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Socioeconomic inequalities in HIV/AIDS prevalence in sub-Saharan African countries: evidence from the Demographic Health Surveys

Mohammad Hajizadeh[1*], Drissa Sia[1], S Jody Heymann[2] and Arijit Nandi[3]

Abstract

Introduction: Extant studies universally document a positive gradient between socioeconomic status (SES) and health. A notable exception is the apparent concentration of HIV/AIDS among wealthier individuals. This paper uses data from the Demographic Health Surveys and AIDS Indicator Surveys to examine socioeconomic inequalities in HIV/AIDS prevalence in 24 sub-Saharan African (SSA) countries, the region that accounts for two-thirds of the global HIV/AIDS burden.

Methods: The relative and generalized concentration indices (RC and GC) were used to quantify wealth-based socioeconomic inequalities in HIV/AIDS prevalence for the total adult population (aged 15-49), for men and women, and in urban and rural areas in each country. Further, we decomposed the RC and GC indices to identify the determinants of socioeconomic inequalities in HIV/AIDS prevalence in each country.

Results: Our findings demonstrated that HIV/AIDS was concentrated among higher SES individuals in the majority of SSA countries. Swaziland and Senegal were the only countries in the region where HIV/AIDS was concentrated among individuals living in poorer households. Stratified analyses by gender showed HIV/AIDS was generally concentrated among wealthier men and women. In some countries, including Kenya, Lesotho Uganda, and Zambia, HIV/AIDS was concentrated among the poor in urban areas but among wealthier adults in rural areas. Decomposition analyses indicated that, besides wealth itself (median = 49%, interquartile range [IQR] = 90%), urban residence (median = 54%, IQR = 81%) was the most important factor contributing to the concentration of HIV/AIDS among wealthier participants in SSA countries.

Conclusions: Further work is needed to understand the mechanisms explaining the concentration of HIV/AIDS among wealthier individuals and urban residents in SSA. Higher prevalence of HIV/AIDS could be indicative of better care and survival among wealthier individuals and urban adults, or reflect greater risk behaviour and incidence. Moreover, differential findings across countries suggest that effective intervention efforts for reducing the burden of HIV/AIDS in the SSA should be country specific.

Keywords: Socioeconomic inequality, Relative and generalized concentration indices, Decomposition analysis, HIV/AIDS, Sub-Saharan Africa

* Correspondence: mohammad.hajizadeh@mcgill.ca
[1]Institute for Health and Social Policy, McGill University, 1130 Pine Avenue West, Montreal, QC H3A 1A3, Canada
Full list of author information is available at the end of the article

Introduction

Notwithstanding general improvement in health status worldwide, inequalities in health among different socioeconomic groups still remain one of the main challenges for public health [1]. Extant studies in both high- and low-income countries almost universally document a positive gradient between socioeconomic status (SES) and health; individuals in higher SES are in better health than lower SES individuals [2,3]. A notable exception is the apparent concentration of HIV/AIDS, one of the leading causes of death in sub-Saharan Africa (SSA) [4], among wealthier individuals [5].

Research showing socioeconomically disadvantaged groups, including women, are disproportionately affected by HIV/AIDS [6] suggest poverty is a risk factor for infection [7]. Poverty may constrain individuals' means to negotiate safe practices, such as condom use, and avoid risky ones, including transactional sex [8]. However, growing empirical evidence suggests the prevalence of HIV/AIDS is concentrated among wealthier rather than poorer individuals in SSA. Historically, this may be a consequence of the HIV/AIDS epidemic first emerging in urban areas in SSA and then spreading to the other regions [9]. Additionally, epidemiologic evidence suggests wealthier individuals may engage in riskier behaviours, such as having multiple sexual partners, that increase the probability of HIV transmission [10,11]. Socioeconomically advantaged individuals may also have improved access to treatment for HIV/AIDS, as well as ability to adhere to treatment, prolonging survival and increasing HIV/AIDS prevalence among wealthier individuals [12].

Several studies (e.g., [5,6,13-18]) have examined whether socioeconomic status is associated with HIV/AIDS status in SSA countries. Although this work suggests HIV/AIDS is concentrated among the better-off in selected SSA countries, extant work does not report within-country summary measures of socioeconomic inequality that account for the probability of HIV/AIDS across the entire socioeconomic gradient and can be used for making cross-national comparisons. Moreover, the determinants of observed socioeconomic inequalities in HIV/AIDS have not been empirically investigated. The present study attempts to address these gaps in the literature by estimating socioeconomic inequalities in HIV/AIDS prevalence among adults aged 15-49 in 24 SSA countries using the concentration approach. Additionally, we decompose socioeconomic inequalities in HIV/AIDS prevalence to identify some of the determinants of socioeconomic inequalities in HIV/AIDS prevalence.

Socioeconomic status and HIV/AIDS: a review of empirical studies

Studies assessing the relation between SES (as measured by education) and HIV/AIDS prevalence in SSA, a region that accounts for two thirds of the global epidemic [19], show a positive education gradient in HIV infection [5,20,21]. The concentration of HIV/AIDS among more highly educated individuals was corroborated by a meta-analysis of published studies by Hargreaves and Glynn [15], which also adjusted for gender and age. In contrast, different results were obtained in a study by Glynn and colleagues [14] in several cities in SSA; this study showed that education and HIV/AIDS were negatively associated among men in Cotonou (Benin) and women in Yaoundé (Cameroon). Using Demographic and Health Surveys (DHSs) and World Population Prospects (WPP) data from 19 SSA countries, Iorio and Santaeulalia [22] demonstrated that the association between educational attainment and HIV status is strongly related to the stage of the HIV/AIDS epidemic. During the early stage of the epidemic the association is positive, the association becomes negative as the epidemic develops, and the negative association reverses back to positive in the more advanced stage of the HIV epidemic. Other work [23] using DHSs for Lesotho, Malawi, Swaziland, and Zimbabwe also indicated that the relation between HIV infection and education varies by country.

Prior work also supports a positive relation between individual- and household-level wealth and HIV/AIDS prevalence across SSA countries [18,24-26]. However, recent studies by Fortson [5] and Asiedu et al. [23] indicated that the association between wealth and HIV infection varies by country. In addition, using information from 170 regions in sixteen SSA countries, Fox [17] demonstrated that in poorer countries/regions wealthier individuals were more likely to be HIV positive, whereas in wealthier countries/regions it was poorer individuals who had a higher probability of being infected with HIV. In summary, recent cross-national evidence suggests there is substantial heterogeneity in the magnitude and direction of the association between SES and HIV/AIDS across SSA countries.

The determinants of socioeconomic inequalities in HIV/AIDS are poorly understood. Socio-demographic factors such as age, gender, and marital status may be associated with levels of household wealth, as well as risk of HIV infection, and contribute to differences in prevalence of HIV/AIDS among SES groups. Age, for example, is associated with the accumulation of household wealth and risk of HIV infection [23,26]. Women are more biologically susceptible to HIV infection and, on average, more likely to be infected in SSA countries [6]; however, inequitable economic arrangements place women at greater risk of poverty and thus gender is unlikely to explain the concentration of HIV/AIDS among wealthier individuals. Socioeconomic factors, such as educational attainment, are positively associated with wealth and, to the extent that education is correlated with knowledge of HIV transmission [27], may help lower transmission. However, it is also possible that

educational attainment is associated with riskier sexual behaviours because of differences in wealth, nature of employment or travel [28]. Behaviours themselves, which can be on the pathway between SES and risk of HIV infection, may also affect economic outcomes. For example, women with limited economic opportunities may engage in transactional sex [29], which increase risk of infection. Using DHSs from 19 SSA countries Burke and colleagues [30] showed that negative income shocks due to drought led to substantial increase in HIV/AIDS prevalence, especially for women working in agriculture. Geographic factors, such as urban residence, are positively associated with employment opportunities. In turn, urban residence might increase the probability of HIV infection via the pathways discussed, or by increasing the probability of survival conditional on infection by improving access to health services and treatment availability.

Previous work has measured the magnitude of socioeconomic inequality by comparing the prevalence of HIV/AIDS at the extremes of the socioeconomic distribution. Unlike summary measures, such as the relative and generalized concentration (RC and GC) indices, that quantify inequality across the entire SES gradient [31], this approach limits our ability to compare the magnitude of inequalities in HIV/AIDS across countries. Furthermore, the determinants of socioeconomic inequalities in HIV/AIDS are unclear. In this study, we *first* measured socioeconomic inequalities in HIV/AIDS within 24 SSA countries using the concentration approach. *Second*, since other factors (e.g., urban/rural residence) might explain the socioeconomic gradient in HIV/AIDS, we then used the decomposition property of the RC and GC indices to identify the factors that contribute to socioeconomic inequalities in HIV/AIDS prevalence.

Methodology

Data

The main source of data in this study is based on data collected through the Demographic Health Surveys programme in sub-Saharan African countries. The DHS programme has collected data from more than 85 low-and-middle-income countries (LMICs) around the world since 1984 [32]. DHS surveys are nationally representative cross-sectional surveys of household samples for selected LMICs [32] and collect comparable information about a wide range of topics [33]. To ensure standardisation and comparability of surveys across countries and time the DHS uses well-trained interviewers, standardized tools and measurement techniques, and a similar core set of survey questions [34,35]. Starting from 2001, the DHS programme has conducted HIV testing in the DHS or AIDS Indicator Surveys (AIS) in a number of

participant countries. Availability of HIV test results data from recent DHS surveys presents a unique opportunity for population-based research about HIV/AIDS in different areas [6]. This study uses information derived from 24 DHS surveys carried out in SSA. We used the most recent survey for each country in the analysis if there was more than one available survey. Moreover, the World Bank's World Development Indicators and Global Development Finance (WDI and GDF) [36] and Worldwide Governance Indicators (WGI) [37] databases were used to obtain country-level information on socioeconomic and governance indicators.

Measures

The primary outcome of interest in the study, HIV/AIDS infection, was determined using confirmatory HIV antibody testing. We calculated socioeconomic inequalities in HIV/AIDS using a constructed wealth index provided in all DHS. The DHS employs a method proposed by Filmer and Pritchett [38] to construct the wealth index [39] using information on household's ownership of selected assets (e.g., bicycle and televisions), environmental conditions and housing characteristics (e.g., type of water source, sanitation facilities, materials used for housing construction).

We examined patterns of socioeconomic inequalities in HIV/AIDS prevalence according to economic, governance, social and cultural structures. The Gross Domestic Product (GDP) per capita (purchasing power parity, constant 2005 international $) was used as an indicator of country-level socioeconomic status. The World Bank's estimated Gini index and the Country Policy and Institutional Assessment (CPIA) gender inequality rating were used as measures of state-level income and gender equality, respectively. The CPIA gender equality indicator (1 = low to 6 = high) measures the degree to which a country has installed institutions and programs to promote gender equality in access to health, the economy, education and protection under law [36]. The Worldwide Governance Indicators *viz.* voice and accountability, political stability and absence of violence, government effectiveness, regulatory quality, rule of law and control of corruption were used as measures of a country's quality of governance (For more information about these indicators see [37]).

