV can reduce the chance of getting HIV, knowing that a healthy-looking person can have HIV and rejecting the two most common local misconceptions about transmission or prevention of HIV (HIV can be transmitted by mosquito bites and by sharing food with a person who has HIV).[1]

Comprehensive knowledge of HIV in the general population increased by 1% per year between 2003 and 2015[4] and this is expected to reverse the HIV incidence and prevalence. Analysis of Demographic Health Survey (DHS) data for 15 countries in sub-Saharan

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Africa (SSA) show 38.6% of the population with comprehensive knowledge of HIV.[5] The 15 countries included Burundi (2016/2017), Ethiopia (2016), Rwanda (2015), Uganda (2016), Zambia (2018/2019), Benin (2017/2018), Gambia (2019/2020), Guinea (2018), Liberia (2019/2020), Mali (2018), Nigeria (2018), Sierra Leone (2019), Cameroon (2018/2019) and Chad (2015). Data further show a higher level of comprehensive knowledge of HIV is associated with being old, attaining at least a primary level of education, belonging to a wealthy household, using contraceptives, listening to a radio and reading newspapers at the individual level.[5] At the regional level, residing in an urban area or the Eastern African region is similarly associated with a higher comprehensive knowledge of HIV.[5] Another analysis of DHS data for 30 countries in SSA by Frimpong found more than 4 in 10 adolescent girls and young women (15–24 years) have comprehensive knowledge of HIV and are more likely to negotiate for safe sex.[6] However, limitations of Frimpong's study include a lack of an appropriate comparator, a design that precluded assessment of the effect of comprehensive knowledge of HIV on sexual behaviours associated with HIV transmission due to selection bias and confounding[7] and an analytic approach that is susceptible to model misspecification.[8]

The 2016 Uganda DHS (UDHS) data show 48% of the population surveyed have comprehensive knowledge of HIV[9] but did not examine the effect of comprehensive knowledge of HIV on sexual behaviours at population and subpopulation levels. Overall, previous studies focused on the magnitude of comprehensive knowledge of HIV and the associated factors.[5 6]

Between 2016 and 2019, the prevalence of HIV among married or cohabiting couples in Uganda was 6.6%, exceeding the 6.0% prevalence among adults aged 15–49 years.[10] Low condom use among married/cohabiting couples in an extramarital sexual relationship is a risk for HIV infection. The 2016 UDHS[9] reports condom use at the last sexual intercourse among married/cohabiting couples with ≥2 sexual partners in the past 12 months is higher among men (9.7%) than women (7.9%).

Few studies have attempted to examine the link between comprehensive knowledge of HIV and risky sexual behaviour and where attempts have been made, significant design and analytic limitations exist. Currently, there is limited information about the effect of comprehensive knowledge of HIV on risky sexual behaviours associated with HIV transmission among married or cohabiting couples in Uganda and SSA in general. Our study analysed the 2016 UDHS data from a nationally representative survey to establish the effect of comprehensive knowledge of HIV on extramarital sexual relationships and the consistent use of condoms among married or cohabiting couples in Uganda. As a secondary objective, we examined the effect of comprehensive knowledge of HIV on extramarital sexual relationships and the consistent use of condoms by sex (women vs men). We hypothesised that comprehensive knowledge of HIV reduces the likelihood of extramarital sexual relationships in men and women, and improves consistent use of condoms among married or cohabiting couples in extramarital sexual relationships.

METHODS

Description of data source

We analysed data from a nationally representative population-based household survey, the 2016 UDHS,[9] conducted by the Uganda Bureau of Statistics. Elsewhere,[11] the dataset is described. Data collection took place between 20 June 20 2016 and 16 December 2016. The survey sample was stratified and selected in two stages. The first stage consisted of the selection of 697 enumeration areas: 162 urban versus 535 rural. Due to land disputes, one cluster from the Acholi subregion in northern Uganda was excluded for security reasons. The second stage involved the sampling of households within the clusters. This was achieved through a listing of all households within each of the 696 accessible selected enumeration areas between April and October 2016, with some listings overlapping with fieldwork. The survey drew maps for each of the sampled clusters and then listed all the households except for institutional living arrangements, namely army barracks, hospitals, police camps and boarding schools. To minimise the task of household listing, each large enumeration area yielding more than 300 households selected for the survey was segmented, and one segment was selected for the survey with probability proportional to segment size, and the household listing was conducted within the segment. Therefore, in the 2016 UDHS, a cluster was regarded as either an enumeration area or a segment of an enumeration area. Overall, a representative sample that consisted of 20 880 households corresponding to 30 per enumeration area or a segment of the enumeration area was randomly selected for the survey.

