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INFECTIOUS DISEASES

Unprotected sex following HIV testing among women in Uganda and Zimbabwe: short- and long-term comparisons with pre-test behaviour

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Background Despite widespread condom promotion for HIV prevention, prospective measurement of condom use before and after HIV testing is infrequent.

Methods We analysed data from a prospective study of hormonal contraception and HIV acquisition among Zimbabwean and Ugandan women (1999–2004), in which HIV testing and counselling were performed approximately every 3 months. We used zero-inflated negative binomial (ZINB) models to examine the number and proportion of unprotected sex acts, comparing behaviour reported 2–6 months before HIV testing with behaviour reported both 2–6 months (short-term analysis) and 12–16 months (long-term analysis) after HIV testing.

Results Short- and long-term analyses were similar, so we present only long-term findings from 151 HIV-infected and 650 uninfected participants. The proportion of HIV-infected women reporting any unprotected acts in a typical month declined from 74% (pre-infection behaviour) to 56% (12–16 months after HIV diagnosis). In multivariable models, HIV-infected women were twice as likely to report that all sex acts were protected by condoms after diagnosis compared with beforehand [adjusted odds ratio (aOR): 1.99, 95% confidence interval (CI): 1.12–3.53]; uninfected women were somewhat less likely to report that all acts were protected (aOR: 0.82, 95% CI: 0.64–1.04). HIV-infected women also reduced their number of unprotected acts by 38% (95% CI: −16 to −55%). However, their proportion of unprotected acts changed little (7% reduction, 95% CI: −18 to +6%). Uninfected women reported little change in number or proportion of unprotected acts over the same time period.

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Conclusions HIV-infected women reduced the number, but not the proportion, of unprotected acts. HIV-negative women did not increase condom use after testing and counselling, but neither did they decrease condom use, suggesting that testing negative was not interpreted as endorsement of risky behaviour.

Keywords Zero-inflated, negative binomial, HIV/AIDS, male condom, risk behaviour, positive prevention, women, Uganda, Zimbabwe, unprotected sex

Introduction

Recent prevention initiatives for human immunodeficiency virus (HIV) focus on 'positive prevention'—targeting and supporting HIV-infected individuals to modify their behaviour and consequently reduce the risk of future transmission.[1–4] Whether among infected or uninfected individuals, HIV prevention interventions typically include counselling on the use of male condoms.[5] However, few studies have prospectively measured condom use before and after notification of HIV status in African women. In a longitudinal voluntary counselling and testing intervention in rural Zimbabwe,[6] 3 years after HIV testing, HIV-infected women (but not men) reported more consistent condom use with their primary partners. Little change in condom use was observed in participants testing HIV-negative at baseline, though these individuals reported increases in other risky sexual behaviours.[6]

In the absence of other strictly comparable prospective studies on condom use before and after knowledge of HIV status, we reviewed cross-sectional reports of repeat HIV testing. Among Senegalese female sex workers, those who self-reported a previous negative HIV test were significantly less likely to use condoms consistently with primary partners than women with no previous HIV testing; those who reported a previous positive test were also somewhat less likely to use condoms with primary partners.[7] Previous testing did not affect condom use with clients.[7] A London study reported that repeat (compared with first-time) male testers were more likely to report unprotected sex with two or more partners in the previous 6 months; there was no association for women between repeat testing and condom use.[8] A second cross-sectional study in the same clinic found no significant associations between repeat HIV testing and condom use except among homosexual men with three or more previous HIV tests.[9]

Several condom promotion interventions have compared condom use after the intervention to behaviour reported at the time of the intervention, or to a control group. A meta-analysis of HIV prevention studies from 1985 to 1997 found that the benefits of condom counselling (including increases in condom use) were more apparent in those testing HIV-positive than those testing negative.[10] Another review found that reported condom use and abstinence increased over time in HIV-infected women receiving counselling, and that HIV-infected individuals are more likely than HIV-uninfected individuals to use condoms.[11]

Is notification of HIV status, together with repeat risk reduction counselling, sufficient to induce and maintain increased condom use? We aimed to assess the effect of notification of HIV-positive status on African women's use of condoms 2–6 months after diagnosis and 12–16 months after diagnosis, compared with their pre-diagnosis behaviour. Because a negative HIV test may be interpreted as endorsement of risky behaviour,[6–9] we also assessed the effect of notification of HIV-negative status on condom use among uninfected participants over the same time periods.