We collected information on demographic, socioeconomic, behavioural and ecological determinants of HIV/AIDS, based on the relevant literature (e.g., [5,6,17,18,23,25,26]). Given the literature and availability of variables across the DHSs, we used age, gender and marital status variables to control for demographic factors in our decomposition analysis. The wealth index, educational attainment, and occupation status were used to account for socioeconomic factors affecting HIV/

AIDS status. As the wealth index contains negative values, similarly to previous studies (e.g. [40,41]), we normalized it to a scale of 0 to 100 points to allow the calculation of the RC and GC for household wealth. To control for sexual behaviours we measured the number of sexual partners outside marriage and the age at first sex. Finally, we included dummy variables for urban areas to control for residential characteristics. Table 1 reports the definition of all variables used in the decomposition analysis.

Statistical analysis

Our statistical analysis involves the following two steps: First, we used the relative and generalized concentration indices to quantify the degree of wealth-related inequality in HIV/AIDS prevalence in sub-Saharan countries. Second, a decomposition approach was employed to identify the factors contributing to inequality in HIV/AIDS in each country.

The relative and generalized concentration indices

We used the concentration index approach to measure within country inequality in HIV/AIDS prevalence. The RC index, which is based on the (standard) concentration curve, quantifies the degree of socioeconomic inequality in a health-related outcome variable of interest. The concentration curve is obtained by plotting the cumulative share of the population, ranked in ascending order of SES (i.e., household wealth), against the cumulative share of the outcome variable (i.e. HIV/AIDS). The RC index is twice the area between the line representing perfect inequality and the concentration curve. The "convenient regression" approach to compute the RC index can be formulated as follows [42]:

$$2\sigma_r^2 \left(\frac{y_i}{\mu} \right) = \alpha + \varphi r_i + \varepsilon_i, \tag{1}$$

where y_i is the outcome variable of interest (i.e. HIV/AIDS) for individual i, μ is the mean of the outcome variable for the whole sample, $r_i = i/N$, is the fractional rank of individual i in the distribution with $i = 1$ for the poorest and $i = N$ for the wealthiest individual, and σ_r^2 is the variance of fractional rank. The ordinary least squares estimate of φ is the RC [43]. As the nature of the fractional rank variable causes a certain pattern of autocorrelation in the data, the standard error of φ provides an estimate of the standard error of the RC which is inaccurate. The Newey-West estimator [44] can be used to correct for autocorrelation as well as heteroskedasticity [45]. The RC index is negative if ill-health outcome is concentrated among individuals of lower SES and positive if it is concentrated among those with

higher SES [45]. The value of the RC ranges from -1 and +1 with zero representing perfect equality.

Wagstaff [46] demonstrated that when the outcome variable of interest is bounded between 0 and 1, the minimum and maximum of the C are not -1 and +1 and depend on μ. In such cases the index can be normalized by multiplying the estimated index by $1/1 - \mu$. As the outcome variable in our study is binary, we used the normalized *RC* to quantify wealth-related inequalities in HIV/AIDS prevalence.

The RC is attractive to those who are interested in relative differences in health outcomes between different SES groups. We can also generalize the concentration curve such that it becomes sensitive to variations in μ and reflects absolute, rather than relative, differences in health between socioeconomic groups. The generalized concentration curve is the standard concentration curve multiplied by the μ. It represents the cumulative share of population, ranked based on a socioeconomic factor, against the cumulative amount of health-related variable. The generalized (absolute) concentration index (GC) is defined as twice the area between the generalized concentration curve and the diagonal (i.e. perfect equality line). The GC can be formulated as:

$$GC = \mu \times RC. \tag{2}$$

The GC ranges from $-\mu$ to μ, with zero indicating "no disparity" [31].

The RC and GC do not take into account the contribution of demographics (unavoidable factors) to overall socioeconomic inequalities in health. Thus, using the direct standardisation approach [47] we corrected for differences in demographic composition and measured standardized relative and generalized concentration indices (SRC and SGC) for HIV/AIDS prevalence. The SRC and SGC demonstrate avoidable health inequality, making it more relevant for policy interventions [48].

We estimated a summary measure of socioeconomic inequality in HIV/AIDS prevalence across sampled countries by ranking countries based on their GDP per capita and estimating the RC and GC. We measured wealth-related inequalities in HIV/AIDS prevalence by gender and place of residence to examine gender and urban/rural differences in the association between socioeconomic status and HIV/AIDS prevalence. A method suggested by Altman and Bland [49] was used to assess the significance of differences in socioeconomic inequalities across gender and place of residence at the p-value = 0.05 level with 95% confidence intervals.

To examine patterns of socioeconomic inequalities in HIV/AIDS prevalence, in a framework similar to [48], we also compared the estimated RC/SRC and GC/SGC for HIV/AIDS prevalence across countries with respect

Table 1 Description of the variables

Variables	Description
Outcome variable	
HIV/AIDS	1 = if the individual is HIV-positive, 0 otherwise
Demographic variables	
Age	
15-20	1 = if male aged 15-19 years, 0 otherwise
20-29	1 = if male aged 20-29 years, 0 otherwise
30-39	1 = if male aged 30-39 years, 0 otherwise
40-49 (Ref.)	1 = if male aged 40-49 years, 0 otherwise
Gender	
Male (Ref.)	1 = if male, 0 otherwise
Female	1 = if female, 0 otherwise
Marital status	
Married (Ref.)	1 = if the individual is married, 0 otherwise
Separated/divorced/widowed	1 = if the individual is separated/divorced/widowed, 0 otherwise
Never married	1 = if the individual is never married, 0 otherwise
Socioeconomic variables	
Standard of living	
Wealth index	Normalized wealth score on a scale of 0-100
Education level	
None (Ref.)	1 = if the individual has no education, 0 otherwise
Primary	1 = if the individual has primary education, 0 otherwise
Secondary and above	1 = if the individual has secondary and above education, 0 otherwise
Occupation type	
Agriculture (Ref.)	1 = if the individual's occupation is agriculture, 0 otherwise
White-collar	1 = if the individual is employed in occupations such as management, and office/service, 0 otherwise
Blue-collar	1 = if the individual is employed in manual work, 0 otherwise
Other occupations	1 = if the individual is employed in other occupations such as trade and domestic, 0 otherwise
Unemployed	1 = if the individual is unemployed, 0 otherwise
Behavioural variables	
Number of sex partners	Number of sex partners the individual, excluding spouse, has in last 12 months.
Age at first sex	
Never had sex	1 = if the individual never had sex, 0 otherwise
<16	1 = if the individual had sex before the age of 16, 0 otherwise
16-17	1 = if the individual had sex in ages 16 and 17, 0 otherwise
18-19	1 = if the individual had sex in ages 18 and 19, 0 otherwise
20 and above (Ref.)	1 = if the individual had sex after the age of 19, 0 otherwise
Ecological variable	
Geographical area	
Urban	1 = if the individual resides in urban area, 0 otherwise
Rural (Ref.)	1 = if the individual resides in rural area, 0 otherwise

to economic, governance, social and cultural structures. We first assessed socioeconomic patterns of inequality in HIV/AIDS with regard to the living standard of countries, measured by GDP per capita. Additionally, recent studies (e.g. [50]) suggest a positive association between income and gender inequalities and HIV/AIDS prevalence in SSA region. Thus, we investigated the association between Gini index and the CPIA gender equality

and socioeconomic inequalities in HIV/AIDS prevalence across countries. Since some studies (e.g. [51]) suggested a negative association between governance and HIV/AIDS prevalence, we further compared the association between the RC/SRC and GC/SGC and the Worldwide Governance Indicators. Finally, we investigated the pattern of socioeconomic inequality across countries with different social and cultural characteristics by using three dummy variables for neighbouring countries: Western Africa (Burkina Faso, Cote d'Ivoire, Ghana, Guinea, Liberia, Mali, Niger, Senegal and Sierra Leone), Eastern and Central Africa (Cameroon, Congo Brazzaville, Congo Democratic Republic, Ethiopia, Kenya, Rwanda, Uganda, Sao Tome & Principe and Tanzania), Southern Africa (Lesotho, Malawi, Mozambique, Swaziland, Zambia and Zimbabwe). In all regressions we also included a survey year variable to capture the effect of temporal variation.

Decomposition of the relative and generalized concentration indices

A decomposition technique was employed to quantify and compare the extent to which observed determinants of HIV/AIDS, such as education, age, gender, and marital status, contributed to the socioeconomic inequality in HIV/AIDS in each country. Suppose we start with a linear regression model linking our variable of interest, y, to a set of k explanatory factors, x_k, such as:

$$y = \propto + \sum_k \beta_k x_k + \varepsilon. \qquad (3)$$

Wagstaff et al. [52] showed that the RC index of y can be decomposed into the contribution of factors which determine HIV/AIDS. They demonstrated that the RC index for y, can be formulated as:

$$RC = \sum_k \left(\frac{\beta_k \overline{x_k}}{\mu} \right) RC_k + \frac{GC_\varepsilon}{\mu}, \qquad (4)$$

where $\overline{x_k}$ is the mean of x_k, RC_k is the RC index for x_k, and GC_ε is the generalized concentration index for the error term defined as $GC_\varepsilon = \frac{2}{n} \sum_{i=1}^{n} \varepsilon_i r_i$, where r_i is the fractional rank of the ith person in the relevant distribution [52]. The residual component (the error term) in equation (4) reflects the wealth-related inequality in HIV/AIDS prevalence that is not explained by systematic differences in x_k across wealth groups [43]. Using the Wagstaff's correction to normalize the RC index yields:

$$RC_{normalized} = \frac{RC}{1-\mu} = \frac{\sum_k \left(\frac{\beta_k \overline{x_k}}{\mu} \right) RC_k}{1-\mu} + \frac{\frac{GC_\varepsilon}{\mu}}{1-\mu}. \qquad (5)$$

The decomposition of the generalized concentration index can be written as:

$$GC_{normalized} = \frac{\mu RC}{1-\mu} = \frac{\sum_k \beta_k GC_k}{1-\mu} + \frac{GC_\varepsilon}{1-\mu}, \qquad (6)$$

where GC_k indexes the generalized concentration index for the determinant k. According to Equation 6 the extent of the contribution of each factor (x_k) to the GC in HIV/AIDS prevalence depends on the β_k and GC_k. A factor that influences the probability of HIV/AIDS and is distributed unequally by wealth can contribute to socioeconomic inequality in HIV/AIDS prevalence.

A limitation of this decomposition approach is that it only works with linear models. Thus, although it is preferable to use a non-linear estimator in our application because our outcome is binary variable, we employed a linear probability model (LPM) in the analysis. Some approaches have been proposed to address the issue [53]. These methods, however, lead to other problems and restrictions, such that they are not explicitly preferable to using LPM [54].

Results

Descriptive results

Table 2 presents the sample size, GDP per capita (constant 2005 international $), and overall and gender-specific HIV/AIDS prevalence for each county. HIV/AIDS prevalence ranged from less than 1 per cent in Senegal and Niger to greater than 20 per cent in Swaziland and Lesotho. Gender differentials in HIV/AIDS varied widely across countries, with prevalence higher for women in all countries except Sao Tom & Principe. With the exception of Niger, Sao Tom & Principe and Senegal, prevalence of HIV/AIDS was higher in urban compared to rural areas.

