Systematic review exploring time trends in the association between educational attainment and risk of HIV infection in sub-Saharan Africa

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Objective: To assess the evidence that the association between educational attainment and risk of HIV infection is changing over time in sub-Saharan Africa.

Design and methods: Systematic review of published peer-reviewed articles. Articles were identified that reported original data comparing individually measured educational attainment and HIV status among at least 300 individuals representative of the general population of countries or regions of sub-Saharan Africa. Statistical analyses were required to adjust for potential confounders but not over-adjust for variables on the causal pathway.

Results: Approximately 4000 abstracts and 1200 full papers were reviewed. Thirty-six articles were included in the study, containing data on 72 discrete populations from 11 countries between 1987 and 2003, representing over 200 000 individuals. Studies on data collected prior to 1996 generally found either no association or the highest risk of HIV infection among the most educated. Studies conducted from 1996 onwards were more likely to find a lower risk of HIV infection among the most educated. Where data over time were available, HIV prevalence fell more consistently among highly educated groups than among less educated groups, in whom HIV prevalence sometimes rose while overall population prevalence was falling. In several populations, associations suggesting greater HIV risk in the more educated at earlier time points were replaced by weaker associations later.

Discussion: HIV infections appear to be shifting towards higher prevalence among the least educated in sub-Saharan Africa, reversing previous patterns. Policy responses that ensure HIV-prevention measures reach all strata of society and increase education levels are urgently needed.

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Introduction

HIV has spread most rapidly in sub-Saharan Africa, the world's poorest region, where access to medical care for those infected is also most constrained [1]. While the pandemic of HIV has been widely characterized as a disease of poverty, the association between socioeconomic status and risk of HIV infection is more complex than this suggests.

In 2001, we published a systematic review on the association between educational attainment and risk of HIV infection in developing countries [2]. This examined studies reporting on data mostly collected before 1996. With one exception, in studies conducted in sub-Saharan Africa, there was either no association between educational attainment and HIV infection or individuals with the highest levels of education were more likely to be infected. Other authors have also reached this

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conclusion [3]. This finding is likely to have reflected the higher socioeconomic status and greater mobility of those with greater levels of education, which, in turn, facilitated engagement in larger, more risky sexual networks.

We and others hypothesized that as the public-health response to HIV grew in sub-Saharan Africa, so the most educated, empowered members of society would be the first to adopt protective behaviours [2,4,5]. Since HIV campaigns are often delivered within schools, longer attendance at school might also increase contact with health-promotion messages and reduce risk of infection among young adults. In the absence of effective interventions that engaged the least educated, HIV would, over time, increasingly affect this group.

This article updates the systematic review to include new data published between 2001 and July 2006 and new data on time trends. The analysis explores the hypothesis that later studies of the association between educational attainment and HIV infection (those conducted from 1996 onwards) are more likely to show a lower risk of HIV infection among the most educated than earlier studies (those where data were collected before 1996).

Methods

Details of the search strategy employed in 2001 are published elsewhere [2]. This strategy was repeated in July 2006, involving a comprehensive search of the major biomedical databases (Pubmed, Embase), hand searching key journals (*AIDS, International Journal of STD & AIDS, Journal of Acquired Immune Deficiency Syndrome*) and checking reference lists of relevant articles. Two modifications were made to the original strategy: the search only looked for data from sub-Saharan Africa and it included a search term for 'sexual behaviour'. The search sought to identify articles reporting original data comparing individually measured educational attainment and HIV status among at least 300 individuals from population groups broadly representative of the general population. Studies restricted to high-risk groups and other unrepresentative sections of the population were excluded. Standardized forms were used to collect data from selected articles.

Only articles that presented appropriately analysed information on the association between schooling and HIV were reviewed. Appropriately analysed articles were those that adjusted for, or restricted by, at least setting (rural/urban), age and sex. Inappropriately analysed articles were those containing univariate analysis only or multivariate analysis that 'over-adjusted' for sexual behaviour or the presence of sexually transmitted infections, which might mediate any true effect of education on risk of HIV infection. Where necessary, authors were contacted to provide full details of analyses described, but not reported in full, in published articles.

In order to summarize the findings of the studies, discrete populations were identified in whom the association between educational attainment and HIV infection had been assessed. If appropriately adjusted analyses were stratified by sex, setting or time period, these were considered discrete populations. In many cases a single article reported on multiple populations while in some cases more than one article reported on the same population. The results of age-stratified analyses are described separately, with an emphasis on the results of studies conducted among younger groups, in whom patterns of prevalent infection are likely to most closely reflect incidence.

Analyses generally compared levels of HIV infection among individuals grouped by two to five categories of educational attainment, measured as years of school attended or grade achieved. First, we examined the comparison between the most educated and the least educated within each population. In each case the result was classified as a statistically significant ($P < 0.05$) increased risk of HIV infection among the most educated compared with the least educated, a significantly lower risk, or no association. Since only three articles assessed evidence for linearity or trend or presented the results of likelihood ratio tests examining the total evidence for an impact of education on risk of HIV infection, in most cases judgements about the type of association reported were made on the basis of the 95% confidence intervals around the odds ratio describing the comparison between the highest and lowest educational groups. Where this approach gave a misleading impression of the association across more than two educational categories, relevant additional data has been provided. Summarized results are presented by year of study, sex and type of study population, study design, setting and country. The year 1996 was chosen *a priori* as a cut-off to describe changes over time, since most articles included in the previous review presented data from before 1996 and since about half the data were collected either side of this date.

