

Socioeconomic inequalities in the 90–90–90 target, among people living with HIV in 12 sub-Saharan African countries — Implications for achieving the 95–95–95 target — Analysis of population-based surveys

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Summary

Background Inequalities undermine efforts to end AIDS by 2030. We examined socioeconomic inequalities in the 90–90–90 target among people living with HIV (PLHIV) —men (MLHIV), women (WLHIV) and adolescents (ALHIV).

Methods We analysed the available Population HIV Impact Assessment (PHIA) survey data for each of the 12 sub-Saharan African countries, collected between 2015 and 2018 to estimate the attainment of each step of the 90–90–90 target by wealth quintiles. We constructed concentration curves, computed concentration indices (CIX) —a negative (positive) CIX indicated pro-poor (pro-rich) inequalities— and identified factors associated with, and contributing to inequality.

Findings Socioeconomic inequalities in achieving the 90–90–90 target components among PLHIV were noted in 11 of the 12 countries surveyed: not in Rwanda. Awareness of HIV positive status was pro-rich in 5/12 countries (Côte d'Ivoire, Tanzania, Uganda, Malawi, and Zambia) ranging from CIX=0.085 ($p < 0.05$) in Tanzania for PLHIV, to CIX = 0.378 ($p < 0.1$) in Côte d'Ivoire for ALHIV. It was pro-poor in 5/12 countries (Côte d'Ivoire, Ethiopia, Malawi, Namibia and Eswatini), ranging from CIX = -0.076 ($p < 0.05$) for PLHIV in Eswatini, and CIX = -0.192 ($p < 0.05$) for WLHIV in Ethiopia. Inequalities in accessing ART were pro-rich in 5/12 countries (Cameroun, Tanzania, Uganda, Malawi and Zambia) ranging from CIX=0.101 ($p < 0.05$) among PLHIV in Zambia to CIX=0.774 ($p < 0.1$) among ALHIV in Cameroun and pro-poor in 4/12 countries (Tanzania, Zimbabwe, Lesotho and Eswatini), ranging from CIX = -0.072 ($p < 0.1$) among PLHIV in Zimbabwe to CIX = -0.203 ($p < 0.05$) among WLHIV in Tanzania. Inequalities in HIV viral load suppression were pro-rich in 3/12 countries (Ethiopia, Uganda, and Lesotho), ranging from CIX = 0.089 ($p < 0.1$) among PLHIV in Uganda to CIX = 0.275 ($p < 0.01$) among WLHIV in Ethiopia. Three countries (Tanzania CIX = 0.069 ($p < 0.5$), Uganda CIX = 0.077 ($p < 0.1$), and Zambia CIX = 0.116 ($p < 0.1$)) reported pro-rich and three countries (Côte d'Ivoire CIX = -0.125 ($p < 0.1$), Namibia CIX = -0.076 ($p < 0.05$), and Eswatini CIX = -0.050 ($p < 0.05$)) pro-poor inequalities for the cumulative CIX for HIV viral load suppression. The decomposition analysis showed that age, rural-urban residence, education, and wealth were associated with and contributed the most to inequalities observed in achieving the 90–90–90 target.

Interpretation Some PLHIV in 11 of 12 countries were not receiving life-saving HIV testing, treatment, or achieving HIV viral load suppression due to socioeconomic inequalities. Socioeconomic factors were associated with and explained the inequalities observed in the 90–90–90 target among PLHIV. Governments should scale up equitable 95–95–95 target interventions, prioritizing the reduction of age, rural-urban, education and wealth-related inequalities. Research is needed to understand interventions to reduce socioeconomic inequities in achieving the 95–95–95 target.

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eClinicalMedicine

2022;53: 101652

Published online xxx

<https://doi.org/10.1016/j.eclinm.2022.101652>

eclinm.2022.101652

Funding This study was supported by the Swiss National Science Foundation (grant 202660).