As illustrated in Figure 1, there were geographic differences in HIV/AIDS levels across sub-Saharan Africa. HIV prevalence was higher in countries located in south-eastern SSA, including Swaziland, Lesotho, Zimbabwe, Zambia, Mozambique and Malawi. The descriptive statistics suggested a strong positive cross-country correlation (r(22) = 0.399, p = 0.054) between (log) per capita GDP and HIV/AIDS prevalence (See Figure 2).

Socioeconomic inequality in HIV/AIDS

Table 3 reports the relative and generalized concentration indices for HIV/AIDS prevalence for 24 sub-Saharan countries. Using aggregate data to estimate socioeconomic inequalities in HIV/AIDS prevalence across sampled countries demonstrated that wealthier countries (based on GDP rank) in the SSA region had a greater prevalence of HIV/AIDS than their poorer counterparts (RC = 0.213 and GC = 0.96). Results stratified by gender showed that the positive association between country-

Table 2 Survey year, sample size, GDP per capita and HIV/AIDS prevalence in SSA countries

| Name of country	Country code	Survey year	Sample size (total)	GDP per capita	HIV/AIDS prevalence				
					Total	Male	Female	Urban	Rural
Burkina Faso	BF	2010	15380	283	1.02	0.84	1.17	2.07	0.62
Cameroon	CM	2011	14198	666	4.25	2.89	5.57	4.67	3.76
Congo Brazzaville	CG	2009	12109	101	3.16	2.06	4.12	3.35	2.84
Congo Democratic Republic	CD	2007	8936	98	1.27	0.92	1.62	1.86	0.80
Cote d'Ivoire	CI	2005	8464	578	4.74	3.11	6.21	5.45	4.10
Ethiopia	ET	2011	28503	230	1.43	0.98	1.86	4.16	0.62
Ghana	GH	2003	9554	276	2.20	1.63	2.71	2.30	2.12
Guinea	GN	2005	6767	385	1.54	1.10	1.89	2.65	0.95
Kenya	KE	2008/2009	6906	457	6.36	4.55	26.43	7.25	6.07
Lesotho	LS	2009/2010	6924	485	22.97	18.45	26.73	26.83	21.27
Liberia	LR	2005	11688	187	1.60	1.23	1.91	2.54	0.94
Malawi	MW	2010	13905	181	10.67	8.39	12.88	17.74	8.88
Mali	ML	2006	8629	255	1.34	1.11	1.54	1.73	1.12
Mozambique	MZ	2009	10305	368	11.11	9.04	12.67	15.52	8.95
Niger	NE	2006	7673	172	0.71	0.71	0.71	1.46	0.50
Rwanda	RW	2010	13248	353	3.09	2.41	3.71	7.03	2.37
Sao Tome & Principe	ST	2008/2009	4710	1874	1.54	1.79	1.29	0.88	2.26
Senegal	SN	2011	9917	560	0.68	0.51	0.83	0.63	0.74
Sierra Leone	SL	2008	6455	259	1.47	1.16	1.73	2.40	0.94
Swaziland	SZ	2006/2007	8186	1745	25.88	19.70	31.15	31.43	23.79
Tanzania	TZ	2007/2008	15044	420	5.67	4.56	6.61	8.73	4.69
Uganda	UG	2011	10599	393	7.28	6.11	8.21	8.85	6.89
Zambia	ZM	2007	10874	385	14.21	12.29	16.09	19.51	10.27
Zimbabwe	ZW	2010/2011	13897	335	15.32	12.66	17.71	16.84	14.65
Total†			262871	328	4.51	3.51	6.96	5.90	3.90

†These values are weighted averages. We applied total number of adults aged 15-49 years in each country (calculated from the United Nations World Population Database) as a weight in the calculation.

level wealth and prevalence of HIV/AIDS was more pronounced for women (RC = 0.322, GC = 2.41) than for men (RC = 0.206, GC = 0.725). However, female-male differences in the RC and GC were not statistically different at the 95% confidence level (see Table 3). Results also suggested that the association between country-level wealth and HIV/AIDS was stronger among rural residents than their urban counterparts.

Within countries HIV/AIDS prevalence was concentrated among the socioeconomically advantaged, based on household wealth, in the majority of SSA countries. Swaziland and Senegal were the only countries with negative RC/SRC and/or GC/SGC. Results of the RC/SRC suggested that the relative concentration of HIV/AIDS prevalence among the better-off was higher in countries such as Ethiopia, Burkina Faso, Sierra Leon, Liberia, Niger, and Congo Democratic Republic, whereas the absolute concentration of HIV/AIDS among wealthier individuals was greatest in Zambia, Mozambique,

Malawi, Ethiopia, Lesotho, and Tanzania. Although, the calculated RC/SRC and/or GC/SGC generally suggested similar patterns of socioeconomic inequality in HIV/AIDS within countries for men and women, the concentration of HIV/AIDS prevalence among individuals from wealthier households was greater for women than for men (see statistically significant negative values of the difference in socioeconomic inequalities indices for men and women in Table 3). Results also showed that HIV/AIDS was more prevalent among the poor in urban areas in countries such as Uganda, Kenya, Zimbabwe and Swaziland. In rural areas, however, HIV/AIDS was more prevalent among wealthier individuals in most countries.

Table 4 reports multivariate regression results using the RC, SRC, GC and SGC as dependent variables. As illustrated by Figure 3, there was a statistically significant negative relation between the living standard of countries, measured by GDP per capita, and the RC/SRC for

Figure 1 Prevalence of HIV/AIDS in SSA region.
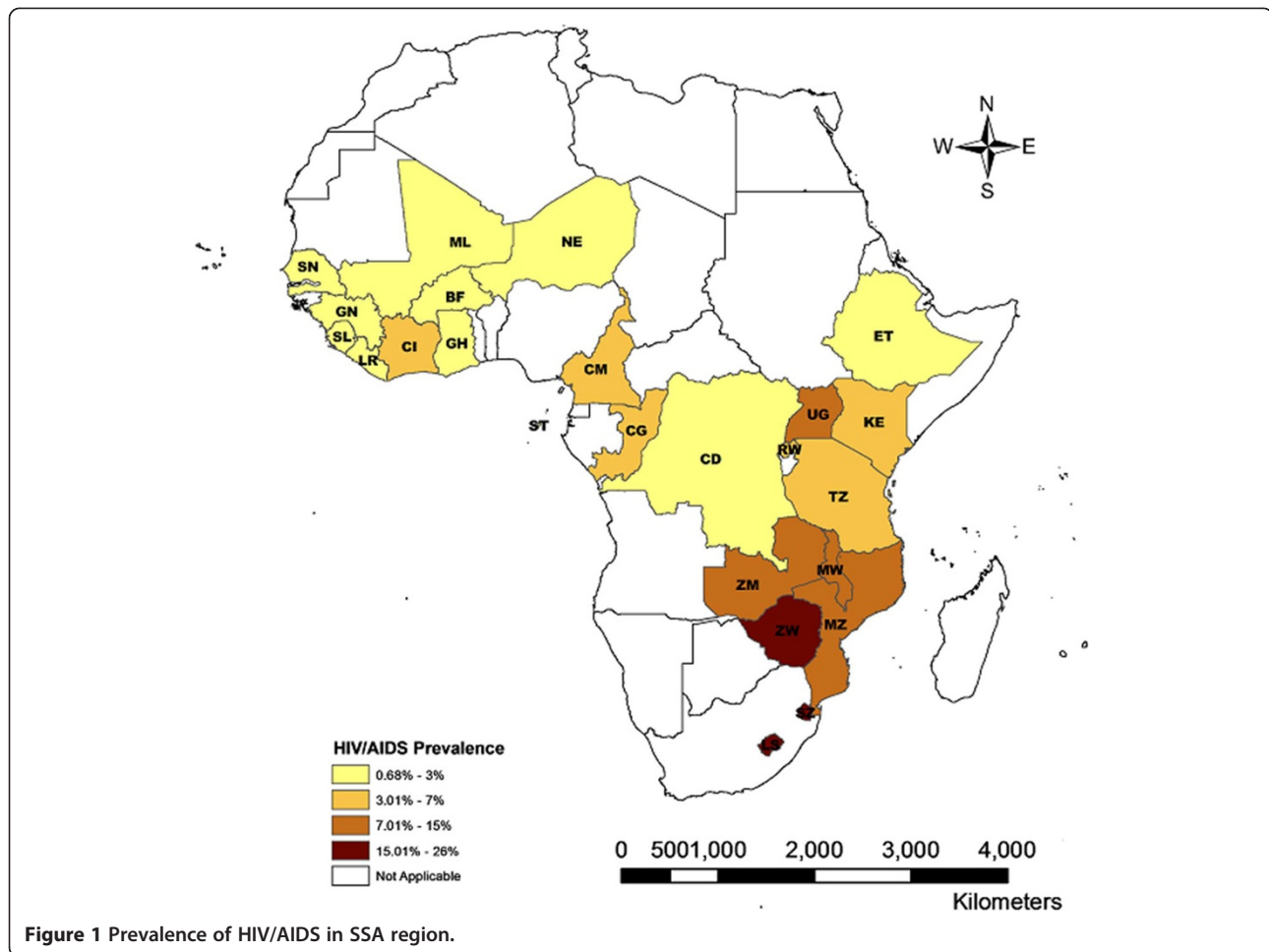
HIV/AIDS, indicating that HIV/AIDS was less concentrated among the better-off in wealthier countries. Similarly, the Gini index was negatively associated with the RC and SRC. There was also a positive association between countries in the region of Southern Africa and the GC, suggesting that absolute socioeconomic inequality for HIV/AIDS was greater in these countries relative to countries in other regions. Country-level gender inequality and governance indicators were not consistently associated with levels of inequality in HIV/AIDS.

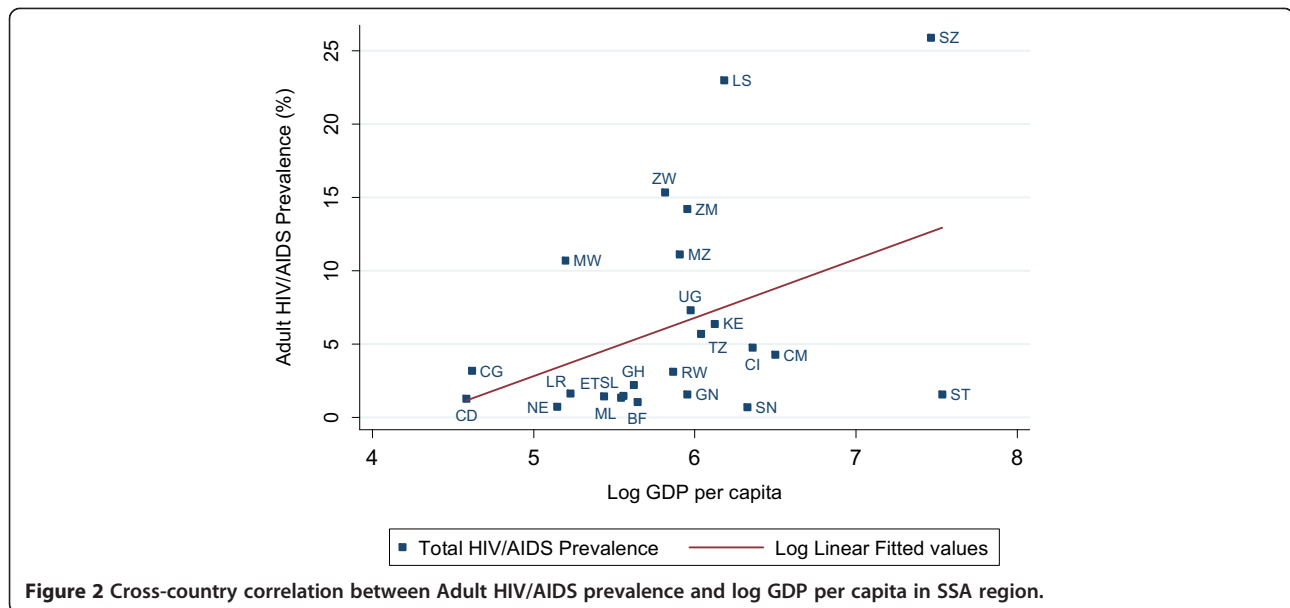**Determinants of socioeconomic inequalities in HIV/AIDS**

Table 5 presents beta coefficients in the decomposition regression, Equation 3, in 24 SSA countries. The coefficients indicate the effect of each explanatory factor on the probability of HIV/AIDS in each country.

