Explaining continued high HIV prevalence in South Africa: socioeconomic factors, HIV incidence and sexual behaviour change among a rural cohort, 2001–2004

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Objectives: To estimate HIV incidence and explore evidence for changing sexual behaviour over time among men and women belonging to different socioeconomic groups in rural South Africa.

Design and methods: A cohort study conducted between 2001 and 2004; 3881 individuals aged 14–35 years enumerated in eight villages were eligible. At least three household visits were made to contact each eligible respondent at both timepoints. Sexual behaviour data were collected in structured, respondent-focused interviews. HIV serostatus was assessed using an oral fluid enzyme-linked immunosorbent assay at each timepoint.

Results: Data on sexual behaviour were available from 1967 individuals at both timepoints. A total of 1286 HIV-negative individuals at baseline contributed to the analysis of incidence. HIV incidence was 2.2/100 person-years among men and 4.9/100 person-years in women, among whom it was highest in the least educated group. Median age at first sex was lower among later birth cohorts. A higher number of previously sexually active individuals reported having multiple partners in the past year in 2004 than 2001. Condom use with non-spousal partners increased from 2001 to 2004. Migrant men more often reported multiple partners. Migrant and more educated individuals of both sexes and women from wealthier households reported higher levels of condom use.

Discussion: HIV incidence is high in rural South Africa, particularly among women of low education. Some risky sexual behaviours (early sexual debut, having multiple sexual partners) are becoming more common over time. Condom use is increasing. Existing HIV prevention strategies have only been partly effective in generating population-level behavioural change.

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Introduction

In recent years, there have been reports of decreases in HIV prevalence [1,2], HIV incidence [3] and sexual risk behaviour [4–6] from a number of sub-Saharan African countries. In contrast, antenatal surveillance data and repeated national HIV prevalence surveys from South Africa suggest a continued rise in HIV prevalence despite

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extensive efforts to reduce sexual risk behaviour [7–10]. HIV prevalence data are, however, an uncertain guide to incidence because prevalence is affected both by HIV incidence and changing mortality patterns. Despite this, few studies have reported direct measures of HIV incidence in any South African population. There is an urgent need to understand better the pattern of new HIV infections in South Africa and whether this is associated with changes in sexual behaviour.

We report data from a cohort study conducted in rural South Africa between 2001 and 2004, as part of a cluster-randomized trial of a microfinance and training intervention reported elsewhere [11]. The current paper has three objectives: to estimate HIV incidence among a rural South African cohort; to explore evidence for changing sexual behaviour between 2001 and 2004 in this study population; and to assess the evidence that HIV incidence rates and sexual behaviour patterns differed across socioeconomic groups identified on the basis of wealth, education and temporary migrancy.

Methods

Setting

The study was conducted in Limpopo province in South Africa's north east. Poverty remains widespread in the study area [12,13] and unemployment rates exceed 40% [14]. There are high levels of labour migration, with 60% of adult men and 25% of women residing away from home for more than 6 months per year [15]. Few households have land or livestock sufficient to support livelihoods.

Data collection

Ethical approval for the study was granted by committees at the London School of Hygiene and Tropical Medicine and the University of Witswatersrand.

Two hundred dwellings were randomly sampled in each of eight study villages in 2001. A household roster was assembled including all individuals identified as household members by the household head, regardless of whether they were currently sleeping at the dwelling, in order to account for high levels of temporary labour migration in South Africa. Individuals of both sexes aged 14–35 years were eligible for inclusion in the cohort.

Data were collected by trained female fieldworkers through face-to-face structured interviews conducted in the local language (Sepedi). Witnessed verbal consent was obtained from all subjects. Attempts were made to maximize response and follow-up rates by instituting a full-time field office and making repeated efforts to trace migrants. Effort was also made to ensure accurate reporting through the use of limited recall times, a respondent-oriented interview and stressing confidentiality, anonymity and the importance of honesty in reporting. Household wealth was assessed through a participatory wealth-ranking technique based on community informant rankings of each household's wealth repeated three times [13].

Oral fluid samples were collected using the OraSure collection device (UCB Group, Belgium) and analysed with the Vironostika HIV Uni-Form II assay (bioMerieux, France). HIV data from one interviewer at baseline raised quality concerns and were excluded from the analysis ($n = 168$). Samples testing negative at baseline were included in the analysis of HIV incidence. Of these, 34% were stored for slightly longer than recommended by the manufacturer before analysis, but were included in the analysis after checking that their inclusion did not bias the measure of incidence.

