Temporal trends in socioeconomic inequalities in HIV testing: an analysis of cross-sectional surveys from 16 sub-Saharan African countries

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Summary

Background Overall increases in the uptake of HIV testing in the past two decades might hide discrepancies across socioeconomic groups. We used data from population-based surveys done in sub-Saharan Africa to quantify socioeconomic inequalities in uptake of HIV testing, and to establish trends in testing uptake in the past two decades.

Methods We analysed data from 16 countries in sub-Saharan Africa where at least one Demographic and Health Survey was done before and after 2008. We assessed the country-specific and sex-specific proportions of participants who had undergone HIV testing in the previous 12 months across wealth and education groups, and quantified socioeconomic inequalities with both the relative and slope indices of inequalities. We assessed time trends in inequalities, and calculated mean results across countries with random-effects meta-analyses.

Findings We analysed data for 537 784 participants aged 15–59 years (most aged 15–49 years) from 32 surveys done between 2003 and 2016 (16 before 2008, and 16 after 2008) in Cameroon, Côte d'Ivoire, DR Congo, Ethiopia, Guinea, Kenya, Lesotho, Liberia, Malawi, Mali, Niger, Rwanda, Sierra Leone, Tanzania, Zambia, and Zimbabwe. A higher proportion of female participants than male participants reported uptake of HIV testing in the previous 12 months in five of 16 countries in the pre-2008 surveys, and in 14 of 16 countries in the post-2008 surveys. After 2008, in the overall sample, the wealthiest female participants were 2·77 (95% CI 1·42–5·40) times more likely to report HIV testing in the previous 12 months than were the poorest female participants, whereas the richest male participants were 3·55 (1·85–6·81) times more likely to report HIV testing than in the poorest male participants. The mean absolute difference in uptake of HIV testing between the richest and poorest participants was 11·1 (95% CI 4·6–17·5) percentage points in female participants and 15·1 (9·6–20·6) in male participants. Over time (ie, when pre-2008 and post-2008 data were compared), socioeconomic inequalities in the uptake of HIV testing in the previous 12 months decreased in male and female participants, whereas absolute inequalities remained similar in female participants and increased in male participants.

Interpretation Although relative socioeconomic inequalities in uptake of HIV testing in sub-Saharan Africa has decreased, absolute inequalities have persisted or increased. Greater priority should be given to socioeconomic equity in assessments of HIV-testing programmes.

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For a French translation of the Article see **Online** for appendix 1

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Introduction

As the gateway to many HIV prevention and care services, including antiretroviral therapy (ART), HIV testing has a central role in the HIV response. Testing strategies have evolved as ART became increasingly available in most countries, from a cautious approach that focused on counselling and confidentiality to a push to increase routine access to testing in clinical settings and through large-scale community approaches.[1,2] This evolution has resulted in substantial increases in access to, and uptake of, HIV testing in many countries.

The proportion of people living with HIV who know their HIV status increased from 10% in 2005, to 85% in eastern and southern Africa and 64% in western and central Africa in 2018.[3] However, an estimated 1·1 million people with HIV in eastern and southern Africa, and 1·3 million in western and central Africa, remain unaware of their HIV status. Thus, efforts are still needed to reach the target of 90% of people with HIV knowing their status by 2020—the first 90 of the global 90-90-90 target adopted by UNAIDS.[4] Ensuring that no specific group of the population is left behind in efforts to achieve these objectives is essential.

Several cross-sectional studies[5–8] done in sub-Saharan Africa have shown low uptake of HIV testing in the poorest and least educated population groups, and whether these inequalities increased or decreased during the intensification of HIV testing activities remains unknown. Scale-up of health interventions

Research in context

Evidence before this study

We searched PubMed with the search terms ("inequality" OR "inequity" OR "equity") AND ("HIV testing") AND ("Africa") for articles published in any language up to Oct 15, 2019. We also screened the reference lists of relevant articles returned by our search to identify other potentially relevant papers. Many studies documented socioeconomic inequalities in access to HIV treatment and to specific HIV prevention services, such as HIV testing, prevention of mother-to-child transmission, and voluntary medical male circumcision. Most of the studies assessed socioeconomic inequalities in specific subgroups of the population (eg, pregnant women), or specifically focused on other forms of inequalities, such as gender or age inequalities. Among studies focusing on wealth-related or education-related inequalities, most focused on one country only. All of these studies showed that wealth or education, or both, were predictors of HIV testing. A study of the relation between socioeconomic status and knowledge of one's HIV status in 13 sub-Saharan African countries, which was done in the pre-treatment era (ie, before 2006), showed a general trend of greater knowledge of HIV status among wealthier and more educated individuals compared with among poorer and less educated people. One grey-literature report based on Demographic and Health Survey data up to 2011 described the demographic characteristics associated with HIV testing in several sub-Saharan African countries. In gender-specific univariate analyses, uptake of HIV testing tended to increase monotonically with wealth. There were a few exceptions, however, especially in countries with very high or very low overall levels of testing. Although socioeconomic inequalities in HIV testing in sub-Saharan Africa have been detailed in many studies, no pooled estimate of the effect was available. Furthermore, whether these inequalities were decreasing or worsening was not reported in any study.

Added value of this study

We analysed data from the standardised, population-based Demographic and Health Surveys to identify the magnitude of the effect of wealth-related and education-related inequalities on uptake of HIV testing in 16 sub-Saharan African countries. We also investigated how this effect changed over time, by comparing data from surveys done before and after 2008 (when international recommendations to expand provider-initiated opt-out testing were released, and by when antiretroviral therapy in sub-Saharan Africa had been scaled up). We report both relative and absolute inequalities based on indicators that are widely used for the quantification and comparison of socioeconomic gradients in health, and also calculated mean overall estimates for the 16 countries included. In the most recent surveys (ie, those done after 2008), we noted a general trend of inequalities that disfavoured poor and less educated people (ie, these groups were less likely to have undergone an HIV test in the previous 12 months). Relative socioeconomic inequalities were sharper in male than in female participants: overall, in the post-2008 surveys, the wealthiest male participants were roughly 3·6 times more likely to report HIV testing in the previous 12 months than were the poorest participants; the corresponding ratio among female participants was roughly 2·8. Relative inequalities tended to be greater in western and central African countries than in eastern and southern African countries. When we contrasted the pre-2008 and post-2008 surveys, relative inequalities in HIV testing uptake had decreased in both sexes, whereas absolute inequalities remained similar among female participants and increased among male participants.