Among socio-demographic characteristics, younger age was associated with lower HIV/AIDS prevalence in the majority of SSA countries. Women had a greater burden of HIV/AIDS than men in all countries. Additionally, being separated, divorced and widowed was consistently associated with higher probability of being

HIV positive compared to married individuals, whereas those who never married were at lower risk of being HIV positive than married individuals.

With respect to SES, there was a positive association between wealth and HIV/AIDS in most countries, including Cameroon, Ethiopia, Lesotho, Malawi, Mozambique and Zambia. A few countries (i.e., Guinea, Senegal, Swaziland, and Zimbabwe) showed the opposite pattern. Greater educational attainment (i.e. secondary and above) was associated with higher probability of being HIV positive in Cameroon, Ghana, Zambia, and Zimbabwe; this association was negative in countries such as Senegal, Swaziland, and Tanzania. Compared to agriculture workers, individuals with other occupations had higher prevalence of HIV/AIDS in Liberia, Malawi, Rwanda, Uganda, and Zambia, but lower prevalence in Sao Tome & Principe and Swaziland.

Multiple partners and early sexual activity were positively associated with HIV/AIDS in some countries. For example, number of sexual partners was positively associated with HIV/AIDS in Ghana, Malawi, Niger, Swaziland, and Zimbabwe. Additionally, younger age of

Figure 2 Cross-country correlation between Adult HIV/AIDS prevalence and log GDP per capita in SSA region.

first sexual experience was associated with the probability of being HIV positive in Ghana, Malawi, Sao Tome & Principe, Senegal, Sierra Leone, Tanzania, Uganda, Zambia and Zimbabwe. Results also showed that residing in urban areas was associated with higher probability of being HIV positive in most SSA countries.

Table 6 reports the relative and generalized concentration indices, RC_k and GC_k, for all explanatory variables included in the decomposition analysis. A positive value of the RC_k and GC_k indicates that variable x_k is concentrated among socioeconomically advantaged individuals, and *vice versa*. Results of the RC_k and GC_k suggest that individuals who were never married, reported completion of secondary school, worked in white collar occupations, had sexual partners outside their marriage and resided in urban areas were relatively wealthier in all countries studied.

Based on the regression coefficients and generalized concentration index of each explanatory variable, we measured the contribution of each factor to the overall RC and GC as $\beta_k \times GC_k/(\mu - \mu^2)$ and $\beta_k \times GC_k/1 - \mu$, respectively. The "contribution" indicates how much of the association between wealth and HIV/AIDS in each country is explained by variation in a given explanatory factor among different socioeconomic groups. A positive contribution of a given factor to the RC and GC suggests that the socioeconomic distribution of the factor and the association of the relevant factor with HIV/AIDS contribute to a greater prevalence of HIV/AIDS among wealthier respondents and *vice versa*.

Figure 4 and 5 illustrate the overall contribution of each category to the relative and generalized socioeconomic inequality in HIV/AIDS prevalence for the total population, as well as for men and women separately

(for detailed contribution of each factor see Additional file 1). Wealth contributed positively to HIV/AIDS, independently of other determinants of socioeconomic inequality, in the majority of the SSA countries. However, wealth contributed negatively to the relative inequality in Senegal and Guinea (see Figure 4), and to the absolute inequality in Swaziland and Zimbabwe (see Figure 5). Based on the decomposition results for the total population, wealth made a significant percentage contribution (calculated as its contribution multiplied by 100 and divided by the RC or GC) to socioeconomic inequalities in HIV/AIDS prevalence, either measured in absolute or relative terms, across SSA countries (median = 49%, interquartile range [IQR] = 90%).

Apart from wealth, urban residence increased the absolute and relative concentration of HIV/AIDS among wealthier individuals in the majority of countries. According to the decomposition results of the RC and GC for the total population, the median percentage contribution of urban residence to wealth-based inequality in HIV/AIDS across the 24 countries was 54% (IQR = 81%). In general, occupation status also contributed to the concentration of HIV/AIDS among the better-off. The education factor increased the concentration of HIV/AIDS prevalence among poorer individuals in Swaziland and Lesotho. This factor, however, increased the concentration of HIV/AIDS among the rich in Cameroon. Sexual behaviours, in general, did not contribute significantly to observed SES inequalities in HIV/AIDS in SSA countries.

Discussion and conclusions

We used data from the DHS and AIDS Indicator Surveys to measure inequalities in HIV/AIDS prevalence in

Table 3 Relative and generalized concentration indices for HIV/AIDS prevalence in SSA countries

Country	Relative concentration indices													
	Total		Male		Female		RC_{male}-RC_{female}	SRC_{male}-SRC_{female}	Urban		Rural		RC_{urban}-RC_{rural}	SRC_{urban}-SRC_{rural}
	RC	SRC	RC	SRC	RC	SRC			RC	SRC	RC	SRC		
BF	**0.269**	**0.298**	**0.248**	**0.009**	**0.284**	**0.324**	-0.036	**-0.315**	0.047	0.056	0.039	0.055	0.008	0.001
CM	**0.12**	**0.138**	**0.098**	**0.015**	**0.138**	**0.152**	-0.04	**-0.137**	0.059	0.06	**0.212**	**0.223**	**-0.153**	**-0.163**
CG	0.03	0.058	-0.097	-0.003	**0.09**	**0.104**	**-0.187**	**-0.107**	-0.033	-0.022	0.09	0.111	-0.123	-0.133
CD	**0.211**	**0.219**	**0.374**	**0.015**	0.125	0.153	**0.249**	-0.138	0.011	0.025	0.177	0.174	-0.166	-0.149
CI	**0.117**	**0.139**	-0.008	0.002	**0.166**	**0.193**	-0.174	**-0.191**	0.01	0.035	**0.145**	**0.158**	-0.135	-0.123
ET	**0.507**	**0.523**	**0.507**	**0.023**	**0.501**	**0.518**	0.006	**-0.495**	0.068	0.054	**0.266**	**0.288**	-0.198	-0.234
GH	0.038	0.052	0.013	0.002	0.044	0.065	-0.031	-0.063	-0.09	-0.1	**0.135**	**0.145**	-0.225	-0.245
GN	**0.167**	**0.209**	-0.019	0.001	**0.268**	**0.297**	-0.287	-0.296	**-0.149**	**-0.117**	-0.105	-0.098	-0.044	-0.019
KE	**0.07**	0.06	0.073	0.009	**0.039**	0.052	0.034	-0.043	**-0.148**	**-0.16**	**0.086**	**0.083**	-0.234	-0.243
LS	**0.03**	0.019	0.023	0.025	**0.026**	0.01	-0.003	0.015	-0.083	**-0.091**	**0.031**	**0.043**	-0.114	-0.134
LR	**0.244**	**0.262**	**0.276**	**0.014**	**0.226**	**0.239**	0.05	**-0.225**	0.032	0.044	**0.102**	**0.116**	-0.07	-0.072
MW	**0.143**	**0.154**	**0.127**	**0.048**	**0.155**	**0.159**	-0.028	**-0.111**	-0.012	-0.002	**0.084**	**0.087**	-0.096	-0.089
ML	0.097	0.113	0.185	0.01	0.044	0.063	0.141	-0.053	0.136	0.161	-0.058	-0.062	0.194	0.223
MZ	**0.188**	**0.211**	**0.188**	**0.085**	**0.192**	**0.203**	-0.004	**-0.118**	0.009	0.023	**0.176**	**0.189**	**-0.167**	**-0.166**
NE	**0.228**	**0.255**	0.217	0.008	**0.237**	**0.257**	-0.02	**-0.249**	-0.029	-0.013	0.028	0.026	-0.057	-0.039
RW	**0.128**	**0.15**	**0.107**	**0.016**	**0.148**	**0.161**	-0.041	**-0.145**	-0.025	-0.001	-0.019	0	-0.006	-0.001
ST	-0.063	-0.047	-0.03	0	-0.105	-0.096	0.075	0.096	-0.062	-0.044	0.025	0.035	-0.087	-0.079
SN	**-0.177**	**-0.165**	-0.215	-0.005	-0.151	-0.148	-0.064	0.143	-0.122	-0.145	**-0.248**	**-0.236**	0.126	0.091
SL	**0.255**	**0.273**	**0.41**	**0.019**	0.163	**0.169**	0.247	-0.15	0.078	0.096	0.129	0.133	-0.051	-0.037
SZ	-0.005	**-0.027**	0.011	**-0.052**	-0.01	**-0.021**	0.021	-0.031	**-0.069**	**-0.07**	**-0.033**	**-0.04**	-0.036	-0.03
TZ	**0.102**	**0.108**	**0.093**	**0.018**	**0.104**	**0.111**	-0.011	**-0.093**	-0.023	-0.015	-0.011	-0.004	-0.012	-0.011
UG	**0.051**	**0.064**	0.021	0.011	**0.067**	**0.08**	-0.046	**-0.069**	**-0.11**	**-0.095**	**0.042**	**0.05**	-0.152	-0.145
ZM	**0.15**	**0.177**	**0.125**	**0.076**	**0.167**	**0.187**	-0.042	**-0.111**	-0.04	-0.027	**0.12**	**0.133**	-0.16	-0.16
ZW	-0.017	-0.008	-0.035	-0.015	-0.002	0.006	-0.033	-0.021	**-0.072**	**-0.07**	-0.044	-0.031	-0.028	-0.039
Total†	**0.213**	-	**0.206**	-	**0.322**	-	-0.116		0.162	-	**0.253**	-	-0.091	

