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Research article

Changes over time in sexual behaviour among young people with different levels of educational attainment in Tanzania

James R Hargreaves[§1], Emma Slaymaker[1], Elizabeth Fearon[1] and Laura D Howe[2]

[§]**Corresponding author:** London School of Hygiene and Tropical Medicine, Keppel St, London, WC1E 7HT, UK. Tel: +44 (0)20 7927 2955. (james.hargreaves@lshtm.ac.uk)

Abstract

Background: HIV prevalence trends in Tanzania differ between socioeconomic groups. While HIV prevalence was initially higher among those with higher levels of educational attainment, it has fallen fastest among these groups. Among those with lower levels of education HIV prevalence has been stable. The behavioural dynamics underlying this phenomenon remain unclear, and a theory to guide interpretation of these trends and enable predictions of future patterns has not emerged.

Methods: We analysed data from two large nationally representative surveys conducted in Tanzania in 2003/2004 and 2007/2008. We focused on young people aged 15 to 24 years and explored reports of (i) first sex, (ii) having had more than one sexual partner in the last year and (iii) unprotected last sex with a non-cohabiting partner. Our analysis explored whether the behaviours differed by educational attainment in 2003/2004 and in 2007/2008, and whether changes over time in these behaviours differed between educational groups.

Results: The rate of first sex was lower among more educated males in 2007/2008 but not in 2003/2004, and among females in both surveys. The change over time in educational patterning of the rate of first sex in males was mostly due to a declining rate among the secondary educated groups. Among males, having had more than one sexual partner in the last year was associated with lower education in 2003/2004 and in 2007/2008. Among females, those with less education were more likely to report more than one partner in 2003/2004, although by 2007/2008 there was little association between education and reporting more than one partner. Unprotected last sex with a non-cohabiting partner was less common among the more educated. Among both sexes this decreased over time among those with no education and increased among those with secondary education.

Conclusions: Patterns of behaviour suggest that differences in HIV incidence might explain trends in HIV prevalence among different educational groups in Tanzania between 2003/2004 and 2007/2008. The ''inverse equity hypothesis'' from child health research might partially help explain the changing social epidemiology of HIV incidence in Tanzania.

Keywords: sexual behaviour; Tanzania; educational attainment; inverse equity hypothesis.

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Background

In sub-Saharan Africa, HIV prevalence trends differ between individuals with different socioeconomic backgrounds [1]. HIV infections were concentrated among those with higher levels of education or wealth in sub-Saharan Africa before 1996 in many countries [2]. It therefore seems that during the 1980s and 1990s, in the absence of widespread health promotion, prevailing sexual behaviour patterns led to more rapid spread of infection among the relatively wealthy, more mobile and more educated within African countries.

However, over time, prevalent infections are increasingly concentrating among those of lower education. In a systematic review published in 2008, including more than 200,000 individuals from 11 countries between 1987 and 2003, HIV infections appeared ''to be shifting towards higher prevalence among the least educated in sub-Saharan Africa, reversing previous patterns'' [1]. In Tanzania, studies in the 1990s suggested a higher prevalence of HIV among the more educated [3,4]. In a rural population in Tanzania, the association between educational attainment and HIV prevalence reversed between 1991 and 2005. In 1991, secondary education was associated with a higher risk of HIV infection compared with those with no formal education (odds ratio 4.5), whereas in 2005 it was associated with a lower risk (odds ratio 0.4) [5]. Subsequently, we (JH and LH) have reported on data from two large nationally representative surveys conducted in 2003/2004 and 2007/2008 in Tanzania, and showed that over this relatively short time period, HIV prevalence was stable among those with no formal education, whereas it had fallen quite steeply among those with secondary education [6]. While this trend was not statistically significant in any population subgroup, the same patterns were noted among the younger groups aged 15 to 24 years in whom prevalence trends are thought to be most indicative of incidence patterns linked to sexual behaviour. Among these young people, comparing HIV prevalence in 2007/8 with that in 2003/4 the point estimate odds ratios suggested stable or even increasing prevalence among those

with no education (adjusted odds ratios aOR of 1.29 males and 1.50 in females, respectively), and falling prevalence among those having attended primary education (aORs: 0.41 males, 0.74 females) or secondary education, particularly among males (aORs: 0.18 males, 0.85 females).