Statistical analysis

Data were entered into an Access database (Microsoft, California, USA) with statistical analysis conducted using Stata version 9 (Stata Corp., College Station, Texas, USA). The key exposure variable was date of interview (baseline predominantly in 2001 and follow-up predominantly in 2004). The exposure period was recorded as the duration between the first and last interview, or half of this for those who HIV seroconverted. Household wealth was assessed at baseline and identified households as 'very poor', 'poor, but a bit better off' or 'doing OK'. Temporary migrancy status was assessed on the basis of whether an individual was sleeping in the home at the time of interview at both timepoints and was coded as a binary measure. Educational attainment was coded into three categories (no or primary education only; attended but did not complete secondary education; completed secondary or postsecondary study). This measure used data collected at follow-up rather than baseline because education had not changed for most except the very young in whom the later data were considered more relevant to our outcomes.

Data from baseline and follow-up surveys were compiled to analyse age of sexual debut by a survival approach with censoring at the current age for those not yet sexually active because there were many individuals in this category. The number of sexual partnerships during the past 12 months (including spousal and non-spousal partnerships) was explored via a binary variable (>1 sexual partner; 1 or no partner). Condom use at last sex with a non-spousal partner was analysed as a binary characteristic of sexual partnerships, as opposed to individuals, and was recorded for the three most recent partnerships from the past 12 months for each respondent.

HIV incidence rates by age at baseline, sex and socioeconomic status were calculated among those who were HIV negative at baseline. Logistic regression was used to assess whether socioeconomic status variables were associated with HIV seroconversion. In order to

assess whether there was evidence for any change in age of sexual debut over time, we used Cox regression to assess the evidence that the rate of sexual debut differed between those aged 14 and 19 years at baseline (many of whose sexual debut occurred after 2001) and those aged 20–35 years (whose sexual debut mostly occurred before 2001). After this, the influence of household wealth on age of first sex was investigated. We did not investigate the association between current educational or mobility status and age at first sex because these socioeconomic factors were likely to have changed since the time at which first sex occurred.

The proportion reporting more than one sexual partner during the past 12 months was calculated at both 2001 and 2004. To limit selection biases and residual confounding as a result of cohort ageing, we restricted the analysis to individuals who had data available at both timepoints and had been previously sexually active, because we expected age to be a strong determinant of first sex, but less strongly associated with the number of partners in the past year among those who had already started sexual activity. To explore the influence of time and socioeconomic factors, a dataset was constructed containing a record for each individual at each timepoint with the temporary migration variable being allowed to vary with time. A logistic regression model, specifying individual-level clustering via population-averaged general estimating equations was constructed for each sex separately, with multiple partners during the previous 12 months as the outcome variable.

Analysis of condom use at last sex included data on all non-spousal partnerships reported at both baseline and follow-up and was thus limited to individuals reporting a non-spousal partner at each time point. Logistic regression, employing general estimating equations and specifying individual clustering, was used to estimate the effects of date of interview and socioeconomic status variables.

All analyses were stratified by sex. Variables considered as potential confounders of the effect of time or socioeconomic status variables on outcome characteristics were: age; marital status; village-pair; trial arm; and (among women for sexual behaviour outcomes) ever having had a child. For the partnership-level analysis, models were also adjusted for a measure of frequency of sex during the previous 12 months (more than five times, five or fewer times). When confounders varied over time this was accounted for in the model. For each analysis interaction terms were fitted between the time period variable and each of the socioeconomic status variables.

Results

Some 1482 households were succesfully enumerated, identifying 3881 eligible 14–35 year olds. Of these, 2858 (73.5%) were succesfully interviewed at baseline and 1967 (68.8%) of those interviewed at baseline had data available at follow-up. Inability to contact the interviewee was the primary reason for lack of interview (16% at baseline, 19% at follow-up), refusal being rare (3%, 3%) and missing data accounting for most other exclusions. In addition, 44 individuals died during the follow-up period, and 371 migrated and could not be traced. Men were less likely to have complete follow-up, as were men and women who were older, married, sleeping away from the home or had more education (Table 1). The average time between baseline and follow-up was 3.1 years. Among those succesfully followed up, valid data on HIV serostatus was collected at both timepoints on 1396 individuals, of whom 1286 were HIV negative at baseline, these contributing to the analysis of HIV incidence.

There were 34 seroconversions among men and 108 among women. HIV incidence was 2.2/100 person-years [95% confidence interval (CI) 1.5–3.0] for men and 4.9/100 person-years (95% CI 4.0–5.9) for women. HIV incidence in the age group 15–24 years at baseline was 2.0 (1.3–3.0) for men and 4.7 (3.7–6.0) for women. Incidence was lowest in the youngest age group among both sexes and higher among women than men at all ages (Table 2). Among men, there was little evidence that HIV seroconversion was associated with any socioeconomic factor. Among women, HIV seroconversion was significantly less common among those with higher levels of education [adjusted odds ratio (aOR) comparing attended secondary school versus none/primary 0.49, 95% CI 0.28–0.85; comparing those completing secondary school versus none/primary 0.25, 95% CI 0.12–0.53]. There was less evidence for differing HIV incidence by marital status, trial arm, household wealth or temporary migrancy.