Methods

This analysis draws data from the 'Hormonal Contraception and Risk of HIV Acquisition' (HC-HIV) study, a prospective cohort study conducted in Uganda, Zimbabwe and Thailand, and an ancillary study called the 'Effect of Hormonal Contraception on HIV Genital Shedding and Disease Progression among Women with Primary HIV Infection' (GS) study. HC-HIV assessed the effect of hormonal contraception on women's HIV risk; detailed methods and main findings have been published elsewhere.[12] GS followed Ugandan and Zimbabwean women who became HIV infected during HC-HIV.

Study setting and population

The HC-HIV study followed women from 1999 to 2004. All Zimbabwean and most Ugandan participants were recruited from family planning and maternal-child health clinics. Owing to low initial HIV incidence rates among Ugandan women, recruitment there was expanded to include referrals from 'higher-risk' populations, such as sexually transmitted disease (STD) clinics, sex workers and military wives. Eligible women were 18–35 years of age; HIV-uninfected; sexually active and using either oral contraceptive pills, injectable depot medroxyprogesterone

acetate, or a non-hormonal or no contraceptive method. The 24-month retention rate for participants in the HC-HIV study was 92%: 96% in Uganda and 88% in Zimbabwe.

Starting in March 2001, all women in Zimbabwe and Uganda who became HIV infected during HC-HIV were invited to enrol in GS. Because few incident HIV infections occurred in Thailand, the Thai site was included neither in GS nor in the current analysis.

Study procedures

HC-HIV study

At enrolment and each follow-up visit, women received face-to-face interviews about their reproductive, contraceptive and sexual behaviour, including condom use. All HIV pre- and post-test counselling sessions included instructions on condom use. Visits took place approximately every 3 months for up to 2 years or until HIV seroconversion.

GS study

Women who became HIV infected during HC-HIV were told about GS; interested women returned for GS enrolment. Follow-up visits during GS took place, as in HC-HIV, approximately quarterly. At each GS visit the same face-to-face HC-HIV questionnaires were administered to collect reproductive and sexual behaviour data; women also underwent physical examinations with specimen collection.

Beginning in June 2003, all GS participants who met specific criteria were offered highly active antiretroviral therapy (HAART). The GS study used the standard World Health Organization (WHO) criteria for HAART initiation in resource-poor countries (WHO Clinical Stage 4 or severe Clinical Stage 3 disease or two successive CD4 counts $\leqslant 200$ cells).

Counselling

Hormonal contraceptive counselling and condom counselling were performed by trained counsellors during both HC-HIV and GS.

In HC-HIV, contraceptive counselling was conducted at each visit only for women using hormonal methods. In GS, all non-pregnant women (regardless of current contraceptive use) were counselled about the most effective methods of contraception, including hormonal options.

All women in both studies received condom counselling at each visit. Condom counselling included a demonstration of condom use using a wooden model, the opportunity for participants to practise using male condoms on the model, instructions to use male or female condoms to prevent sexually transmitted infection (STI)/HIV acquisition (and in GS, HIV transmission), and information on condom negotiation. All participants in both studies were given condoms to take home at each visit. Condom counselling followed the same general script for women in HC-HIV and GS, with a slightly extended session for HIV-positive women. The content and intensity of condom counselling were similar for HIV-positive and HIV-negative women.

Counselling sessions were comparable to expanded counselling sessions in a clinical context, and lasted 30 min for HIV-negative women and 45 min for HIV-infected women. Prior to initiation of the study, counsellors underwent training sessions that involved rehearsing the counselling script and role playing.

HIV-positive and HIV-negative participants were counselled at every visit that their partners could be counselled and tested free of charge at the study clinic, and study counsellors offered to help HIV-infected women to tell their partners of their serostatus. However, we did not systematically collect data on how often couples were counselled together, how often male partners came to the clinic for counselling and testing, and whether women chose to inform their partners of their serostatus.

Study counsellors discussed prevention of mother-to-child transmission (PMTCT) of HIV with HIV-infected women at their regular counselling sessions. If a participant became pregnant and met the specific GS study criteria for antiretroviral therapy, she was given the study regimen for pregnant women. If she did not meet GS study criteria, she was referred immediately to local PMTCT programmes.

Statistical analyses

Exposure measure: notification of HIV-positive status

Participants received HIV test results at every HC-HIV visit using a combination of two enzyme-linked immunosorbent (EIA) assays or rapid tests. Positive results were confirmed by western blot or HIV DNA or RNA polymerase chain reaction (PCR) tests. The full HIV testing algorithm and specific tests used are described elsewhere.[12] None of the HIV tests (rapid, EIA, western blot or PCR tests) was performed at the clinic where participants' blood was drawn. Blood was sent to the laboratories and when positive results were received at the clinic, participants were called back for a confirmatory blood draw 10–21 days after the initial test (results were normally received within 10 days, but it sometimes took women up to 3 weeks to return to the clinic for their results and confirmatory redraw visit). At the redraw visit, counsellors informed the woman that her HIV test appeared positive, but that further confirmatory tests were needed. Final results were typically given to women within 2 weeks. We used the date of the redraw visit as the date of diagnosis.