While there is relatively strong empirical evidence for a changing association over time between indicators of relative socioeconomic position and prevalent HIV infection in sub-Saharan African countries, the behavioural patterns that underlie these trends remain poorly understood. Sexual behaviour is influenced by an individual's sex, age and marital status; their perception of cultural and religious norms; and social and economic factors. Consequently patterns of sexual behaviour vary across different geographical regions and over time [7]. Sexual behaviour can also be influenced by health promotion. In countries with severe HIV epidemics, health promotion efforts provide information about the health implications of sexual activity and its link to risk of HIV infection, attempt to influence social norms around sexual behaviours and have made technologies such as male condoms more accessible. A key focus has been encouraging young people to delay their first sexual experience (''abstain''), have only one sexual partner (''be faithful'') and use condoms (''condomise''). There is evidence from wealthy countries and, more recently, from sub-Saharan Africa that these efforts have been at least partly successful in reducing the HIV infection rates [8].

We analysed sexual behaviour patterns among young people with different levels of educational attainment in Tanzania. We established whether sexual behaviour characteristics were associated with educational attainment using data from each of the 2003/2004 and 2007/2008 national surveys. Finally we sought to establish whether the association between educational attainment and sexual behaviour was changing over time by fitting interaction terms between educational attainment and time period in our regression models in a manner similar to our previous paper on prevalent HIV infection using the same datasets [6].

Methods

We analysed data from two national cross-sectional surveys conducted in Tanzania in 2003/4 and 2007/8, which were available from www.measuredhs.com. These surveys used two-stage sampling to identify nationally representative samples of adults aged 15 to 49 years. Our analysis in this paper is focused on 15- to 24-year-olds. Both surveys achieved high response rates [9]. We restricted our analysis to individuals for whom full data were available on a small set of variables relevant to our purpose (sex, age, urban/rural residence, educational attainment, household asset-wealth, date of interview, prevalent HIV infection and a number of characteristics of sexual behaviour described in more detail below). All of our analyses used the ''*survey*'' commands in Stata v. 11 to reflect the sampling strategy and ensure that our results would be representative of the national population structure.

Data were collected on whether each participant had ever previously had sex during their life and, among those who reported ever sexual activity: age at first sex, the total number of sexual partners in the last year and condom use at last sex with non-spousal partners occurring during the last year.

We approached the questions using two data analysis strategies described below and applied to a pooled data set. We stratified all our analyses by sex. In line with our previous work we considered three categories of educational attainment: no education, primary education and secondary education or higher.

First, we used data on age of first sex, date of birth and date of interview to analyse progression to first sex for two time periods. We used survival analysis to describe the incidence of first sex, which can be used as a population-level measure of the beginning of exposure to STIs [10,11]. This analysis was restricted to respondents aged between 19 and 22 years in each survey in order to describe the experience of those mostly likely to have had their first sex in the years immediately before each survey. Using the survival commands in Stata we estimated the total person years and the median age at first sex for each education group by sex and survey. We fitted crude and adjusted Cox regression models to compare the effect of education on progression to first sex adjusting for current age, for each survey by sex. Adjusted models included covariates for household wealth and urban/rural residence. We fitted further Cox regression models for each sex for both surveys combined and included a term for interaction between education and year of survey to formally assess whether the association between educational attainment and rate of first sex was changing over time.

Our second data analysis strategy concentrated on the year prior to interview and measures for individuals aged 15 to 24 years at time of interview who reported having ever been sexually active. We considered two outcomes coded as binary responses (no/yes). These measures were whether in the last year respondents had had more than one sexual partner and whether they had not used a condom at last sex with a non-cohabiting partner (''unprotected last sex'') among those who reported having had such a partner. We conducted separate logistic regression analyses for the outcomes adjusting for age, urban/rural residence and asset wealth. Again we assessed whether there was an association between educational attainment and each characteristic in 2003/2004 and in 2007/2008 (reporting odds ratios and Wald-test *p*-values), and whether there was evidence for interaction between education and survey year. We report the results for each characteristic of sexual behaviour in separate tables (Tables 2–4), and additionally report the key terms from the final models with an interaction term in a separate table (Table 5).