All women aged 15–49 years who were either permanent residents of the selected households or visitors who had stayed in the household the night before the survey were eligible to be interviewed. In one-third of the sampled households, all men aged 15–54 years, including both usual residents and visitors who had stayed in the household the night preceding the interview, were eligible for individual interviews. Data were collected using four questionnaires: the household, women, men and biomarker questionnaires. The women's questionnaire collected information from all eligible women aged 15–49 years and they were questioned on the following among others: (1) husbands' background characteristics and women's work: husbands' age, level of education, and occupation and women's occupation and sources of earnings; (2) sexually transmitted infections (STIs) and HIV/AIDS: knowledge of STIs and AIDS and methods of transmission, sources of information, behaviours to avoid STIs and HIV, and stigma; (3) questions on reproduction included the number of children ever born, birth

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history and current pregnancy; (4) family planning questions included knowledge and use of contraception, the sources of contraceptive methods and information on family planning; (5) questions on maternal and child health, breast feeding and nutrition included prenatal care, delivery, postnatal care, practices of breast feeding and complementary feeding, coverage of vaccination, diarrhoea prevalence and treatment, symptoms of acute respiratory infection, fever, knowledge of oral rehydration salts and use of oral rehydration therapy; (6) questions on fertility preferences included desire for more children, the ideal number of children, gender preferences and the intention to use a family planning method; (7) questions were asked regarding knowledge, attitudes and behaviours related to injections and smoking; (7) additional questions focused on adult and maternal mortality, domestic violence and early childhood development. Additional questions are described in the 2016 UDHS report.[9]

The men's questionnaire was administered to all men aged 15–54 years in the subsample of households selected for the male survey and collected much of the same information elicited with the women's questionnaire. However, it was shorter because it did not contain a detailed reproductive history or questions on maternal and child health.

Data were collected on the knowledge and attitudes of women and men about STIs and HIV/AIDS, potential exposure to the risk of HIV infection (risk behaviours and condom use), and coverage of HIV testing and counselling and other key HIV/AIDS programmes. The primary objective was to provide data on trends in HIV/AIDS knowledge, attitudes and behaviours, including knowledge of HIV prevention methods, stigma and discrimination, number of sexual partners, condom use, self-reported HIV testing, prevention of mother-to-child transmission of HIV and voluntary medical male circumcision. The 2016 UDHS data were collected by 21 trained research teams, with each consisting of a team leader, field manager, 3 female interviewers, 1 male interviewer, 1 health technician and 1 driver. A detailed description of the survey can be found in the 2016 UDHS report.[1]

Study design

This was a non-randomised, quasi-experimental study since no true randomisation was employed.[12] We simulated a randomised control trial (RCT) from observational data by applying propensity-scores matched (PSM) analysis to remove selection bias arising from a lack of randomisation and confounding. PSM analysis ensured that both the exposed and non-exposed groups are comparable/or balanced on all measured covariates, except for the exposure.[12 13] Although an RCT is the gold standard design for measuring the effect of interventions since randomisation ensures balance in both known and unknown baseline covariates thereby achieving comparability between the intervention and control groups,[14] it is infeasible and unethical for beneficial interventions such as comprehensive knowledge of HIV. Observational data provides an option for the measure of effect but the presence of selection bias from lack of randomization and confounding of the exposure–outcome relationship due to other factors are important limitations[15] that have to removed hence the use of PSM analysis.

Variables and measurements

Exposure

Comprehensive knowledge of HIV was the exposure of interest, measured on a binary scale (yes vs no) using five indicators, namely (1) knowing that consistent use of condoms during sexual intercourse can reduce the chance of getting HIV; (2) knowing that having just one faithful partner without HIV can reduce the chance of getting HIV; (3) knowing that a healthy-looking person can have HIV; (4) rejecting that HIV can be transmitted through mosquitoes; and (5) rejecting that HIV can be transmitted by sharing of food. Indicators 4–5 are the two most common local misconceptions about HIV transmission or prevention in Uganda. Participants with correct responses to all the five indicators were considered as having comprehensive knowledge of HIV otherwise no. The exposed group consisted of participants with comprehensive knowledge of HIV while the unexposed (comparison) group consisted of those without comprehensive knowledge of HIV.