Country	Generalized concentration indices													
	Total		Male		Female		GC_{male}-GC_{female}	SGC_{male}-SGC_{female}	Urban		Rural		GC_{urban}-GC_{rural}	SGC_{urban}-SGC_{rural}
	CG	SGC	GC	SGC	GC	SGC			GC	SGC	GC	SGC		
BF	**0.274**	**0.304**	**0.208**	**0.008**	**0.333**	**0.38**	-0.125	**-0.372**	0.098	0.118	0.024	0.033	0.074	0.085
CM	**0.51**	**0.587**	**0.283**	**0.044**	**0.771**	**0.846**	-0.488	**-0.802**	0.276	0.28	**0.797**	**0.847**	-0.521	-0.567
CG	0.096	0.184	-0.2	-0.007	**0.369**	**0.429**	-0.569	-0.436	-0.108	-0.073	0.256	0.31	-0.364	-0.383
CD	**0.269**	**0.279**	**0.343**	**0.014**	0.202	0.248	0.141	-0.234	0.02	0.048	0.141	0.139	-0.121	-0.091
CI	**0.553**	**0.659**	-0.025	0.006	**1.029**	**1.202**	-1.054	**-1.196**	0.056	0.189	**0.596**	**0.648**	-0.54	-0.459
ET	**0.726**	**0.749**	**0.495**	**0.022**	**0.932**	**0.964**	-0.437	**-0.942**	0.285	0.225	**0.164**	**0.173**	0.121	0.052
GH	0.085	0.114	0.022	0.004	0.118	0.176	-0.096	-0.172	-0.208	-0.23	**0.286**	**0.305**	-0.494	-0.535
GN	**0.257**	**0.322**	-0.021	0.001	**0.506**	**0.561**	-0.527	-0.56	**-0.402**	**-0.315**	-0.1	-0.098	-0.302	-0.217
KE	**0.447**	**0.379**	0.334	0.042	**1.03**	1.375	-0.696	-1.333	**-1.08**	**-1.168**	**0.519**	0.507	**-1.599**	**-1.675**
LS	**0.685**	0.426	0.425	0.463	**0.685**	0.273	-0.26	0.19	**-2.229**	**-2.445**	**0.649**	**0.926**	-2.878	-3.371
LR	**0.39**	**0.418**	**0.34**	**0.017**	**0.431**	**0.456**	-0.091	**-0.439**	0.081	0.11	0.095	0.104	-0.014	0.006
MW	**1.524**	**1.643**	**1.063**	**0.4**	**1.998**	**2.054**	-0.935	**-1.654**	-0.207	-0.033	**0.747**	**0.774**	-0.954	-0.807
ML	0.13	0.151	0.205	0.011	0.067	0.097	0.138	-0.086	0.232	0.274	-0.065	-0.068	0.297	0.342

Table 3 Relative and generalized concentration indices for HIV/AIDS prevalence in SSA countries (Continued)

MZ	**2.094**	**2.342**	**1.702**	**0.764**	**2.428**	**2.577**	-0.726	**-1.813**	0.143	0.364	**1.575**	**1.684**	**-1.432**	-1.32
NE	**0.162**	**0.181**	0.155	0.006	**0.168**	**0.182**	-0.013	**-0.176**	-0.044	-0.019	0.014	0.013	-0.058	-0.032
RW	**0.394**	**0.462**	**0.257**	**0.038**	**0.549**	**0.598**	-0.292	**-0.56**	-0.173	-0.01	-0.044	0	-0.129	-0.01
ST	-0.098	-0.073	-0.055	0.000	-0.136	-0.124	0.081	0.124	-0.056	-0.04	0.056	0.081	-0.112	-0.121
SN	**-0.121**	**-0.112**	-0.11	-0.003	-0.125	-0.123	0.015	0.12	-0.073	-0.087	**-0.183**	**-0.165**	0.11	0.078
SL	**0.373**	**0.4**	**0.477**	**0.022**	0.282	**0.292**	0.195	-0.27	0.188	0.23	0.121	0.12	0.067	0.11
SZ	-0.141	**-0.705**	0.219	**-1.016**	-0.319	**-0.648**	0.538	-0.368	**-2.174**	**-2.202**	**-0.79**	**-0.95**	**-1.384**	**-1.252**
TZ	**0.578**	**0.615**	**0.425**	**0.083**	**0.69**	**0.731**	-0.265	**-0.648**	-0.2	-0.127	-0.053	-0.021	-0.147	-0.106
UG	0.37	**0.469**	0.129	0.065	**0.553**	**0.653**	-0.424	**-0.588**	**-0.982**	**-0.845**	0.287	0.343	**-1.269**	**-1.188**
ZM	**2.13**	**2.511**	**1.531**	**0.935**	**2.689**	**3.016**	-1.158	**-2.081**	-0.782	-0.522	**1.233**	**1.37**	**-2.015**	**-1.892**
ZW	-0.256	-0.129	-0.444	-0.188	-0.032	0.105	-0.412	-0.293	**-1.212**	**-1.17**	**-0.645**	**-0.455**	-0.567	**-0.715**
Total†	**0.96**	-	**0.725**	-	**2.241**	-	-1.516		0.957	-	**0.977**	-	-0.02	

Note: Bold font indicates statistically significantly different from zero at the five per cent level; GC and SGC is multiplied by 100 for ease of interpretation.
†We calculated the overall RC and GC by ranking countries based on their GDP per capita. Also, we applied total number of adults (15-59 years) during the study period for each country as a weight in the calculation.

24 SSA countries. The generalized concentration index was used to quantify and decompose wealth-based inequalities in HIV/AIDS for the whole population, for men and women, as well as for urban and rural regions in each country. Our results suggested that HIV/AIDS is more prevalent among relatively wealthier countries and individuals in the SSA region. Separate analysis by gender also showed HIV/AIDS was concentrated among wealthier men and women in the majority of countries. These results confirm the findings of recent studies [5,18,24,55,56] showing higher concentration of HIV/AIDS prevalence among socioeconomically advantaged individuals in some SSA countries. Our findings for urban areas showed that the HIV/AIDS was more prevalent among the poor in countries such as Uganda, Kenya, Zimbabwe and Swaziland. However, in rural areas, HIV/AIDS was concentrated among wealthier individuals in the majority of countries. These findings support a recent study by Magadi [57] suggesting that poorer individuals in urban areas in SSA face comparative disadvantage with respect of HIV/AIDS prevalence. These results, thus, suggest that the positive association between wealth and HIV/AIDS that we found for whole population in the majority of SSA countries reflects the situation in rural regions where most people reside.

Results from our decomposition analyses showed that, aside from wealth *per se*, urban residence was the most important factor contributing to the relative and absolute concentration of HIV/AIDS prevalence among the better-off. Urban residents were wealthier than their rural counterparts (as indicated by the positive values of the RC_k and GC_k in Table 6). Additionally, living in urban areas was positively associated with the probability of being HIV positive (as indicated by the positive value of the coefficient, β, in

Table 5). Further work is needed to clarify the mechanisms through which urban residence influences the prevalence of HIV/AIDS. One possibility is that the positive association between urban residence and prevalence of HIV/AIDS is not explained by increased incidence, but rather by improved access to treatment (and survival conditional on infection) among urban compared to rural populations. For example, a study by Zungu-Dirwayi and colleagues [58] that examined HIV/AIDS prevention programs in six SSA countries (Botswana, Lesotho, Mozambique, South Africa, Swaziland and Zimbabwe) showed that the provision of services such as voluntary counseling and testing were lower in rural compared with urban areas.

Our findings indicated that wealth-based inequalities in HIV/AIDS persisted after accounting for other demographic characteristics, region of residence, number of partners and early sexual activity. Household wealth was associated with higher prevalence of HIV/AIDS in most SSA countries. Unfortunately, it was not possible to examine differences in the frequency or quality of HIV treatment, or details on HIV prevention. The concentration of HIV/AIDS among wealthier men and women may be explained by behavioural differences [56]. Our results indicated that wealthier individuals (both men and women) in SSA countries reported more sexual partners than their poorer counterparts (see the positive value of the RC_k and GC_k for the number of sexual partners in Table 6). The concentration of HIV/AIDS among wealthier individuals may also be partially explained by unsafe sexual practices. Another potential explanation for the higher prevalence of HIV/AIDS among wealthier individuals is that socially advantaged individuals are more likely to receive treatment for HIV/AIDS, extending their survival relative to poorer individuals [25,56].

Table 4 Aggregate multivariate regressions

Independent variables	GDP/Cap (Log)	Gini index	Gender equality†	Governance indicators							Western Africa	Eastern and Central Africa	Southern Africa
Dependent variables				Control of corruption	Government effectiveness	Political stability	Regulatory quality	Rule of law	Voice and accountability				
Total													
RC	**-0.093**	**-1.298**	-0.057	-0.035	-0.032	-0.046	-0.040	-0.022	-0.043		0.023	0.028	-0.050
SRC	**-0.100**	**-1.376**	-0.057	-0.041	-0.036	-0.046	-0.043	-0.024	-0.045		0.021	0.042	-0.061
GC	-0.126	-1.119	0.242	0.224	0.319	0.194	0.281	0.259	0.264		-0.264	-0.456	**0.703**
SGC	-0.220	-1.816	0.224	0.124	0.285	0.191	0.260	0.229	0.302		-0.262	-0.420	0.667
Male													
RC	**-0.107**	**-1.327**	-0.086	-0.026	-0.059	-0.039	-0.045	-0.012	-0.001		0.033	0.017	-0.052
SRC	-0.012	-0.077	0.011	0.008	0.014	0.009	0.012	0.013	0.019		-0.008	-0.010	0.018
GC	-0.067	-0.902	0.208	0.286	0.298	0.220	0.296	0.294	0.298		-0.216	-0.371	**0.572**
SGC	-0.144	-0.368	0.172	0.090	0.177	0.122	0.138	0.155	**0.271**		-0.117	-0.073	0.194
Female													
RC	**-0.089**	**-1.312**	-0.086	-0.036	-0.018	-0.049	-0.038	-0.025	-0.069		0.009	0.037	-0.044
SRC	**-0.095**	**-1.387**	0.011	-0.045	-0.024	-0.054	-0.038	-0.028	-0.073		0.013	0.046	-0.057
GC	-0.157	-1.157	0.208	0.100	0.324	0.137	0.297	0.180	0.214		-0.241	-0.588	**0.798**
SGC	-0.210	-1.642	0.172	-0.054	0.274	0.082	0.309	0.105	0.213		-0.166	-0.592	0.720
Urban													
RC	-0.033	**-0.549**	-0.046	-0.005	-0.035	0.004	-0.025	0.001	0.006		-0.009	0.039	-0.026
SRC	-0.035	-0.511	-0.047	-0.007	-0.043	0.004	-0.029	-0.004	0.002		-0.005	0.038	-0.029
GC	-0.401	**-7.420**	-0.348	-0.353	-0.182	-0.113	-0.034	-0.044	0.117		0.291	**0.717**	**-0.970**
SGC	-0.418	**-7.456**	-0.335	-0.363	-0.190	-0.100	-0.015	-0.043	0.107		0.274	0.691	**-0.927**
Rural													
RC	-0.045	-0.388	-0.077	-0.057	-0.045	-0.035	-0.040	-0.034	-0.023		0.078	-0.091	-0.001
SRC	-0.047	-0.400	-0.076	-0.056	-0.044	-0.035	-0.043	-0.034	-0.025		0.078	-0.089	-0.003
GC	-0.099	-0.309	0.102	0.039	0.220	0.118	0.287	0.186	0.296		-0.040	-0.273	0.293
SGC	-0.113	0.127	0.129	0.051	0.222	0.134	0.254	0.177	0.316		-0.083	-0.298	0.362