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Keywords: Socioeconomic inequalities; 90–90–90 target; 95–95–95 target; Equity; Decomposition approach; Concentration Index; HIV care cascade

Research in context

Evidence before this study

We searched PubMed, Google Scholar, WHO, UNAIDS websites with the terms (socioeconomic inequalities, AND (90-90-90 target OR HIV testing OR HIV treatment OR ART OR HIV Care OR HIV viral suppression OR Retention in HIV CARE) or (UNAIDS 90–90–90 target). The search dates were January 2016 to December 2021. We reviewed 50 articles published in English (See supplement A1). Twenty-two studies examined HIV testing, awareness of HIV positive status and viral load suppression by age, rural-urban residence, education, and wealth including a systematic review from sub-Saharan African countries. Sixteen studies measured progress or factors associated with achieving the 90–90–90 target and eleven studies covered various aspects of the 90–90–90 target and socioeconomic and decomposition analysis. None of these studies looked at socioeconomic inequalities across the 90–90–90 target.

Added value of this study

Our study is the first to examine socioeconomic inequalities across the 90–90–90 target achievement in 12 sub-Saharan African countries. In 11 of the 12 countries surveyed, we found significant inequalities favouring PLHIV from either poor or wealthy households in achieving the 90–90–90 target. In Rwanda, there were no inequalities in achieving the 90–90–90 target. Age, rural-urban residence, food insecurity, unemployment, education, and wealth status, were associated with, and accounted for most of the inequalities observed in achieving the 90–90–90 target.

Implications of all the available evidence

Some PLHIV from either poor or wealth backgrounds in 11 of 12 countries were not receiving life-saving HIV testing, treatment, or HIV viral load services due to socioeconomic inequities. This situation is unjust and avoidable. Age, rural-urban residence, education, and wealth status were essential determinants of PLHIV attaining the 90–90–90 target. Plans to meet the 95–95–95 target should include activities to reduce socioeconomic inequalities related to age, rural-urban residence, education, and wealth status. They should also include indicators to measure equity.

Introduction

In 2014, UNAIDS set the 90–90–90 target, alongside other targets, to put the world on track to end AIDS by 2030.¹ This target aimed to ensure that by 2020, 90% of people living with HIV (PLHIV) would be aware of their HIV status, 90% of people diagnosed with HIV would have access to antiretroviral therapy (ART), and 90% of people on ART would have suppressed HIV viral loads, keeping them healthy and preventing the spread of HIV.¹ The global HIV testing, treatment, and care efforts have made remarkable progress.² By the end of 2020, 84% of the 37.7 million PLHIV knew their HIV status. Of these, 87.0% were on ART, and 90.0% of PLHIV on ART had achieved HIV viral load suppression.² However, one-third of PLHIV did not receive ART for several reasons, including inequalities in HIV service delivery and sociodemographic factors such as belonging to key populations — gay men and other men who have sex with men, sex workers and their clients, transgender people, people who inject drugs, prisoners, and people incarcerated.² According to UNAIDS and stakeholders, inequalities are preventing the world from ending AIDS.² The United Nations General Assembly approved the 95–95–95 HIV testing, ART access, and HIV viral suppression target in June 2021, with the goal of ensuring that all PLHIV across all demographics and geographic settings achieve the 95–95–95 target by 2025.³

Inequalities in access to HIV testing, treatment, and care outcomes have been studied in terms of gender, education, location, age, and socioeconomic status.^{4–9} With a few exceptions, these studies found that older than younger, urban dwellers than rural dwellers, women than men, more educated than uneducated, and wealthier than poor PLHIV were more likely to be aware of their HIV-positive status, access ART, and achieve HIV viral load suppression.^{4,5,9,6–9} In China, poorer PLHIV were found to use HIV virological monitoring more than richer PLHIV.⁴ In Vietnam, poor PLHIV were more likely than rich PLHIV to begin treatment early, though rich PLHIV had better adherence to ART.¹⁰ Lower socioeconomic status was associated with a higher risk of self-reported HIV-positive status among young men who have sex with men (MSM) compared to higher socioeconomic status in Brazil and Peru.¹¹ In sub-Saharan Africa, female sex workers 30 years and

older had a higher chance of suppressing HIV viral load than those younger than 30.⁷ Socioeconomic inequalities across the 90–90–90 target cascades have not been studied. This study examined socioeconomic inequalities in the 90–90–90 target among PLHIV aged 15 and older — 15 years +— (15 to 56, 64 or 80 years depending on the country) from 12 Sub-Saharan African countries that had a Population HIV Impact Assessment (PHIA) survey data available in 2021.¹² We hypothesized that in countries, socioeconomic inequalities in achieving the 90–90–90 target existed and that gender, age, rural-urban residence, food insecurity, household size, education, and wealth were associated with and explained the observed inequalities in achieving the 90–90–90 target.