Implications of all the available evidence

Socioeconomic inequalities in the uptake of HIV testing remain substantial in many countries, despite reductions in relative inequalities. Our results highlight the need to monitor not only overall progress in HIV testing uptake, but also progress in socioeconomic subgroups. A better understanding of the drivers of these inequalities is needed to ensure that current and future HIV testing policies reach every part of the population, especially the poorest and the least educated groups.

does not necessarily translate into reduced health inequalities, and could even exacerbate inequalities. For instance, data from high-income countries suggest that programmes that increased cancer screening services did not reduce the effect of socioeconomic inequalities on uptake of these services.[9,10] Monitoring of temporal trends in socioeconomic inequalities in response to expanded HIV testing is thus essential to assess and ensure equity of HIV programmes in line with the Sustainable Development Goals. In this study, we used data from population-based surveys in several sub-Saharan African countries to assess temporal trends relative and absolute socioeconomic inequalities in the uptake of HIV testing during the era of HIV testing progression and ART scale-up.

For the **Demographic and Health Surveys** see https://dhsprogram.com/

Methods

Study design and data sources

In this cross-sectional study, we analysed data from Demographic and Health Surveys (DHS) from 16 sub-Saharan African countries to quantify socioeconomic inequalities in uptake of HIV testing in the previous 12 months. DHS are nationally representative cross-sectional surveys in which data are collected for a wide range of health indicators. DHS have a multistage design: households are sampling units, and generally all people aged 15–59 years from selected households are eligible for inclusion. However, the bulk of the surveys were done in participants aged 15–49 years, and depending on the survey, data for men or for HIV indicators and biomarkers, or both, might be collected in

only a subsample of selected households. Consenting adults are interviewed face-to-face by trained interviewers, who use a standardised questionnaire that includes items on sociodemographic characteristics, sexual behaviours, and reproductive health, and a specific section focusing on HIV-related issues.[11]

For our analysis, we selected sub-Saharan African countries where at least two DHS including questions about HIV indicators and biomarkers had been done—one before 2008 and one after 2008. In 2007, international recommendations to expand provider-initiated opt-out testing were released,[12] and the recommendation of provider-initiated testing might have caused the profile of HIV-testing users to broaden from a small self-selecting group.[5] For countries where multiple surveys were available either before or after 2008, we considered only the most recently done one (as of March, 2019). Pre-2008 and post-2008 surveys were thereafter termed earlier and later surveys, respectively.

Data

In the DHS, each included household was classified as rural or urban according to nationally defined boundaries. There are many ways to measure socioeconomic position in low-income and middle-income countries, and each method has both strengths and limitations. Asset-based measures and education are commonly used complementarily and are often highly correlated, although they rely on different theoretical bases.[13] Individual sociodemographic characteristics collected as part of the DHS included age, level of school attended (ie, none, primary, or secondary or higher) and marital status (ie, married or cohabiting, single, or widowed or separated). Household wealth was assessed with the DHS's wealth index—a composite measure of living standards that is based on the household's assets (eg, televisions, refrigerators) and characteristics (eg, type of water access, type of flooring).[14] In the DHS, participants were asked whether they had ever been tested for HIV, and if so, the time since their last test. The outcome of interest was self-reporting of undergoing an HIV test in the past 12 months.

Statistical analysis

For each survey, we calculated the proportion of participants reporting an HIV test in the past 12 months. In the calculation, we accounted for survey design and sampling weights. For each survey round (ie, the pre-2008 and post-2008 surveys), we assessed within-country inequalities on the basis of participants' relative rank in the cumulative distribution of the wealth index. Inequalities were then measured both on relative and absolute scales. The reporting of inequalities on both scales is highly recommended, especially when monitoring changes, because conclusions can be skewed when only one or the other is used.[15] Furthermore, the choice of a relative scale over an absolute scale—or vice versa—carries an implicit normative judgment on what a

	Sierra Leone				Guinea				Liberia				Côte d'Ivoire			
	2008		2013		2005		2012		2007		2013		2005		2011–12	
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
Response rate* (%)	94%	93%	97%	96%	97%	95%	98%	97%	95%	93%	98%	95%	90%	88%	93%	91%
n	7374	3280	16 658	7262	7954	3174	9142	3782	7092	6009	9239	4118	5183	4503	10 060	5135
Living in rural area (%)	64%	63%	64%	63%	69%	61%	64%	61%	58%	60%	39%	41%	53%	53%	49%	50%
Age, years (%)																
15–24	32%	28%	39%	34%	35%	36%	40%	36%	38%	37%	40%	39%	46%	41%	40%	34%
25–34	36%	25%	31%	25%	30%	20%	30%	24%	30%	28%	30%	30%	31%	32%	34%	29%
≥35	31%	47%	30%	41%	35%	44%	30%	40%	32%	36%	29%	31%	24%	28%	26%	37%
Marital status																
Married or cohabiting	75%	63%	66%	57%	79%	59%	74%	55%	64%	57%	58%	54%	59%	44%	63%	53%
Single	19%	33%	28%	39%	17%	37%	23%	43%	26%	38%	31%	43%	32%	50%	30%	42%
Widowed or separated	6%	3%	6%	4%	4%	4%	4%	2%	10%	5%	11%	4%	9%	6%	7%	5%
Education level																
None	66%	50%	56%	43%	78%	51%	67%	43%	42%	18%	33%	13%	54%	34%	53%	36%
Attended primary	13%	14%	14%	12%	11%	17%	14%	18%	33%	33%	31%	29%	27%	25%	25%	26%
Attended secondary or higher	21%	36%	30%	45%	11%	32%	19%	39%	25%	49%	36%	58%	20%	41%	21%	38%
HIV prevalence	2%	1%	2%	1%	2%	1%	2%	1%	2%	1%	2%	2%	6%	3%	5%	3%
Uptake of HIV testing in previous 12 months	5%	5%	18%	8%	1%	3%	5%	5%	2%	3%	22%	14%	5%	4%	15%	10%

The DHS data, on which these percentages are based, are available online. *Based on each country's United States Agency for International Development Demographic and Health Survey final report.