Outcomes

The primary outcome was extramarital sexual relationships measured on a binary scale (yes or no). Participants in sexual relations with another sexual partner other than the spouse or cohabiting partner were considered to have indulged in extramarital sexual relationships in the 12 months preceding the survey. The secondary outcome was the consistent use of condoms measured on a binary scale, computed as the percentage of respondents who had used a condom every time they had sex with any non-spouse or non-cohabiting partner over the past 12 months.[1]

Matching covariates

These included sex (male or female), age group (15–19, 20–24, 25–29, 30–34, 35–39, 40–44, 45–49 and 50–54), level of education (none/no education, primary, secondary and higher), marital status (never in a union, currently in a union and formerly in a union), number of living children, wealth index (poorest, poorer, middle, richer and richest), religion (no religion, Anglican, Catholic, Muslim, Seventh Day Adventist, Pentecostal and others) and the 15 regions in Uganda (Kampala, Central 1, Central 2, Busoga, Bukedi, Bugishu, Teso, Karamoja, Lango, Acholi, West Nile, Bunyoro, Tooro, Ankole and Kigezi).

Data analysis

We used R V.4.02[16] and Stata V.15.1 for the analysis. In R, we used the MatchIt[17] and tableone[18] statistical packages. We descriptively summarised categorical data as frequencies and percentages, and numerical data using

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the mean with its SD. We performed PSM analysis using eight matching covariates known to influence either the exposure or the outcome, or both based on the unconfoundedness assumption.[19–21] We computed propensity scores in a logit model by fitting comprehensive knowledge of HIV as a function of the matching covariates. We assessed the initial balance in propensity scores using a back-to-back histogram.[22] We then matched participants with and without compressive knowledge of HIV on similar propensity scores[23] using different matching approaches, namely nearest neighbour matching with and without calliper adjustment,[20] and optimal pair and optimal full matching.[21] A calliper is a distance within which matching occurs, computed as 20% of the SD of the propensity score to prevent bias from distant matches. In nearest-neighbour matching without calliper adjustment, the participants were randomly matched to one another while in nearest-neighbour matching with calliper adjustment, the matching was performed within a calliper, all without replacement.

In the optimal pair matching, the matching was done in pairs and the non-matched pairs were excluded from the analysis. In the optimal full matching, the matching was done in a ratio of 1: many or many: 1. Furthermore, we performed exact matching where the participants were matched on the identical values of propensity scores.[24] The best matching approach was one that balanced all the covariates between the two groups.

Following the matching, we checked the covariate balance between the group with and without comprehensive knowledge of HIV using standardised mean differences (SMD), with an SMD<0.1 considered confirmatory of good covariate balance.[7] We further assessed covariate balance graphically using a jitter plot and histogram. Here, distributional similarity in propensity scores was taken to suggest covariate balance.[7 25] After successful matching, the PSM dataset was saved for the outcome analysis. We performed analysis on both the unmatched and matched datasets. We fitted a binary logistic regression model for the unadjusted and adjusted analysis, with the latter model adjusted for all the matching covariates. For the PSM dataset, we fitted a conditional logistic regression taking into consideration the matched pairs. We reported OR and 95% CI.

Sensitivity analysis

We checked the robustness of the findings to hidden bias/unmeasured confounders and the matching approach using Rosenbaum Wilcoxon's signed-rank test.[22] We interpreted distant gamma values to achieve statistical significance or non-significance as indicative of robustness.

Reporting of findings

The findings are reported following the improving the reporting quality of non-randomised evaluations of behavioural and public health interventions: The TREND (reporting of intervention evaluation studies using nonrandomized designs) statement shown in online supplemental file 1.[26]

Patient and public involvement

Patients or the public were not involved in the design, or conduct, or reporting, or dissemination plans of our research.

RESULTS

Characteristics of participants

We present participants' characteristics in table 1 both before and after PSM. We analysed data for 23 711 participants of whom 11 314 (47.7%) had comprehensive knowledge of HIV. Before PSM, we observed systematic differences in the comprehensive knowledge of HIV concerning the participants' age group, level of education, wealth index and region, with all the variables showing an SMD>0.1. We matched 18 504 participants in a ratio of 1:1, with all the covariates balanced among the participants with and without comprehensive knowledge of HIV (SMD<0.1).

Table 2 presents the study outcomes before and after PSM analysis. In the PSM unmatched sample, 4187 (17.7%) participants had extramarital sexual relationships but there was no difference between those without and with comprehensive knowledge of HIV: 2056 (16.6%) vs 2131 (18.8%), SMD=0.059. Of 4187 participants in extramarital sexual relationships, 1425 (34.0%) reported consistent use of condoms, and the proportion of consistent use of condoms was significantly lower among those without comprehensive knowledge of HIV compared with those with comprehensive knowledge of HIV: 623 (30.3%) vs 802 (37.6%), SMD=0.155.

In the PSM sample, 3260 (17.6%) participants had extramarital sexual relationships, with a statistically non-significant difference between those without and with comprehensive knowledge of HIV: 1608 (17.4%) vs 1652 (17.9%), SMD=0.012. Of 1117 (34.3%) participants who reported consistent use of condoms, 520 (32.3%) had no comprehensive knowledge of HIV while 597 (36.1%) had comprehensive knowledge of HIV. However, we observed a statistically non-significant difference in the consistent use of condoms SMD=0.080).

