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How do HIV-negative individuals in sub-Saharan Africa change their sexual risk behaviour upon learning their serostatus? A systematic review

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ABSTRACT

Objective To determine whether, and how, sexual behaviour of HIV-negative individuals in sub-Saharan Africa (SSA) changes upon learning their serostatus.

Methods We systematically reviewed the published literature using EMBASE and Medline to search for publications between 2004 and 2014. We included studies that quantified behaviour change (condom use, number of sexual partners or sex acts) following an HIV test in HIV-negative adults in SSA, and extracted relevant data including study characteristics and measurement type.

Results From 2185 unique citations, n=14 studies representing 22 390 participants met our inclusion criteria. We did not pool data due to marked heterogeneity in study outcome measures. The proportion of participants reporting consistent condom use (n=6) post-testing ranged from 7.6% greater, to 10.6% fewer, while 'no condom use' (n=5) ranged from 40.0% less, to 0.7% more. Condom use in serodiscordant couples increased (n=3). Five studies measured the proportion reporting abstinence, finding an increase of 10.9% to a decrease of 5.3% post-testing. The post-testing change in the mean number of sex acts (n=3) ranged from a relative decrease of 15.7% to a relative increase of 9.4%. Two studies reported relative decreases in the mean number of sexual partners of 35.2% and 14.0%. Three studies examining serodiscordant primary relationships specifically all showed increases in extrarelational sex.

Conclusions With the exception of serodiscordant couples, there is variable evidence that awareness of one's serostatus leads to substantial changes in risk behaviour among HIV-negative individuals. Further research is needed to estimate the behavioural impact of learning one's serostatus in SSA.

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INTRODUCTION

Behavioural interventions remain important for HIV prevention in sub-Saharan Africa (SSA)—a region accounting for 70% of HIV cases worldwide.[1] HIV testing offers an opportunity to promote safer sexual behaviour through counselling. The potential for antiretroviral therapy (ART) to reduce transmission[2] has led to intensifying of HIV testing efforts,[3] with a focus on positive prevention[4] where HIV-positive individuals are targeted for prevention efforts. However, it remains important to understand behavioural changes after individuals receive an HIV-negative test result.

Mathematical models suggest that universal testing and treatment, where all are offered HIV testing and counselling with immediate ART for those with HIV, could substantially reduce HIV incidence.[5–9] However, these models rarely include potential behaviour changes of HIV-negative individuals post-testing,[5–7] and when they do the parameter inputs are either assumed,[9] or are based on a few studies conducted before 2000.[8] As more people become aware of their serostatus, it is important to understand how the awareness and associated counselling impact the larger HIV-negative population.

Three systematic reviews have previously examined the impact of voluntary counselling and testing (VCT) on the sexual behaviours of clinic attendees in low-income and middle-income countries.[10–12] Two estimated outcomes by serostatus, finding that the effects (change in condom use; number of sexual partners) were not statistically significant when restricted to HIV-negative persons.[11 12] When considering HIV-positive and HIV-negative individuals jointly, all three studies found that VCT positively influences risk behaviour, including increased condom use[10–12] and reduced number of sexual partners.[11 12] The reviews were all restricted to data collected between 1990 and 2005–2006[10 11] or 2010.[12] To our knowledge, there have been no systematic reviews focused on HIV-negative populations in SSA in the era following the scale-up of HIV testing and ART, which began in 2003.[13] Changes in HIV test delivery (such as opt-out systems), improved on-treatment survival among HIV-positive individuals, and increases in HIV awareness and knowledge all occurred around this time, and may have influenced how individuals perceived HIV severity and responded to HIV-negative test results.

We sought to determine how the sexual behaviour of HIV-negative individuals in SSA changes after learning their serostatus in this period after ART roll-out (post-2003).

METHODS

Study selection

We systematically reviewed the peer-reviewed, published literature according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines.[14] We searched two electronic databases using the search terms detailed in the online supplementary material: EMBASE and Medline for articles published between 1 January 2004 and 8 November 2014, with no language restrictions. Reference lists of included studies were not screened to identify further data.