Table 1: **Survey and population characteristics in Sierra Leone, Guinea, Liberia, and Côte d'Ivoire**

	Mali				Niger				Cameroon				DR Congo			
	2006		2012–13		2006		2012		2004		2011		2007		2013–14	
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
Response rate* (%)	97%	91%	96%	93%	96%	92%	95%	88%	94%	93%	97%	96%	97%	95%	99%	97%
n	14 583	4207	10 424	4399	9223	3549	11 160	3928	10 656	5280	15 426	7191	9995	4757	18 827	8656
Living in rural area (%)	66%	64%	75%	75%	80%	74%	81%	75%	45%	43%	47%	45%	55%	57%	62%	63%
Age, years (%)																
15–24	40%	36%	36%	29%	37%	31%	34%	28%	46%	41%	43%	39%	43%	39%	41%	36%
25–34	32%	23%	36%	24%	34%	25%	37%	25%	29%	27%	30%	26%	30%	26%	33%	26%
≥35	29%	41%	28%	47%	29%	44%	29%	47%	25%	32%	27%	34%	27%	35%	26%	37%
Marital status																
Married or cohabiting	85%	65%	85%	68%	86%	67%	89%	70%	67%	51%	63%	50%	66%	57%	64%	58%
Single	12%	31%	14%	32%	10%	31%	8%	29%	24%	40%	28%	45%	24%	38%	26%	38%
Widowed or separated	3%	4%	2%	1%	4%	2%	4%	2%	9%	9%	9%	5%	9%	5%	10%	4%
Education level																
None	78%	60%	76%	62%	84%	69%	80%	63%	22%	12%	21%	10%	21%	6%	15%	4%
Attended primary	11%	19%	9%	14%	10%	17%	11%	19%	39%	37%	33%	33%	39%	30%	37%	22%
Attended secondary or higher	10%	21%	15%	24%	6%	14%	9%	18%	39%	52%	46%	57%	41%	64%	48%	74%
HIV prevalence	2%	1%	1%	1%	1%	1%	<1%	<1%	7%	4%	6%	3%	2%	1%	2%	1%
Uptake of HIV testing in previous 12 months	3%	4%	7%	7%	1%	2%	8%	3%	5%	8%	24%	21%	5%	5%	9%	8%

The Demographic and Health Surveys data, on which these percentages are based, are available online. *Based on each country's United States Agency for International Development Demographic and Health Survey final report.

Table 2: Survey and population characteristics in Mali, Niger, Cameroon, and DR Congo

fair and socially just distribution of health should be.[16] We used the relative index of inequality (RII) as our relative scale and the slope index of inequality (SII) as our absolute scale.[17] The former expresses the ratio of the predicted outcomes between the richest and the poorest people in the wealth distribution, whereas the latter represents the absolute difference in the predicted proportions of these two extremes. Both indicators were obtained by fitting a modified Poisson regression, with robust variance and a log link function to estimate the association between participants' relative wealth rank and HIV testing in the past 12 months, and by using generalised estimating equations to account for the clustering of observations.[18] We used the Wilcoxon rank-sum test to compare indices of inequalities between west and central versus eastern and southern African countries.

We also assessed temporal trends in relative and absolute inequalities in uptake of HIV testing in the previous 12 months. For each country, we computed the ratio of RIIs between the later and the earlier surveys:

$$RII\ ratio = \frac{RII_{after\ 2008}}{RII_{before\ 2008}}$$

For the SII, we calculated the difference between the later and earlier surveys:

$$SII\ difference = SII_{after\ 2008} - SII_{before\ 2008}$$

We also calculated 95% CIs for both the RII ratio and the SII difference. Both indicators were standardised on the basis of the number of years elapsed between the earlier and the later surveys (appendix 2 p 2). An RII ratio value greater than 1 reflects increasing relative inequalities, whereas a value less than 1 suggests decreasing relative inequalities. An SII difference of greater than 0 shows increasing absolute inequalities, whereas a difference of less than 0 shows decreasing absolute inequalities.

We averaged inequality estimates across countries for each survey round, as well as trends indicators, by using random-effects meta-analyses.[19] Between-country heterogeneity was assessed with I^2 statistics. To track socioeconomic inequalities in access to HIV testing in young people—a vulnerable population who generally lack access to HIV prevention services—we did a subgroup analysis in participants aged 15–24 years. Because inequalities can differ according to the dimension measured, we repeated all our analyses but used the relative rank in the cumulative distribution of educational attainment instead of wealth as the measure of socioeconomic position. All analyses were also stratified according to sex. We used R (version 3.6.0) for all analyses.

Role of the funding source

The funders of the study had no role in study design, data collection, data analysis, data interpretation, or writing of

the report. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Results

The 16 sub-Saharan African countries included in the analyses were Cameroon, Côte d'Ivoire, DR Congo, Ethiopia, Guinea, Kenya, Lesotho, Liberia, Malawi, Mali, Niger, Rwanda, Sierra Leone, Tanzania, Zambia, and Zimbabwe. The earlier surveys were done between 2003 and 2008, and the later surveys were done between 2008–09 and 2016, with the inter-survey period ranging from 5 years to 11 years across countries (tables 1–4).

90–100% of women and girls approached participated, and 82–100% of men and boys (tables 1–4). Overall, data were collected from 537 784 people, 354 431 female participants and 183 353 male participants. In the surveys done after 2008, most participants in most countries were living in rural areas (except for Cameroon, Côte d'Ivoire, and Liberia) and most were married or cohabiting (except for male participants in Cameroon and Lesotho; tables 1–4). Across all surveys, HIV prevalence was lowest in Niger (0·7% in the pre-2008 survey and 0·4% in the post-2008 survey) and highest in Lesotho (23·0% in the pre-2008 survey and 25·0% in the later survey; appendix 2 p 3).

The uptake of HIV testing improved in all countries between the pre-2008 survey and the post-2008 survey (figure 1). Overall, uptake of HIV testing in the past 12 months was lowest in Niger (1·3%) in the pre-2008 surveys and in Guinea (5·0%) in the post-2008 surveys (figure 1; appendix 2 p 3). It was highest in Zambia (17·0%) in the pre-2008 surveys and in Lesotho (52·6%) in the post-2008 surveys (figure 1; appendix 2 p 4). In the pre-2008 surveys (table 1), a higher proportion of female participants than male participants took an HIV test in five of the 16 countries, whereas in the post-2008 surveys, female participants reported higher uptake than male participants in 14 of 16 countries (tables 1–4). With some exceptions, uptake of HIV testing in the previous 12 months was more frequently reported in urban than in rural areas (appendix 2 pp 4–10).

Figure 2 presents, for each country, the proportions of people who underwent HIV testing in the previous 12 months per survey round and by sex among the richest and poorest wealth quintiles. Among both sexes, we noted a pattern of higher uptake of testing in the richest quintile than in the poorest quintile across survey rounds (figure 2).