Methods

Using the concentration index (CIX) and a decomposition approach, we investigated socioeconomic inequalities in countries in achieving the 90–90–90 target. The wealth index is frequently used to assess socioeconomic status because it predicts health and well-being better than income.¹³ The wealth index combines information on household assets, materials, and durable goods. It is a relative measure of a country's household wealth, ranking the households in quintiles from poorest to wealthiest.¹⁴ This ranking results in a socioeconomic position or hierarchy in society, which influences household members' access to health care, and health outcomes.¹⁵ The concentration index (CIX) and decomposition approach is a common method in economics for assessing health and healthcare inequalities.¹⁵ Its main advantage over other methods is that it measures inequalities in a population's utilization of health services or outcomes across the wealth distribution and identifies factors associated with and contributing to the observed inequalities. Significant associations between factors and variables of interest, on the other hand, do not imply the presence of inequality.¹⁵ Inequality is defined as the unequal distribution of goods or services among people according to their age, gender, education, rural-urban residence, wealth, or other characteristics.¹⁶ In contrast, equity is normative—fairness—that is, the absence of avoidable and correctable differences in service distribution or outcomes based on people's socioeconomic status in society.^{14,16} Equality can be just or unjust, equitable or inequitable.^{14,16} This paper investigates socioeconomic inequality related to a household's wealth and position in society as measured by the wealth index. It conforms to the revised Standards for Quality Improvement Reporting Excellence (SQUIRE 2.0) guidelines.¹⁷

A concentration curve is a plot of the cumulative percentage of an interest variable (i.e., each of the 90–90–90 targets) (y-axis) versus the cumulative proportion of the population ranked by socioeconomic status, from poorest to richest.¹⁴ The concentration curve is plotted

against the line of perfect equality, which runs at a 45-degree angle from 0 to 100%. When everyone receives the same amount of the variable of interest, the curve is on the line of equality or is statistically not different from perfect equality.¹⁴ A concentration curve that is higher (lower) than the line of equality indicates that the variable of interest is concentrated among the poor (rich). The greater the distance between the curve and the equality line, the greater the pro-poor (pro-rich) inequality.¹⁴

The CIX assesses the magnitude of socioeconomic inequality. It is defined as the area between the concentration curve and the line of perfect equality multiplied by two. Inequality favoring the poor is represented by negative values, and vice versa. When the variable of interest is dichotomous, the normalized CIX ranges from -1 to 1 , is used. A value of 0 denotes complete equality.¹⁴

The Wagstaff, van Doorslaer, and Watanabe (2003) decomposition approach is used to measure socioeconomic inequalities in the variable of interest, examine factors associated with the variable of interest, and identify the relative contribution of each factor to inequalities.¹⁸ This method employs a regression framework that allows for the examination of associations between outcomes, in this case, achievement of each of the 90s, and factors, and the identification of the relative contribution of the factors to inequalities.¹⁸ In a decomposition analysis, the residual reflects the inequality unexplained by variation in wealth. A positive (negative) contribution indicates that a factor increases pro-rich (pro-poor) inequality.¹⁸

Variables and outcome descriptions

We used the PHIA survey data for 12 sub-Saharan African countries collected between 2015 and 2018, specifically the Household, Adult, and Adult HIV Biomarker data sets, which were publicly available at the time of this study, with variables measuring the achievement of the 90–90–90 target.¹² Annex A2 summarizes the datasets. PHIA surveys are HIV-focused, cross-sectional, household-based, nationally representative surveys of adults and adolescents aged 15 and above and children if applicable, conducted in the most HIV-affected countries. Adults and adolescents aged 15 years and above living with HIV refer to PLHIV in the age range of the sample of the country included the values in the 90–90–90 target for each country: Cameroun 15–64 years, Côte d'Ivoire 15–64, Eswatini 15–80, Ethiopia 15–64, Lesotho 15–59, Malawi 15–64, Namibia 15–64, Rwanda, 15–64, Tanzania 15–80, Zambia 15–59, and Zimbabwe 15–80.¹² PHIA survey participation is entirely voluntary. Participants provided informed consent before participating in the survey interviews. Household interviews, individual interviews, laboratory testing, and the immediate return of HIV test results were used to collect data by trained survey staff. In each participating country, the Ministry of