Among men, the median age at first sex was 16 years for those aged 14–19 years at baseline compared with 17 years for those aged over 20 years at baseline (Fig. 1a; hazard ratio 0.60, 95% CI 0.50–0.72). Among women, earlier first sex was also signficantly more often reported by those aged 14–19 years at baseline (median 16 years) than the older group (17 years, hazard ratio 0.77, 95% CI 0.67–0.89). Household wealth was not significantly associated with age at first sex among either sex.

Men were more likely to report multiple partners in the past year than women at both timepoints (aOR 5.14 95%, CI 4.06–6.53; Fig. 1b and Table 3). Among men, having had multiple partners during the previous year tended to be most common among those aged 20–25 years. The number of previously sexually active men reporting multiple partners in the past year increased between the baseline and follow-up interviews (Fig. 1b; aOR 1.34, 95% CI 1.02–1.77). Ever having been married, trial arm, household wealth and educational attainment were not associated with having had multiple partners in the past

Table 1. Sociodemographic differences between individuals interviewed at both timepoints and those not included in the final analysis in a rural South African cohort study, 2001–2004.

	Men					Women				
	Interviewed at both timepoints		Eligible individuals not included in the final analysis		*P* value (chi square)	Interviewed at both timepoints		Eligible individuals not included in the final analysis		*P* value (chi square)
	N	%	*N*	%		*N*	%	*N*	%	
	767 (41.2%)	1094				1200 (59.4%)	819			
Age group (years)										
14–19	426	55.5	292	26.7		523	47.5	259	31.6	
20–25	187	24.4	384	35.1		332	27.7	273	33.3	
26–35	154	20.1	418	38.2	<0.01	345	28.8	287	35.0	<0.01
Marital status										
Never married	670	87.4	792	85.3		851	70.9	447	74.1	
Married during follow-up	46	6.0	0	0.0		84	7.0	1	0.2	
Ever married at baseline	51	6.7	137	14.8	<0.01	265	22.1	155	25.7	<0.01
Household wealth										
Very poor	226	29.6	326	33.0		343	28.9	253	31.0	
Poor, but a bit better off	423	55.4	632	58.2		657	55.4	449	55.0	
Doing OK	115	15.1	128	11.8	0.116	186	15.7	114	14.0	0.435
Migrancy status										
Non-migrant	570	79.4	324	36.6		922	85.9	237	44.4	
Becomes migrant	72	10.0	137	15.5		73	6.8	79	14.8	
Returns home	21	2.9	207	23.4		19	1.8	120	22.5	
Migrant both timepoints	55	7.7	218	24.6	<0.01	59	5.5	98	18.4	<0.01
Educational attainment										
None/primary only	112	14.6	197	18.0		162	13.5	152	18.6	
Attended secondary	484	63.1	584	53.4		799	66.6	457	55.8	
Completed secondary	171	22.3	313	28.6	<0.01	239	19.9	210	25.6	<0.01

Among those included in the final analysis there were missing data on household wealth (17 individuals) and migrancy (176). Among those not included there were missing data on marital status (381 individuals), household wealth (11) and migrancy (493).

Table 2. HIV incidence rates among men and women in a rural South African cohort study 2001–2004, by socioeconomic factors.