Second, situations were identified where successive cross-sectional data were available covering the same target population at different time points. To be included, analyses had to be conducted on a study population selected from the same, or similar, sampling frame in terms of geographic area and age group, and they had to use a comparable analytic approach at different time points. Data over time could be reported in the same article or across a number of articles. Values for the odds ratio and 95% confidence intervals are provided for the relative risk of HIV infection between the highest and lowest educational categories at the different time points and the trend in prevalence of HIV infection among the most and least educated groups was examined over time. Formal meta-analysis was not conducted since the association between educational attainment and HIV infection was not expected to be the same across different populations.

Results

In 2001, approximately 2000 articles were reviewed, and 18 meeting the inclusion criteria were identified [6–23]. For this review, the titles and abstracts of a further 1830 articles published between January 2001 and June 2006 were also examined. The full texts of 335 articles were reviewed and a further 18 articles containing relevant data were identified [24–41]. Appropriately conducted analyses were available for 32 discrete populations for which data had been collected predominantly before 1996 and 40 populations where the data were collected from 1996 onwards. This covered a total of over 200 000 individuals from 11 countries. See Table 1 for details of all selected articles and populations.

Cross-sectional data came from general population surveys employing systematic random sampling [8–12,15–17,20–23,25–29,31–33,37–40], and from samples of young people [34], army recruits [24], residents of a sugar estate [7] and antenatal clinic surveillance [14,18,19,30,36]. Additionally, incident infections were identified in one factory-based cohort study [13] and one nested case–control study within a cluster-randomized trial among the general population [35]. Studies reported on data collected from populations between 1987 and 2003. Information on HIV serostatus was collected from a variety of assays and algorithms, most commonly employing at least one enzyme-linked immunosorbent assay on a fresh blood sample. However, dried blood spots, oral fluid and urine samples were also collected and analysed.

Comparing the highest and lowest educational categories, increased educational attainment was not statistically significantly associated with risk of HIV infection in 44 populations, was associated with an increased risk of HIV infection in 20 populations and was associated with a decreased risk of infection in eight populations. Populations from which data were collected prior to 1996 were more likely to show a higher risk of HIV infection among the most educated (15/32 populations) than those studied from 1996 onwards (5/40) (Table 2). Only one pre-1996 population [35], compared with 7/40 from 1996 onwards, had a lower risk of HIV infection among the most educated. Similar patterns of results were seen in studies conducted in different settings, among different population types, with different study designs and in countries where data were available from both time periods. There was some suggestion that there was more likely to be a higher HIV risk among the most educated compared with the least educated among females (compared with males), antenatal clinic surveillance populations (compared with general population samples) and rural (compared with urban) populations (Table 2).

Eligible data from different time periods were available for 13 populations from five countries: Malawi (1 population), Tanzania (2 populations), Uganda (3 populations), Zambia (6 populations) and Zimbabwe (1 population) (Fig. 1). Downward trends in HIV prevalence in the most educated, together with a reduction in the relative HIV prevalence between the most and least educated were seen in rural (but not urban) Kagera, Tanzania; females (but not males) from Masaka, Uganda; antenatal clinic users in Fort Portal, Uganda, and in Manicaland, Zimbabwe; and among urban (but not rural) populations in Zambia. In Karonga, Malawi, a reduction in the relative prevalence of HIV between the early and late 1990s reflected an increase in prevalence in the least educated rather than a fall in the more educated. In Zimbabwe and Zambia, increases, or stabilization, in the HIV prevalence in the least educated contributed to the changing relative prevalence seen. Only in Masaka, Uganda, was there evidence of reduction in HIV prevalence in both the most and the least educated. In general, from 1996 onwards, changes in the adjusted odds ratio for HIV infection comparing groups of the highest and lowest levels of educational attainment tended to shift towards no association or a lower risk in the most educated (Fig. 2). Multiple studies were also conducted in Mwanza, Tanzania, and Rakai, Uganda, but these varied over time in sampling frame, age group, study design or analysis. In Mwanza, two cross-sectional studies conducted a single year apart showed a slightly higher adjusted odds ratio comparing the most and the least educated in 1991–2 than in 1990–1 for both sexes [6,8,12]. Data from a later nested case–control study of incident HIV infections between 1991 and 1994 in Mwanza, Tanzania, suggested a significantly lower risk of infection among the most educated among males, while among females there was no association with education [35].

Age-stratified or restricted analyses were available for 35 populations under 30 years of age (Table 1). In Kisumu, Kenya, and Ndola, Zambia, there was no association between educational attainment and HIV among males or females aged 15–24 years. In Yaounde, Cameroon, among females aged 15–24 years, the most educated were at the lowest risk of infection, while there was no association among young males. In Cotonou, Benin, the most educated males aged 15–24 years were at the lowest risk of infection, but there was no association among females. In Manicaland, Zimbabwe, there was a lower risk of infection among the most educated females aged 15–24 years, while among males aged 17–29 years there was no association. In Mwanza, Tanzania, ever having attended school was associated with a lower risk of infection among males, but not females, aged 15–19 years.

Time-series analyses were also available for some populations of young people. In Masaka, Uganda, there

Table 1. Details of articles identified for inclusion in the review.