Health oversees the PHIA surveys. The surveys are supported by the President's Emergency Plan for AIDS Relief (PEPFAR) and the Centers for Disease Control and Prevention (CDC), with technical assistance from Columbia University's International Center for AIDS Care and Treatment Programs (ICAAP). For each country, we included PLHIV aged 15 and above with a laboratory confirmed HIV-positive test result. The survey design and sampling details can be obtained from the [PHIA Data Manager \(columbia.edu\)](https://phia.columbia.edu).

Our primary outcomes were the three 90s: the first 90 represents the percentage of PLHIV who are aware of their HIV-positive status, the second 90 represents the percentage of people who have access to ART among those who are aware of their HIV-positive status, and the third 90 represents the percentage of people who have HIV viral load suppression among those who are on ART. Because the three 90s are sequential, we included a separate analysis that calculated the cumulative percentage of people who are HIV virally suppressed among all PLHIV aged 15 years and above. Other variables associated with the 90–90–90 target identified through literature review included gender, age, household size, rural–urban residence, food insecurity, employment status, region, educational status, and wealth, as defined in Supplement Table A1. Ethiopian data was collected only in urban areas and thus does not represent the entire country. It comprised a large area, with more than 50,000 inhabitants and small area with less 50,000 inhabitants. We coded small areas as rural and large areas as urban.

Analysis

We used descriptive statistics to describe the sample characteristics for each country: the proportion of adults living with HIV by sex, achievement of the 90–90–90s, age, gender, rural-urban residence, employment status, food insecurity, household size, education, and wealth quintiles. To account for the complex survey design, we estimated the proportion of PLHIV who were aware of their HIV-positive status, received ART, and were HIV virally suppressed using the Jack-knife estimation method.¹⁹ For each indicator, we calculated point estimates and 95% confidence intervals (CI).

We used three approaches to assess socioeconomic inequality. First, we calculated each country's 90–90–90 target achievement by wealth quintile. Second, for each 90–90–90 target component, we created concentration curves and calculated CIX, including their p-values. We disaggregated the concentration indices by gender. Because inequalities differ between adolescents and adults living with HIV, we calculated concentration indices separately for adolescents aged 15–24 years. Third, we decomposed the CIX using a survey-weighted generalized linear model with a binomial logit link, including their p-values. We identified factors associated with achieving each step

of the 90–90–90 target cascade of care and contributing to inequalities in achieving the 90–90–90 target based on the decomposition. We used statistical significance thresholds of $p < 0.01$ (***) , $p < 0.05$ (**) and $p < 0.1$ (*). We clustered the standard errors in the enumeration area strata. Missing data comprised less than 1% of the sample. It was assumed to occur at random and excluded from analyses.

We used Stata v17 for the analyses. The code is available on request.

Ethical considerations

The study did not require ethical clearance because the data is de-identified and publicly available. However, the participants provided informed consent before participating in the survey. The data collection conformed to local and international ethical standards of research with human subject as described at [PHIA Data Manager \(columbia.edu\)](https://phia.columbia.edu).

Role of the funding source

This study was supported by the Swiss National Science Foundation (NSF) (grant 202660). NSF was not involved in the study design, access to data, analysis, or interpretation, manuscript writing, or decision to submit the manuscript for publication. The authors were not paid to write this manuscript.

Even though David Chipanta works for UNAIDS, the opinions expressed are those of the authors and not those of UNAIDS.

Results

The results are presented by increasing HIV prevalence, starting from the country with the lowest HIV prevalence (Côte d'Ivoire, 2.8%) to the highest (Eswatini, 27.0%). The survey-weighted sample size ranged from 444 in Côte d'Ivoire to 3507 in Zimbabwe. The median age of PLHIV ranged from 36 years (interquartile range 28–45) in Uganda to 40 years [32–47] in Côte d'Ivoire (Table 1). None of the surveyed countries fully achieved the 90–90–90 target, consistent with published PHIA results.¹² Women made up around two-thirds of PLHIV, ranging from 59.2% [57.6%–60.7%] in Zimbabwe to 68.9% [65.6%–71.9%] in Cameroun. The proportion of PLHIV in the poorest households (Quintile 1), ranged from 9.9% [8.9%–11.9%] in Zambia and 14.0% [12.0%–16.3%] in Uganda, to 27.2% [20.6%–34.9%] in Côte d'Ivoire and 27.3% [24.4%–30.6%] in Namibia. In the wealthiest households (Quintile 5), the proportions of PLHIV ranged from 6.1% [4.7%–7.9%] in Namibia and 10.0% [6.1%–15.8%] in Côte d'Ivoire to 27.8% [24.5%–31.3%] in Malawi and 29.5% [25.7%–33.6%] in Zambia (Table 1).