Additional balance diagnostics

Figure 1 is a histogram showing the distribution of propensity scores among participants with and without comprehensive knowledge of HIV. The propensity scores were distributed differently among the participants with (raw treated) and without (raw control) comprehensive knowledge of HIV before PSM. However, the propensity scores were distributed similarly among participants with (matched treated) and without (matched control) comprehensive knowledge of HIV after PSM.

Effect of comprehensive knowledge of HIV on risky sexual behaviours associated with HIV transmission

We present the results for the effect of comprehensive knowledge of HIV on having multiple sexual partners

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Table 1 Baseline characteristics of participants before and after PSM

		Unmatched (original) sample				PSM sample			
		Comprehensive knowledge of HIV				Comprehensive knowledge of HIV			
		Overall (n=23 711)	No (n=12 397)	Yes (n=11 314)		Overall (n=18 504)	No (n=9252)	Yes (n=9252)	
Variables	Level	No. (%)	No. (%)	No. (%)	SMD	No. (%)	No. (%)	No. (%)	SMD
Sex	Male	5295 (22.3)	2692 (21.7)	2603 (23.0)	0.031	4168 (22.5)	2037 (22.0)	2131 (23.0)	0.024
	Female	18 416 (77.7)	9705 (78.3)	8711 (77.0)		14 336 (77.5)	7215 (78.0)	7121 (77.0)	
Age group (years)	15–19	5466 (23.1)	3263 (26.3)	2203 (19.5)	0.179	3985 (21.5)	2014 (21.8)	1971 (21.3)	0.019
	20–24	4712 (19.9)	2311 (18.6)	2401 (21.2)		3676 (19.9)	1832 (19.8)	1844 (19.9)	
	25–29	3741 (15.8)	1811 (14.6)	1930 (17.1)		2914 (15.7)	1471 (15.9)	1443 (15.6)	
	30–34	3327 (14.0)	1610 (13.0)	1717 (15.2)		2671 (14.4)	1325 (14.3)	1346 (14.5)	
	35–39	2521 (10.6)	1324 (10.7)	1197 (10.6)		2030 (11.0)	997 (10.8)	1033 (11.2)	
	40–44	2110 (8.9)	1109 (8.9)	1001 (8.8)		1768 (9.6)	887 (9.6)	881 (9.5)	
	45–49	1542 (6.5)	832 (6.7)	710 (6.3)		1220 (6.6)	605 (6.5)	615 (6.6)	
	50–54	292 (1.2)	137 (1.1)	155 (1.4)		240 (1.3)	121 (1.3)	119 (1.3)	
Level of education	No education	2279 (9.6)	1475 (11.9)	804 (7.1)	0.459	1617 (8.7)	816 (8.8)	801 (8.7)	0.033
	Primary	13 849 (58.4)	8139 (65.7)	5710 (50.5)		11 276 (60.9)	5681 (61.4)	5595 (60.5)	
	Secondary	5648 (23.8)	2243 (18.1)	3405 (30.1)		4464 (24.1)	2215 (23.9)	2249 (24.3)	
	Higher	1935 (8.2)	540 (4.4)	1395 (12.3)		1147 (6.2)	540 (5.8)	607 (6.6)	
Marital status	Never in union	6681 (28.2)	3604 (29.1)	3077 (27.2)	0.049	4904 (26.5)	2469 (26.7)	2435 (26.3)	0.01
	Currently in union	14 352 (60.5)	7365 (59.4)	6987 (61.8)		11 441 (61.8)	5715 (61.8)	5726 (61.9)	
	Formerly in union	2678 (11.3)	1428 (11.5)	1250 (11.0)		2159 (11.7)	1068 (11.5)	1091 (11.8)	
Living children	≤2	12 840 (54.2)	6648 (53.6)	6192 (54.7)	0.049	9589 (51.8)	4770 (51.6)	4819 (52.1)	0.011
	3–5	6681 (28.2)	3449 (27.8)	3232 (28.6)		5410 (29.2)	2714 (29.3)	2696 (29.1)	
	≥6	4190 (17.7)	2300 (18.6)	1890 (16.7)		3505 (18.9)	1768 (19.1)	1737 (18.8)	
Wealth index	Poorest	4901 (20.7)	3071 (24.8)	1830 (16.2)	0.340	3496 (18.9)	1746 (18.9)	1750 (18.9)	0.005
	Poorer	4661 (19.7)	2653 (21.4)	2008 (17.7)		3719 (20.1)	1859 (20.1)	1860 (20.1)	
	Middle	4508 (19.0)	2453 (19.8)	2055 (18.2)		3783 (20.4)	1884 (20.4)	1899 (20.5)	
	Richer	4518 (19.1)	2254 (18.2)	2264 (20.0)		3814 (20.6)	1911 (20.7)	1903 (20.6)	
	Richest	5123 (21.6)	1966 (15.9)	3157 (27.9)		3692 (20.0)	1852 (20.0)	1840 (19.9)	
Religion	No religion	350 (1.5)	201 (1.6)	149 (1.3)	0.026	258 (1.4)	119 (1.3)	139 (1.5)	0.018
	Muslim	2793 (11.8)	1468 (11.8)	1325 (11.7)		2126 (11.5)	1063 (11.5)	1063 (11.5)	
	Christianity	20 568 (86.7)	10 728 (86.5)	9840 (87.0)		16 120 (87.1)	8070 (87.2)	8050 (87.0)	
Region	Kampala	1640 (6.9)	596 (4.8)	1044 (9.2)	0.302	1125 (6.1)	574 (6.2)	551 (6.0)	0.037
	Central 1	2058 (8.7)	946 (7.6)	1112 (9.8)		1575 (8.5)	812 (8.8)	763 (8.2)	
	Central 2	1864 (7.9)	930 (7.5)	934 (8.3)		1532 (8.3)	767 (8.3)	765 (8.3)	