After screening titles and abstracts, we performed a full-text review of remaining articles. The

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screening and full-text review were conducted by two independent reviewers (SR and NC), with arbitration in case of disagreement (MP). We contacted authors for clarifications when consensus could not be reached after full-text review, or when appropriate data on pre-test and post-test behaviour was present but not stratified by serostatus.

The inclusion criteria were as follows: (1) studies conducted in SSA as defined by the United Nations Statistics Division;[15] (2) participants enrolled after 1 January 2003; (3) serostatus defined by documented HIV test result (not self-report); (4) participants ≥15 years of age; (5) quantitative measurement on at least one behavioural outcome collected before and after HIV testing. Thus, inclusion criteria were restricted to 'pre/post', serial cross-sectional, prospective cohort and time series studies. During screening and full-text review, a study was excluded once it met any exclusion criterion. The exclusion criteria were always applied in the order given in the online supplementary material. Studies focused exclusively on persons who inject drugs were excluded.

Types of outcome

Outcomes were divided into three domains: condom use, number of sexual partners and number of sex acts (see online supplementary material for more detail). In the later two domains, zero partners or zero sex acts were defined as abstinence.

We give a descriptive analysis of the outcomes, and report the absolute change in outcomes between baseline and follow-up unless otherwise stated. In studies reporting outcomes over multiple follow-up periods, we report the latest recorded outcome to represent longer-term changes. Data over other periods are reported in the online supplementary material. The number of studies is indicated by n. We did not pool outcomes due to the marked heterogeneity in study outcome measures, particularly in the follow-up period and study populations.

We evaluated four types of potential bias in the primary studies: sampling bias, social desirability bias, recall bias and attrition bias. For each study, we assigned a qualitative assessment of whether it was at risk of bias for the outcome of interest, based on literature.[16–18] Details are provided in the online supplementary material.

RESULTS

Of 2185 unique records, we excluded 1960 by abstract/title screening, and 210 by full-text review (see online supplementary figure S1). Fourteen studies met inclusion criteria, and provided outcomes on 22 390 HIV-negative adults in SSA.

Description of studies

Table 1 describes the characteristics of included studies. Settings included southern and eastern Africa, primarily Uganda,[19–26] South Africa[23 27–30] and Tanzania.[23 28 30] Five studies covered multiple countries.[23 25 28–30] The recruitment setting was community-based (n=5),[19 22 24 28 30] clinic-based (n=3),[20 21 27] a combination of community-based and clinic-based (n=5)[23 25 26 29 31] and workplace-based in one study.[32] The majority of studies were prospective cohorts (n=9),[20 21 23 24 26–28 31 32] while the remainder were randomised controlled trials (n=5).[19 22 25 29 30]

In seven studies, the primary purpose was to evaluate changes in sexual behaviour following HIV testing.[20 23–25 27 31 32] Participants in all 14 studies underwent either individual[19 20 22 24 26–32] or couples[21] counselling, or a combination of both.[23 25] Of studies specifying whether counselling was pre-testing or post-testing, two used post-test counselling only,[20 32] while two used both.[25 29]

Description of participants

Six studies recruited sexually active adults from the general population[19 22 28–31] (one recruited half the sample from bar and hotel workers, regarded as higher risk individuals[28]), four evaluated HIV-negative partners in serodiscordant relationships,[21 23 25 26] one focused on STI clinic attendees,[27] one on general outpatients,[20] one on employees[32] and one on non-spousal household members of those initiating ART.[24] No study specifically enrolled key populations, aside from seronegative partners in serodiscordant partnerships, or reported data by risk factors such as formal sex work. The minimum age of recruitment ranged from 15[19 22] to 18 years. Five studies did not set a maximum age limit,[20 23 27 28 32] while in those that did it varied from 35[31] to 69[24] years.