	Men			Women		
	HIV+/pyar	Rate/100 pyar	aOR	HIV+/pyar	Rate/100 pyar	aOR
All	34/1578	2.2 (1.5–3.0)	–	108/2196	4.9 (4.0–5.9)	–
Age at baseline (years)						
14–19	13/959	1.4	1	41/1139	3.6	1
20–25	13/340	3.8	2.86 (1.24–6.58)	34/504	6.7	2.32 (1.39–3.87)
26–35	8/279	2.9	1.70 (0.58–4.97)	133/552	6.0	2.55 (1.40–4.66)
Marital status						
Never married	27/1418	1.9	1	79/1575	5.0	1
Married during follow-up	5/81	6.2	2.28 (0.72–7.21)	6/140	4.3	0.57 (0.23–1.43)
Ever married at baseline	2/79	2.5	0.82 (0.16–4.26)	23/481	4.8	0.55 (0.29–1.02)
Trial arm						
Control	21/785	2.7	1	49/1125	4.4	1
Intervention	13/793	1.6	0.70 (0.33–1.48)	59/1070	5.5	1.32 (0.87–2.01)
Household wealth at baseline						
Very poor	11/446	2.5	1	35/574	6.1	1
Poor, but a bit better off	13/854	1.5	0.56 (0.24–1.33)	61/1223	5.0	0.84 (0.53–1.33)
Doing OK	10/276	3.6	1.42 (0.56–3.64)	12/366	3.3	0.54 (0.27–1.11)
Migrancy status						
Non-migrant	20/1199	1.7	1	77/1692	4.6	1
Becomes migrant	5/157	3.2	1.75 (0.60–5.13)	7/144	4.8	1.08 (0.46–2.53)
Returns home	2/31	6.4	3.43 (0.55 –21.41)	3/27	11.3	2.87 (0.70–11.75)
Migrant at both timepoints	4/100	4.0	1.49 (0.43–5.12)	7/88	8.2	1.47 (0.60–3.61)
Educational attainment at follow-up						
None/attended primary only	4/233	1.7	1	24/265	9.1	1
Attended secondary	22/999	2.2	1.57 (0.51–4.85)	71/1495	4.7	0.49 (0.28–0.85)
Completed secondary	8/346	2.3	1.23 (0.35–4.36)	13/436	3.0	0.25 (0.12–0.53)

aOR, Adjusted odds ratio for seroconversion comparing socioeconomic categories adjusted for age, village pair, trial arm and marital status; pyar, person-years at risk.

year. There was some evidence that migrant men were more likely to report multiple partners (aOR versus non-migrants 1.51, 95% CI 1.03–2.20).

Among previously sexually active women, having had multiple partners in the past year was most common among the youngest age group and was least common among women who had ever been married. As was the case for men, there was some evidence for an increase over time, adjusting for age and other potential confounders, in the number of women reporting multiple partnerships (Fig. 1b; aOR 2.09, 95% CI 1.39–3.17). Having had multiple partners was not associated with household wealth (aOR for household 'doing OK' versus 'very poor' aOR 1.13, 95% CI 0.62–2.05), migrancy (aOR 1.05, 95% CI 0.53–2.07) or education (aOR 0.69, 95% CI 0.36–1.30). There was some evidence that living in a village receiving the intervention was associated with a lower chance of having had multiple partners in the past year (aOR 0.66, 95% CI 0.46–0.93). There was little evidence of interaction between interview date and socioeconomic status variables for either sex.

Condom use at last sex within a partnership was more often reported when the reporting partner was male than female at both timepoints (aOR 1.24, 95% CI 1.01–1.52; Fig. 1c and Table 4). Among the 1686 non-spousal partnerships reported by men, condom use was most commonly reported when the man was aged 20–25 years. There was strong evidence that condom use at last sex was more common among partnerships reported at follow-up than at baseline (Fig. 1c; aOR 1.43, 95% CI 1.07–1.92). Men who had ever been married more often reported condom use than those who had not, although this was not statistically significant (aOR 1.50, 95% CI 0.73–3.09). Condom use was also more frequent in sexual relationships in which sex occurred fewer than five times during the previous year (aOR 2.20, 95% CI 1.63–2.97). Condom use tended to be reported more often by migrants than non-migrants (aOR 1.46, 95% CI 0.98–2.19) and by those of increasing educational status (aOR comparing completed secondary with none/primary education 2.91, 95% CI 1.73–4.90) but was not associated with mens' household wealth (aOR comparing household 'doing OK' with 'very poor' 1.20, 95% CI 0.75–1.92).

Among the 2547 non-spousal partnerships reported by women, condom use was most often reported by the youngest women. There was strong evidence that condom use was reported by women more commonly at follow-up than at baseline (Fig. 1; aOR 1.46, 95% CI 1.14–1.87). Condom use at last sex was more commonly reported by women who had ever been married (aOR 1.81, 95% CI 1.04–3.14) and in non-spousal relationships in which sex occurred less frequently (aOR 1.45, 95% CI 1.11–1.89). Condom use was less commonly reported by women who reported previously ever having had a child (aOR 0.72, 95% CI 0.53–0.99). Condom use at last sex was more commonly reported by women from