Continued

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Table 1 Continued

Variables	Level	Unmatched (original) sample				PSM sample			
		Comprehensive knowledge of HIV				Comprehensive knowledge of HIV			
		Overall (n=23 711)	No (n=12 397)	Yes (n=11 314)	SMD	Overall (n=18 504)	No (n=9252)	Yes (n=9252)	SMD
		No. (%)	No. (%)	No. (%)		No. (%)	No. (%)	No. (%)	
	Busoga	1959 (8.3)	1080 (8.7)	879 (7.8)		1563 (8.4)	783 (8.5)	780 (8.4)	
	Bukedi	1554 (6.6)	845 (6.8)	709 (6.3)		1259 (6.8)	625 (6.8)	634 (6.9)	
	Bugishu	1247 (5.3)	689 (5.6)	558 (4.9)		958 (5.2)	458 (5.0)	500 (5.4)	
	Teso	1695 (7.1)	867 (7.0)	828 (7.3)		1406 (7.6)	709 (7.7)	697 (7.5)	
	Karamoja	883 (3.7)	579 (4.7)	304 (2.7)		562 (3.0)	273 (3.0)	289 (3.1)	
	Lango	1638 (6.9)	901 (7.3)	737 (6.5)		1309 (7.1)	644 (7.0)	665 (7.2)	
	Acholi	1460 (6.2)	653 (5.3)	807 (7.1)		1183 (6.4)	611 (6.6)	572 (6.2)	
	West Nile	1589 (6.7)	1113 (9.0)	476 (4.2)		913 (4.9)	452 (4.9)	461 (5.0)	
	Bunyoro	1551 (6.5)	792 (6.4)	759 (6.7)		1281 (6.9)	636 (6.9)	645 (7.0)	
	Tooro	1696 (7.2)	918 (7.4)	778 (6.9)		1421 (7.7)	710 (7.7)	711 (7.7)	
	Ankole	1672 (7.1)	853 (6.9)	819 (7.2)		1408 (7.6)	699 (7.6)	709 (7.7)	
	Kigezi	1205 (5.1)	635 (5.1)	570 (5.0)		1009 (5.5)	499 (5.4)	510 (5.5)	

Distribution of study outcomes before and after PSM.
PSM, propensity score-matched; SMD, standardised mean differences.

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Table 2 Distribution of study outcomes by comprehensive knowledge of HIV before and after PSM

Variables	Levels	Comprehensive knowledge of HIV (before PSM)				Comprehensive knowledge of HIV (after PSM)			
		Overall (n=23711)	No (n=12397)	Yes (n=11314)	SMD	Overall (n=18504)	No (n=9252)	Yes (n=9252)	SMD
Extramarital sexual relationship	No	19524 (82.3)	10341 (83.4)	9183 (81.2)	0.059	15244 (82.4)	7644 (82.6)	7600 (82.1)	0.012
	Yes	4187 (17.7)	2056 (16.6)	2131 (18.8)		3260 (17.6)	1608 (17.4)	1652 (17.9)	
Consistent condom use*	No	2762 (66.0)	1433 (69.7)	1329 (62.4)	0.155	2143 (65.7)	1088 (67.7)	1055 (63.9)	0.080
	Yes	1425 (34.0)	623 (30.3)	802 (37.6)		1117 (34.3)	520 (32.3)	597 (36.1)	