One largely unexplored issue is participants' prior testing history. Only three studies in this review reported how many participants had received prior VCT.[19 20 22]

Risk of potential bias

The majority of studies used face-to-face interviews, so were judged to be at risk of social desirability bias (n=12). The rest used audio-computer-assisted structured interview[27] and computer-assisted personal interview[20] to ascertain self-reported behavioural data, reflecting reduced risk of social desirability bias. All studies were at risk of sampling bias, due to the use of convenience sampling or recruitment from specific locations such as clinics. Nine studies were at risk of recall bias,[19–22 24 26 29 31 32] while only one study[24] was deemed at risk of attrition bias. A full list of the potential biases of each study is given in table 1. Six studies were at higher risk of confounding as the primary study outcome was not to measure changes in behaviour post-testing. All studies were at risk of temporal confounding, owing to the pre-post design used.

HIV testing and condom use

Thirteen studies presented data on condom use (table 2; additional time-points in online supplementary table S1).

Six studies measured consistent condom use, reporting one of 'always/100% using a condom',[20 21 28] 'consistent condom use'[19 22] and 'no unprotected sex'.[32] Baseline levels of consistent condom use were low (eg, 0.3%–33.7% reported consistent condom use in the last year, n=3). The post-testing change in the proportion of participants reporting consistent condom use ranged from 7.6% greater,[20] to 10.6% fewer[21] (median across studies: decrease of 0.2%; 2/6 studies showed an increase).

Between baseline and follow-up, the change in the proportion of participants reporting 'no condom use' ranged from 40.0% less[21] to 0.7% more[28] (median: decrease by 2.2%, 4/5 studies showed a decrease). Two studies found decreases of 19.8%[20] and 16.6%,[24] respectively in the proportion of participants engaging in condomless sex with an HIV-positive partner or a partner whose HIV status was unknown. In the proportion of participants not using a condom at last sex increased by 8% in the intervention arm, but decreased by 15% in the control arm.[29]

Four studies measured unprotected sex acts.[20 26 27 30] Two reported absolute reductions of 23.0%[27] to increase of 0.8%.[20] A third reported a 24.2% relative decrease in the number of unprotected sex acts[30] after testing. The condom use was assessed through a 'sexual behaviour score',[26] approximating the likelihood of HIV acquisition using the frequencies of

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Table 1 Characteristics of studies included for qualitative synthesis

Study	Data			Was behaviour primary purpose?	Study design	Geographic setting	Study population characteristics	Age range and gender	Potential biases*
	Condom use	No. of partners	Sex acts						
Gray *et al*[19]	Y	Y		No	RCT	Rakai, Uganda (R)	General population	15–49, male	SD, sampling, recall
Kiene *et al*[20]	Y	N		Yes	Prospective cohort	Mpigi District, Uganda (R)	Outpatients	18+, male and female	Sampling, recall
Ruzagira *et al*[21]	Y	Y		No	Prospective cohort	Masaka, Uganda (R)	HIV partners in serodiscordant relationships	18–60, male and female	SD, sampling, recall
Wawer *et al*[22]	Y	Y		No	RCT	Rakai, Uganda (R)	General population	15–49, female	SD, sampling, recall
Ndase *et al*[23]	N	Y		Yes	Prospective cohort	Botswana, Kenya, Rwanda, SA, Tanzania, Uganda and Zambia (14 sites)	HIV partners in serodiscordant relationships	18+, male and female	SD, sampling
Bechange *et al*[24]	Y	N		Yes	Prospective cohort	Tororo and Busia districts, Uganda (R)	Non-spousal household members of those commencing ART†	18–69, male and female	SD, sampling, recall, attrition
Mugwanya *et al*[25]	Y	N		Yes	RCT	Kenya: Eldoret, Kisumu, Nairobi and Thika (U) Uganda: Jinja, Kabwohe, Kampala, Mbale, Tororo (U)	HIV partners in serodiscordant relationships	18–65, male and female	SD, sampling
Ritchie *et al*[26]	Y	N		Yes	Prospective cohort	Entebbe, Uganda (U)	HIV partners in serodiscordant and seroconcordant relationships	18+, male and female	SD, sampling, recall
Kalichman *et al*[27]	Y	Y		Yes	Prospective cohort	Cape Town, SA (U)	STI clinic attendees	Unspecified, male and female	Sampling
Ramjee *et al*[28]	Y	Y		No	Prospective cohort	Durban, SA (U); Hlabisa, SA (R); Lusaka, Zambia (U); Moshi, Tanzania (U+R)	Sexually active women, largely from general population	Tanzania and Zambia: 16+, female SA: 18+, female	SD, sampling
Padian *et al*[29]	Y	N		No	RCT	Durban, SA (U); Johannesburg, SA (U); Harare, Zimbabwe (U)	Sexually active women from general population	18–49, female	SD, sampling, recall
Van Damme *et al*[30]	Y	Y		No	RCT	Bondo, Kenya (U); Pretoria, SA (U); Bloemfontein, SA (U); Arusha, Tanzania (U)	High risk‡ members from general population	18–35, female	SD, sampling
Djomand *et al*[31]	Y	Y		Yes	Prospective cohort	Gaborone, Botswana (U)	High risk§ heterosexual men and women	18–35, male and female	SD, sampling, recall
Matambo *et al*[32]	Y	N		Yes	Prospective cohort	Harare, Zimbabwe (U)	Employees	Unspecified, mostly male	SD, sampling, recall