Results

The total number of individuals included in the analysis in 2003/4 was 4710 and in 2007/8 it was 6691 (Table 1). Both surveys included more female than male participants and a greater proportion of rural respondents. The proportion of respondents who had attended secondary school was higher in 2007/2008 than in 2003/2004, and in both years men were more likely than women to have attended secondary school. In both years, it was most common for respondents to have

Table 1. Characteristics of participants aged 15 to 24 in nationally representative AIDS Indicator Surveys in Tanzania in 2003/2004 ($n = 4710$) and 2007/2008 ($n = 6691$).

	2003/2004 Survey				2007/2008 Survey			
	Males		Females		Males		Females	
	n	%	*n*	%	*n*	%	*n*	%
Location								
Urban	522	32.1	752	34.5	594	24.6	877	26.5
Rural	1591	67.9	1845	65.5	2283	75.4	2937	73.5
Wealth tertiles								
Poorest	760	30.9	957	32.7	879	34.4	1106	32.6
Middle	771	34.5	783	29.2	1015	33.4	1316	33.9
Richest	582	34.6	857	38	983	32.2	1392	33.5
Educational attainment								
None	237	10.6	475	17.7	257	10.4	625	18.8
Primary	1663	77.4	1865	71	1918	70.1	2342	68.5
Secondary	213	12.1	257	11.3	702	19.5	847	12.7
HIV								
Negative	2048	96.7	2481	95.1	2852	98.7	3717	96.2
Positive	65	3.3	116	4.9	25	1.2	97	3.8
Ever had sex								
No	781	35.4	728	27.8	1583	43.9	1596	29.7
Yes	1332	64.6	1869	72.3	1294	56.1	2245	70.3
More than one partner in last year								
No	1766	83.0	2469	94.9	2667	90.1	3747	97.6
Yes	347	17.0	128	5.1	210	10	67	2.4
Unprotected last sex with a non-cohabiting partner*								
No	379	47.8	228	42.1	360	49.2	226	45.9
Yes	449	52.2	347	57.9	422	50.8	296	54.1

*Of those reporting a non-cohabiting partner.

attended some primary school, but not Secondary school. HIV prevalence was lower in 2007/2008 than in 2003/2004 and was higher in women than in men in both years. More young men than young women reported more than one partner in the last year in both surveys, although prevalence of this behaviour was lower for both sexes in 2007/8 compared with 2003/2004. Unprotected last sex with a non-cohabiting partner was reported by more females than males and was slightly lower in 2007/2008 compared with 2003/2004 for both sexes.

Rate of first sex (Tables 2 and 5)

In the 2003/2004 survey, there was little evidence that educational attainment was associated with age at first sex among males (adjusted hazard ratio comparing secondary to primary education 0.88). In the 2007/2008 survey, there was evidence that higher educational attainment was associated with later first sex (hazard ratio comparing secondary to primary education 0.53, 95% CI 0.40 to 0.70). The association between education and age at first sex in males changed between these surveys, and this is supported by the small *p*-value for the interaction term in the Cox regression model (interaction $p = 0.04$, Table 5).

Among females, compared to those with primary education, women with no education had sex at a younger age, and women with secondary education were older at first sex. There was relatively weak evidence that this association changed between the surveys (*p*-value for interaction term 0.17). Women were on average younger at first sex and showed a larger differential by educational status than men.

Multiple partners (Tables 3 and 5)

Among males in 2003/2004, greater educational attainment was associated with a lower prevalence of reported sex with more than one partner in the last year, although after adjustment this relationship became slightly weaker (aOR, comparing secondary to no education 0.63, 95% CI 0.35 to 1.13). A similar, though slightly stronger, association was seen in 2007/2008 (interaction *p*-value for change over time in the strength of association = 0.75).