*Data are for participants in extramarital sexual relationships.
PSM, propensity score-matched; SMD, standardised mean differences.

and consistent use of condoms in table 3. The results show that comprehensive knowledge of HIV was significantly associated with extramarital sexual relationships at the unadjusted analysis (OR 1.17, 95% CI 1.09 to 1.25) but not adjusted (aOR 1.07, 95% CI 0.99 to 1.15) and PSM analysis (OR 1.03, 95% CI 0.96 to 1.11). Concerning the secondary outcome, the results show that comprehensive knowledge of HIV was significantly associated with consistent use of condoms at the unadjusted analysis (OR 1.39, 95% CI 1.22 to 1.58) and at the PSM analysis (OR 1.18, 95% CI 1.02 to 1.37) but not at the adjusted analysis (aOR, 1.10, 95% CI 0.95 to 1.27).

Effect of comprehensive knowledge of HIV on risky sexual behaviours associated with HIV transmission by sex

In table 4, we display the findings for the effect of comprehensive knowledge of HIV on having multiple sexual partners and consistent use of condoms by sex. Among males, comprehensive knowledge of HIV showed no effect on extramarital sexual relationships (OR 0.95, 95% CI 0.83 to 1.08) but improved consistent use of condoms among those in extramarital sexual relationships (OR 1.31, 95% CI 1.04 to 1.66). In females, we found no effect on extramarital sexual relationships (OR 1.06, 95% CI 0.97 to 1.17) and consistent use of condoms among those in extramarital sexual relationships (OR 1.06, 95% CI 0.97 to 1.17).

Sensitivity analysis results

The Rosenbaum sensitivity analysis using the Wilcoxon signed-rank test showed that a statistically non-significant upper bound of the gamma value occurred at 5.0 (p=0.9798), which was distant from the point of no hidden bias where the gamma value was 1.0 (p<0.0001). This showed that the results are robust to unmeasured confounders and the analytic approach.

DISCUSSION

Our study shows that among married or cohabiting couples in Uganda, comprehensive knowledge of HIV has no effect on extramarital sexual relationships but improves the consistent use of condoms among couples in extramarital sexual relationships. In subgroup analysis, comprehensive knowledge of HIV improves consistent use of condoms among married or cohabiting males in extramarital sexual relationships but has no effect on consistent use of condoms among married or cohabiting females.

The finding that compressive knowledge of HIV improves consistent use of condoms among married or cohabiting couples in extramarital relationships is not unique. Comprehensive knowledge of HIV raises an individual's level of awareness regarding potential risks associated with not using condoms and helps them adopt safer sexual practices such as consistent use of condoms.[27] Inconsistent use of condoms in extramarital sexual relationships places a couples at a greater risk of acquisition