*Biases refer to biases in our outcomes of interest, not necessarily the primary purpose of the given study.
†Non-spousal household member includes any individual aged 18–69 living in the household, except the spouse of the individual receiving ART.
‡High risk defined as "one or more vaginal sex acts in the previous 2 weeks or more than one sex partner in the previous month".
§High risk defined as police officers.
ART, antiretroviral therapy; R, rural; RCT, randomised controlled trial; SA, South Africa; SD, social desirability; U, urban.

different types of unprotected sex acts. It found that HIV-negative persons in serodiscordant and seroconcordant relationships underwent relative decreases in their scores of 100% and 25%, respectively (representing increased condom use and/or reduced sexual activity).

With respect to population-specific findings, three studies assessed the general population recruited from the community. Two found negligible changes (≤1%) in consistent or zero condom use after testing,[22 28] while the third saw an overall decrease of 3.0% in consistent condom use[19] post-testing. Two studies examined condom use in serodiscordant partnerships. One found a reduction in consistent condom use of 10.6% but 40.0% more people reported using condoms at least once (ie, reduction in zero condom use),[21] while the second, a randomised controlled trial examining behaviour change post-testing in the context of HIV pre-exposure prophylaxis, found an 18%

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Table 2 Summary of results for studies assessing condom use before and after testing for HIV