	Côte d'Ivoire (N=444)	Ethiopia (N=614)	Rwanda (N=934)	Cameroun (N=980)	Tanzania (N=1831)	Uganda (N=1772)
HIV prevalence	2.8 [2.5–3.2]	3.0 [2.6–3.5]	3.0 [2.7–3.4]	3.7 [3.4–4.1]	4.9 [4.5–5.2]	6.3 [5.8–6.7]
Awareness of HIV+ status	50.0 [43.6–56.5]	79.0 [74.4–83.0]	83.7 [80.0–86.9]	55.6 [51.9–59.2]	60.7 [57.2–64.0]	72.5 [70.0–74.9]
Accessing ART	92.0 [84.7–96.0]	97.1 [94.8–98.4]	97.5 [96.0–98.4]	93.0 [89.7–95.4]	93.6 [91.7–95.1]	90.3 [88.1–92.1]
HIV Viral load suppression	73.7 [63.1–82.1]	87.4 [83.6–90.5]	90.0 [87.3–92.3]	80.0 [74.5–84.6]	87.0 [84.1–89.5]	83.8 [81.3–85.9]
Sex: Female	68.7 [63.3–73.6]	67.5 [63.5–71.3]	64.6 [61.5–67.7]	68.8 [65.6–71.9]	65.9 [63.2–68.5]	64.2 [62.2–66.1]
Age: Median [IQR] years	40.0 [32.0–47.0]	38.0 [30.0–45.0]	40.0 [31.0–50.0]	38.0 [30.0–46.0]	38.0 [30.0–47.0]	36.0 [28.0–45.0]
15–24	7.6 [5.2–11.0] ‡	8.6 [6.3–11.5]	10.0 [8.1–12.1]	11.4 [9.2–14.1]	10.0 [8.3–11.9]	14.2 [12.4–16.3]
25–34	25.0 [19.0–32.2]	26.1 [22.5–30.1]	22.8 [19.7–26.3]	26.8 [23.9–29.9]	25.9 [23.0–29.0]	31.0 [29.0–33.1]
35–44	34.0 [27.6–41.0]	39.1 [35.0–43.5]	29.4 [26.5–32.5]	32.7 [29.1–36.5]	32.2 [29.5–35.0]	28.9 [26.6–31.3]
45–54	19.3 [15.1–24.3]	20.2 [16.1–25.0]	23.7 [20.9–26.8]	20.1 [17.0–23.7]	19.6 [17.5–22.0]	18.8 [17.0–20.8]
55+	14.1 [11.0–18.4]	6.0 [4.3–8.2] ‡	14.1 [11.4–17.2]	9.0 [7.4–10.8]	12.3 [10.5–14.4]	7.1 [5.9–8.5]
Location: Urban	68.8 [61.4–75.3]	53.7 [45.8–61.5]	32.8 [25.9–40.5]	54.4 [47.6–61.2]	45.6 [40.9–50.4]	34.2 [28.7–40.1]
Food insecure	—	8.7 [6.3–12.0]	53.5 [49.0–57.9]	28.8 [24.8–33.2]	29.2 [25.8–32.9]	32.1 [28.7–35.8]
Household size members (7+)	31.0 [25.4–37.2]	16.6 [12.9–21.1]	32.0 [26.9–37.5]	31.1 [27.4–35.1]	20.4 [17.3–23.8]	30.5 [27.4–33.8]
1–3	33.7 [27.5–40.6]	48.8 [43.4–54.2]	22.0 [18.7–25.6]	28.3 [24.8–32.0]	39.7 [36.1–43.4]	30.9 [27.8–34.2]
4–6	35.2 [28.8–42.3]	35.3 [29.5–41.6]	45.1 [41.5–50.7]	40.6 [36.4–44.9]	39.9 [36.7–43.2]	38.6 [35.7–41.5]
Employed	46.5 [39.2–54.0]	50.9 [46.0–55.8]	44.4 [40.0–46.9]	60.7 [57.2–64.2]	47.6 [44.5–50.7]	61.2 [58.1–64.2]