Table 2. Differences in the rates of first sex among those aged 19 to 22 at time of survey by educational attainment, gender and survey.

	Educational attainment	Person years	Median age at first sex (IQR)	Hazard ratio, unadjusted 95% CI	Hazard ratio adjusted for urban/rural and wealth 95% CI	Wald-test	Interaction-term *p*-value from pooled model^
Males							
2003/2004	None	1524	17.4 (15.9–19.6)	1.07 (0.77–1.49)	1.04 (0.74–1.45)	0.642	0.04
	Primary	10,070	18.2 (16.5–20.1)	1	1		
	Secondary	1918	18.6 (16.7–20.2)	0.80 (0.61–1.04)	0.88 (0.66–1.17)		
2007/2008	None	2494	18.3 (15.7–20.3)	1.08 (0.77–1.52)	1.06 (0.76–1.48)	<0.001	
	Primary	10,731	18.3 (16.3–20.3)	1	1		
	Secondary	4366	19.8 (17.4–n/a*)	0.50 (0.39–0.66)	0.53 (0.40–0.70)		
Females							
2003/2004	None	2929	16.2 (15.0–17.8)	1.52 (1.23–1.88)	1.44 (1.16–1.79)	<0.001	0.17
	Primary	11,237	17.6 (16.1–19.0)	1	1		
	Secondary	2338	19.6 (18.3–20.5)	0.47 (0.39–0.57)	0.53 (0.43–0.64)		
2007/2008	None	4648	16.1 (15.1–18.0)	1.38 (1.11–1.71)	1.14 (0.91–1.42)	<0.001	
	Primary	12,649	17.3 (16.1–18.9)	1	1		
	Secondary	2741	19.8 (17.7–22.4)	0.40 (0.31–0.50)	0.44 (0.34–0.56)		

*Less than 75% of this cohort had had sex by the time of the survey.
^This is the Wald-test *p*-value for the education*time period interaction term in the pooled model. See Table 5 for more detail of changes over time in behaviour by educational strata.

Females with primary or secondary education were less likely to report more than one sexual partner in the last year than those with no education in 2003/4 (e.g. aOR for secondary versus no education 0.28, 95% CI 0.10 to 0.80). By 2007/2008 there was slightly less evidence of association between education and reporting more than one partner in the last month (e.g. aOR for secondary versus no education 0.46, 95% CI 0.16 to 1.28). The limited change over time in

Table 3. Association between educational attainment and reporting more than one partner in the previous year among young people in Tanzania, stratified by sex and year of survey.

		n/N (%) reporting >1 partner	Unadjusted odds ratio	Odds ratio adjusted for age, rural/urban and wealth tertile	Wald-test	Interaction-term *p*-value from pooled model^
Males						
2003/2004	No education	51/237 (19.4%)	1	1	0.15	0.75
	Primary	274/1389 (17.4%)	0.88 (0.61–1.26)	0.99 (0.67–1.47)		
	Secondary	22/213 (11.9%)	0.56 (0.33–0.96)	0.63 (0.35–1.13)		
2007/2008	No education	30/314 (15.2%)	1	1	0.01	
	Primary	153/2253 (10.6%)	0.66 (0.40–1.01)	0.97 (0.57–1.66)		
	Secondary	32/798 (5.0%)	0.29 (0.16–0.55)	0.47 (0.25–0.89)		
Females						
2003/2004	No education	34/475 (7.6%)	1	1	0.05	0.36
	Primary	89/1865 (5.0%)	0.64 (0.40–1.01)	0.65 (0.39–1.06)		
	Secondary	5/257 (2.2%)	0.27 (0.10–0.72)	0.28 (0.10–0.80)		
2007/2008	No education	18/625 (3.6%)	1	1	0.15	
	Primary	40/2342 (2.1%)	0.59 (0.32–1.08)	0.53 (0.27–1.02)		
	Secondary	9/847 (2.1%)	0.59 (0.24–1.47)	0.46 (0.16–1.28)		

^This is the Wald-test *p*-value for the education*time period interaction term in the pooled model. See Table 5 for more detail of changes over time in behaviour by educational strata.