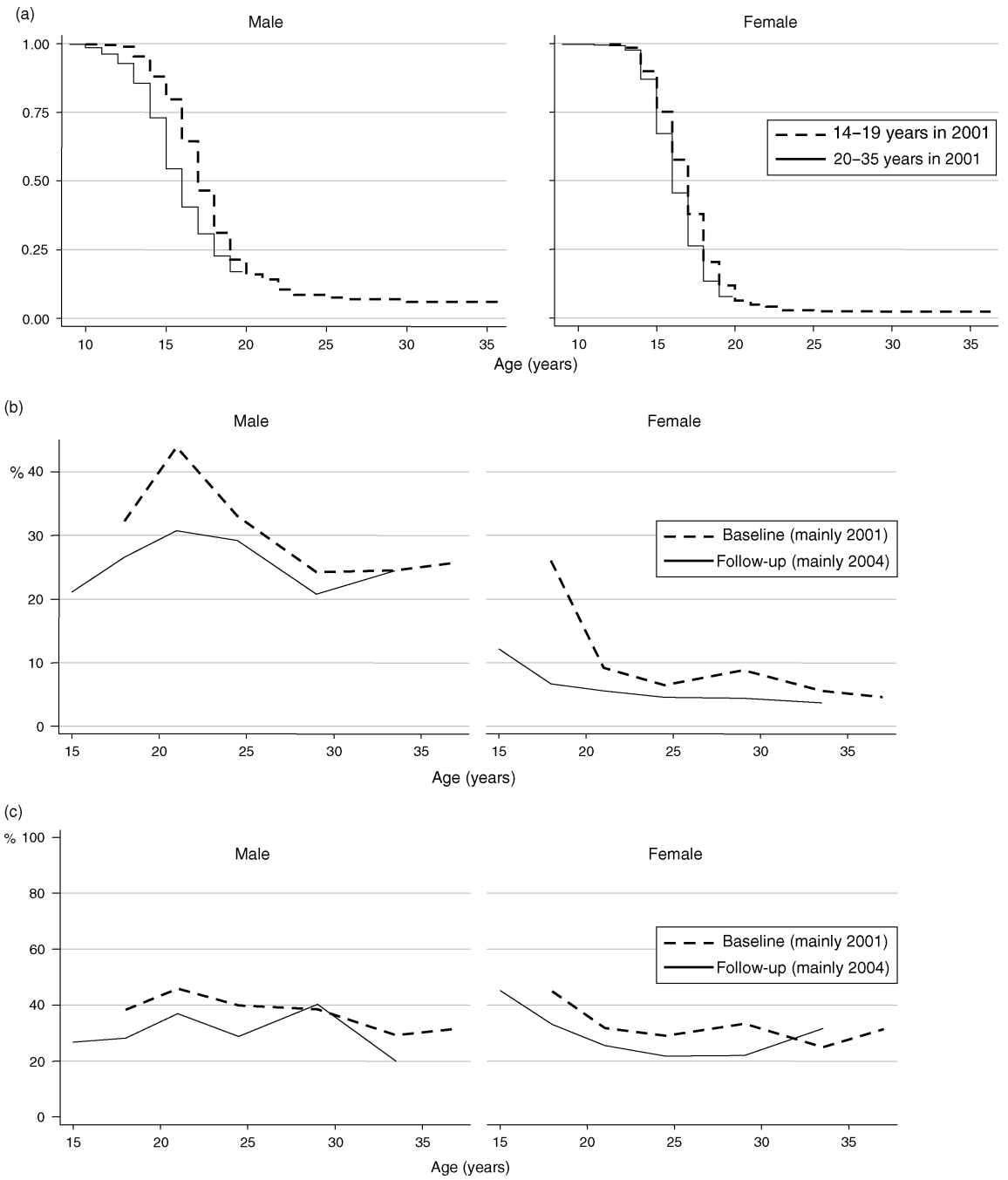

Fig. 1. Age patterns of sexual behaviour by timeperiod among males and females in a rural South African cohort 2001–4. (a) Survival analysis of age at first sex, by sex and birth cohort; (b) Percentage of previously sexually active individuals reporting more than one sexual partner during the previous 12 months (3-year average), by sex and time-period of survey; (c) Percentage of non-spousal sexual partnerships reporting condom use at last sex (3-year average), by sex and time-period of survey.

households of greater wealth (aOR comparing household 'doing OK' with 'very poor' 2.03, 95% CI 1.29–3.20), those who had completed secondary education (aOR compared to none/primary only 2.25, 95% CI 1.34–3.78) and migrants (aOR 1.48, 95% CI 0.98–2.23). There was little evidence of interaction between interview date and socioeconomic status variables among either sex.

Discussion

We report data from a cohort study conducted in rural South Africa between 2001 and 2004. HIV incidence was high among both men and women. Among both sexes there was evidence that age of first sexual intercourse declined over time, whereas, if anything, having had multiple sexual partnerships during the previous year was

Table 3. Multiple partnerships among those previously sexually active reported by men and women in 2001 and 2004 in a rural South African cohort, by socioeconomic factors.