Outcome measure: number of unprotected sex acts in a typical month

At each visit, during both HC-HIV and GS, participants were asked: 'In the last 3 months, in a typical month, how many times did you have sex?' And 'In the last 3 months, in a typical month, how many

times did your partner use a male condom during sex with you?' Women answered these questions separately for primary and other partners. Women were given clarification that 'sex' referred to vaginal sex, and interviewers informed women that a 'typical month' referred to the month since their last study visit that they considered the most 'average' (of the 3 months in question) in terms of the frequency of sex. The number of unprotected acts in a typical month was calculated as the total number of acts with all partners minus the total number of acts where condoms were used.

Analytic procedures

We examined condom use in two analyses, by merging data collected during HC-HIV with data collected during GS. We constructed pairs of observations for each participant, with one 'before' and one 'after' measure. Statistical analyses were performed using SAS (Version 9.1.3, SAS Institute, Cary, NC) and Stata (Version 9.2, Statacorp, College Station, TX).

Short-term comparison

Our first analysis examined short-term changes in participants' self-reported condom use. For women who acquired HIV during HC-HIV, we selected one HC-HIV visit 2–6 months prior to notification of HIV-positive status (the 'before' visit) and one GS visit 2–6 months after HIV diagnosis ('after' visit). For women who remained HIV uninfected, we randomly selected a visit at which she received a negative HIV result using SAS's random number generator (her 'anchor' visit). We then chose corresponding visits 2–6 months before and 2–6 months after the anchor visit. From all uninfected women with visits within the specified timeframe, we randomly selected a sample in an approximate 4 : 1 ratio with HIV-infected women.

Long-term comparison

We also examined changes in self-reported condom use over a longer time period. For women who became HIV infected, we again selected one HC-HIV visit 2–6 months prior to notification of HIV-positive status, but we paired it with one GS visit 12–16 months after HIV diagnosis. For women remaining uninfected, we chose corresponding visits 2–6 months before the randomly selected anchor visit and 12–16 months after the anchor visit. We again randomly selected a sample of uninfected women in an approximate 4 : 1 ratio with HIV-infected participants.

Comparisons of coital frequency and unprotected sex

Using McNemar's test,[13] we examined whether the number of women reporting any sex in a typical month, or the number reporting any unprotected acts, changed a short and longer period after HIV testing, separately for HIV-infected and uninfected women.

Multivariable models

Because the outcome—number of acts where condoms were not used—is a count, we assessed various model types for count data, including the Poisson, negative binomial (NB), zero-inflated Poisson and zero-inflated negative binomial (ZINB) distributions.[14–16] We graphically compared the predicted probabilities of the count outcomes produced by each model type to the observed count data. We assessed fit using the likelihood ratio test (to compare the Poisson model to the NB model) and the Vuong test (to compare the ZINB model with the NB model).[17] ZINB models provided the best fit. We ran each ZINB multivariable model without and then with an offset variable capturing the total number of acts in a typical month.

ZINB models produce two sets of parameter estimates. First, a logistic procedure yields an odds ratio (OR): this OR compares the odds of having no unprotected acts in a typical month after HIV diagnosis (for HIV-positive women) or anchor visit (uninfected women) with the odds of having no unprotected acts in a typical month beforehand: in other words, the odds of all acts being protected by condoms in a typical month after HIV diagnosis or anchor visit compared with the odds all acts being protected in a typical month before diagnosis or anchor visit. A second set of parameter estimates is produced by the NB procedure. Without an offset variable, the NB effect estimate represents the relative change in the number of unprotected acts in a typical month after HIV diagnosis or anchor visit, compared with the number of unprotected acts in a typical month beforehand. When including an offset variable, the NB estimate is the relative change in the proportion of acts in a typical month where condoms were not used.

To generate separate effect estimates for HIV-infected and uninfected participants, we used three independent variables: HIV, coded 0 for women who remained HIV negative and 1 for women who became HIV infected; timepoint, coded 0 for visits prior to HIV testing and 1 for visits after; and a product-interaction term between timepoint and HIV.