Study	Condom outcome measure	Sample size	Baseline value of outcome	Absolute change after testing	Follow-up time (months)	p Value
Consistent condom use						
Gray *et al*[19]	Consistent use in last year	2474 (circumcised) 2522 (uncircumcised)	32.6% 33.7%	3.1% decrease 3.0% decrease	24	NR
Ruzagira *et al*[21]	Always used in last year	495	16.4%	10.6% decrease	24	NR
Wawer *et al*[22]	Consistent use in last year	648 (with circumcised partners) 597 (with uncircumcised partners)	0.3% 0.8%	0.8% increase 0.2% decrease	24	NR
Kiene *et al*[20]	100% use with risky partner* in last 3 months	131 (risky participants)	NR	7.6% increase	3	NR
Ramjee *et al*[28]	100% use in last week	958	49.2%	0.1% decrease	12	NR
Matambo *et al*[32]	No unprotected sex in last 3 months	388	17.5%	0.2% decrease	3	0.84
No condom use						
Gray *et al*[19]	Not used in last year	2474 (circumcised) 2522 (uncircumcised)	39.5% 37.3%	3.1% decrease 1.2% decrease	24	NR
Ruzagira *et al*[21]	Not used in last year	495	40.0%	40.0% decrease	24	NR
Wawer *et al*[22]	Not used in last year	648 (with circumcised partners) 597 (with uncircumcised partners)	85.5% 81.2%	1.0% decrease 2.8% decrease	24	NR
Ramjee *et al*[28]	Not used in last week	958	45.4%	0.7% increase	12	NR
Padian *et al*[29]	% did not use condoms at any time in last 3 months	2523 (intervention†) 2522 (control†)	30% 30%	19% decrease 25% decrease	24	<0.0001 <0.0001
Unprotected sex						
Bechange *et al*[24]	% reporting risky sex in last 3 months‡	236 (sexually active)	30.9%	16.6% decrease	24	NR
Mugwanya *et al*[25] §	% reporting unprotected sex with HIV+partner in last month	4747 (taking pre-exposure prophylaxis)	27.3%	18% decrease	24	NR
Djomand *et al*[31]	% reporting unprotected sex in last 6 months	64 (males) 33 (females)	66.7% 60.6%	10.0% decrease 17.1% decrease	12	NR
Padian *et al*[29]	% did not use condom at last sex	2523 (intervention†) 2522 (control†)	32% 33%	8% increase 15% decrease	24	NR NR
Measures of unprotected acts						
Kiene *et al*[20]	% of risky acts* that were unprotected in the last 3 months	213	93.1%	0.8% increase		
Kalichman *et al*[27]	% of acts for which condoms not used in last 30 days	29 (seroconverted after initial −ve test) 77 (persistently HIV−)	33.1% 33.3%	24.0% decrease 22.6% decrease	12	<0.01 <0.01
Van Damme *et al*[30]	Number of sex acts without condom in past week	2120	1.9 acts	Relative decrease by 24.2%	12	<0.001
Ritchie *et al*[26]	Median sexual behaviour score¶	72 (serodiscordant) 28 (seroconcordant)	0.0085 0.024	Relative decrease of 100.0% Relative decrease of 25.0%	9	NR

Baseline percentages are calculated as the percentage of people reporting a given outcome. Changes after testing represent absolute changes unless explicitly reported as relative.
*Kiene *et al*[20] risky sex is sex with a partner who is HIV-positive or of unknown serostatus.
†In Padian *et al*[29] intervention participants received a diaphragm, lubricant and male condoms, while control arm participants received only male condoms.
‡Bechange *et al*[24] defined risky sex as "risky sex as intercourse with inconsistent condom use with an HIV-infected partner or a partner of unknown serostatus during the prior 3 months".
§Additional data obtained from Baeten *et al*.[39]
¶Ritchie *et al* define a sexual behaviour score by the number of different types of unprotected sex acts over the last 3 months weighted by the likelihood of HIV acquisition by the given type of sex act. Note that, unlike in Gray *et al*[19] and Ramjee *et al*[28] we include individuals reporting no sexual activity as having 100% condom use.
NR, not reported.

decrease in reported unprotected sex.[25] Among individuals in serodiscordant partnerships,[26] the 'sexual behaviour score' decreased to zero, meaning no unprotected sex acts were reported post-testing.

With the exception of the two studies among serodiscordant couples, overall there was no pattern observed between the direction of condom use and study factors such as sample size, risk of bias, study population characteristics, purpose of study, provision of free condoms during HIV testing and the nature or number of risk reduction counselling sessions involved. This was assessed through counting the proportion of positive outcomes. In all studies reporting multiple follow-ups, post-test condom use appeared stable over different lengths of follow-up[19 22 24 25 29 31] (see online supplementary material).