Relative and absolute inequalities in uptake of HIV testing in the previous 12 months based on wealth distribution are shown in tables 5 (female participants) and 6 (male participants). In the pre-2008 surveys, relative inequalities that favoured the richest participants over the poorest were noted in all 16 countries, for both male and female participants (all RII values >1; tables 5, 6). Before 2008, the wealthiest female

	Zambia				Lesotho				Zimbabwe				Rwanda			
	2007		2013–14		2004		2014		2005–06		2015		2005		2014–15	
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
Response rate* (%)	97%	91%	96%	91%	94%	85%	97%	94%	90%	82%	96%	92%	98%	97%	100%	100%
n	7146	6500	16 411	14 773	7095	2797	6621	2931	8907	7175	9955	8396	11 321	4820	13 497	6217
Living in rural area (%)	58%	57%	54%	54%	76%	79%	64%	66%	61%	60%	62%	64%	83%	83%	81%	80%
Age, years (%)																
15–24	41%	38%	40%	38%	45%	45%	42%	43%	46%	47%	39%	41%	44%	43%	39%	37%
25–34	34%	30%	32%	26%	26%	24%	31%	25%	30%	27%	33%	27%	28%	24%	33%	30%
≥35	25%	32%	27%	35%	29%	31%	27%	32%	24%	26%	28%	32%	28%	34%	28%	33%
Marital status																
Married or cohabiting	62%	56%	60%	55%	52%	43%	55%	40%	58%	48%	62%	52%	49%	52%	52%	54%
Single	26%	39%	28%	41%	33%	51%	33%	52%	27%	48%	25%	43%	38%	46%	38%	44%
Widowed or separated	12%	5%	12%	4%	14%	7%	12%	9%	15%	5%	13%	5%	14%	3%	11%	2%
Education level																
None	10%	5%	8%	4%	2%	17%	1%	10%	4%	2%	1%	1%	23%	17%	12%	11%
Attended primary	54%	46%	47%	40%	59%	55%	39%	45%	33%	27%	26%	23%	67%	70%	64%	65%
Attended secondary or higher	35%	49%	45%	56%	39%	28%	60%	45%	63%	71%	73%	76%	10%	12%	23%	24%
HIV prevalence	16%	12%	15%	12%	26%	19%	30%	20%	21%	15%	17%	11%	4%	2%	4%	3%
Uptake of HIV testing in previous 12 months	21%	13%	48%	39%	8%	6%	59%	38%	8%	8%	49%	37%	13%	12%	40%	37%

The Demographic and Health Surveys data, on which these percentages are based, are available online. *Based on each country's United States Agency for International Development Demographic and Health Survey final report.

***Table 3:* Survey and population characteristics in Zambia, Lesotho, Zimbabwe, and Rwanda**

	Malawi				Tanzania				Kenya				Ethiopia			
	2004		2015–16		2003–04		2011–12		2003		2008–09		2005		2016	
	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male	Female	Male
Response rate* (%)	96%	86%	98%	95%	96%	91%	96%	89%	94%	86%	96%	89%	96%	89%	95%	86%
n	11 698	3261	24 562	7478	6863	5659	10 967	8352	8195	3578	8444	3465	14 070	6033	15 683	12 688
Living in rural area (%)	82%	80%	82%	82%	69%	70%	73%	74%	75%	75%	75%	74%	82%	85%	78%	80%
Age, years (%)																
15–24	45%	38%	42%	43%	42%	42%	39%	42%	43%	43%	41%	41%	41%	40%	39%	35%
25–34	31%	34%	31%	26%	33%	31%	31%	26%	30%	26%	32%	27%	31%	25%	34%	29%
≥35	24%	28%	27%	31%	25%	27%	30%	32%	27%	31%	27%	32%	28%	36%	27%	36%
Marital status																
Married or cohabiting	71%	64%	66%	58%	64%	53%	63%	53%	60%	51%	58%	51%	64%	57%	65%	59%
Single	17%	33%	21%	38%	25%	41%	25%	42%	30%	45%	31%	44%	25%	40%	26%	39%
Widowed or separated	12%	3%	13%	4%	12%	6%	12%	5%	10%	4%	10%	5%	11%	3%	9%	3%
Education level																
None	23%	11%	12%	6%	22%	11%	18%	9%	13%	6%	9%	4%	66%	43%	48%	30%
Attended primary	62%	63%	62%	59%	69%	78%	65%	67%	58%	57%	57%	52%	22%	37%	35%	47%
Attended secondary or higher	16%	26%	26%	36%	8%	11%	18%	24%	29%	37%	34%	44%	12%	20%	17%	23%
HIV prevalence	14%	10%	11%	7%	8%	6%	6%	4%	9%	5%	8%	5%	2%	1%	1%	1%
Uptake of HIV testing in previous 12 months	8%	8%	44%	42%	6%	8%	33%	28%	8%	8%	31%	23%	4%	2%	21%	20%

The Demographic and Health Surveys data, on which these percentages are based, are available online. *Based on each country's United States Agency for International Development Demographic and Health Survey final report.

Table 4: **Survey and population characteristics in Malawi, Tanzania, Kenya, and Ethiopia**

participants were nearly ten times more likely to report an HIV test in the previous 12 months than the poorest (mean RII for all 16 countries 9·79 [95% CI 4·24–22·60]). By comparison, the equivalent RII after 2008 was 2·77 (95% CI 1·42–5·40), and thus the standardised mean RII ratio was 0·85 per yr⁻¹ (95% CI 0·80–0·90). However, in the post-2008 surveys, inequalities between the richest and poorest female participants persisted in 13 of 16 countries (table 5). This pattern was similar in male participants, with large relative inequalities favouring the richest over the poorest in the pre-2008 surveys, inequalities which decreased in the post-2008 surveys (standardised mean RII ratio for all 16 countries 0·91 per yr⁻¹ [95% CI 0·86–0·96]; table 6). However, inequalities persisted in the post-2008 surveys in 14 of the 16 countries, and overall the richest male participants were 3·55 times more likely to report HIV testing in the previous 12 months than the poorest male participants (mean overall RII 3·55 [95% CI 1·85–6·81]). In the post-2008 surveys, relative inequalities were more marked in the countries in west and central Africa than in those in eastern and southern Africa among both female ($p=0·0070$) and male participants (Wilcoxon rank-sum test $p<0·0001$). Notably, socioeconomic inequalities in testing uptake persisted even when other variables, such as urban versus rural location, were accounted for in multivariate analyses (appendix 2 pp 11–18).