We used a Directed Acyclic Graph (DAG)[18] to identify variables that could confound the association between HIV testing and condom use. Following DAG analysis, variables assessed in preliminary analyses prior to the multivariable modelling phase included age, age at coital debut, education, nights the primary partner was away from home in the previous 30 days, cohabitation, employment status of the woman and her primary partner, alcohol and drug use in the previous 3 months, commercial sex in the previous 3 months, number of partners in the previous 3 months, country and referral population (Uganda high-risk vs Uganda low-risk vs Zimbabwe), prior STI in the study period and

circumcision status of the primary sex partner. We included in each starting multivariable model all factors that were associated with HIV status or condom use. Age was the only variable forced into the models. Prior literature indicated that age is associated with becoming HIV infected and with changes in risk behaviour generally. We assessed continuous variables graphically by examining the linearity of the log risk of the outcome according to incremental categories of each continuous variable. We did not include hormonal contraceptive use in the models, because contraception could be affected by notification of HIV status.[19] (The measures of effect did not change measurably when hormonal contraception was excluded for this methodological reason.) We used robust variance estimation to account for non-independence resulting from repeated measures on individual participants; we implemented this in Stata by specifying the 'robust' option, with participant as the repeated observation. [20,21]

To construct final models, we used a backward elimination, change-in-estimate strategy.[22] One by one, we manually removed covariates from the starting model, beginning with the variable leading to the smallest change in the association of interest; if removal changed the condom use association by $< 10\%$, a given covariate was not retained. We designated models as 'final' when the remaining covariates confounded the main association or were retained for *a priori* considerations (age).

Any covariate that confounded the estimate for HIV-infected participants or for uninfected women, in either short- or long-term analyses, in the logistic or NB portions of the model, or in a model with or without the offset variable, was included in the final adjustment set for all analyses.

Ethical approval

All women enrolled in HC-HIV and GS gave written informed consent prior to participating, and local ethics committees at collaborating institutions gave approval for the studies.

Results

Short-term changes in self-reported condom use

Selection of HIV-infected and uninfected participants

Of 213 Ugandan and Zimbabwean women who became HIV infected during HC-HIV, 191 (90%) eventually participated in GS. A smaller proportion, 74% ($n = 158$) had a GS visit 2–6 months after HIV diagnosis and are included in the short-term comparison. For these 158 participants, the median time between the 'before' visit and the redraw visit was 3.3 months [interquartile range (IQR): 2.8–3.9 months], and the median time between the redraw visit and the 'after' visit was 2.7 months (IQR: 2.3–3.7 months). We observed no meaningful differences between characteristics of HIV-infected women choosing and declining to enrol in GS (data not shown).

From 4226 HC-HIV participants who remained HIV uninfected, 650 women were randomly selected for the short-term analysis. For these uninfected women, the median time between the 'before' visit and the anchor visit was 2.7 months (IQR: 2.6–2.8 months), and between the anchor visit and the 'after' visit was also 2.7 months (IQR: 2.6–2.9 months).

Because participant characteristics (Table 1), changes in frequencies of coitus and unprotected sex (Table 2), and results of multivariable models (Tables 3 and 4) for short-term comparisons were similar to long-term analyses, we describe only long-term findings in detail (below).

Long-term changes in self-reported condom use

Selection of HIV-infected and uninfected participants

Of 191 HIV-infected women who joined GS, 151 participants (79% of GS participants and 71% of HIV-infected HC-HIV participants) had a GS visit 12–16 months after HIV diagnosis. For these women, the median time between the 'before' visit and the redraw visit was 3.2 months (IQR: 2.7–3.7 months), and the median time between the redraw visit and the 'after' visit was 13.8 months (IQR: 13.1–14.3 months). Uninfected women ($n = 650$) for the long-term comparison were randomly selected from the 4226 HC-HIV participants who remained HIV-uninfected, independent of inclusion in the short-term analysis. The median time between the 'before' visit and the anchor visit for uninfected women in the long-term comparison was 2.7 months (IQR: 2.6–2.9 months), and between the anchor visit and 'after' visit was 13.5 months (IQR: 13.1–14.0 months).

Most HIV-infected women in the long-term analysis (91%, $n = 137$) were also included in the short-term analysis. Approximately one-third of uninfected participants (35%, $n = 225$) were common to both the short- and long-term analyses.