HIV testing and number of sex partners

The effects of HIV testing on the number of sex partners were variable (n=8, table 3; additional time-points in online

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Table 3 Summary of results for studies assessing number of partners before and after testing for HIV

Study	Outcome measure	Sample size	Baseline value of outcome	Change after testing	Follow-up time (months)	p Value
Multiple partnerships and concurrency						
Gray *et al*[19]	2+ partners in last year	2474 (circumcised) 2522 (uncircumcised)	34.5% 34.1%	1.0% increase 1.3% increase	24	NR
Wawer *et al*[22]	2+ partners in last year	648 (with circumcised partners) 597 (with uncircumcised partners)	3.5% 3.7%	0.1% decrease 0.9% increase	24	NR
Ramjee *et al*[28]	2+ partners in last 3 months	958	1.7%	1.0% decrease	12	NR
Djomand *et al*[31]	2+ partners in last 6 months 4+ partners in last 6 months	33 (females) 64 (males)	66.7% 21.9%	58.0% decrease 16.9% decrease	12	NR
Ndase *et al*[23]	Concurrency in last month	2284 (males) 1097 (females)	4.1% 0.5%	2.6% increase No change	24	NR NR
	Sex with outside partner in last month	2284 (males) 1097 (females)	4.3% 0.5%	14.8% increase 3.5% increase		<0.001 <0.001
Ruzagira *et al*[21]	Extramarital sex in last year	495	35.7%	8.3% increase	24	NR
Monogamy or no partners						
Ndase *et al*[23]	Sex with HIV+ primary partner only	2284 (males) 1097 (females)	90.1% 91.6%	23.8% decrease 18.1% decrease	24	NR NR
Gray *et al*[19]	No partners in last year	2474 (circumcised) 2522 (uncircumcised)	18.9% 19.6%	5.5% decrease 5.0% decrease	24	NR
Wawer *et al*[22]	No partners in last year	648 (with circumcised partners) 597 (with uncircumcised partners)	0.0% 0.3%	0.5% increase 0.1% decrease	24	NR
Ramjee *et al*[28]	No partners in last 3 months	958	0.0%	5.9% increase	12	<0.01
Number of partners						
Kalichman *et al*[27]	Mean number of partners in last 30 days	29 (seroconverters) 77 (persistently HIV-negative)	2.2 1.7	Relative decrease by 59.1% Relative decrease by 23.5%	12	<0.01
Van Damme *et al*[30]	Number of partners in past week	2120	1.0	Relative decrease of 14%	12	<0.001

Baseline percentages are calculated as the percentage of people reporting a given outcome. Changes after testing represent absolute changes unless explicitly reported as relative.
NR, not reported.

supplement table S2). Four of eight studies noted decreases in partner numbers, and two reported more partners after HIV testing. One found changes of <1% for all outcomes.[22] As with studies of condom use, there was no discernible pattern underlying the variability.

In the two studies reporting mean number of sexual partners, both found statistically significant relative decreases of 35.2%[27] and 14.0%.[30] Four studies assessed changes in the proportion of participants with more than one current partner. Three studies found a decrease of 1.0% to an increase of 1.1%,[19 22 28] but two of them had few participants reporting multiple partners at baseline (3.6%[22] and 1.7%[28]). The fourth recorded a large decrease of 58.0% in the proportion of women reporting two or more partners a year after testing.[31]

Three studies measured the proportion of participants reporting no partners,[19 22 28] finding an increase of 5.9%[28] to a decrease of 5.3%[19] post-testing, while the third found all changes <1%.[22]

Studies of the general population recruited from the community also demonstrated variability. One study found negligible changes in the number of partners after testing (all changes <1%, p value not reported).[22] Another found a statistically significant trend towards individuals reporting no partners (5.9% increase, p<0.01).[28] The third study found changes in number of partners (5.3% decrease in those reporting no partners and 1.1% increase in those reporting 2 or more partners post-testing).[19]

Four studies examined sexual partnerships outside the primary relationship.[19 21–23] Two found that 16.1%[19] fewer to 1.2%[22] more participants reported extramarital sexual partnerships post-testing compared with baseline. The remaining two studies examined serodiscordant primary relationships specifically.[21] and found an increase of 8.3% in extramarital relationships post-testing.[23] noted significant increases in those reporting sexual partners outside their primary relationship in the last month, from 3.1% at baseline to 13.9% after 24 months follow-up (p<0.001), with this increase mirrored by a steady decline throughout the quarterly follow-ups in the proportion of those reporting sex with their HIV-positive primary partner in the last month, possibly suggesting partner switching.[23]