Table 4. Association between educational attainment and reporting unprotected last sex with a non-cohabiting partner among young people reporting a non-cohabiting partner in Tanzania, stratified by sex and year of survey.

		n/N (%) reporting unprotected last sex	Unadjusted odds ratio	Odds ratio adjusted for age, rural/urban and wealth tertile	Wald-test	Interaction-term *p*-value from pooled model^
Males						
2003/2004	No education	83/108 (77.5%)	1	1	<0.001	<0.001
	Primary	348/640 (53.4%)	0.33 (0.21–0.53)	0.48 (0.29–0.79)		
	Secondary	18/80 (20.5%)	0.07 (0.04–0.14)	0.18 (0.09–0.36)		
2007/2008	No education	62/91 (62.9%)	1	1	<0.001	
	Primary	291/543 (52.4%)	0.65 (0.40–1.06)	0.62 (0.38–1.03)		
	Secondary	69/148 (33.5%)	0.30 (0.16–0.55)	0.42 (0.21–0.82)		
Females						
2003/2004	No education	82/98 (80.9%)	1	1	<0.001	<0.001
	Primary	242/404 (58.9%)	0.34 (0.18–0.64)	0.36 (0.20–0.67)		
	Secondary	23/73 (29.1%)	0.10 (0.04–0.22)	0.14 (0.06–0.34)		
2007/2008	No education	53/78 (65.9%)	1	1	0.25	
	Primary	196/347 (54.6%)	0.62 (0.35–1.10)	0.76 (0.41–1.40)		
	Secondary	47/97 (40.0%)	0.34 (0.16–0.74)	0.51 (0.23–1.15)		

^This is the Wald-test *p*-value for the education*time period interaction term in the pooled model. See Table 5 for more detail of changes over time in behaviour by educational strata.

association between education and more than one sexual partner among females (*p*-value for interaction = 0.36) primarily arose because of a decrease in the proportion of females with no or primary education reporting this behaviour.

Unprotected last sex (Tables 4 and 5)

Among men reporting a non-cohabiting partner there was strong evidence that men with primary or secondary education were less likely to report unprotected last sex with these partners compared to those with no education in both 2003/2004 and 2007/2008 (aORs comparing secondary with no education 0.18, 95% CI 0.09 to 0.36 and 0.42, 95% CI 0.21 to 0.82). Over time there was a fall in reported unprotected last sex among those with no education, while this had increased among those with secondary education. Consequently, there was strong evidence that the magnitude of this relationship was decreasing over time (interaction $p < 0.001$).

The pattern among women was similar to that among men. In 2003/2004 among women with a non-cohabiting partner in the previous year, those with primary or secondary education were less likely to report non-condom use at last sex (aOR comparing secondary with no education 0.14, 95% CI 0.06 to 0.34). By 2007/2008, while this pattern was seen in an unadjusted analysis, this relationship was no longer present after further adjustment for age, urban/rural location and wealth tertile (aOR 0.51, 95% CI 0.23 to 1.15). Among women, there was strong evidence for a weakening in the association between education and unprotected sex over time (interaction $p < 0.001$).

Discussion

We have previously described how HIV prevalence among adults in Tanzania remained stable at about 4% among those with no prior education between 2003/2004 and 2007/2008, while falling steeply from approximately 8% to just 2% over the same period among those with secondary education [6]. Here, we sought to examine the patterns and trends in characteristics of sexual behaviour that might explain the shifting socioeconomic distribution of HIV prevalence over time, focusing on young people since this is the population subgroup in which prevalence trends are most likely to represent incidence patterns. Sexual behaviour patterns generally followed a pattern of ''less risk'' (or at least, behaviour patterns more in line with core HIV prevention messages) in more educated groups, or had no association with education. There was almost no evidence of more risky characteristics in the more educated groups. This strengthens the evidence that since 2000 new infections have been concentrating among the least educated. Our second interest was in changes over time in the association between educational attainment and behavioural risk factors: the data we present here suggest that the gap in risky behaviours between more and less educated was increasing (males) or stable (females) over time for age at first sex, stable for multiple partners and may be closing for unprotected last sex (Table 5).