Participant characteristics

At the 'before' visit, women who ultimately became HIV infected were less likely than women remaining HIV negative to be from Uganda (36 vs 56%), although the proportion recruited from high-risk settings in Uganda was similar (11 vs 10%) (Table 1). Half of all participants were employed, and most (76–83%) lived with their primary partner. Mean age (25.0 vs 25.5 years), mean age at coital debut (17.5 years in both groups) and mean years of education (9.1 for both groups) were similar between participants who ultimately became HIV infected and those remaining uninfected. Alcohol or drug use during sex in the last 3 months was rare (3–4%), and commercial sex was also uncommon (1% in both groups). Women who became HIV infected were more likely than women remaining uninfected

Table 1 Selected participant characteristics reported 2–6 months before HIV diagnosis (HIV-infected women) or anchor visit (uninfected women)

	Short-term analysis		Long-term analysis	
Characteristic	HIV infected $n=158$[a]	HIV uninfected $n=650$[b] (%)	HIV infected $n=151$[a] (%)	HIV uninfected $n=650$[b] (%)
Country/referral population				
Uganda				
Family planning and MCH clinic	36 (23)	291 (45)	38 (25)	299 (46)
STD clinics, sex worker networks, military wives	18 (11)	59 (9)	16 (11)	62 (10)
Zimbabwe	104 (66)	300 (46)	97 (64)	289 (45)
Employed				
Yes	80 (51)	325 (50)	75 (50)	326 (50)
No	78 (49)	325 (50)	76 (50)	324 (50)
Cohabit with primary partner				
Yes	122 (77)	534 (82)	115 (76)	538 (83)
No	36 (23)	116 (18)	36 (24)	112 (17)
Alcohol or drug use during sex in last 3 months				
Yes	6 (4)	15 (2)	6 (4)	19 (3)
No	152 (96)	635 (98)	145 (96)	631 (97)
Current contraceptive method				
COC	43 (27)	234 (36)	45 (30)	218 (34)
DMPA	65 (41)	239 (37)	64 (42)	258 (40)
COC and DMPA	1 (1)	2 (0.3)	0 (0)	3 (1)
Non-hormonal method	49 (31)	175 (27)	42 (28)	171 (26)
Commercial sex in last 3 months				
Yes	2 (1)	5 (1)	2 (1)	5 (1)
No	156 (99)	645 (99)	149 (99)	645 (99)
Number of sex partners in last 3 months				
0 partners	6 (4)	12 (2)	7 (5)	4 (1)
1 partner	142 (90)	629 (97)	134 (89)	628 (97)
$\geqslant 2$ partners	10 (6)	9 (1)	10 (7)	18 (3)
	Mean (SD)	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**
Age (years)	24.9 (4.1)	25.6 (4.4)	25.0 (4.2)	25.5 (4.5)
Age at coital debut (years)	17.6 (2.2)	17.5 (2.5)	17.5 (2.2)	17.5 (2.7)
Education (years)	9.2 (2.5)	9.2 (3.0)	9.1 (2.5)	9.1 (3.1)
Partner nights away in last 30 days	8.3 (11.1)	6.8 (10.7)	8.0 (10.9)	6.7 (10.7)

[a]137 HIV-infected women are common to the short- and long-term analyses.
[b]225 HIV-uninfected women are common to both the short- and long-term analyses.
MCH = maternal-child health; STD = sexually transmitted disease; COC = combined oral contraceptive pills; DMPA = depot medroxyprogesterone acetate.

to report multiple partnerships in the last 3 months (7 vs 3%) and to have a higher mean number of nights in the last month that the partner spent away from home (8.0 vs 6.7 nights).

Changes in coital frequency and frequency of unprotected sex

We first examined changes in the number of HIV-infected and uninfected participants who reported any sex acts in a typical month. The number of women engaging in sex in both groups declined slightly. Before HIV diagnosis, 144 participants (95%) who ultimately became HIV infected reported at least one act in a typical month; 12–16 months after notification of HIV-positive status, 137 women (91%) reported at least one act in a typical month. Of uninfected women, 642 (99%) reported at least one act before the anchor visit, compared with 623 women (96%) who reported at

Table 2 Coital frequency of and condom use by HIV-infected and HIV-uninfected participants