Setting	Group	Age	Education levels compared	Year	Urban/rural	Sex	No.	HIV positive [No. (%)] Lowest education group	HIV positive [No. (%)] Highest education group	Adjusted OR comparing highest with lowest (95% CI)[a]	Factors adjusted for	Age-stratified results (year ranges) summary[b]
Cotonou, Benin [28,37]	Pop	15–49	< Primary, primary, ≥secondary	1997–8	U	F	1013	26/629 (4.1%)	1/38 (2.6%)	0.52 (0.07–4)	Age, ethnic group, religion	15–24 (=), 25–49 (=)
					U	M	927	15/299 (5%)	2/152 (1.3%)	0.17 (0.04–0.78)		15–24 (=), 25–49 (–)
Bobo DiouLasso, Burkina Faso [38]	Pop	20–34	None, primary, ≥secondary	2000	U	M	449	8/130 (6.2%)	6/192 (3.1%)	NS	Age	
		15–24			U	F	359	10/140 (7.1%)	11/124 (8.9%)	NS		
Yaounde, Cameroon [28,37]	Pop	15–49	<Primary, primary, ≥secondary	1997–98	U	F	1017	16/139 (11.5%)	6/40 (4.8%)	0.3 (0.11–0.78)	Age, ethnic group, religion	15–24 (–), 25–49 (–)
					U	M	895	3/75 (4%)	8/276 (2.9%)	0.49 (0.12–2.1)		15–24 (=), 25–49 (=)
Various remote villages, Cameroon [33]	Pop	15–70	Illiterate, primary, ≥secondary	2000	R	F	2394	28/731 (3.8%)	26/417 (6.2%)	1.2 (0.6–2.3)	Age, marital status	
					R	M	1762	9/222 (4%)	40/575 (7%)	1.7 (0.8–3.8)	Age	
Army recruits, Ethiopia [24]	Army	18–49	None, grade1–6, grade 7–12	2000	R	M	61913	636/24454 (2.6%)	770/14077 (5.5%)	**1.8 (1.5–2)**	Age, region, marital status, occupation, religion.	
					U	M	9713	NR	NR	NS	As above – but not retained in stepwise model.	
Sugar estate, Ethiopia [7]	Wor	15–54	< 1, 1–11 years	1995–6	R	M&F	1239	16/295 (5.5%)	21/944 (2.2%)	0.41 (0.17–0.98)[c,d]	Age, sex, residence, migration, occupation	
Kisumu, Kenya [28,37]	Pop	15–49	< Primary, primary, ≥secondary	1997–8	U	F	893	115/384 (30%)	48/156 (30.8%)	0.92 (0.6–1.4)	Age, ethnic group, religion	15–24 (=), 25–49 (=)
					U	M	622	29/159 (18.2%)	39/206 (18.9%)	0.8 (0.45–1.4)		15–24 (=), 25–49 (=)
Karonga, Malawi [29]	Pop	14+	None, 1–5 years, 6–8 years, ≥secondary	1987–9	R	M&F	8237	16/2196 (0.7%)	6/199 (3%)	**3 (1.1–8.4)**[e]	Age, year, position in household, sex, place and all interactions	
Karonga, Malawi [26]	Pop	15+	None, 1–5 years, 6–8 years, ≥secondary	1988–90	R	M&F	1720	4/314 (1.3%)	2/39 (5.1%)	1.5 (0.22–9.6)	Age, sex, area	
				1991–93	R	M&F	723	4/131 (3.1%)	3/15 (20%)	**8 (1.3–47)**		
				1998–01	R	M&F	833	12/101 (11.9%)	29/138 (21%)	1.3 (0.55–3)		
National, Niger [25]	Pop	15–49	None, primary, ≥secondary	2002	U+R	M&F	6056	NR	NR	1.27 (0.6–2.63)[c]	Gender, age, rural/urban, blood transfusion, marital status, surgery	
Arusha, Tanzania [42]	Pop	15–54	None, primary, ≥secondary	1992	U+R	F	567	3/87 (3.4%)	1/29 (3.4%)	0.63 (0.06–6.7)	Age, marital status, area of residence	
Kisesa, Tanzania [39]	Pop	15–44	None, primary, ≥secondary	1994–95	R	M	2271	14/329 (4.3%)	12/122 (9.8%)	**3.0 (1.26–7.17)**	Age	
					R	F	2752	33/863 (3.8%)	9/59 (15.3%)	**4.83 (2.74–8.51)**		