Inequalities favouring the richest participants over the poorest were also noted on the absolute scale among both male and female participants in all countries in the pre-2008 surveys (tables 5, 6). However, we identified no changes in the absolute inequalities in female participants between the pre-2008 surveys and the post-2008 surveys (standardised mean SII difference 0·001 per yr⁻¹ [95% CI –0·006 to 0·008]). In the post-2008 surveys, a difference of more than 10 percentage points persisted between the wealthiest and poorest female participants in uptake of HIV testing in the previous 12 months (mean SII 0·111 [95% CI [0·046 to 0·176]). Among male participants, absolute inequalities increased between the pre-2008 and post-2008 surveys (standardised mean SII difference 0·007 per yr⁻¹ [95% CI 0·001 to 0·014]; table 6). When results were averaged in the random-effects meta-analysis, important heterogeneity (I^2>75%) was noted for all inequality estimates.

In Malawi, Rwanda, Zambia, and Zimbabwe, relative and absolute inequalities were reduced in the post-2008 data compared with the pre-2008 data in both male and female participants (tables 5, 6). A subgroup analysis in participants aged 15–24 years (144 165 women and girls, and 69 597 men and boys) had similar results to those obtained in the overall sample, in terms of both magnitude and temporal trends (appendix 2 pp 19–20).

When inequalities were based on educational attainment rather than wealth, similar results were noted. Mean relative inequalities decreased in both female (standardised RII ratio 0·86 per yr⁻¹ [95% CI 0·81 to 0·92]) and male

(0·91 per yr^{-1} [0·87 to 0·96]) participants, whereas mean absolute inequalities plateaued in female participants (standardised mean SII difference 0·003 per yr^{-1} [95% CI −0·002 to 0·007]) and increased in male participants (0·009 per yr^{-1} [0·004 to 0·014]; appendix 2 pp 22, 23).

Discussion

We analysed repeated cross-sectional population-based surveys to provide a comprehensive assessment of socioeconomic inequalities in uptake of HIV testing in sub-Saharan Africa and to measure temporal trends in the past two decades. Uptake of HIV testing in the previous 12 months increased between surveys done before and after 2008 in the 16 countries included in the analysis. HIV testing was more frequent in urban than in rural areas in nearly all countries both before and after 2008. Before 2008, testing uptake was roughly equivalent between the sexes, but after 2008, women were more likely to have been tested for HIV during the previous 12 months in 14 of the 16 countries. Overall, we noted large relative and absolute inequalities favouring the richest participants over the poorest participants both before and after 2008. Relative inequalities decreased with time in both sexes, whereas absolute inequalities plateaued in female participants but increased in male participants. Results were similar in a subgroup analysis of participants aged 15–24 years, in whom testing uptake is known to be a particular challenge. In the most recent surveys, important relative and absolute inequalities persisted in most countries.

We consistently noted increases over time in uptake of HIV testing in both sexes, as has been previously documented.[7] Indeed, funding for HIV programmes, including funding for HIV counselling and testing, increased substantially during the era of treatment scale-up in sub-Saharan Africa.[20] Concomitantly, the development and spread of new approaches for HIV outreach and testing allowed the intensification of testing programmes—notably the expansion of provider-initiated HIV testing after 2007,[21] and the subsequent development of community-based HIV testing.[2] Despite encouraging increases in the availability and uptake of HIV testing in the past decades, efforts are still required to fulfil the target of 90% of people living with HIV knowing their status, especially in western and central Africa.[22]

We noted that, after 2008, during the time of ART scale-up, higher proportions of female participants than male participants reported HIV testing in the past 12 months in most included countries—a pattern that was not apparent before 2008. Our analysis did not distinguish across HIV testing settings, but a global push on prevention of mother-to-child transmission of HIV via provider-initiated routine testing and the provision of ART in antenatal clinics could have largely contributed to the overall increase in testing among female participants.[21] The apparent absence of efforts to pursue the integration of HIV testing services into other relevant clinical settings could partly explain why fewer men and boys seem to have access to HIV testing and treatment, and could contribute to the HIV prevention blind spot in men and boys.[23] Provider-initiated testing has been suggested to reduce socioeconomic inequalities in the uptake of HIV testing.[6] The higher levels of both relative and absolute inequalities that we noted in male compared with female participants in the post-2008 DHS could thus also be linked to the differing opportunities for provider-initiated testing between sexes. Integration of HIV testing into a wider range of clinical settings could help to reduce the effect of socioeconomic inequalities on HIV testing uptake in men and boys, but would probably not be sufficient to close the gap with women and girls because of the low level of health-seeking behaviours in men and boys. Innovative approaches to HIV testing, such as HIV self-testing, assisted partner notification, and index partner testing, have improved the availability and uptake of HIV testing in key populations and partners of people with HIV.[24] However, few data are available about the relation between such approaches and socioeconomic inequalities in terms of HIV testing uptake. We recommend the inclusion of socioeconomic inequality in future assessments of these approaches.

The trends in inequalities we noted diverged according to whether we used relative or absolute measures of inequalities, and thus we can draw different conclusions about the effect of the scale-up of HIV testing on socioeconomic inequalities in uptake of HIV testing. Such a situation is quite common in the study of health inequalities, and shows the importance of using both absolute and relative effect measures when reporting inequalities.[15] Relative inequalities tend to be larger at low overall levels of the considered outcome, whereas

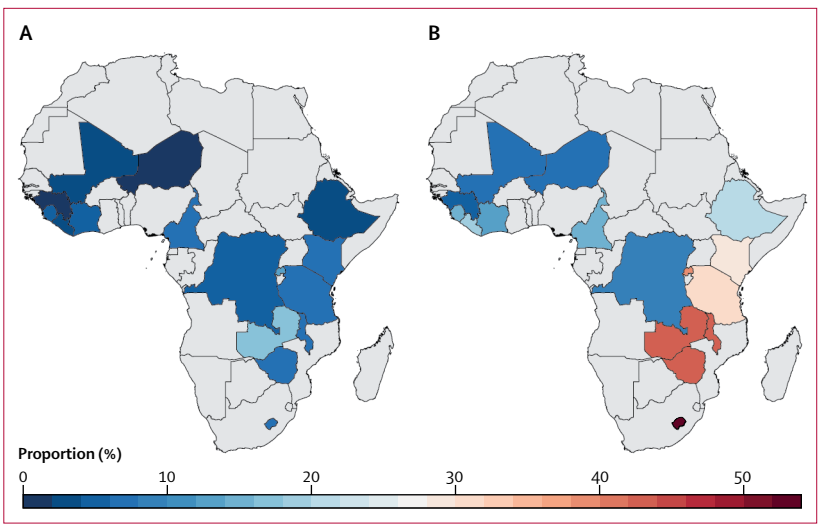

Figure 1: **Proportion of participants who underwent HIV testing during the previous 12 months in 16 sub-Saharan African countries before (A) and after (B) 2008**
Percentages were estimated from the Demographic and Health Surveys. Countries shown in grey were not included in the analyses.