Note: All multivariate regressions included an independent variable and survey year variable; Bold font indicates statistically significantly different from zero at the five per cent level.
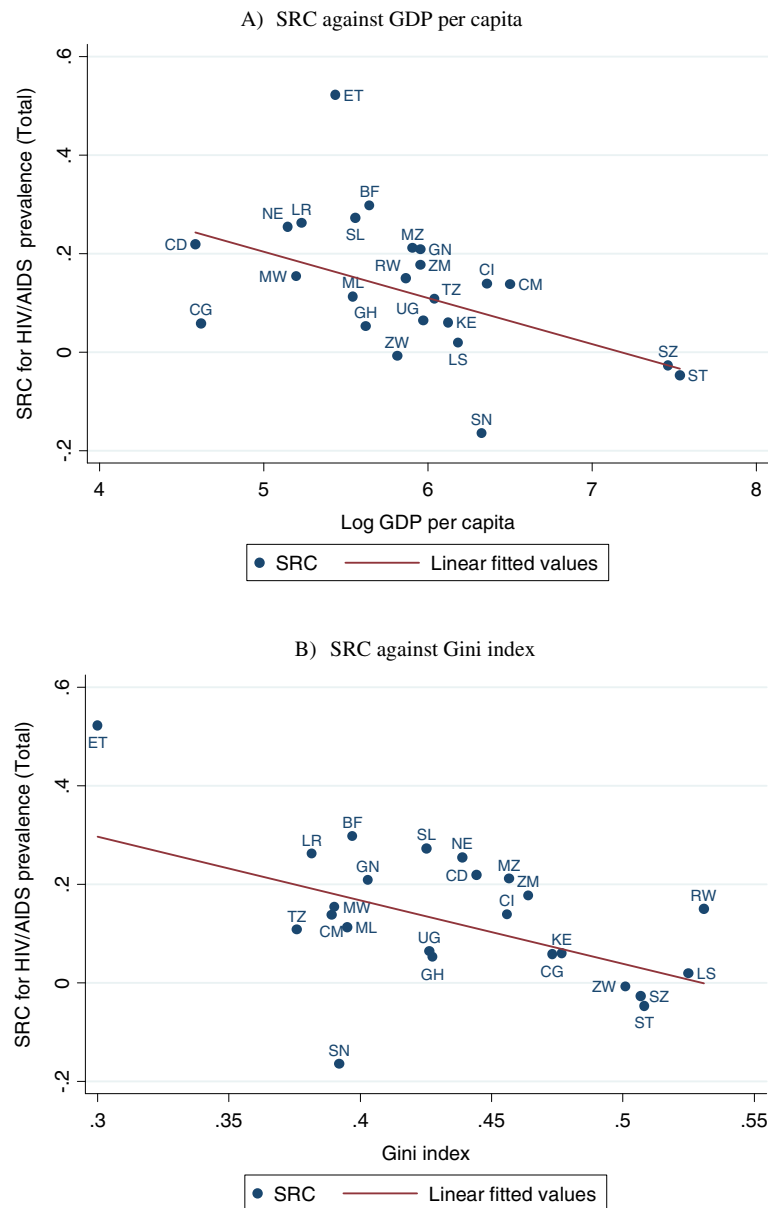†Data was not available for Swaziland.

Figure 3 Cross-country correlations between the SRC for HIV/AIDS prevalence (total) and log GDP per capita and Gini index in SSA region. A) SRC against GDP per capita. **B)** SRC against Gini index.

The direction of the association between wealth and HIV/AIDS was not consistent across all sampled countries. For example, there was a negative association between wealth and HIV/AIDS in Swaziland and Zimbabwe. The higher absolute concentration of HIV/AIDS among poorer individuals in Swaziland may be explained by cultural beliefs that discourage safe sexual practices, including monogamous relationships and condom use [59], and the concentration of these behaviours among socioeconomically disadvantaged groups. Based on the DHS 2006/07, for example, around 17 per cent of individuals who had sex with someone other than their spouse in Swaziland did not use a condom and this behaviour was more common among poorer individuals (GC = -2.056, CI: -1.60 -2.52). Recent studies by Asiedu and colleagues [23] and Fox [17] have also demonstrated that poorer individuals in Swaziland are at higher risk of being HIV positive than their wealthier counterparts. Similarly, based on the DHS 2010/11, socioeconomically disadvantaged groups in Zimbabwe reported a higher prevalence of unsafe sexual practices with sexual partners outside their marriage compared to wealthier individuals (GC = -0.348, CI: -0.30 -0.39).

Table 5 Coefficient results (full sample)

Country	Age-Gender				Marital status		Living standard	Education		Occupation	
	15-20	21-29	31-39	Female	Never married	Separated/divorced/widowed	Wealth index	Primary	Secondary and above	White collar	Blue collar
BF	-0.0147†	-0.0104†	-0.0008	0.0053‡	-0.0054	0.0333‡	0.000	0.0029	0.0031	0.0006	-0.0042
CM	-0.0284†	-0.0142‡	0.015‡	0.0241†	-0.0109*	0.0745†	0.0004†	0.0299†	0.0316†	-0.0034	-0.0011
CG	-0.0543†	-0.0333†	-0.0201‡	0.0231†	0.0132*	0.0265†	0.0001	0.0079	0.0115	–	–
CD	-0.0012	-0.0059	-0.0008	0.0053	-0.0027	0.0122	0000	0.0081*	0.0051	0.0071*	-0.0023
CI	-0.055†	-0.0263‡	0.0145	0.0276‡	0.0095	0.0647†	0.0004	0.0075	0.0024	0.008	0.0064
ET	-0.0085†	-0.0029	0.01†	0.0019	-0.0106‡	0.0481†	0.0006†	0.0086†	0.0004	-0.0043	0.0212†
GH	-0.0201†	-0.012‡	0.0068	0.0058*	-0.0074	0.0197‡	-0.0001	0.0162†	0.011‡	0.0094	-0.0029
GN	-0.0142‡	-0.0118‡	-0.0055	0.0117†	-0.0049	0.0318	-0.0003‡	0.004	0.0107	0.0151	0.0036
KE	-0.0042	0.0032	0.0162	0.0265†	-0.0147	0.1884†	0.0006*	0.0325‡	0.0051	0.0274*	-0.0022
LS	-0.1687†	-0.0346*	0.1048†	0.0646†	-0.0428‡	0.2234†	0.000	0.008	-0.005	-0.0167	0.0628†
LR	-0.0148*	-0.007	0.0001	0.0093‡	0.007	0.0123*	0.000	0.0047	0.0059	0.0152‡	0.0123
MW	-0.1041†	-0.09†	0.0068	0.028†	-0.047†	0.1583†	0.0007‡	0.0152	0.0122	0.0956†	0.0178*
ML	-0.0124‡	-0.0057	0.0011	0.0044	-0.0027	0.0147	0.0002	0.0042	-0.0011	0.0189	-0.0069
MZ	-0.0051	0.0358†	0.048†	0.0303†	-0.0497†	0.1285†	0.0015†	0.0266†	-0.0063	-0.0456	-0.0203
NE	-0.0036	0.0021	0.0098†	0.0013	-0.0052	0.0418†	0.000	0.0007	-0.0042	0.0099	-0.0002
RW	-0.0311†	-0.0264†	-0.0063	0.0104†	-0.0065	0.0676†	0.0001	0.0065	0.007	0.0235‡	0.0154†
ST	-0.0155*	-0.01	0.0033	-0.0016	-0.003	0.0095	0.0001	-0.021	-0.0181	-0.014	-0.0175*
SN	-0.0156†	-0.0115†	-0.0059	0.0002	0.0041	0.0182‡	-0.0001‡	-0.0012	-0.005‡	-0.0013	-0.0074†
SL	-0.0121	-0.0038	-0.0008	0.0063	0.0067	0.0134	0.0004*	-0.0001	-0.0043	-0.004	0.0076
SZ	-0.0482‡	0.109†	0.1685†	0.0852†	-0.0691†	0.1931†	-0.001†	-0.012	-0.0507‡	-0.0501‡	0.0004
TZ	-0.036†	-0.0066	0.0279†	0.0019	-0.0086	0.092†	0.0002	0.0046	-0.0117	-0.0034	-0.0109
UG	-0.0409†	-0.0183†	0.0223†	0.0049	-0.0112	0.1087†	0.0003*	0.0171‡	-0.0019	0.025†	0.0226†
ZM	-0.0556†	-0.0294‡	0.0545†	0.02‡	-0.0688†	0.1928†	0.0008†	0.0433†	0.0405†	0.0704†	0.0457†
ZW	-0.1666†	-0.1152†	0.0091	0.0205†	-0.013	0.2179†	-0.001†	0.0925†	0.0991†	-0.0121	0.0062

Table 5 Coefficient results (full sample)

| Country | Occupation | | Sexual Behaviours | | | | | Urban residence |
	Other	Unemployed	Number of sex partners	Never had sex	<16	16-17	18-19	Urban
BF	0.0045	-0.0039	0.0049	0.0077*	-0.0147†	-0.0104†	-0.0008	0.0053‡
CM	0.0085	-0.0039	-0.0002	-0.0042	-0.0284†	-0.0142‡	0.015‡	0.0241†
CG	–	–	0.0006	0.0107	-0.0543†	-0.0333†	-0.0201‡	0.0231†
CD	–	0.0031	0.0014	-0.0005	-0.0012	-0.0059	-0.0008	0.0053
CI	0.0201*	0.019	-0.0046‡	-0.0315*	-0.055†	-0.0263‡	0.0145	0.0276†
ET	0.0032	-0.0005	0.0053	0.0048	-0.0085†	-0.0029	0.01†	0.0019
GH	0.0125*	0.006	0.001	-0.0012	-0.0201†	-0.012‡	0.0068	0.0058*
GN	0.0131‡	-0.0042	0.0069*	0.0039	-0.0142‡	-0.0118‡	-0.0055	0.0117†
KE	0.0137	-0.0121	0	-0.0232	-0.0042	0.0032	0.0162	0.0265†
LS	0.0883†	0.0051	0.0194	-0.0217	-0.1687†	-0.0346*	0.1048†	0.0646†
LR	0.013‡	0.0169†	-0.0028*	-0.0103	-0.0148*	-0.007	0.0001	0.0093‡
MW	0.0299†	-0.0006	0.0128*	0.0478†	-0.1041†	-0.09†	0.0068	0.028†
ML	0.004	0.0001	0.0028	0.0062	-0.0124‡	-0.0057	0.0011	0.0044
MZ	-0.07	-0.0921‡	0.0062	0.0097	-0.0051	0.0358†	0.048†	0.0303†
NE	-0.001	-0.0027	0.0114*	0.007	-0.0036	0.0021	0.0098†	0.0013
RW	0.0135*	0.0124‡	0.0061	-0.0126‡	-0.0311†	-0.0264†	-0.0063	0.0104†
ST	-0.0193*	-0.0121	0.0003	0.0151	-0.0155*	-0.01	0.0033	-0.0016
SN	-0.0008	0.0001	0.001	0.0015	-0.0156†	-0.0115†	-0.0059	0.0002
SL	0.0014	-0.0032	0.0028	-0.0042	-0.0121	-0.0038	-0.0008	0.0063
SZ	0.0336	-0.0416‡	0.0468†	-0.0715†	-0.0482‡	0.109†	0.1685†	0.0852†
TZ	0.0261‡	-0.0009	-0.0011	0.0121	-0.036†	-0.0066	0.0279†	0.0019
UG	0.0313†	0.0129‡	0.0014	0.0104	-0.0409†	-0.0183†	0.0223†	0.0049
ZM	0.0509†	0.0334†	0.0236†	-0.0039	-0.0556†	-0.0294‡	0.0545†	0.02‡
ZW	0.0014	0.0047	-0.0009	0.0104	-0.1666†	-0.1152†	0.0091	0.0205†

Note: Significant levels are †, ‡, * for 1, 5 and 10% respectively.