Kagera, Tanzania [9]	Pop	15–54	None, 1–4 years, 5–7 years, ≥secondary	1987	U	M&F	553	10/41 (24.4%)[f]	12/104 (11.5%)[f]	0.46 (0.16–1.33)	Age, sex, religion, occupation, marital status	
				1993	U	M&F	653	13/71 (18.3%)[f]	12/84 (14.3%)[f]	0.63 (0.25–1.59)		
				1987	R	M&F	538	9/114 (7.9%)[f]	5/26 (19.2%)[f]	3.31 (0.83–13.3)		
				1996	R	M&F	1728	29/378 (7.7%)[f]	3/48 (6.3%)[f]	2.1 (0.71–6.27)		
Mwanza, Tanzania [6,8,12,34,35]	Pop	15–54	< 4, ≥ 4 years	1990–91	U+R	M	2000	16/467 (3.4%)	81/1531 (5.3%)	1.2 (0.7–2.3)	Age, area of residence	
	Pop	15–54	< Standard 4, ≥standard 4	1991–92	R	M	5857	46/1730 (2.7%)	173/4127 (4.2%)	1.7 (1.19–2.44)	Age, community	
	Pop[g]	15–54	None or only adult, primary and above	1991–4	R	M	494	NR	NR	<u>0.46 (0.22–0.94)</u>[e]	Age, residence, treatment arm	
	Young	15–19	None, any	1997–98	R	M	4746	9/733 (1.2%)	18/4011 (0.4%)	<u>0.37 (0.16–0.83)</u>[c,e]	Age	
	Pop	15–54	< 4, ≥4 years	1990–91	U+R	F	2161	47/1003 (4.7%)	112/1155 (9.7%)	1.1 (0.8–1.7)	Age, area of residence	
	Pop	15–54	< Standard 4, ≥standard 4	1991–92	R	F	6643	106/3505 (3%)	185/3137 (5.9%)	**1.85 (1.4–2.45)**	Age, community	
	Pop	15–54	None or only adult, primary and above	1991–4	R	F	500	NR	NR	1.15 (0.55–2.38)[e]	Age, residence, treatment arm	
	Young	15–19	None, any	1997–98	R	F	4690	29/1103 (1.3%)	84/3585 (2.3%)	1 (0.67–1.43)[c,e]	Age	
Mwanza Factory, Tanzania [13]	Fac[g]	Mean 28.7	< Secondary, ≥secondary	1991–96	U	F	880	18/1118 (1.6%)[h]	5/77 (6.5%)[g]	**4 (1.4–11.3)**[h]	Age	
					U	M	1594	NR	NR	NS		
Masaka, Uganda [11,27]	Pop	18+	None, some primary, primary completed, ≥secondary	1989–90	R	M	1388	16/204 (8.1%)[j]	25/173 (14.4%)[i]	0.65 (0.19–2.12)[i]	Age, marital status, wealth	18–29 (=), ≥30 (=)
				1999–2000	R	M	1836	7/216 (3.2%)[j]	25/439 (5.7%)[j]	0.92 (0.19–4.39)		18–29 (=), ≥30 (=)
				1989–90	R	F	1627	49/623 (7.8%)[j]	17/131 (12.9%)[j]	0.93 (0.33–2.61)		18–29 (=), ≥30 (=)
				1999–2000	R	F	2271	21/502 (4.20%)[j]	30/401 (7.5%)[j]	0.38 (0.13–1.08)		18–29 (−), ≥30 (=)
Gulu District, Uganda [36,41]	ANC	Not reported	≤ Primary, ≥ secondary	2000–03	U+R	F	3454	364/3345 (10.9%)	18/109 (16.5%)	1.1 (0.65–1.87)	Age, urban/rural	
Fort Portal [19]	ANC	15–49	Illiterate, primary, ≥secondary	1991–94	U	F	1769	131/677 (19.4%)	64/219 (29.2%)	**1.54 (1.08–2.19)**	Age, marital status, year	15–24 (=), 25–49 (+)
				1995–97	U	F	1493	115/588 (19.6%)	37/200 (18.5%)	0.94 (0.62–1.42)		15–24 (−), 25–49 (=)
Rakai, Uganda [20,22,23]	Pop	13+	None, primary, ≥secondary	1989	R	M	585	12/161 (7.5%)	13/66 (19.7%)	NS[e]	Age, area of residence, marital status, travel, occupation	
					R	F	693	40/297 (13.5%)	33/81 (40.7%)	NS[e]		
				1990	R	M	1397	19/248 (7.6%)	55/220 (25%)	**2.8 (1.5–5.5)**[e]	Age	
					R	F	1707	62/551 (11.3%)	63/185 (34.1%)	**2.8 (1.8–4.6)**[e]		
		10–95	None, some primary, completed primary, ≥secondary	1992	R	M&F	1784	5/41 (11.2%)	22/75 (29.4%)	2.01 (NR)[e]	Age, sex, area of residence, occupation, wealth	
Ndola, Zambia [28,37]	Pop	15–49	< Primary, primary, ≥secondary	1997–8	U	F	910	95/321 (29.6%)	51/154 (33.1%)	1.1 (0.69–1.6)	Age, ethnic group, religion	15–24 (=), 25–49 (=)
					U	M	624	24/117 (20.5%)	62/242 (25.6%)	0.85 (0.48–1.5)		15–24 (=), 25–49 (=)

(*continued overleaf*)

Table 1 (*continued*)