Education: Not educated	48.6 [41.5–55.8]	20.3 [16.1–25.1]	17.7 [15.1–20.7]	9.5 [7.7–11.7]	19.9 [17.6–22.5]	10.4 [8.8–12.3]
Primary	30.2 [24.2–36.9]	49.2 [43.6–54.9]	64.8 [61.1–68.3]	35.9 [32.3–39.7]	67.8 [64.9–70.6]	60.8 [57.9–63.7]
Secondary	19.2 [13.8–26.1]	22.7 [18.4–27.6]	15.4 [13.1–18.2]	34.0 [30.1–38.2]	10.6 [8.9–12.7]	21.8 [19.3–24.6]
Higher	—	7.8 [5.3–11.5]	2.1 [1.2–3.5] ‡	20.6 [17.5–24.1]	1.7 [1.0–2.8]	6.9 [5.4–8.8]
Wealth quintiles: Poorest Q1	27.2 [20.6–34.9]	17.3 [13.2–22.4]	17.2 [13.8–21.2]	12.1 [9.3–15.6]	16.1 [13.3–19.3]	14.0 [12.0–16.3]
Q2	27.0 [21.1–33.5]	18.4 [13.7–24.4]	14.5 [11.7–17.9]	24.7 [20.3–29.6]	18.3 [15.8–21.1]	16.1 [13.8–18.8]
Q3	19.1 [14.8–24.2]	22.7 [18.5–27.6]	18.3 [15.1–22.0]	20.7 [17.2–24.7]	25.4 [22.0–29.0]	21.4 [18.6–24.4]
Q4	16.9 [12.3–22.9]	23.3 [18.9–28.3]	24.6 [21.1–28.5]	21.1 [17.9–24.7]	23.2 [20.3–26.3]	28.2 [25.3–31.4]
Q5 Richest	10.0 [6.1–15.8]	18.3 [14.8–22.5]	25.4 [20.8–30.6]	21.5 [16.5–27.4]	17.1 [14.7–20.3]	20.3 [17.0–23.9]
	Malawi (N=2227)	Zambia (N=2467)	Namibia (2446)	Zimbabwe (N=3507)	Lesotho (N=3199)	Eswatini (N=3003)
HIV prevalence	10.6 [10.0–11.2]	12.0 [11.4–12.7]	12.6 [11.7–13.5]	13.6 [12.9–14.2]	25.6 [24.7–26.4]	27.0 [25.7–28.3]
Awareness of HIV+ status	77.0 [74.8–79.0]	71.7 [69.2–73.9]	86.0 [83.8–87.9]	76.8 [75.0–78.6]	81.0 [79.5–82.4]	87.0 [85.7–88.2]
Accessing ART	91.4 [89.7–92.9]	87.7 [85.8–89.3]	96.3 [94.5–97.6]	88.8 [87.4–90.0]	91.8 [90.4–93.1]	88.8 [87.1–90.3]
HIV viral load suppression	91.3 [89.0–93.1]	89.1 [87.1–90.9]	91.3 [89.6–92.7]	85.4 [83.5–87.1]	87.6 [86.0–89.1]	91.3 [90.2–92.4]
Sex: Female	61.0 [58.7–63.3]	62.6 [60.7–64.4]	64.5 [62.7–66.2]	59.2 [57.6–60.7]	59.3 [57.7–60.8]	65.6 [64.2–67.0]
Age: Median [IQR] years	37.0 [30.0–45.0]	37.0 [30.0–44.0]	40.0 [32.0–47.0]	38.0 [30.0–46.0]	37.0 [30.0–45.0]	36.0 [29.0–45.0]
15–24	9.2 [7.9–10.9]	13.0 [11.4–14.6]	10.6 [9.3–12.1]	11.2 [9.9–12.6]	9.6 [8.7–10.7]	11.4 [10.2–12.7]
25–34	30.2 [27.9–32.6]	28.5 [26.7–30.4]	21.6 [19.5–23.8]	26.6 [24.9–28.2]	31.8 [30.2–33.4]	32.4 [30.9–33.8]