Table 6 Concentration index and generalized concentration index of independent variables (full sample)

Country		15-20	21-29	31-39	Female	Never married	Separated/divorced/widowed	Wealth Index	Primary	Secondary and above	White collar	Blue collar	Other	Unemployed	Number of Sex Partners	Never had sex	<16	16-17	18-19	Urban
		Age-Gender				Marital status		Living standard	Education		Occupation				Sexual behaviours					Urban residence
BF	RC	0.022	0.058	0.002	0.000	0.148	0.061	0.505	0.225	0.638	0.724	0.242	0.309	0.215	0.350	0.054	-0.123	-0.018	0.046	0.637
	GC	0.004	0.019	0.001	0.000	0.035	0.002	7.269	0.037	0.083	0.027	0.022	0.053	0.030	0.045	0.008	-0.018	-0.004	0.009	0.170
CM	RC	0.011	0.053	-0.007	-0.016	0.129	0.021	0.346	-0.195	0.288	0.487	0.159	0.152	0.160	0.350	0.054	-0.123	-0.018	0.046	0.395
	GC	0.003	0.019	-0.001	-0.008	0.047	0.001	11.829	-0.065	0.149	0.032	0.033	0.030	0.037	0.182	0.008	-0.033	-0.004	0.008	0.214
CG	RC	0.036	0.052	-0.011	-0.011	0.088	-0.078	0.320	-0.306	0.123	–	–	–	–	0.021	0.119	-0.092	0.061	0.081	0.330
	GC	0.007	0.019	-0.003	-0.006	0.029	-0.009	12.765	-0.072	0.089	–	–	–	–	0.021	0.119	-0.092	0.061	0.081	0.208
CD	RC	0.085	0.008	-0.009	-0.001	0.161	-0.098	0.465	-0.201	0.244	0.342	0.253	–	0.178	0.038	0.166	-0.112	0.016	0.028	0.438
	GC	0.017	0.003	-0.002	-0.001	0.050	-0.007	12.477	-0.069	0.125	0.088	0.027	–	0.053	0.058	0.054	-0.053	0.007	0.011	0.195
CI	RC	0.057	0.029	-0.030	0.008	0.140	0.001	0.352	0.002	0.316	0.354	0.280	0.108	0.129	0.109	0.126	-0.078	0.030	0.073	0.361
	GC	0.013	0.012	-0.007	0.004	0.058	0.000	13.897	0.001	0.092	0.053	0.023	0.022	0.036	0.137	0.039	-0.037	0.013	0.027	0.172
ET	RC	0.025	0.041	-0.015	0.000	0.132	0.024	0.189	0.045	0.622	0.696	0.354	0.259	0.035	0.375	0.087	-0.099	-0.026	0.009	0.697
	GC	0.006	0.014	-0.004	0.000	0.044	0.002	6.198	0.020	0.083	0.035	0.030	0.035	0.009	0.019	0.025	-0.021	-0.003	0.001	0.160
GH	RC	0.028	0.045	-0.029	0.016	0.136	0.011	0.484	-0.161	0.210	0.411	0.194	0.263	0.154	0.146	0.095	-0.129	-0.042	0.031	0.443
	GC	0.006	0.014	-0.007	0.009	0.047	0.001	12.372	-0.029	0.124	0.044	0.031	0.044	0.035	0.031	0.019	-0.021	-0.008	0.006	0.207
GN	RC	0.102	0.072	-0.076	-0.035	0.187	0.134	0.540	0.133	0.477	0.502	0.339	0.281	0.326	0.192	0.156	-0.103	0.042	0.074	0.597
	GC	0.021	0.020	-0.019	-0.019	0.047	0.006	12.917	0.019	0.096	0.020	0.038	0.055	0.068	0.059	0.017	-0.037	0.009	0.011	0.205
KE	RC	-0.129	0.082	0.037	-0.025	0.007	-0.087	0.249	-0.141	0.291	0.327	0.046	0.234	-0.060	0.075	-0.064	-0.129	0.014	0.077	0.668
	GC	-0.027	0.029	0.009	-0.013	0.003	-0.007	11.176	-0.077	0.112	0.067	0.006	0.022	-0.017	0.017	-0.010	-0.036	0.003	0.014	0.165
LS	RC	-0.021	-0.004	0.040	0.026	0.042	-0.065	0.320	-0.217	0.298	0.390	0.177	0.214	-0.022	0.025	0.000	-0.091	0.010	0.025	0.553
	GC	-0.005	-0.001	0.009	0.014	0.018	-0.006	11.755	-0.104	0.135	0.044	0.027	0.016	-0.010	0.012	0.000	-0.020	0.002	0.005	0.169
LR	RC	0.099	0.002	-0.016	-0.066	0.184	-0.003	0.406	-0.082	0.312	0.448	0.209	0.391	0.356	0.142	0.080	-0.056	0.019	0.035	0.535
	GC	0.015	0.001	-0.005	-0.029	0.050	0.000	11.098	-0.026	0.109	0.044	0.015	0.085	0.043	0.062	0.006	-0.017	0.006	0.007	0.194
MW	RC	0.040	-0.016	-0.008	-0.020	0.130	-0.123	0.446	-0.109	0.429	0.523	0.015	0.180	0.110	0.121	0.111	-0.068	0.019	-0.011	0.587
	GC	0.009	-0.006	-0.002	-0.010	0.037	-0.010	8.958	-0.070	0.108	0.032	0.003	0.026	0.022	0.019	0.015	-0.021	0.004	-0.002	0.119
ML	RC	0.051	0.046	-0.045	-0.008	0.092	0.203	0.506	0.072	0.528	0.509	0.287	0.226	0.070	0.285	0.043	-0.040	0.031	0.050	0.574
	GC	0.011	0.014	-0.011	-0.004	0.019	0.008	7.337	0.011	0.077	0.013	0.027	0.042	0.024	0.042	0.007	-0.013	0.005	0.006	0.198
MZ	RC	0.035	0.029	-0.052	-0.031	0.285	0.046	0.452	-0.043	0.591	0.597	0.386	0.240	-0.178	0.262	-0.015	-0.069	0.057	0.059	0.452
	GC	0.003	0.009	-0.014	-0.017	0.030	0.006	8.010	-0.026	0.077	0.043	0.041	0.029	-0.122	0.061	0.000	-0.024	0.015	0.011	0.126

Table 6 Concentration index and generalized concentration index of independent variables (full sample) *(Continued)*

NE	RC	0.086	0.019	-0.050	-0.037	0.265	0.117	0.611	0.223	0.676	0.421	0.046	0.086	0.017	0.463	0.237	-0.108	-0.047	0.029	0.713
	GC	0.016	0.006	-0.013	-0.021	0.051	0.004	7.313	0.030	0.065	0.028	0.005	0.015	0.006	0.018	0.037	-0.037	-0.007	0.003	0.159
RW	RC	0.014	0.020	-0.012	-0.035	0.079	-0.205	0.267	-0.058	0.436	0.641	0.172	0.493	0.096	0.172	0.045	-0.005	-0.039	-0.017	0.518
	GC	0.003	0.007	-0.002	-0.018	0.033	-0.014	5.427	-0.040	0.077	0.023	0.027	0.035	0.012	0.015	0.013	0.000	-0.004	-0.003	0.080
ST	RC	0.087	-0.029	-0.033	0.018	0.109	-0.282	0.392	-0.179	0.306	0.174	-0.116	-0.096	0.075	0.007	0.103	-0.095	-0.050	0.021	0.152
	GC	0.020	-0.009	-0.008	0.009	0.034	-0.029	9.758	-0.103	0.119	0.051	-0.014	-0.013	0.022	0.002	0.015	-0.020	-0.014	0.005	0.079
SN	RC	-0.035	0.048	0.006	-0.009	0.127	0.095	0.263	0.119	0.314	0.327	0.161	0.090	0.003	0.141	0.123	-0.227	-0.103	-0.007	0.370
	GC	-0.008	0.017	0.001	-0.005	0.053	0.003	13.810	0.029	0.084	0.045	0.024	0.017	0.001	0.018	0.037	-0.040	-0.011	-0.001	0.192
SL	RC	0.142	0.045	-0.067	-0.005	0.251	0.014	0.340	0.014	0.470	0.386	0.254	0.277	0.320	0.232	0.158	-0.091	0.066	0.089	0.537
	GC	0.022	0.015	-0.019	-0.002	0.061	0.001	9.636	0.002	0.129	0.039	0.013	0.050	0.061	0.065	0.014	-0.033	0.013	0.015	0.193
SZ	RC	-0.084	0.028	0.075	-0.010	-0.002	-0.120	0.252	-0.240	0.190	0.191	0.035	0.241	-0.101	0.016	-0.050	-0.117	-0.022	0.024	0.491
	GC	-0.025	0.010	0.015	-0.005	-0.001	-0.009	11.529	-0.082	0.109	0.040	0.005	0.018	-0.052	0.006	-0.012	-0.018	-0.005	0.005	0.135
TZ	RC	0.025	0.020	-0.019	0.005	0.111	-0.054	0.506	-0.007	0.563	0.616	0.422	0.362	0.176	0.001	0.093	-0.131	-0.028	0.034	0.611
	GC	0.006	0.007	-0.005	0.003	0.036	-0.005	10.678	-0.005	0.066	0.037	0.025	0.040	0.035	0.000	0.016	-0.033	-0.006	0.007	0.144
UG	RC	0.039	0.045	-0.022	0.004	0.152	-0.080	0.390	-0.122	0.369	0.252	-0.084	0.280	0.070	0.203	0.087	-0.062	-0.003	-0.002	0.665
	GC	0.008	0.014	-0.005	0.002	0.041	-0.009	12.008	-0.071	0.112	0.037	-0.027	0.028	0.017	0.051	0.012	-0.016	-0.001	0.000	0.132
ZM	RC	0.101	0.028	-0.066	0.000	0.190	0.003	0.447	-0.229	0.335	0.525	0.196	0.259	0.132	0.082	0.226	-0.119	-0.047	0.011	0.533
	GC	0.021	0.010	-0.017	0.000	0.060	0.000	17.060	-0.114	0.144	0.044	0.019	0.039	0.044	0.020	0.030	-0.037	-0.010	0.002	0.227
ZW	RC	0.000	0.027	-0.033	-0.014	0.112	-0.028	0.349	-0.304	0.128	0.535	0.120	0.204	-0.093	0.098	0.100	-0.196	-0.083	-0.007	0.568
	GC	0.000	0.010	-0.008	-0.007	0.037	-0.003	8.513	-0.083	0.091	0.032	0.022	0.028	-0.043	0.019	0.021	-0.021	-0.016	-0.001	0.171