Setting	Group	Age	Education levels compared	Year	Urban/ rural	Sex	No.	HIV positive [No. (%)] Lowest education group	HIV positive [No. (%)] Highest education group	Adjusted OR comparing highest with lowest (95% CI)[a]	Factors adjusted for	Age-stratified results (year ranges) summary[b]
National surveys, Zambia [15,32,43]	Pop	15–49	0–7, 8–10, ≥ 11 years	1995	U	M	801	26/164 (15.9%)	105/348 (30.2%)	1.49 (0.67–3.3)	Age, marital status, religion, travel, current work	15–24 (=), 25–49 (=)
				1999	U	M	743	18/95 (8.9%)	95/418 (22.7%)	0.93 (0.45–1.9)		15–24 (=), 25–49 (=)
				2003	U	M	1041	23/117 (19.7%)	77/657 (11.7%)	0.45 (0.27–0.74)		15–24 (−), 25–49 (−)
			0–4, 5–7, ≥ 8 years	1995	R	M	398	8/84 (9.5%)	25/138 (18.1%)	2.27 (0.98–5.26)		15–24 (=), 25–49 (=)
				1999	R	M	652	14/152 (9.2%)	29/212 (13.7%)	1.25 (0.46–3.4)		15–24 (=), 25–49 (=)
				2003	R	M	813	22/167 (13.2%)	51/333 (15.3%)	1.17 (0.5–2.38)[i]		15–24 (=), 25–49 (=)
			0–7, 8–10, ≥ 11 years	1995	U	F	1296	122/495 (24.6%)	103/315 (34.3%)	**1.59 (1.16–2.2)**		15–24 (−), 25–49 (+)
				1999	U	F	1218	79/350 (22.6%)	114/415 (27.5%)	1.33 (0.86–2)		15–24 (=), 25–49 (+)
				2003	U	F	1540	90/332 (27.1%)	132/754 (17.5%)	0.65 (0.42–0.98)		15–24 (−), 25–49 (=)
			0–4, 5–7, ≥ 8 years	1995	R	F	495	17/157 (10.8%)	38/128 (29.7%)	**4.44 (1.75–11.2)**		15–24 (=), 25–49 (+)
				1999	R	F	893	51/341 (14.9%)	23/153 (15%)	1 (0.52–1.93)		15–24 (+), 25–49 (=)
				2003	R	F	1048	45/354 (12.7%)	44/255 (17.3%)	1.87 (0.44–3.73)		15–24 (=), 25–49 (+)
National ANC, Zambia [14,15,40]	ANC	15–39	0–6, 7–9, ≥10 years	1994	R	F	4346	214/2291 (9.3%)	70/312 (22.4%)	**2.68 (1.98–3.64)**	Age, marital status	15–24 (+), 25–49 (+)
				1998	R	F	5120	239/2693 (8.9%)	60/264 (22.7%)	**2.84 (2.04–3.94)**		15–24 (+), 25–49 (+)
				2002	R	F	4409	201/2380 (8.4%)	56/221 (25.3%)	**3.76 (2.68–5.29)**[f]		15–24 (+), 25–49 (+)
				1994	U	F	4571	242/1109 (21.8%)	376/993 (37.9%)	**2.03 (1.67–2.48)**		15–24 (+), 25–49 (+)
				1998	U	F	6556	383/1726 (22.2%)	370/1202 (30.8%)	**1.44 (1.22–1.72)**		15–24 (+), 25–49 (+)
				2002	R	F	7403	335/1647 (20.3%)	451/1631 (27.7%)	**1.36 (1.15–1.6)**[f]		15–24 (+), 25–49 (+)
Manicaland ANC, Zimbabwe [18,30]	ANC	15–49	None, primary, ≥secondary	1993–4	R	F	470	9/52 (17.3%)	34/138 (24.6%)	1.2 (0.5–3.3)	Age, marital status, parity, geographic location.	
	ANC	15–44	Not attended secondary, ≥secondary	1998–2000	R	F	1214	139/637 (21.8%)	117/547 (20.3%)	1.1 (0.8–1.4)	Age	

Manicaland, Zimbabwe [31]	Pop	M: 17–54; F:15–44	None or primary, ≥secondary	1998–2000	R	M	3959	331/1356 (24.4%)	500/2962 (16.9%)	1.0 (0.8–1.2)	Age, residential area	17–19 (=), 20–29 (=), 30–44 (=), 45–54 (=)
					R	F	5137	617/2778 (22.2%)	696/2359 (29.5%)	0.7 (0.6–0.9)		15–19 (–), 20–24 (–), 25–29 (=), 30–44 (=),
Mutasa & Nyanga districts [17]	Pop	M: 17–54; F:15–44	< Secondary, ≥secondary	1998	R	M&F	689	88/331 (26.6%)	67/334 (20.1%)	NS	Age, sex, marital status, employment, spousal separation	

OR, odds ratio; CI, confidence interval; M, male; F, female; U, urban; R, rural; U+R, mixed urban and rural; Pop, general population sample of adults; Young, population sample of young people; Fac, cohort of factory workers; Army, recruits into the army; Wor, sugar estate workers; ANC, antenatal clinic attendees; NR, not reported; NS, not significant, odds ratio or prevalence not reported;
[a]Results reported in bold show a statistically significantly ($P < 0.05$) higher risk of HIV among the most educated; underlined results show a statistically significantly lower risk of HIV among the most educated.
[b]Age-stratified results are summarized: (+), statistically significantly higher risk of HIV among the most educated; (–), statistically significantly lower risk of HIV among the most educated; (=), no association.
[c]Odds ratio presented in paper used highest educational category as reference group. For presentation we have presented the inverse of the reported figures.
[d]Considered for summary analysis to be data collected since 1995 as data collection period was November 1995 to April 1996.
[e]Not considered as part of time-series since sampling strategy differed in 1987 (Karonga), different study design used and different age-groups reported on (Mwanza), and analysis strategy, presentation of odds ratios and age-group differed over time (Rakai).
[f]Additional data provided by authors.
[g]All data come from cross sectional study designs except in Mwanza, Tanzania in 1991–4 where data come from a nested case-control study of incident infections, and from a factory setting in Mwanza, Tanzania 1991–96 where data come from a cohort study.
[h]Incidence rates per 100 person years at risk and rate ratio presented.
[i]Additional data are provided where a comparison between most and least educated could be misleading. Among males and females in Masaka, Uganda, in 1989–90, the highest level of infection was among individuals with postprimary education [females: adjusted OR, 2.09 (95% CI, 0.82–5.35); males: adjusted OR, 2.08 ((5% CI, 0.40–10.7)]. In 1999–2000, an approximately downward linear gradient was seen among females, yet among males the highest levels of infection again occurred in the middle education groupings [some primary: adjusted OR, 4.26 (95% CI, 1.19–15.2); primary completed: adjusted OR, 2.81 (95% CI, 0.53–14.7)]. Among rural Zambian males (2003) the lowest levels of infection were seen among the middle group, those with 5–7 years education (adjusted OR, 0.59; 95% CI, 0.29–1.18).
[j]Numerator estimated from data provided in paper.