	Men reporting multiple partners in previous year			Women reporting multiple partners in previous year		
	2001	2004		2001	2004	
	n/*N* (%)	*n*/*N* (%)	aOR	*n*/*N* (%)	*n*/*N* (%)	aOR
Interview date						
Baseline (2001)	129/495 (26.1)	–	1	54/943 (5.7)	–	1
Follow-up (2004)	–	158/493 (32.1)	1.34 (1.02–1.77)	–	82/943 (8.7)	2.09 (1.39–3.17)
Age at baseline (years)						
14–19	44/180 (24.4)	20/62 (32.3)	1	23/278 (8.3)	19/73 (26.0)	1
20–25	52/167 (311)	84/214 (39.3)	1.40 (0.96–2.06)	17/323 (5.3)	31/390 (8.0)	0.44 (0.27–0.73)
26+	33/148 (22.3)	54/217 (24.9)	0.78 (0.51–1.18)	14/342 (4.1)	32/480 (6.7)	0.41 (0.23–0.71)
Marital status						
Never married	114/444 (25.7)	136/401 (33.9)	1	48/680 (7.1)	59/622 (9.0)	1
Ever married	15/51 (29.4)	22/92 (23.9)	1.01 (0.62–1.64)	6/263 (2.3)	23/321 (7.2)	0.71 (0.45–1.10)
Trial arm						
Control	66/247 (26.7)	85/245 (34.7)	1	23/478 (4.8)	58/478 (12.1)	1
Intervention	63/248 (25.4)	73/248 (29.4)	0.80 (0.60–1.08)	31/467 (6.7)	24/465 (5.2)	0.66 (0.46–0.93)
Ever had a child						
No	–	–	–	22/282 (7.8)	20/159 (12.6)	1
Yes	–	–	–	32/652 (4.9)	62/780 (8.0)	0.87 (0.57–1.34)
Household wealth						
Very poor	38/141 (27.0)	47/142 (33.1)	1	12/276 (4.4)	22/276 (8.0)	1
Poor, but a bit better off	73/278 (26.3)	84/277 (30.3)	0.91 (0.65–1.27)	35/513 (6.8)	43/513 (8.4)	1.23 (0.81–1.87)
Doing OK	17/75 (22.7)	27/73 (37.0)	0.95 (0.58–1.54)	7/143 (4.9)	13/143 (9.1)	1.13 (0.62–2.05)
Migrancy status						
Non-migrant	108/424 (25.5)	118/383 (30.8)	1	50/865 (5.8)	61/761 (8.0)	1
Migrant	21/71 (29.6)	31/71 (43.7)	1.51 (1.03–2.20)	4/78 (5.1)	6/73 (8.2)	1.05 (0.53–2.07)
Educational attainment at follow-up						
None/primary only	22/73 (30.1)	18/73 (24.7)	1	11/138 (8.0)	9/137 (6.6)	1
Attended secondary	72/286 (25.2)	93/285 (32.6)	1.02 (0.65–1.60)	35/602 (5.8)	61/602 (10.1)	0.97 (0.58–1.64)
Completed secondary	35/136 (25.7)	47/135 (34.8)	1.12 (0.68–1.84)	8/203 (3.9)	12/204 (5.9)	0.69 (0.36–1.30)

aOR, Adjusted odds ratio comparing socioeconomic groupings across both timepoints, adjusted for interview date, age, marital status, village pair and trial arm, and, for women only, ever had a child.

more commonly reported in 2004 than in 2001. Condom use at last sex with non-spousal partners was, however, more commonly reported in 2004.

Regarding socioeconomic patterns among these outcomes, HIV incidence among men was not associated with socioeconomic factors, but among women infections occurred fastest among the least educated. Sexually active migrant men more often reported multiple sexual partners, but migrant and more educated men also reported more common condom use with non-spousal partners. Among sexually active women, having had multiple sexual partners in the past year was not associated with socioeconomic factors, but women who were migrants, from wealthier households and with higher levels of education were more likely to report condom use at last sex with a non-spousal partner. There was little evidence that the strength of association between socioeconomic variables and sexual behaviours had changed over time.

The strengths of the study included explicit attempts to maximize follow-up rates and ensure accurate reporting. Furthermore, important potential confounders such as age, childbirth and partnership characterstics were adjusted for in the analysis. Nevertheless, the study had limitations. A proportion of eligible individuals were not represented in the final sample, and these individuals were more likely to be migrants and well educated. It is possible that their sexual behaviour or risk of HIV infection differed from those included in the study; if so, our estimates may have been biased. As the cohort was ageing, there may have been residual confounding by age for outcomes in which age was an important determinant. Many authors have also pointed to the difficulties inherent in capturing accurate sexual behaviour information in one-off interviews, and it is likely that some misreporting occurred [16,17]. If such misreporting varied between individuals from different socioeconomic groups or at different timepoints, this may also have produced some bias, although this is difficult to assess. Misreporting of age of sexual debut might have differed with respect to age at baseline because of the likely greater time intervals involved in recall for older participants. Therefore, the finding of lower age at first sex among later age cohorts should be treated with some caution.