Our research had a number of limitations. There are of course multiple characteristics of sexual behaviour relevant to HIV transmission that we have not reported on here, such as frequency of sex, age-mixing, participation in most-at-risk groups such as female sex workers, marriage and within-

Table 5. Interactions between year of survey and level of educational attainment in adjusted, sex-stratified analysis of self-reported sexual behaviour.

			No education	Primary	Secondary	Interaction term *p*-value from pooled model^
Rate of first sex	Males	Interaction term	1.02 (0.63–1.64)	–	0.61 (0.42–0.90)	0.04
		Rate ratio*	1.00 (0.63–1.59)	0.98 (0.83–1.14)	0.60 (0.42–0.85)	
	Females	Interaction term	0.85 (0.63–1.15)	–	0.77 (0.57–1.03)	0.17
		Rate ratio*	0.95 (0.73–1.23)	1.12 (0.96–1.30)	0.86 (0.65–1.13)	
More than one partner	Males	Interaction term	–	1.05 (0.55–2.02)	0.82 (0.35–1.92)	0.75
		Odds ratio*	0.56 (0.32–1.00)	0.59 (0.45–0.79)	0.46 (0.25–0.85)	
	Females	Interaction term	–	1.43 (0.71–2.89)	2.90 (0.78–10.75)	0.36
		Odds ratio*	0.43 (0.22–0.82)	0.42 (0.27–0.65)	1.03 (0.32–3.31)	
Unprotected last sex with last non-cohabiting partner	Males	Interaction term	–	1.34 (0.67–2.70)	2.57 (1.04–6.35)	<0.001
		Odds ratio*	0.63 (0.33–1.20)	0.87 (0.63–1.15)	1.62 (0.82–3.20)	
	Females	Interaction term	–	2.00 (0.84–4.75)	3.96 (1.29–12.15)	<0.001
		Odds ratio*	0.42 (0.18–0.96)	0.83 (0.59–1.18)	1.64 (0.78–3.44)	

*Rate/odds ratios show the adjusted relative difference in the reported characteristic by survey year, stratified by educational groups.
^These interaction test (Wald-test) *p*-values are also reported in Tables 2–4.

marriage behaviours. We were also missing data, allowing us to investigate in more detail the many potential pathways through which education may be associated with HIV risk [12]. It is also not possible for us to eliminate the possibility that some behavioural patterns over time reported here arise because of changing composition of educational groups that have occurred as access to education has expanded as opposed to changes in behavioural tendency. Sexual behaviour characteristics are also notoriously subject to potential reporting biases including social desirability bias, with the potential for differential misreport at different time points and among different socioeconomic groups. The specific potential effects of such biases on the findings reported here are difficult to predict. The small sample sizes in some strata meant that interaction tests for change in behaviour by survey year had low power. We were also not able to track incident HIV infections, the primary outcome of interest. Finally, while a major strength was that we used data from two surveys, even this approach provided data on only one time period (2000 to 2008).

These limitations require significant care in further interpretation, and ongoing monitoring of this phenomenon is warranted before strong conclusions can be drawn. In addition, robust theories will be required to provide a framework to aid interpretation of emerging data. To contribute to this second component, in the remainder of this discussion we will outline how the emerging data on prevalent HIV infections in Tanzania, to some extent complemented by the analysis of sexual behaviour presented here, perhaps fit with the pattern that would be predicted by the ''inverse equity hypothesis'' [13,14]. The hypothesis, originally described in relation to child health in Brazil, is a variant of the better known Tudor-Hart's ''inverse care law'' [13], which describes the phenomenon that health needs are often inversely associated with the quality and accessibility of health care services. The inverse equity hypothesis suggests that the introduction of health interventions will tend to benefit those of the highest socioeconomic position first, only later benefiting those in lower socioeconomic groups.