Table 2. Summary of analyses of the association between educational attainment and HIV infection in sub-Saharan African countries identified in two systematic searches of the literature conducted in 2001 and 2006: number of discrete populations in each category.

	Data collection prior to 1996			Data collection from 1996 onwards		
	Increased risk of HIV infection with more education	No association	Decreased risk of HIV infection with more education	Increased risk of HIV infection with more education	No association	Decreased risk of HIV infection with more education
Total	**15**	**16**	**1**	**5**	**28**	**7**
Population type						
Antenatal clinics	3	1	0	4	3	0
Population	11	14	1	0	23	5
Other	1	1	0	1	2	2
Sex						
Male	3	6	1	1	11	3
Female	9	6	0	4	13	3
Pooled sex	3	4	0	0	4	1
Setting						
Urban	4	4	0	2	12	4
Rural	11	9	1	3	14	3
Mixed	0	3	0	0	2	0
Study designs						
Cross-sectional	14	14	0	5	28	7
Cohort/nested case–control study of incident infections	1	2	1	0	0	0
Country						
Benin	0	0	0	0	1	1
Burkina Faso	0	0	0	0	2	0
Cameroon	0	0	0	0	3	1
Ethiopia	0	0	0	1	1	1
Kenya	0	0	0	0	2	0
Malawi	2	1	0	0	1	0
Niger	0	0	0	0	1	0
Tanzania	5	8	1	0	2	1
Uganda	4	4	0	0	4	0
Zambia	4	2	0	4	8	2
Zimbabwe	0	1	0	0	3	1

was no significant association among males aged 18–29 years in 1989–90 or 1999–2000. However, among females there was no association in 1989–90 but a significantly lower risk of infection among the most educated in 1999–2000. In Fort Portal, Uganda, there was no association among antenatal clinic attendees aged 15–24 years in 1991–4, whereas by 1995–7 there was a lower risk of infection among the most educated. Among Zambian antenatal clinic attendees aged 15–24 years, there was a higher risk of infection among the most educated in rural and urban areas in 1994, 1998 and 2002. In Zambian population-based surveys, educational attainment was not associated with risk of infection among rural males aged 15–24 years in any year. Among urban males, there was no association in 1995 and 1999, but by 2003 there was a lower risk of infection among the most educated. Among Zambian females from urban areas, there was no association among younger women in 1995 and 1999, whereas by 2003 a lower risk was seen among the most educated women aged 15–24 years. In rural Zambia, there was no association among younger women in 1995 and 2003, but a higher risk of infection among the most educated women in 1999.

Discussion

We present evidence that the epidemiology of HIV infection in sub-Saharan Africa may be changing. Studies conducted before 1996 tended to find either no association with education level or a higher risk of HIV infection among the most educated. A larger proportion of studies conducted from 1996 onwards identified a lower risk of infection among the most educated. Where data over time were available, the trend was generally for strong positive associations to be replaced by weaker or negative associations. Across many settings, HIV prevalence fell more consistently among the higher educated than among the less educated groups, in whom prevalence sometimes rose even while overall population prevalence was falling. Taking these findings together, we suggest that new HIV infections occurring in the latter half of the 1990s and into the 21st century have been occurring disproportionately among the least educated members of society in many sub-Saharan African countries.

Our attempt to synthesize the available evidence might be subject to several limitations. There may have been