HIV testing and number of sex acts

Five studies reported outcomes related to the number of sex acts (table 4; additional time-points in online supplementary table S3).[20 23 25 28 30] Three studies reported on changes in individuals reporting no sex acts: two reported increases in individuals reporting no sex acts from 7.6% to 10.9%,[20 23] while a third study reported a 7.1% reduction in individuals reporting sexual activity in the past week.[28] Three studies reported on the post-testing change in the mean number of sex acts,[20 25 30] which ranged from a relative decrease of 15.7%[30] to a relative increase of 9.4%[20] (increase in 2/3 studies).

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Table 4 Summary of results for studies assessing frequency of sex acts before and after testing for HIV

Study	Outcome measure	Sample size	Baseline value of outcome	Change after testing	Follow-up time (months)	p Value
Had sex/was abstinent						
Ramjee *et al*[28]	Had vaginal sex in last week	958	70.9%	7.1% decrease	12	NR
Kiene *et al*[20]	Became abstinent*	131 (risky participants only)	NR	7.6% increase	3	NR
Ndase *et al*[23]	No sex in last month	2284 (males)	5.6%	9.1% increase	24	NR
	No sex in last month	1097 (females)	7.9%	14.6% increase		
Number of sex acts						
Kiene *et al*[20]	Mean number of sex acts in last 3 months	213 (all participants)	18.1	Relative increase by 9.4%	3	NR
Van Damme *et al*[30]	Number of vaginal sex acts in past week	2120	3.7	Relative decrease of 15.7%	12	<0.001
Mugwanya *et al*[25]	Average number of sex acts per month with HIV+ partner	3024	4.14	Relative decrease of 12.8%	24	0.4 (over time)
	Average of number of sex acts per month outside primary relationship		0.67	Relative increase of 25.4%		0.006 (over time)

Baseline percentages are calculated as the percentage of people reporting a given outcome. Changes after testing represent absolute changes unless explicitly reported as relative.
*No timescale specified for abstinence.
NR, not reported.

Of the above studies, one examined the general population recruited from the community, and found reduced vaginal intercourse (7.1% decrease, p value not reported).[28] One study looked at changes in serodiscordant partnerships, measuring the average frequency of sex acts before and after trial participants found out if they were assigned to oral pre-exposure prophylaxis or placebo in the Partners PrEP study. It found that after unblinding the frequency of sex acts with the main HIV-positive partner decreased non-significantly, accompanied by a 25.4% relative increase in the frequency of sexual acts with another partner.[25] Using a segmented regression model this increase was not significant immediately post-unblinding, but the change over time was significant (p=0.006).

DISCUSSION

Fourteen primary studies carried out in SSA measured various sexual risk behaviour outcomes before and after HIV testing. Findings suggest that awareness of one's serostatus does not increase consistent condom use, but there were increases in the proportion of acts protected by a condom. Furthermore, in 3/4 studies there were increases in the proportion ever using a condom, suggesting that awareness of one's serostatus can shift HIV-negative individuals who never use condoms to start using them, although inconsistently. Condom use in serodiscordant partnerships generally increased: 2/3 studies reported reduced risky sex, while in the third there was an increase in the proportion ever using a condom, although consistent condom use declined. While overall there was variability in the effects of HIV testing on the number of sex partners or sex acts among HIV-negative individuals, there was an increase in individuals reporting no sex acts in 3/3 studies, and 2/3 studies reported increases in individuals reporting no sexual partners. Two studies saw significant decreases in the mean number of reported sexual partners. While a few studies reported large changes, the effect sizes observed were generally moderate. There was also little evidence of consistently increased risk behaviour following a negative HIV test, which may thus be reinforcing past behaviours and not increasing risk. In general, we could not identify any factors predicting behaviour modification. However, a notable exception was seen in HIV-negative partners in serodiscordant relationships, who appear to engage in more extrarelational sex after testing and counselling in studies examining this population,[21 23 25] although they may reduce condomless sex with their positive partner.