See Online for appendix 2

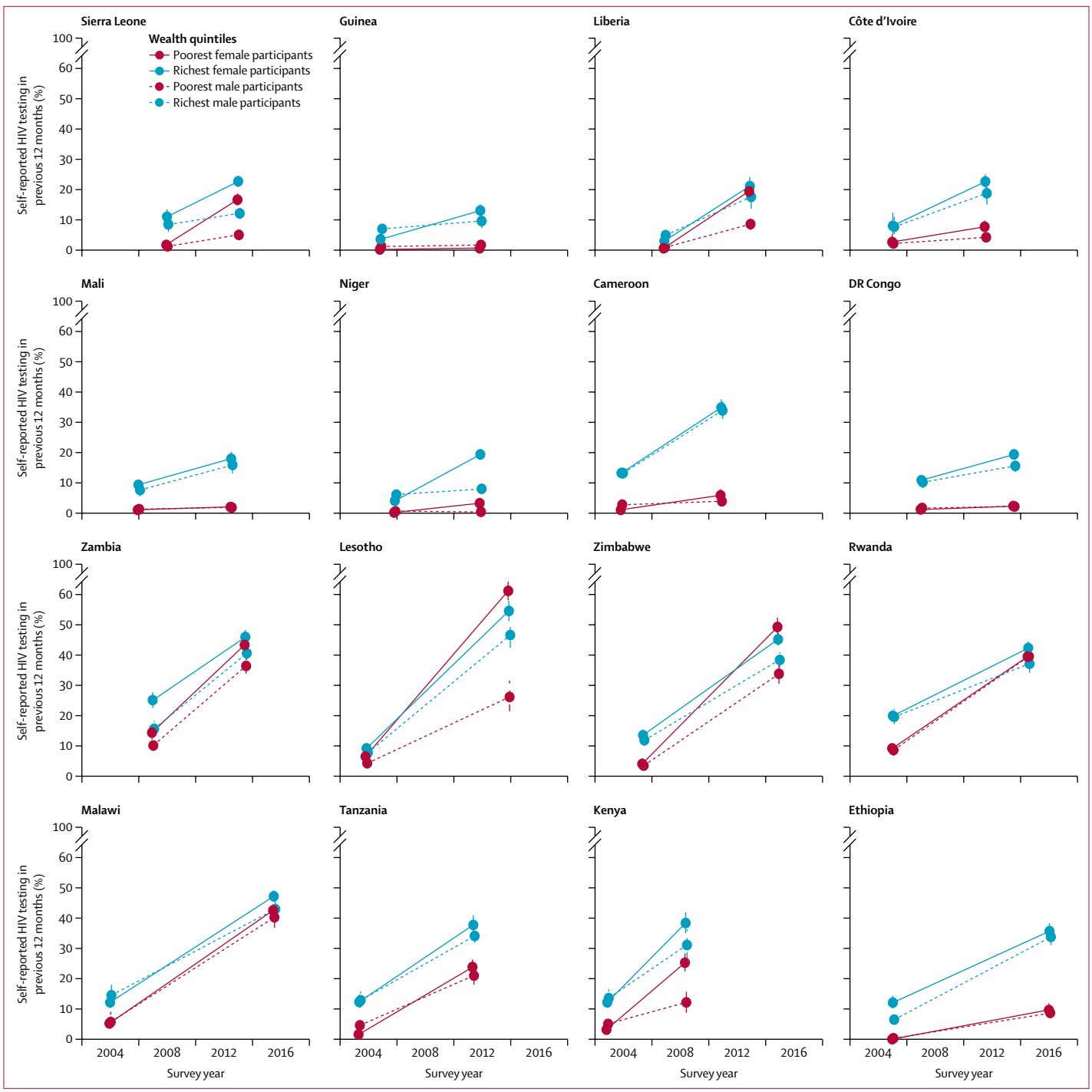

Figure 2: **Proportion of participants in the richest and poorest wealth quintiles who self-reported an HIV test in the previous 12 months in 16 sub-Saharan African countries**

absolute inequalities tend to be larger at intermediate levels of the considered outcome.[25] Thus, an increase in overall level of HIV testing uptake from low to intermediate between survey rounds is consistent with the inequality trends described here, especially the finding of increasing absolute inequalities in some western and central African countries. A corollary is that the overall coverage of HIV testing should be considered when comparing different countries in terms of socioeconomic inequalities, especially when using an absolute scale. For example, for female participants in the post-2008 surveys, it would be correct to interpret