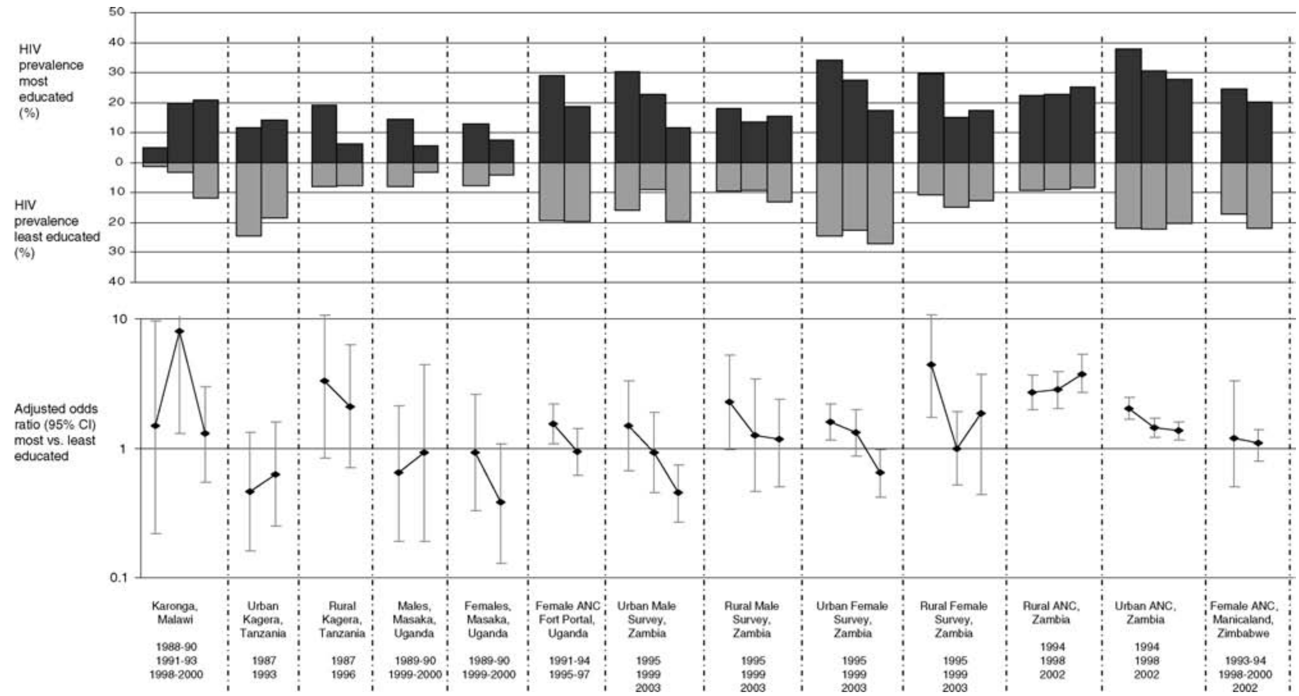

Fig. 1. Time-trends in the association between educational attainment and risk of HIV infection in 13 African populations. For each population, the figure shows trends over time (from earliest data to latest data available) in the prevalence of HIV among the most educated (dark bars) and least educated (light bars, inverted), and the odds ratio (and 95% confidence intervals) comparing these. Data are presented on different time scales for each population (see Fig. 2 for data summarized by year of study). 'Most educated' refers to all individuals with secondary schooling or higher, except in Zambian studies where years of schooling were used to group individuals into approximately equivalent groups (≥ 8 years of schooling for population surveys, ≥ 10 years in Zambian antenatal clinic studies). 'Least educated' refers to all individuals with no education, except in Zambian population surveys (0–7 years of schooling), Zambian antenatal clinic studies (0–6 years) and Manicaland, Zimababwe (no or primary education).

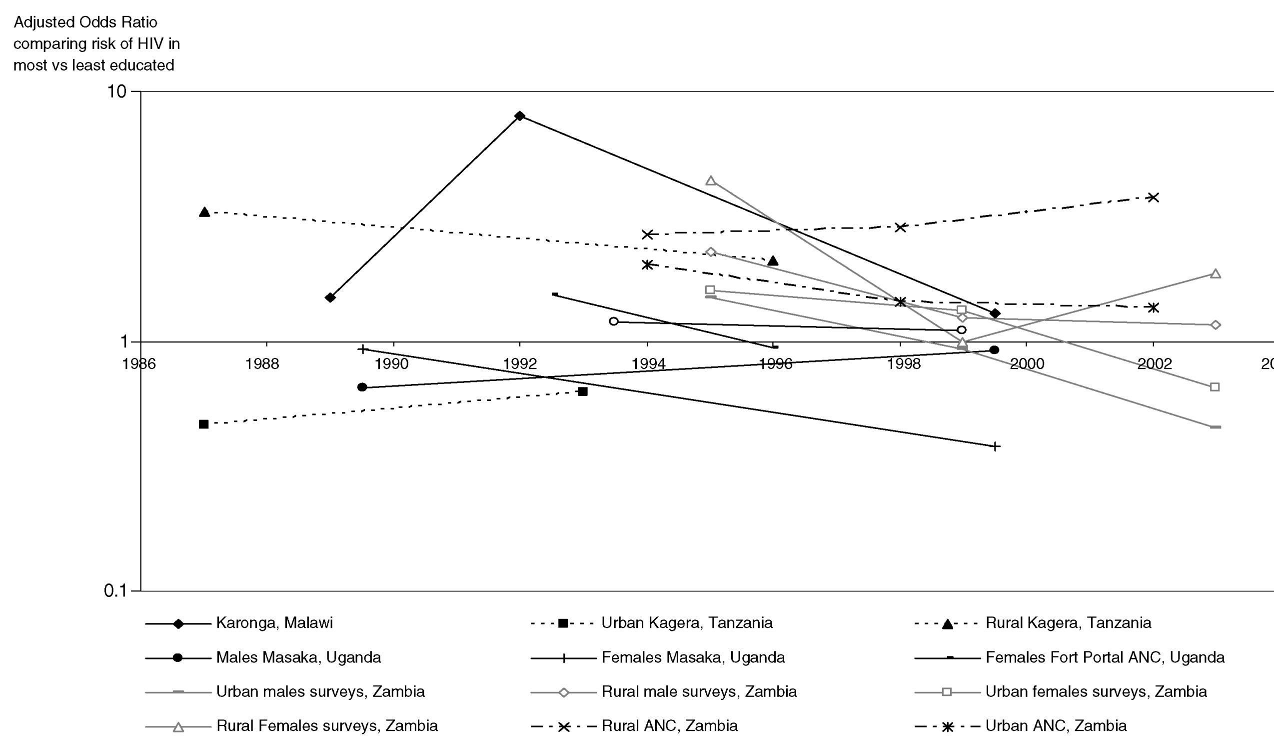

Fig. 2. The association between educational attainment and risk of HIV infection in 13 African populations, by year of study.