Another limitation of the study was relatively low statistical power, particularly with respect to HIV incidence analyses and interaction tests. Finally, although our educational exposure may have been relatively simple to record, our assessment of migrancy did not identify migrations at times other than when surveys were

Table 4. Condom use at last sex within a non-spousal sexual partner reported by men and women in 2001 and 2004 in a rural South African cohort, by socioeconomic factors.

	Men reporting condom use at last sex with non-spousal partner			Women reporting condom use at last sex with non-spousal partner		
	2001	2004		2001	2004	
	n/*N* (%)	*n*/*N* (%)	aOR	*n*/*N* (%)	*n*/*N* (%)	aOR
Interview date						
Baseline (2001)	327/1002 (32.6)	–	1	253/915 (27.7)	–	1
Follow-up (2004)	–	272/684 (39.8%)	1.43 (1.07–1.92)	–	237/723 (32.8)	1.46 (1.14–1.87)
Age (years)						
14–19	101/321 (31.5)	26/66 (39.4)	1	117/340 (34.4)	36/82 (43.9)	1
20–25	139/411 (33.8)	114/261 (43.7)	1.26 (0.86–1.85)	87/361 (24.1)	87/298 (29.2)	0.60 (0.43–0.84)
26+	87/270 (32.2)	132/357 (37.0)	0.91(0.59–1.40)	40/214 (22.9)	114/343 (33.2)	0.56 (0.37–0.86)
Marital status						
Never married	312/964 (32.4)	242/629 (38.5)	1	240/880 (27.3)	214/658 (32.5)	1
Ever married	15/38 (39.5)	30/55 (54.6)	1.50 (0.73–3.09)	13/35 (37.1)	23/65 (35.4)	1.81 (1.04–3.14)
Trial arm						
Control	173/473 (36/6)	142/347 (40.9)	1	110/422 (26.1)	107/373 (28.7)	1
Intervention	154/529 (29.1)	130/337 (38.6)	0.64 (0.47–0.88)	143/443 (29.0)	130/371 (37.1)	1.25 (0.94–1.66)
Ever had a child						
No	–	–	–	122/365 (33.4)	79/18 (42.0)	1
Yes	–	–	–	127/543 (23.4)	158/532 (29.7)	0.72 (0.53–0.99)
Household wealth						
Very poor	100/291 (34.4)	79/203 (38.9)	1	67/274 (24.5)	65/223 (29.2)	1
Poor, but a bit better off	177/588 (30.1)	143/380 (37.6)	0.87 (0.61–1.24)	137/508 (27.4)	131/395 (33.2)	1.26 (0.91–1.75)
Doing OK	49/119 (41.2)	50/100 (50.0)	1.20 (0.75–1.92)	45/125 (36.0)	37/94(39.4)	2.03 (1.29–3.20)
Migrancy status						
Non-migrant	251/807 (31.1)	202/531 (38.0)	1	215/794 (27.1)	178/583 (30.5)	1
Migrant	76/195 (39.0)	58/119 (48.7)	1.46 (0.98–2.19)	38/120 (31.7)	32/84 (38.1)	1.48 (0.98–2.23)
Educational attainment at follow-up						
None/primary only	39/143 (23.9)	24/76 (27.9)	1	31/134 (23.1)	26/90 (28.9)	1
Attended secondary	178/563 (31.6)	160/418 (38.3)	2.06 (1.73–4.90)	150/583 (25.7)	152/477 (31.9)	1.31 (0.83–2.05)
Completed secondary	110/276 (39.9)	88/180 (48.9)	2.91 (1.73–4.90)	72/197 (36.6)	57/156 (37.8)	2.25 (1.34–3.78)
Frequency of sexual intercourse in past year						
More than 5 time	194/639 (30.4)	179/522 (34.3)	1	149/632 (23.6)	172/554 (31.1)	1
Five or fewer times	133/363 (36.6)	93/162 (57.4)	2.20 (1.63–2.97)	104/283 (36.8)	65/169 (38.5)	1.45 (1.11–1.89)

aOR, Adjusted odds ratio comparing socioeconomic groupings across both timepoints, adjusted for interview date, age, marital status, village pair, trial arm, frequency of sexual intercourse and, for women only, ever had a child.

conducted. This is likely to have resulted in an underestimation of associations involving migrancy. Furthermore, the assessment of household wealth in developing countries is complex [18]. Our participatory approach had high internal consistency [13], but a low level of correlation with an indicator based on multiple assets (J. Hargreaves, L. Morison, J. Gear, J.D.H. Porter, M.B. Makhubele, J.C. Kim, *et al.*, in preparation).