	Relative index of inequality (95% CI)			Slope index of inequality (95% CI)		
	Before 2008 DHS	After 2008 DHS	Standardised ratio	Before 2008 DHS	After 2008 DHS	Standardised difference
Western and central Africa						
Sierra Leone	7·2 (4·5 to 11·4)	1·4 (1·2 to 1·7)	0·72 (0·66 to 0·80)	0·12 (0·09 to 0·14)	0·06 (0·03 to 0·09)	–0·011 (–0·019 to –0·003)
Guinea	135·6 (37·1 to 496·1)	49·0 (29·2 to 82·1)	0·87 (0·71 to 1·06)	0·05 (0·04 to 0·07)	0·17 (0·14 to 0·21)	0·017 (0·012 to 0·022)
Liberia	3·9 (2·0 to 7·6)	1·2 (1·0 to 1·4)	0·82 (0·73 to 0·92)	0·03 (0·01 to 0·04)	0·04 (0·00 to 0·07)	0·001 (–0·005 to 0·008)
Côte d'Ivoire	5·4 (2·6 to 11·0)	3·5 (2·8 to 4·4)	0·94 (0·83 to 1·05)	0·05 (0·03 to 0·08)	0·19 (0·16 to 0·22)	0·021 (0·014 to 0·027)
Mali	34·3 (18·8 to 62·5)	25·8 (17·5 to 38·1)	0·96 (0·86 to 1·07)	0·11 (0·08 to 0·13)	0·23 (0·20 to 0·26)	0·019 (0·013 to 0·025)
Niger	58·3 (26·1 to 130·2)	9·4 (7·1 to 12·5)	0·74 (0·64 to 0·85)	0·07 (0·05 to 0·09)	0·23 (0·20 to 0·26)	0·027 (0·021 to 0·033)
Cameroon	29·0 (18·8 to 44·9)	3·8 (3·1 to 4·7)	0·75 (0·70 to 0·80)	0·18 (0·15 to 0·2)	0·15 (0·13 to 0·17)	–0·003 (–0·008 to 0·002)
DR Congo	14·7 (9·4 to 22·9)	12·9 (8·8 to 18·9)	0·98 (0·90 to 1·07)	0·14 (0·11 to 0·17)	0·17 (0·14 to 0·19)	0·003 (–0·003 to 0·009)
Southern and eastern Africa						
Zambia	1·8 (1·4 to 2·2)	1·1 (1·0 to 1·1)	0·92 (0·89 to 0·96)	0·12 (0·08 to 0·16)	0·03 (–0·01 to 0·06)	–0·014 (–0·023 to –0·006)
Lesotho	1·4 (1·1 to 1·9)	0·9 (0·8 to 0·9)	0·95 (0·92 to 0·98)	0·03 (0·01 to 0·05)	–0·10 (–0·14 to –0·05)	–0·012 (–0·018 to –0·007)
Zimbabwe	5·6 (4·1 to 7·5)	0·9 (0·9 to 1·0)	0·83 (0·80 to 0·86)	0·14 (0·11 to 0·17)	–0·04 (–0·08 to 0·00)	–0·019 (–0·024 to –0·014)
Rwanda	2·0 (1·6 to 2·4)	1·1 (1·0 to 1·2)	0·94 (0·92 to 0·96)	0·09 (0·07 to 0·12)	0·02 (–0·01 to 0·06)	–0·007 (–0·012 to –0·003)
Malawi	2·3 (1·7 to 3·1)	1·0 (0·9 to 1·0)	0·93 (0·91 to 0·95)	0·06 (0·04 to 0·08)	–0·01 (–0·03 to 0·02)	–0·005 (–0·008 to –0·003)
Tanzania	9·2 (5·6 to 15·3)	1·4 (1·2 to 1·6)	0·79 (0·74 to 0·84)	0·12 (0·09 to 0·15)	0·10 (0·07 to 0·14)	–0·002 (–0·008 to 0·004)
Kenya	5·5 (4·0 to 7·5)	1·6 (1·3 to 1·8)	0·80 (0·75 to 0·85)	0·13 (0·11 to 0·16)	0·14 (0·09 to 0·18)	0·001 (–0·009 to 0·010)
Ethiopia	295·9 (170·9 to 512·6)	4·6 (4·0 to 5·4)	0·69 (0·65 to 0·72)	0·38 (0·33 to 0·43)	0·39 (0·35 to 0·43)	0·001 (–0·005 to 0·007)
Within-sample mean estimates from random-effects meta-analysis	9·8 (4·2 to 22·6)	2·8 (1·4 to 5·4)	0·85 (0·80 to 0·90)	0·11 (0·07 to 0·15)	0·11 (0·05 to 0·18)	0·001 (–0·006 to 0·008)
I^2	97·75%	99·00%	94·19%	95·72%	97·68%	95·36%

Relative index of inequality ratios and slope index of inequality differences are standardised based on the number of years elapsed between both survey rounds. DHS=Demographic and Health Survey.

Table 5: **Relative and absolute wealth-related inequalities in female participants who self-reported HIV testing in the previous 12 months in 16 sub-Saharan African countries**

that Sierra Leone is more equitable (SII 0·06) than Côte d'Ivoire (SII 0·19) because the overall proportion of the population who underwent HIV testing in the previous 12 months is roughly similar in both countries (18% *vs* 15%). Conversely, it would be inaccurate to deduce that Sierra Leone is more equitable than Kenya (SII 0·14) because the overall proportion of the population who underwent testing in the previous 12 months is substantially higher in Kenya (31%).

Despite progress, especially in terms of relative socioeconomic inequalities, inequalities remained substantial in the post-treatment era, especially in male participants. A better understanding of the sources of heterogeneity in the level of inequalities is required to address this issue. The inequalities we noted were not caused solely by differential access to HIV testing services in urban and rural areas: socioeconomic inequalities in testing uptake persisted even when urban versus rural location was accounted for in multivariate analyses (appendix 2 pp 12–19). The burden of the HIV epidemic seemed to play a role in the pattern we identified. In countries with a high HIV prevalence, such as Lesotho, Malawi, Zambia, and Zimbabwe, the difference in uptake of HIV testing between the richest and poorest participants was less substantial than that in countries with low HIV prevalence (eg DR Congo, Ethiopia, Mali, Niger). Countries with high HIV prevalence also prioritised ambitious HIV testing programmes, and HIV prevalence has been associated with HIV spending.[26] Thus, low-to-moderate efforts to promote and offer HIV testing might perpetuate socioeconomic inequalities in testing uptake, whereas larger efforts might decrease these inequalities, even when they are not specifically targeted at socioeconomically disadvantaged populations.

Our analysis had several limitations. Our results rely on a self-reported outcome. Assessment of the validity of self-reports of HIV testing is challenging, notably because accuracy might differ depending on HIV status.[27] Because inequality measurements rely on the quantification of an association, differential accuracy in self-reporting between socioeconomic groups might have biased our results. To our knowledge, little evidence is available about how the sensitivity and specificity of self-reported HIV testing are affected by socioeconomic status. However, evidence for other conditions (eg, cancer) suggest that over-reporting of self-reported screening is common among disadvantaged groups (eg, racial minorities).[28] If such over-reporting also applies to people self-reporting HIV testing, then the pro-rich inequalities in terms of testing uptake that we noted could be an under-estimation. Over-reporting of HIV testing uptake might also have contributed to the findings in some countries (eg, among female participants in Lesotho and Zimbabwe) that poorer people had higher uptake than wealthier people. Contextual factors such as the community-level stigma towards people with HIV could also affect the validity of