limitations in the included studies [2]. For instance, population studies may have been biased if eligible individuals excluded from the study differed from those included. However, response rates were high where they were reported. Studies of antenatal clinic attendees are generally unlinked–anonymized, with approximately 100% response rates, but include only pregnant women who attend antenatal clinics [30], thus excluding the sexually inactive [44] and those not using clinics, who may be less educated. Since delayed first pregnancy has become more common over time in many settings, young women who do become pregnant may be at particularly high risk of infection, perhaps explaining why antenatal clinic data more often suggested higher levels of infection among the most educated and less evidence of changes over time [40,45].

The synthesis of data from observational studies presents particular challenges [46]. In this case, a standardized measure of exposure (educational attainment) was not available and a variety of scales were used. In addition, most studies used more than two educational groups in the analysis, making the appropriate choice of summary measure complex. It was only possible to identify associations between risk of HIV infection and relative level of education in each study. We chose to summarize studies descriptively, primarily on the basis of the comparison of HIV risk between the highest and lowest educational groups. This implicitly assumes a linear association between education and HIV risk, although in only a relatively small number of cases did we judge that such a comparison led to potentially misleading conclusions (see Table 1, footnote h). Estimates of effect were unstable if the highest and/or lowest groups had relatively small numbers for the calculation of HIV prevalence, and the interpretation of the ratio of highest to lowest education will differ across studies. In some settings, levels of secondary school attendance were very low, while in others these were much higher, and different cut-offs were used. The lowest category of educational level thus varied from no education to less than secondary in different studies (Table 1).

We only included studies that adjusted for (or restricted by) age and sex, and that did not adjust for sexual-behaviour factors that are likely to be on the causal pathway between education level and HIV. An exception was made for marital status, as many of the studies had controlled for this. In one study that explicitly explored the confounding effect of marriage on the association of education status and HIV risk in four different settings, it had little effect on the results [28].

We cannot exclude publication bias: perhaps studies finding a lower risk of HIV infection among more educated groups, or a shifting pattern of infection towards this trend, may have been more likely to be published between 2001 and 2006. However, education level was often not the main focus of the studies, so it is unlikely to have biased publication. Finally, data were only available from 11 of the countries in the region, a minority.

Overall, available data from a number of settings suggested that the trend seen in data collected before 1996, of a higher risk of infection among the most educated groups, was weakening, and in some cases reversing, over time. Since patterns of prevalent HIV infection are relatively slow to respond to changes in HIV incidence, it is possible that these patterns hide much greater relative differences in HIV incidence between the most and least educated in recent years. Where time-series data were available on younger age groups, in whom infection is likely to have been acquired recently, this trend was also seen. Previous studies have attempted to infer time trends by comparing the association between education and HIV between younger and older groups [15,27,32]. However, differential AIDS-related mortality in these groups makes these comparisons difficult [28] and a strength of our study was the inclusion of data collected in different time periods to address this question. Differential mortality could only explain the changes seen in different time periods if overall rates of AIDS-related mortality were changing rapidly in some age groups over time, which is unlikely as these studies predate the widespread accessibility of antiretroviral drugs.

While an overall pattern emerged, there was also some evidence of differences between population groups, for example with differences between rural and urban Zambia. Zambia was the only country with data from a wide range of regions within the country; other results came from single regions or towns, and for most countries of sub-Saharan Africa there were no data at all. It is possible that patterns in other countries may differ.

Strong supporting evidence of behaviour change among the most educated comes from studies that have consistently found higher levels of reported condom use among more educated individuals in a variety of contexts [28,45,47–53]. However, evidence with regard to other safer-sexual behaviours, such as delayed age at first sex and reduced partner numbers, is less consistent: some studies have suggested lower risk among the most educated but this has not been seen in other settings [28,31,45,48,53–56]. The plausibility of the hypothesis of change occurring earlier in those with more education is also supported by well-established theory. For example, the diffusion of innovations model predicts that more-educated, more-empowered members of a population will seek out information on new practices (such as condom use in sub-Saharan Africa in the latter part of the 20th century) and more readily adopt these [4].

The evidence presented here should highlight the importance of monitoring future trends within surveillance systems across sub-Saharan Africa. We believe there is already sufficient evidence to support consideration of policy responses to the changing epidemiology of HIV infection we outline in this paper, since such responses will need to be rapidly rolled out if the trends reported here are confirmed in ongoing surveillance. Current approaches, focusing primarily on the provision of information, distribution of condoms and treatment of sexually transmitted infections have worked and should continue. However, these efforts may effectively serve only some sections of the community, and health inequalities in sub-Saharan Africa may be set to increase. Additional efforts are needed to expand the reach of HIV prevention programmes to target socially vulnerable groups more effectively and to address social inequalities. As an example, recent interventions to improve school enrolment, such as the abolition of primary school fees, have met with dramatic success in Kenya, Malawi, Tanzania and Uganda as part of efforts to achieve universal access to primary education [57]. Such interventions may have a role to play in complementing more traditional HIV prevention methods in reducing HIV incidence in all social groups.

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