Our results complement those from the two systematic reviews and meta-analyses of HIV-negative individuals in low and middle-income countries (LMICs),[11 12] although they did not examine serodiscordant couples. However, our review is more relevant to the present situation in SSA, since only 3 out of 17 studies were included,[12] and no studies[11] began enrolment after 2002.

Our findings, combined with results from other LMICs,[11 12] may allow mathematical modellers to assume, with reasonable confidence, that risk behaviour among the HIV-negative majority does not markedly change post-testing. However, incorporating a sensitivity analysis to changes in risk behaviour is advisable, given the variability in our findings. Furthermore, findings among serodiscordant couples suggest that HIV testing may lead to changes in the sexual network due to partner switching by the seronegative partner.[23]

The results also have implications for universal testing and treatment. Across three studies assessing the general population recruited from the community, results suggest that although VCT does little to improve risk behaviour among individuals

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testing HIV-negative in that population, it importantly also does not increase risk behaviour. However, the lack of consistent evidence in either direction points to the need to incorporate suitable indicators in HIV surveillance to detect local increases in risk behaviour of HIV-negative individuals as HIV testing efforts intensify, so that additional risk reduction interventions may be put in place where necessary. In addition, few studies examined the effectiveness of different testing strategies. For instance, home-based counselling and testing has been shown to be highly acceptable in SSA,[33] but our review failed to identify any studies evaluating its effectiveness in altering HIV-negative individuals' risk behaviour. Therefore, it is important to investigate the impact of new testing modalities on behaviour. More information is also needed on the impact of repeated testing, particularly in the long term, when individuals who have received multiple negative tests may perceive themselves to be at low risk of HIV acquisition.

Identification of serodiscordant couples is a high priority for global public health, as it allows provision of HIV prevention services including counselling about condoms and ART provision.[34] However, this study highlights the need for more understanding of how the HIV risk behaviour of the seronegative partner may change. In particular, ART initiation and viral suppression of the HIV-positive partner may not mitigate HIV risk for the seronegative partner, who may be exposed through other partnerships after a negative HIV test result.

Limitations

There are limitations to this review. First, grey literature and programme data were not included. Second, other important behaviour changes associated with HIV testing, such as propensity to repeat test in the future, were not included. Third, only one study was a randomised controlled trial examining post-testing behaviour change; most data were subject to high risk of sampling and social desirability bias as they came from studies where post-testing behaviour was not the primary aim. Fourth, the quality and type of HIV counselling received when testing may differ.[12 35 36] Fifth, no study in this review measured pre-test intention. As individuals may resolve to reduce risky behaviour as part of the decision-making process to get tested,[37 38] the behaviour change may differ if study recruitment removes the active decision to test. Finally, both the study populations and the outcome measures varied widely, precluding our ability to pool data, and highlighting the need to more consistently measure pre-test and post-test behaviour.

Key messages

- Further primary evidence with the primary purpose of examining behavioural change in HIV-negative individuals after testing is needed in sub-Saharan Africa (SSA), including in key populations.
- Additional research is needed to specifically investigate the behaviour of seronegative individuals in serodiscordant partnerships.
- As was previously found,[12] there remains a need to standardise sexual behavioural outcomes to facilitate valid comparisons across studies and programmes.
- Future studies should aim to use methodologies that minimise sampling and social desirability biases. More qualitative evidence exploring the psychological determinants of behavioural change, or lack thereof, among HIV-negative individuals may help elucidate causal mechanisms underlying our observations.

CONCLUSIONS

Awareness of one's serostatus generally has a small effect on risk behaviour of HIV-negative individuals, although seronegative partners in serodiscordant partnerships may engage in more extrarelational sex. Additional research specifically examining behavioural change is needed in SSA, including in key populations and serodiscordant partnerships.

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