	Relative index of inequality (95% CI)			Slope index of inequality (95% CI)		
	Before 2008 DHS	After 2008 DHS	Standardised ratio	Before 2008 DHS	After 2008 DHS	Standardised difference
Western and central Africa						
Sierra Leone	7·5 (3·1 to 18·0)	2·8 (1·9 to 4·2)	0·82 (0·68 to 1·00)	0·09 (0·05 to 0·13)	0·09 (0·06 to 0·13)	0·001 (–0·010 to 0·012)
Guinea	32·4 (11·0 to 95·2)	10·3 (5·3 to 20·3)	0·85 (0·71 to 1·02)	0·10 (0·06 to 0·14)	0·12 (0·08 to 0·16)	0·002 (–0·006 to 0·011)
Liberia	10·7 (5·5 to 20·9)	3·4 (2·4 to 4·8)	0·83 (0·73 to 0·94)	0·06 (0·04 to 0·09)	0·15 (0·11 to 0·20)	0·015 (0·007 to 0·023)
Côte d'Ivoire	5·5 (2·5 to 12·0)	6·6 (4·3 to 10·1)	1·03 (0·90 to 1·18)	0·04 (0·02 to 0·07)	0·17 (0·13 to 0·21)	0·020 (0·013 to 0·027)
Mali	20·7 (8·7 to 49·1)	20·4 (11·5 to 36·3)	1·00 (0·85 to 1·17)	0·10 (0·06 to 0·13)	0·20 (0·15 to 0·25)	0·016 (0·007 to 0·025)
Niger	33·4 (12·6 to 88·6)	138·3 (47·9 to 399·4)	1·27 (1·00 to 1·61)	0·11 (0·07 to 0·14)	0·17 (0·12 to 0·21)	0·01 (0·001 to 0·019)
Cameroon	5·9 (4·1 to 8·4)	5·5 (4·5 to 6·7)	0·99 (0·94 to 1·05)	0·14 (0·11 to 0·17)	0·35 (0·31 to 0·39)	0·031 (0·024 to 0·038)
DR Congo	8·9 (5·2 to 15·3)	13·8 (8·7 to 21·9)	1·07 (0·96 to 1·19)	0·12 (0·09 to 0·15)	0·17 (0·13 to 0·20)	0·007 (0·000 to 0·014)
Southern and eastern Africa						
Zambia	1·9 (1·5 to 2·5)	1·2 (1·1 to 1·4)	0·93 (0·89 to 0·97)	0·09 (0·05 to 0·13)	0·06 (0·03 to 0·09)	–0·004 (–0·012 to 0·003)
Lesotho	2·7 (1·6 to 4·7)	1·9 (1·6 to 2·2)	0·96 (0·91 to 1·02)	0·05 (0·02 to 0·08)	0·23 (0·17 to 0·29)	0·018 (0·011 to 0·025)
Zimbabwe	4·8 (3·4 to 6·7)	1·2 (1·1 to 1·4)	0·87 (0·83 to 0·90)	0·11 (0·09 to 0·14)	0·07 (0·03 to 0·11)	–0·004 (–0·009 to 0·001)
Rwanda	3·2 (2·3 to 4·3)	0·9 (0·8 to 1·1)	0·88 (0·85 to 0·91)	0·14 (0·10 to 0·18)	–0·02 (-0·07 to 0·02)	–0·017 (–0·024 to –0·011)
Malawi	3·4 (2·1 to 5·5)	1·0 (0·9 to 1·1)	0·90 (0·86 to 0·94)	0·09 (0·05 to 0·13)	0·00 (–0·05 to 0·04)	–0·008 (–0·013 to –0·003)
Tanzania	3·2 (2·3 to 4·6)	1·7 (1·4 to 1·9)	0·92 (0·88 to 0·96)	0·09 (0·06 to 0·12)	0·13 (0·10 to 0·17)	0·005 (–0·001 to 0·011)
Kenya	5·3 (3·4 to 8·3)	2·3 (1·7 to 3·0)	0·86 (0·78 to 0·94)	0·14 (0·10 to 0·18)	0·20 (0·13 to 0·26)	0·011 (–0·003 to 0·024)
Ethiopia	127·6 (56·3 to 289·2)	4·3 (3·7 to 5·1)	0·74 (0·68 to 0·79)	0·16 (0·13 to 0·20)	0·33 (0·30 to 0·37)	0·015 (0·011 to 0·020)
Within-sample mean estimates from random-effects meta-analysis	7·3 (4·1 to 13·1)	3·6 (1·9 to 6·8)	0·91 (0·86 to 0·96)	0·10 (0·08 to 0·12)	0·15 (0·10 to 0·21)	0·007 (0·001 to 0·014)
I^2	91·41%	98·27%	80·72%	79·47%	96·02%	92·69%

Relative index of inequality ratios and slope index of inequality differences are standardised based on the number of years elapsed between both survey rounds. DHS=Demographic and Health Survey.

Table 6: **Relative and absolute wealth-related inequalities in male participants who self-reported HIV testing in the previous 12 months in 16 sub-Saharan African countries**

self-reported HIV testing, although evidence is scant about the probable direction of such a bias.

Our research work relied on data collected up to 2016. Thus, it might not capture the most recent changes in HIV testing patterns in response to UNAIDS' 90-90-90 objective. Another limitation was the heterogeneity noted in the results of the meta-analyses, which prevented us from generalising our results beyond the subset of countries that we included in our analysis (appendix 2 p 24). Further research should be done to identify the drivers of such heterogeneity, and especially to understand the possible interplay between community-level and country-level drivers.

To our knowledge, our study is the first to describe trends in relative and absolute socioeconomic inequalities in the uptake of HIV testing in the previous 12 months across a large number of sub-Saharan African countries in a variety of regional and epidemiological contexts. Furthermore, our analysis was based on large, representative surveys with a high proportion of responses, and the patterns we described were consistent across different measures of socioeconomic inequalities.

In conclusion, this study shows that overall increases in the uptake of HIV testing up to 2016 hid differential progress across socioeconomic groups. Without specific focus on equity, HIV programmes are unlikely to reach every part of the population, and are especially unlikely to reach the poorest and least educated citizens. Persisting socioeconomic inequalities in the uptake of HIV testing could go beyond equity if those least likely to be tested are at greatest risk of HIV infection. Indeed, in some settings, poverty was associated with an increased risk of incident HIV infection.[29,30] Our results show the need to monitor and address socioeconomic inequalities, as well as inequalities related to sex, age, and geography, to ensure an equitable distribution of the benefits and successes in epidemic control of HIV programmes.

Contributors

PAA-T and KJ conceived and planned the study with input from TB and LT. PAA-T collated and processed DHS data. PAA-T and KJ conducted the analysis and produced output figures and tables with input from LT. All authors contributed to the interpretation of the results. PAA-T and KJ wrote the first draft of the report and all authors contributed to subsequent revisions.

Declaration of interests

We declare no competing interests.

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