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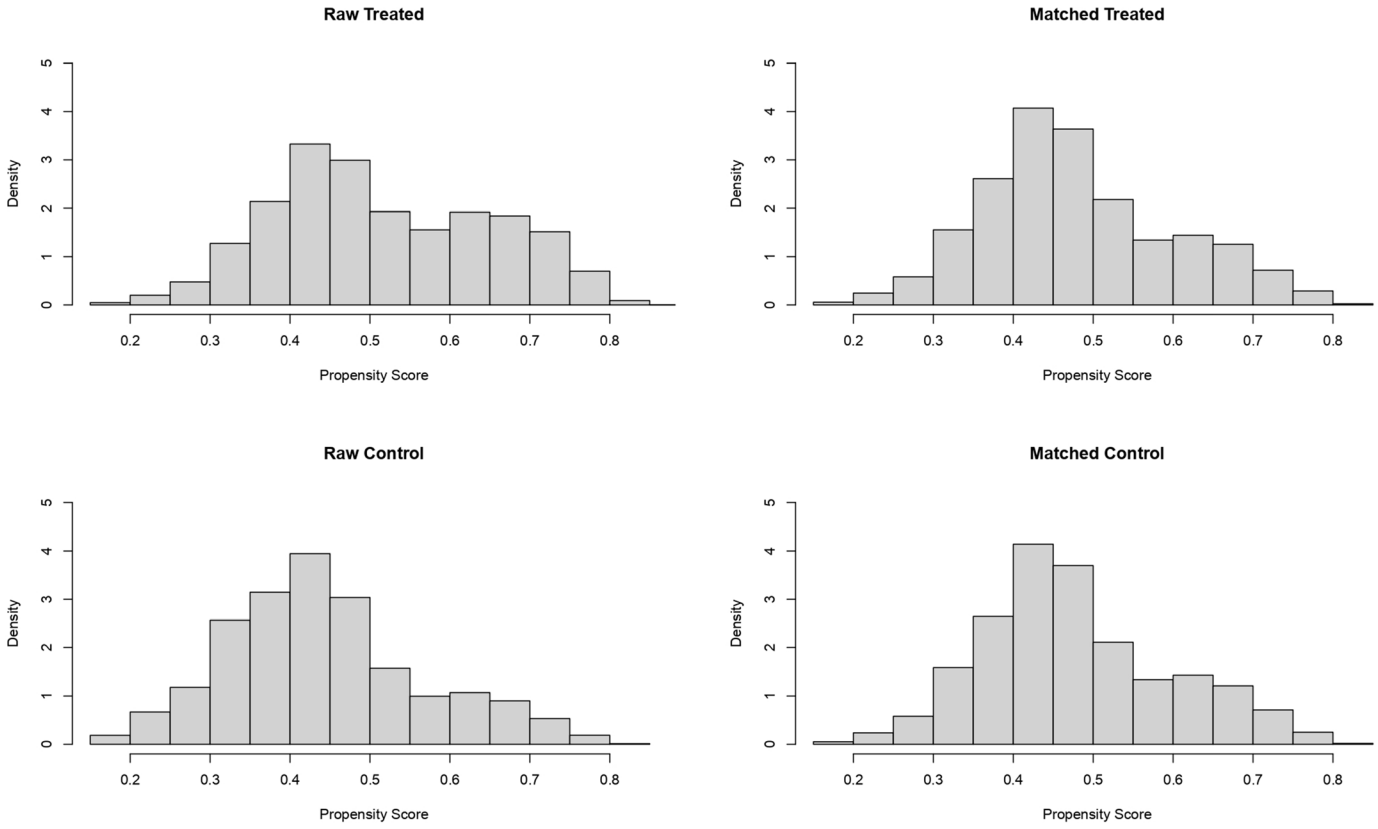

Figure 1 Distribution of propensity-scores between participants with and without comprehensive knowledge of HIV before (left histograms) and after matching (right histograms).

of STIs including HIV.[28] Our finding is consistent with several studies in SSA. One study which analysed the Ghana DHS found exposure to family planning messages is associated with a higher likelihood of consistent condom use among sexually active never-married men.[29] Using the level of education as a proxy for comprehensive knowledge of HIV, one study that analysed DHS data for 29 countries in SSA reports that among men who pay for sex, those that attained a secondary level of education are more likely to use condoms consistently.[30] In Uganda, less than half of the population aged 15–54 years have comprehensive knowledge of HIV.[1] This finding underscores a need to design and implement context-relevant HIV prevention and education messages to improve the level of comprehensive knowledge of HIV in the population for better HIV pandemic control.

We found no effect of comprehensive knowledge of HIV on the consistent use of condoms among married or cohabiting females in extramarital sexual relationships. However, in married or cohabiting males, comprehensive knowledge of HIV improves the consistent use of condoms in extramarital sexual relationships. Although several factors such as cost, moral values, ethnicity, religion, gender inequality, and lack of dialogue among sexual partners concerning condom use among others influence inconsistent or non-use of condoms during sexual intercourse,[31] our findings agree with an earlier study that reports HIV knowledge improves condom use self-efficacy[32] and consequently its use in sexual relationships.

Consistent with our results, a recent study conducted among sexually active men in Nigeria[33] show that

Table 3 Effect of comprehensive knowledge of HIV on risky sexual behaviours associated with HIV transmission

Variable	Level	Crude analysis	Adjusted analysis	Propensity score-matched analysis
Extramarital sexual relationship	No	1	1	1
	Yes	1.17 (1.09 to 1.25)	1.07 (0.99 to 1.15)	1.03 (0.96 to 1.11)
Consistent condom use#	No	1	1	1
	Yes	1.39 (1.22 to 1.58)	1.10 (0.95 to 1.27)	1.18 (1.02 to 1.37)

Significance codes at 5% level: *p<0.05, **p<0.001, ***p<0.0001; # denotes analysis was restricted to participants with multiple sexual partners.