This study provides direct measures of annual HIV incidence from a South African population, among men (2.2%, 95% CI 1.5–3.0) and women (4.9%, 95% CI 4.0–5.9) aged 14–35 years at baseline. National estimates from cross-sectional research employing a detuned enzyme-linked immunosorbent assay that detects infections in the past 180 days have previously estimated HIV incidence among 15–24 year olds at 0.8% per annum for men (compared with 2.0% for this age group in this study) and 6.5% for women (compared with 6.0%), with the overall estimate for Limpopo province among 15–49 year olds at 2.4% per annum [9]. Although not always directly comparable, our study confirms the high incidence of HIV infection with data from a cohort study.

These figures shed light on why HIV prevalence is not, uniquely among sub-Saharan African countries, decreasing in South Africa. Our estimates of incidence do not suggest a declining epidemic, being higher, for example, than annual HIV incidence measures among adult men and women in Uganda in the mid-1990s (1.72% per annum, 95% CI 1.38–2.16 and 1.69% per annum, 95% CI 1.38–2.08, respectively) [19,20]. This is particularly worrying given that previous studies have suggested wide inter-provincial variation in adult HIV incidence within South Africa (0.5–4.2%), with Limpopo, the province under study here, lying only at the midpoint of this range [9].

Furthermore, our research suggests that although condom use has increased over time, young people, if anything, may be initiating sex earlier and the proportion reporting multiple partners has, if anything, increased. These data confirm findings from recent cross-sectional studies in South Africa [9,10,21], and stand in contrast to the experience of Uganda [20], Kenya [22] and Zimbabwe [23,24], where reductions in HIV prevalence have been accompanied by delays in the onset of first sex and reductions in partner numbers.

Our results also draw attention to the socioeconomic patterning of HIV risk. Our finding of higher HIV incidence among the least educated women was not unexpected. Research suggests that up to the mid-1990s prevalent HIV infection was often more common among individuals who were more mobile [25–27], had greater education [2,28–30], or were from more wealthy households [31,32]. More recent studies among young people from Uganda and Zambia [2,33,34] have, however, suggested that whereas HIV prevalence has fallen over time among the most educated, this is not so among the least educated. More surprisingly, we found no association between our measure of mobility and the risk of new HIV infection, although power to detect any association was low for men (because of the relatively small number of seroconversions) and women (because of low migration rates).

With respect to sexual behaviour, migrant men reported greater numbers of sexual partners but also a greater use of condoms. Among women, lower levels of condom use were found among the poorest, those with of the least education and non-migrants. Migrants may be less subject to restrictive social norms and have access to larger sexual networks. Male migrants may also be more likely to have greater personal income than non-migrants. Migrants might also come into greater contact with condoms and HIV-prevention materials as a result of their greater mobility, especially to cities where such resources are likely to be more commonly available. Underlying traits such as self–confidence might also make individuals simultaneously more likely to migrate, more attractive to sexual partners, and more likely to become 'early adopters' of condoms. Whereas such issues require further study, our data suggest that migrants should not be assumed to be engaged in high-risk behaviours although this does not preclude their being a key group in the HIV epidemic dynamics [35]. The data confirm, however, that women experiencing socioeconomic deprivation are among the most vulnerable to HIV in this rural South African setting.

Effective HIV prevention strategies remain an urgent priority in South Africa. Strategies to date may have been partly effective in reducing risk among educated and mobile members of society. It is possible that changes will emerge in all groups over time as safer-sex behaviour diffuses, perhaps leading to reductions in HIV prevalence, as witnessed in other sub-Saharan African countries. This may, however, be some way off unless there is a reassessment of HIV prevention strategies. Just as the HIV epidemic in the United States has increasingly become a disease of women and of racial and ethnic minorities [7], so the epidemic in Africa may also concentrate among the socially vulnerable. Our findings suggested that the least educated women in this rural setting reported more partners, less use of condoms, and experienced higher levels of new infection than other groups. Individual-focused interventions appear on their own to have been insufficient to bring about population-wide change and address barriers to risk-reduction among the most disadantaged groups. There is a strong case for the wider testing and implementation of structural interventions that address the 'upstream' determinants of HIV infection [36].

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