	Short-term analysis		Long-term analysis	
Sexual behaviour	HIV positive *n* (%)	HIV negative *n* (%)	HIV positive *n* (%)	HIV negative *n* (%)
All women				
No sex acts[a]				
Before[b]	7 (4)	13 (2)	7 (5)	8 (1)
After[b]	15 (10)	20 (3)	14 (9)	27 (4)
⩾1 sex act[a]				
Before	151 (96)	637 (98)	144 (95)	642 (99)
After[b]	143 (91)	630 (97)	137 (91)	623 (96)
P-value[‡]	0.10			0.14
Among women with ⩾1 sex act[a,c]				
No unprotected acts[a]				
Before	42 (28)	142 (22)	37 (26)	156 (24)
After	63 (44)	117 (19)	60 (44)	134 (22)
⩾1 unprotected act[a]				
Before	109 (72)	495 (78)	107 (74)	486 (75)
After	80 (56)	513 (81)	77 (56)	489 (79)
P-value[‡]	<0.01			<0.01
	Mean (SD)	**Mean (SD)**	**Mean (SD)**	**Mean (SD)**
Among women with ⩾1 unprotected act[a]				
Total acts[a]				
Before	20.8 (58.7)	14.0 (10.2)	19.9 (59.2)	14.9 (12.3)
After	13.9 (21.1)	13.8 (9.6)	9.5 (7.2)	14.2 (11.9)
Unprotected acts[a]				
Before	11.9 (12.5)	11.7 (8.8)	11.2 (11.7)	11.8 (10.4)
After	8.7 (6.8)	11.5 (8.7)	7.0 (6.0)	12.0 (11.0)
Percentage of acts that are unprotected[a]				
Before	77.0 (30.4)	86.5 (25.2)	78.9 (29.5)	84.1 (27.7)
After	78.4 (31.7)	86.5 (25.5)	78.5 (29.8)	87.1 (25.0)

[a]In a typical month in the last 3 months.
[b]Before and after notification of HIV-positive status (HIV-infected women) or anchor visit (uninfected participants).
[c]Denominator for percentages is women with ⩾1 sex act.
[‡]*P*-values obtained using McNemar's test.

Table 3 ZINB models assessing changes in number of unprotected sex acts in a typical month following notification of HIV-positive status (HIV-infected participants) or randomly-assigned anchor visit (uninfected participants)

		Unadjusted				Adjusted[a]			
Analysis	**Population**	ZI OR: odds of zero UPSA	95% CI	Relative change in number of UPSA	95% CI	ZI OR: odds of zero UPSA	95% CI	Relative change in number of UPSA	95% CI
Short term	HIV positive	2.03	1.29–3.20	0.72	0.56–0.93	1.55	0.91–2.66	0.71	0.55–0.91
	HIV negative	0.77	0.63–0.94	0.98	0.91–1.06	0.77	0.63–0.95	0.98	0.91–1.06
Long term	HIV positive	2.19	1.28–3.74	0.60	0.44–0.81	1.99	1.12–3.53	0.62	0.45–0.84
	HIV negative	0.84	0.67–1.05	1.01	0.92–1.12	0.82	0.64–1.04	1.02	0.92–1.12

[a]All adjusted models control for age, country, recruitment population, prior STI during study and partner symptomatic of STI in past 3 months.
ZI = zero-inflated; OR = odds ratio; UPSA = unprotected sex acts; CI = confidence interval.

Table 4 ZINB models assessing changes in proportion of unprotected sex acts in a typical month following notification of HIV-positive status (HIV-infected participants) or randomly-assigned anchor visit (uninfected participants)

		Unadjusted				Adjusted[a]			
Analysis	Population	ZI OR: odds of zero UPSA	95% CI	Relative change in proportion of UPSA	95% CI	ZI OR: odds of zero UPSA	95% CI	Relative change in proportion of UPSA	95% CI
Short term	HIV positive	2.11	1.31–3.39	0.98	0.86–1.12	1.66	0.95–2.91	0.96	0.83–1.12
	HIV negative	0.74	0.60–0.90	0.99	0.96–1.02	0.73	0.59–0.90	1.00	0.97–1.03
Long term	HIV positive	2.32	1.38–3.90	0.96	0.85–1.10	2.17	1.23–3.83	0.93	0.82–1.06
	HIV negative	0.83	0.67–1.04	1.04	1.00–1.08	0.82	0.65–1.04	1.05	1.01–1.09

[a]All adjusted models control for age, country, recruitment population, prior STI during study and partner symptomatic of STI in past 3 months.
ZI = zero-inflated; OR = odds ratio; UPSA = unprotected sex act; CI = confidence interval.

least one act 12–16 months after the anchor visit (Table 2).

We next examined whether the number of women reporting any unprotected acts changed after testing. Among HIV-infected women reporting at least one act, the number who had at least one unprotected act in a typical month declined substantially: before notification of HIV-positive status, 107 participants (74%) who ultimately became HIV infected reported at least one unprotected act in a typical month; after HIV diagnosis, 77 women (56%) reported at least one unprotected act in a typical month. Uninfected women showed little change: among those with at least one act, 486 (75%) before the anchor visit, compared with 489 women (79%) after the anchor visit, reported at least one unprotected act in a typical month (Table 2).