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Table 4 Effect of comprehensive knowledge of HIV on risky sexual behaviours associated with HIV transmission by sex

Subgroup	Variable	Level	OR (95% CI)
Males	Extramarital sexual relationship	No	1
		Yes	0.95 (0.83 to 1.08)
	Consistent condom use#	No	1
		Yes	1.31 (1.04 to 1.66)
Females	Extra marital sexual relationship	No	1
		Yes	1.06 (0.97 to 1.17)
	Consistent condom use#	No	1
		Yes	1.06 (0.97 to 1.17)

Significance codes at 5% level: *p<0.05, **p<0.00, ***p<0.0001; # denotes analysis was restricted to participants with multiple sexual partners.

knowledge of HIV equally improved condom use. Another study conducted among South African married couples reported that females are less likely to use a condom if their male partner has refused to use a condom,[34] suggesting male dominance or power imbalance between women and men in condom negotiation. In our context, this finding could be explained by sociocultural differences between men and women, with the latter being inherently submissive to the sexual demands of the latter. In general, African women find it difficult to assert themselves regarding condom negotiation and the majority do not negotiate condom use in a sexual relationship. In Uganda, one study[35] reports the social environment as an independent risk factor for HIV vulnerability. Men are the sole decision-makers regarding whether or not to use a condom in a sexual relationship. However, gender equality improves condom use self-efficacy in both general and risky situations.[32] Improving consistent use of condoms among women thus require their emancipation regarding decision-making on matters of sexual health.

Our finding that comprehensive knowledge of HIV has no effect on extramarital sexual relationships among married or cohabiting couples in the general population and in subgroup analysis requires cautious interpretation. First, we acknowledge that HIV is a global health problem, with an estimated 25.7 million people living with HIV (PLHIV) globally[28] and in Uganda, there are 1.4 million PLHIV.[2] However, with the rapid rollout and improved access to antiretroviral therapy over the years, the majority of PLHIV have a nearly normal quality of life and longevity. There is now much hope and optimism that the fight against HIV is nearly over leading to HIV complacency in the general population.[36] Concerns about HIV being a global health problem have lessened and the use of known HIV prevention methods such as abstinence, mutual faithfulness and consistent condom use, among others have dwindled over the years. The problem of HIV complacency in Africa[37] and Uganda[38] has been highlighted earlier. Another plausible explanation relates to behaviour change and the wide know-do gap at the individual level. One would argue that behaviour change is a gradual process, often with strong influences from the social, cultural, economic, environmental and technological dimensions.[39] These challenges require a strong focus on health promotion, a combination of health education and healthy public policy.[40] For instance, without an enabling environment to achieve the desired behaviour change, health education is insufficient. The formulation and implementation of appropriate healthy public policies to create an enabling environment is important to prevent victim blaming where people are victimised for their actions despite a lack of an enabling environment for behaviour change.

Our findings, therefore, emphasise a need for novel approaches to achieve behaviour change in Uganda. There is a need to complement existing behaviour change communication strategies with other approaches that lessen the influence of social and environmental determinants (alcohol consumption and smoking, eg) that place the population at risk for HIV infection.[41] Approaches to mitigate HIV complacency besides other tools for HIV prevention and control are important in ending the HIV pandemic.[42] Further research should be conducted to understand the disparity in the effect of comprehensive knowledge of HIV on extramarital sexual relationships among married/cohabiting men and women.

Study strengths and limitations

Our study has several strengths and limitations. First, we analysed nationally representative data so our findings are likely generalisable to the entire country and other similar settings. Second, the sample size was large and the results are robust to unmeasured confounders and the analytic approach. However, there are limitations. For example, although our results are robust to unmeasured confounders, the matching was performed on observed covariates and other unobserved covariates (such as alcohol consumption and drug and substance use among others) that are known to influence the outcome were not analysed. The outcomes were assessed through self-report so the possibility of social desirability bias cannot be excluded.

Methodological considerations

We highlight a few methodological considerations in this study. First, PSM is appropriate when the sample size is large, typically ≥5000 observations. This is because PSM leads to reduction in sample size due to unmatched observations hence might increase the likelihood of type II error. The specification of the propensity-score model is prone to inaccuracies so the reliance on the unconfoundedness assumption is important. The magnitude of the intervention effect somewhat depends on the type of matching used and whether it was done with or without replacement. Another important consideration is the approach to computing the propensity score thus whether a logistic regression or generalised boosted regression model was used since they determine the sufficiency of

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the common support. Lastly, PSM does not control for unmeasured confounders so sensitivity analysis to assess the credibility of the estimates is important.

CONCLUSIONS AND RECOMMENDATIONS

Comprehensive knowledge of HIV has no effect on extramarital sexual relationships among married or cohabiting couples in Uganda. However, it increases the consistent use of condoms in extramarital relationships among married or cohabiting men but not in married or cohabiting women. Our findings emphasise a need to continue providing consistent and correct HIV prevention health education messages.

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Patient consent for publication Not applicable.

Ethics approval The UDHS dataset is publicly accessible at https://dhsprogram.com/data/available-datasets.cfm. We applied for and received authorisation to analyse the data from the DHS programme (www.dhsprogram.com). Since DHS datasets are publicly available and free, no ethical approval was required.

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