The generalized concentration index for each independent variable was calculated as: $GC_k = \bar{X}_k \times RC_k$.
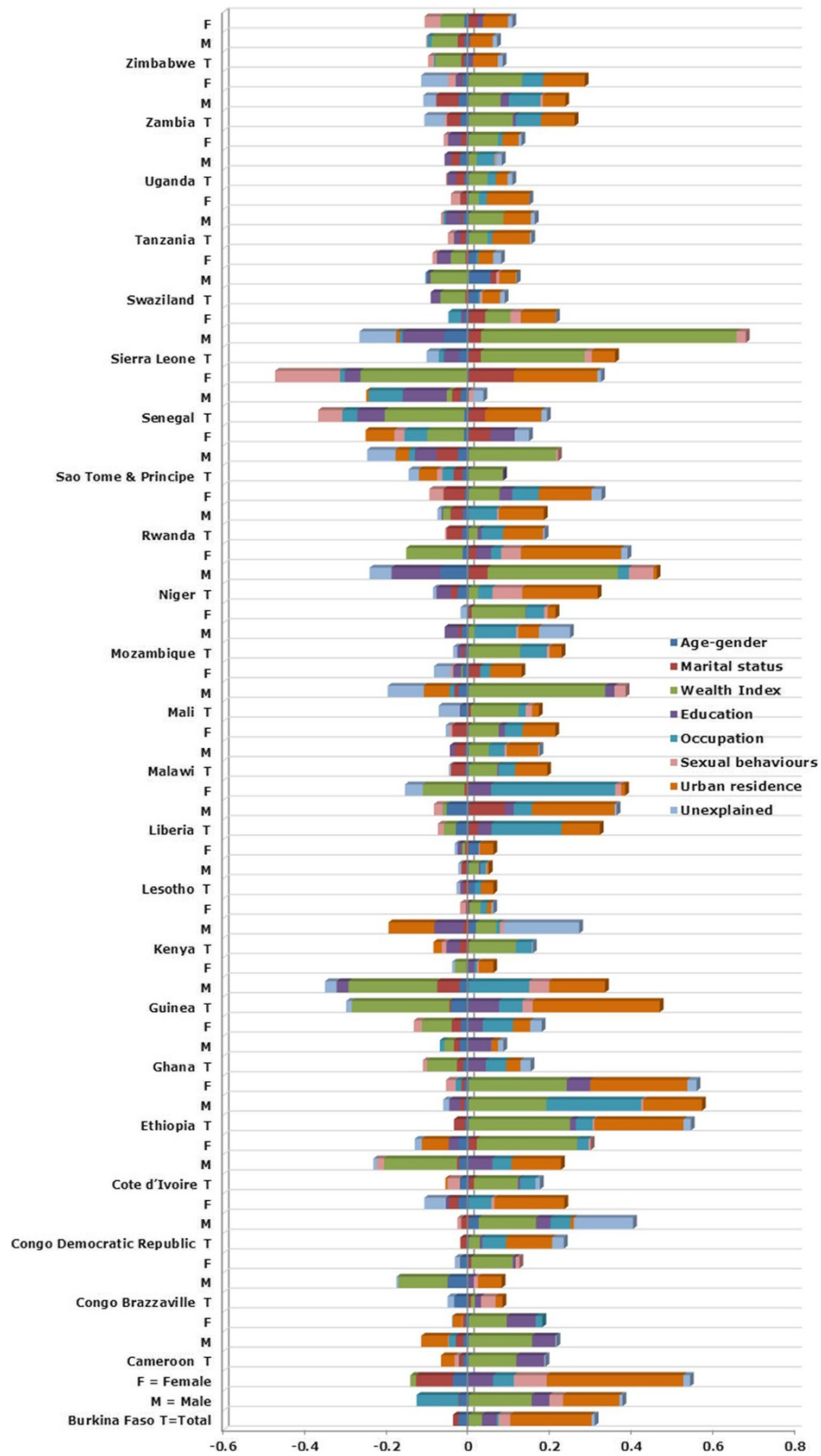
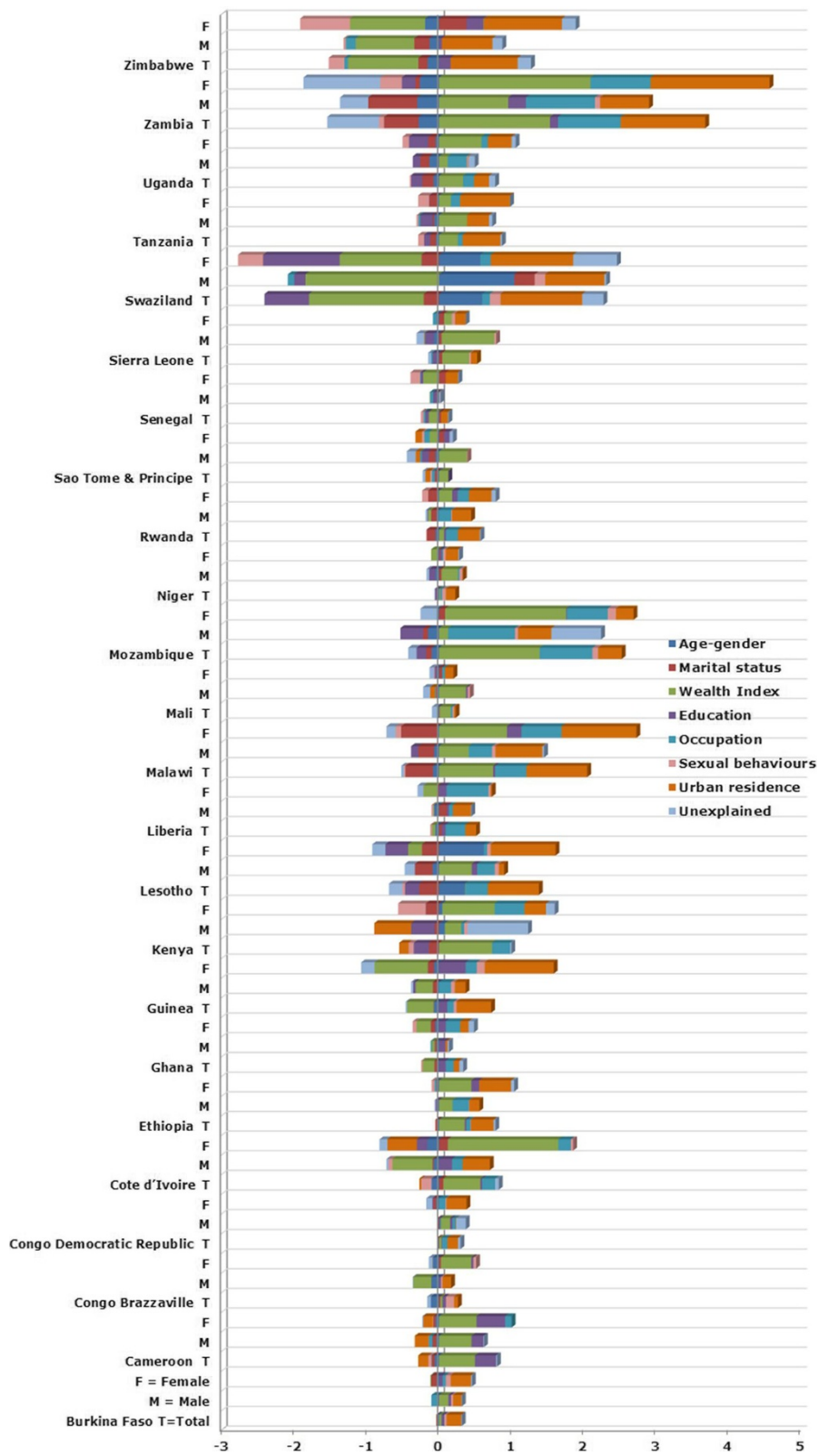**Figure 4 Contribution of each factor to the relative inequality of HIV/AIDS prevalence in SSA region.**

Figure 5 Contribution of each factor to the absolute inequality of HIV/AIDS prevalence in SSA region.

There were limitations to our study. First, although we used the most recent available survey data set for each country to investigate socioeconomic inequality in HIV/AIDS, the DHSs were conducted in different years and inequality estimates might have changed with the time of survey. Second, although self-reported sexual behaviours are likely measured with error [23,60], we included these variables in the decomposition analysis because these sexual practices are associated with HIV infection (e.g., [6,26]) and may also influence levels of household wealth [61,62]. Sensitivity analyses excluding these variables yielded very similar results. Third, our analyses were based on cross-sectional data and it was not possible to establish temporality between explanatory factors and HIV status, limiting causal inference. For example, marital status might influence the probability of HIV infection; in turn, having HIV/AIDS might influence marital status. Thus, our results can be interpreted in terms of observed associations between explanatory variables and HIV/AIDS status. Fourth, the unexplained component in the decomposition analysis contributed significantly to socioeconomic inequalities in HIV/AIDS in some countries although this was not the case in most. This suggests that unmeasured explanatory factors other than those included in the model influence socioeconomic inequalities in HIV/AIDS. Fifth, women may have limited financial autonomy within a household and therefore wealth may be an imperfect proxy for individual SES. Finally, as the variable of interest in this study is binary, the minimum and maximum of the GC are not $-\mu$ and μ and depend on the mean of the variable [46]. There is lively debate in the health economics literature as to whether Wagstaff's correction or Erreygers' Index, which suggests multiplying the concentration index by 4μ [63-66], is a better method for correcting the GC when the outcome variable is bounded. Nevertheless, our sensitivity analyses using Erreygers' correction in the estimations of the GC yielded qualitatively similar inference.

In conclusion, our findings demonstrate substantial variation among SSA countries in the magnitude of relative and absolute socioeconomic inequalities in HIV/AIDS. Unlike the distribution of other health outcomes, HIV/AIDS was generally concentrated among wealthier countries and individuals. This may be due to greater incidence of disease but more effective treatment and thus better outcomes could also be contributing. Our results also suggested a statistically significant negative association between the RC/SRC for HIV/AIDS prevalence and GDP per capita and Gini index across countries. This suggests that HIV/AIDS is relatively less concentrated among wealthier individuals in countries with higher living standards and greater income inequality. Further, we found a positive association between the GC and Southern Africa countries, suggesting that absolute inequality for HIV/AIDS is greater in these countries. Beside wealth, other important contributors to socioeconomic inequalities included urban residence and occupation status. Results also indicated substantial variation in the factors explaining socioeconomic inequalities in HIV/AIDS prevalence across SSA countries. In future work, particular attention should be devoted to understanding the mechanisms by which HIV/AIDS is concentrated among wealthier individuals and urban residents. It is crucial to understand to what extent this is indicative of the success of better treatment which needs to be spread to the entire population and to what extent it is caused by inadequate prevention.

Additional file

Additional file 1: Appendix 1. Contribution of each factor to the relative inequality of HIV/AIDS prevalence in SSA region (detailed results). **Appendix 2.** Contribution of each factor to the absolute inequality of HIV/AIDS prevalence in SSA region (detailed results).

Author details

[1]Institute for Health and Social Policy, McGill University, 1130 Pine Avenue West, Montreal, QC H3A 1A3, Canada. [2]Fielding School of Public Health, The University of California-Los Angeles (UCLA), 650 Charles E. Young Dr. South 16-035, Los Angeles, CA 90095-1772, US. [3]Institute for Health and Social Policy & Department of Epidemiology, Biostatistics, and Occupational Health, McGill University, 1130 Pine Avenue West, Montreal, QC H3A 1A3, Canada.

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