Among the subgroup reporting at least one unprotected act in a typical month, we next examined changes to the mean total number of acts, the mean number of unprotected acts, and the proportion of acts where condoms were not used in a typical month (Table 2). HIV-infected women again showed marked declines in their overall mean coital frequency, but less substantial changes in the mean number of unprotected acts and virtually no change in the proportion of acts where condoms were used. Before HIV diagnosis, HIV-infected women reporting at least one unprotected act had a mean of 19.9 total acts and 11.2 unprotected acts in a typical month; they reported that condoms were not used in 79% of acts. After diagnosis, HIV-infected women with at least one unprotected act reported means of 9.5 total acts and 7.0 unprotected acts in a typical month; the proportion of acts where condoms were not used was again 79%. In contrast, HIV-negative women with at least one unprotected act reported a mean of 14.9 total acts and 11.8 unprotected acts before the anchor visit: very similar to the 14.2 mean total acts and 11.0 mean unprotected acts reported after the anchor visit (Table 2). The proportion of acts where condoms were not used among uninfected women was 84% prior to the anchor visit and 87% afterwards.

Among women reporting at least one unprotected act in a typical month at the 'before' visit, women who ultimately became HIV infected did not differ meaningfully from women who remained uninfected in their mean number of unprotected acts (11.2 vs 11.8 acts) or the mean proportion of unprotected acts (79 vs 84% unprotected).

Multivariable long-term models

Long-term changes in the number of unprotected sex acts

In unadjusted analyses, HIV-positive women were twice as likely to report that all sex acts were protected by condoms (in other words, zero acts were unprotected) in a typical month after HIV diagnosis compared with their pre-diagnosis visit (OR: 2.19, 95% CI: 1.28, 3.74). Uninfected women had somewhat lower odds of reporting that all acts in a typical month were protected by condoms 12–16 months after their anchor visit (OR: 0.84, 95% CI: 0.67, 1.05) compared with 2–6 months before the anchor visit (Table 3).

HIV-infected women also had a 40% reduction (95% CI: −19 to −56%) in the number of unprotected acts in a typical month 12–16 months after notification of HIV-positive status compared with the pre-diagnosis period. Uninfected women did not change their number of unprotected acts in a typical month (1% increase, 95% CI: −8 to +12%) following their anchor visit.

We refit our models after adjusting for variables that confounded associations with condom use (age, country, recruitment population, prior STI during the study and partner symptomatic of STI in the past 3 months). Adjusted measures of effect were similar to unadjusted estimates (Table 3).

Long-term changes in the proportion of unprotected sex acts

Inclusion of an offset variable for the total number of acts did not have a large influence on the logistic portion of the unadjusted or adjusted models, but the NB portion of the models was affected (Table 4).

After diagnosis, HIV-infected women had virtually no reduction in the proportion of acts where condoms were not used (4% reduction, 95% CI: −15 to +10%). Uninfected women similarly had no meaningful change (4% increase, 95% CI: 0 to +8%). Adjustment for confounding variables did not substantially alter the proportion of acts where condoms were not used for HIV-infected or uninfected women (Table 4).

Discussion

In this analysis, women who were notified that they were HIV infected modified their behaviour. Although most did not abstain altogether from coitus, HIV-infected participants were more likely to report that all acts were protected by condoms, and they reduced their absolute number of unprotected acts. However, the proportion of acts where condoms were not used was nearly unchanged and, ultimately, more than half of HIV-positive women still reported some unprotected sex a year after diagnosis. In contrast, women who remained HIV uninfected exhibited few changes over equivalent follow-up periods. These findings are in agreement with the one existing publication (to our knowledge) that compares African women's condom use from the period prior to, and following, notification of HIV status. That study documented that women testing positive for HIV reported increased consistent condom use within their primary partnerships 3 years later, but that women who tested negative did not significantly change their condom use behaviour.[6]

From a public health perspective, a reduction in the number of unprotected acts is more important than an increase in the proportion of acts where condoms were used (unless, of course, the proportion where condoms were used reaches 100%). Sexual transmission of HIV occurs through an act of unprotected sex. Whether that act is a large or small proportion of all acts is less relevant. Because HIV-infected women in this cohort markedly reduced their number of unprotected acts, susceptible partners of HIV-infected women likely faced reduced HIV risk.