The hypothesis has been applied to a diverse range of health questions. For example, in Western Australia, there was a significant time-lag in the diffusion of a range of coronary procedures recommended following myocardial infarction to those of lower socioeconomic position [15]. In Southern Brazil, poor areas were the slowest to adopt water fluoridation [16]. Applied to HIV prevalence, the inverse equity hypothesis would suggest that the roll-out of HIV prevention messages and technologies would be first taken up by higher socio-economic groups, and thus that risky behaviours and incidence rates would start to decrease in these groups before lower socioeconomic groups. Although little data on sexual behaviour are available from earlier in the epidemic, in the 1980s to 1990s prevailing sexual risk patterns must have been higher in higher socioeconomic groups because these groups had the highest levels of HIV prevalence in early studies. Which aspects of sexual behaviour drove this association is unclear, although it seems likely that condom use was low in all sections of society. Efforts to scale-up HIV prevention activities in sub-Saharan Africa grew during the 1990s and were catalysed in particular in the early 2000s, especially following the Durban 2000 World AIDS conference and the United Nations General Assembly Special Session on HIV/AIDS in 2001. Under the inverse equity hypothesis, we might expect this shift in the scale of health promotion activities to have led to faster adoption of safe-sexual behaviour characteristics (such as delaying first sex, only having one partner and using condoms) by those of higher socioeconomic position. Data on HIV prevalence seem to suggest this pattern, although there have previously been few attempts to explore the phenomenon more directly in relation to risk behaviours. Our analysis focused on time trends a few years after 1996: our retrospective analysis of rates of first sex includes data from just after 1 January 2000, but the majority of the changes we

explore are between the years preceding the 2003/2004 and 2007/2008 surveys. As we have described, over this time period the educational gap in rate of first sex was either stable or perhaps widening, the gap in multiple partnerships was also stable, while condom use appeared to be catching up in the least educated. Different aspects of sexual behaviour may themselves change differently over time and in respect to educational attainment. This is an interesting observation that warrants further research to unpick the dynamics in more settings and over a broader time period, and to assess whether this can be considered in line with or contradictory to the hypothesis.

The picture remains incomplete. Nevertheless, we suggest that currently available evidence on the social epidemiology of HIV prevalence in sub-Saharan Africa (closing educational differences in prevalence demonstrated in several studies, and mostly stable or reducing educational difference in risky sexual behaviours over the time period shown in this study) seem broadly consistent with the inverse equity hypothesis. Further research could apply this lens when describing trends in HIV prevalence and behaviour among different socioeconomic groups and thus strengthen or weaken support for this.

It seems unlikely that any single piece of work will allow a definitive conclusion to be drawn about whether the inverse equity hypothesis can be said to apply in relation to the emerging characteristics of the HIV epidemic. This is because much relevant data have simply not been collected, and because the (quasi-)experimental conditions that would allow strong conclusions to be drawn have not been present over the roll-out of HIV prevention activities across the region, and for a variety of other reasons. However, further research could strengthen or undermine support for the hypothesis. First, mathematical models can be used to explore the incidence, mortality and behavioural patterns underlying HIV prevalence trends. Adapting existing models to incorporate markers of socioeconomic stratification is feasible and would be highly instructive. It would allow more comprehensive linking of reported sexual behaviour and HIV prevalence trends, estimates of incidence and predictions about the future course of the epidemic to be made. Second, pooled analysis of data from HIV prevention trials to assess whether there is evidence of differential effect of interventions by socioeconomic status would be useful. Third, a growing number of countries over the next few years will have serial, nationally representative HIV prevalence surveys available. Many also have data on some aspects of sexual behaviour going back to the 1990s. There is much work to do on this body of data to strengthen or challenge the inverse equity hypothesis across multiple settings.

Authors' affiliations
[1]London School of Hygiene and Tropical Medicine, London, UK; [2]MRC Centre for Causal Analyses in Translational Epidemiology, School of Social and Community Medicine, University of Bristol, Oakfield Grove, UK

Competing interests
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Authors' contributions
JH conceived the study and led the design of the analysis and the study write-up. ES helped design the analysis and provided expertise on measures of sexual behaviour. EF conducted the final analysis for the paper. LH contributed to the design of the study. All authors contributed to writing up and approved a final draft of the paper.

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