The decline in number of unprotected acts among HIV-infected women may be due to factors other than intentional risk-reduction behaviour change. The visit 2–6 months prior to HIV diagnosis (the 'before' visit) occurred around the time of HIV acquisition, when women may have engaged in behaviour that was riskier than their normal behaviour. Apparent reductions in risk following notification of HIV infection may simply be a return to more typical behaviour. In addition, women who disclosed HIV status to their partners may have experienced relationship dissolution and consequent reductions in overall coital frequency and numbers of unprotected acts (we unfortunately did not collect data on disclosure to partners).

Our analysis has a number of strengths. Because we systematically captured women's condom use prior to diagnosis, our measure was not biased by women's knowledge of their status or the presence of symptoms that may have prompted them to modify condom use. Secondly, much of the research examining behaviour change after HIV acquisition has been conducted among specialized, high-risk populations (e.g. sex workers or truckers). HC-HIV had a small proportion of participants (9–11%) recruited from STD clinics, including some sex workers. However, our focus on general population women makes the results more generalizable to African women from the general population, at whom HIV-prevention interventions are currently targeted. Finally, earlier studies tracking changes in condom use typically assessed intervention effectiveness for $\leqslant 3$ months. Our long-term analysis demonstrates that behaviour changes may be sustained >1 year after testing positive.

Our analyses also suffer from several limitations. Most importantly, the number of unprotected acts was self reported and may have been influenced by recall and social desirability biases. Because misreporting could be differential by HIV status, the resulting bias could lead to inflated or attenuated effect estimates. Secondly, we do not know which participants had HIV-infected partners. If women knew that their partners were already HIV positive, they would likely lack incentive to reduce unprotected sex upon learning of their own positive status. Thirdly, we did not analyse sexual behaviour data separately by partner type (primary vs non-primary). Few women had multiple partners—at the 'before' visit, 6–7% of women ultimately becoming HIV-infected and 1–3% of participants remaining uninfected—and we expect any bias to be minimal.

Finally, our measures capture the short- and long-term impact of being diagnosed with HIV in the limited context of repeat counselling and provision of condoms. All women, regardless of HIV status, received similar counselling messages and access to free condoms. We therefore believe that the behaviour changes in HIV-positive women are motivated more from knowledge of HIV-positive status than just ongoing counselling, but we acknowledge that the long-term durability of those changes could be due in part to the ongoing counselling. (In addition, we cannot make a general statement about the number of counselling sessions; some women had participated in HC-HIV for >1 year prior to their diagnosis or anchor visit, and others had been in the study for only 3 months). For HIV-negative women, identifying the long-term effect of a single test is difficult because these women continued to be tested (and undergo counselling, and receive condoms) every 3 months. Despite this limitation, comparing behaviour changes over time in women remaining HIV negative was critical because it allowed us to

evaluate secular trends that may have occurred over the course of the study period.

Given that these analyses were conducted on data collected during a study of hormonal contraceptive use, the effect of contraceptive decisions on changes in condom use is important to consider: could condom use have increased after HIV diagnosis as a contraceptive choice, or did some women start using more effective hormonal contraception after HIV diagnosis and therefore stop using condoms? In fact, the primary change seen in HIV-infected women was not an increase in condom use but rather a reduction in both the overall number of sex acts and in the number of unprotected acts. In separate analyses currently under review (data not shown), among women not using hormonal methods just before HIV diagnosis, few women starting using hormonal methods after they received an HIV-positive diagnosis.

We undertook these analyses to explore a fundamental assumption in HIV prevention interventions—that provision of counselling and condom supplies can induce individuals to reduce their risk behaviour. Through both reductions in the number of women engaging in unprotected sex and through declines in overall coital frequency, HIV-infected Ugandan and Zimbabwean women in this cohort reduced the risk of HIV transmission to susceptible partners and sustained these behaviour changes >1 year after HIV diagnosis. The lack of behaviour change among uninfected women suggests that repeated risk reduction counselling and free condoms are not sufficient to reduce unprotected sex in this group. However, because women remaining HIV negative also did not increase their risk taking with regard to condom use, our findings do not support the concern that a negative HIV result may be perceived as an endorsement of risky behaviour.

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KEY MESSAGES

- Women in Zimbabwe and Uganda, more than a year after learning they were HIV infected, successfully adopted risk-reduction prevention strategies including reducing their reported number of unprotected sex acts (compared with their own pre-test behaviour).
- Women who learned that they were HIV negative adopted no substantial changes in the number of unprotected acts compared with their pre-test behaviour.
- In a study setting that included comprehensive condom counselling and provision of male condoms, behavioural changes following HIV testing were seen only in women who tested positive.

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