Table 1 (Continued)

	Malawi (N=2227)	Zambia (N=2467)	Namibia (2446)	Zimbabwe (N=3507)	Lesotho (N=3199)	Eswatini (N=3003)
35–44	33.3 [33.4–35.7]	34.1 [32.3–36.0]	34.9 [32.8–37.0]	32.7 [31.0–34.5]	32.8 [31.4–34.1]	31.2 [29.7–32.8]
45–54	19.1 [17.2–21.2]	19.5 [17.9–21.2]	24.0 [22.1–26.0]	17.9 [16.7–19.3]	19.6 [18.4–20.8]	16.3 [15.1–17.5]
55+	8.2 [6.8–9.7]	4.9 [4.1–5.9]	8.9 [7.8–10.2]	11.7 [10.6–12.8]	6.3 [5.6–7.0]	8.8 [7.9–9.7]
Location: Urban	26.7 [23.0–30.8]	58.9 [54.4–63.3]	49.5 [45.1–53.9]	36.7 [34.2–39.2]	43.4 [40.6–46.3]	29.5 [26.2–33.2]
Food insecure	—	24.4 [21.9–27.2]	33.7 [30.8–36.7]	—	39.8 [37.3–42.3]	39.5 [36.8–42.3]
Household size (7+)	28.7 [25.7–31.8]	28.6 [25.9–31.4]	32.2 [28.9–35.6]	16.8 [15.1–18.6]	21.3 [19.4–23.3]	35.4 [32.6–38.4]
01-Mar	35.6 [32.7–38.4]	26.5 [24.0–29.1]	33.8 [30.4–37.4]	36.9 [34.4–39.4]	47.2 [45.0–49.5]	39.0 [36.1–42.0]
04-Jun	35.8 [32.9–38.9]	44.9 [42.1–47.9]	34.0 [31.2–37.0]	46.3 [44.0–48.7]	31.5 [29.5–33.6]	25.6 [23.6–27.7]
Employed	34.9 [32.6–37.1]	40.4 [38.1–42.7]	39.4 [36.8–42.0]	38.6 [36.4–40.9]	45.4 [43.3–47.6]	48.9 [46.7–51.1]
Education: Not educated	12.9 [11.1–14.9]	4.3 [3.5–5.4]	8.5 [7.3–10.0]	3.3 [2.7–4.1]	7.3 [6.4–8.4]	6.4 [5.5–7.5]
Primary	63.5 [60.9–66.0]	40.9 [38.2–43.8]	36.5 [34.2–38.8]	34.9 [32.9–36.9]	51.7 [49.9–53.8]	33.2 [31.2–35.2]
Secondary	20.8 [18.5–23.3]	45.6 [42.9–48.3]	52.2 [49.8–54.7]	57.3 [55.2–59.4]	35.6 [33.6–37.6]	30.9 [29.2–32.7]
Higher	2.8 [2.1–3.7]	9.1 [7.5–11.1]	2.7 [1.9–3.9]	4.5 [3.5–5.6]	5.5 [4.5–6.7]	29.5 [27.4–31.6]
Wealth quintiles: Poorest Q1	16.2 [13.7–19.0]	9.9 [8.9–11.9]	27.3 [24.4–30.6]	20.7 [18.6–23.0]	17.9 [15.8–20.1]	22.4 [20.2–24.9]
Q2	16.5 [14.3–19.0]	12.2 [10.3–14.4]	24.4 [21.5–27.6]	18.7 [16.9–20.5]	19.9 [17.9–22.2]	21.0 [18.8–23.3]
Q3	18.4 [16.1–21.0]	20.7 [18.1–23.6]	24.2 [21.3–27.4]	19.0 [16.9–21.3]	23.2 [21.0–25.6]	21.3 [19.2–23.7]
Q4	21.1 [18.3–24.1]	27.7 [24.6–31.1]	17.9 [14.8–21.6]	22.2 [19.4; 25.1]	20.8 [18.7–23.2]	19.7 [17.3–22.4]
Q5 - Richest	27.8 [24.5–31.3]	29.5 [25.7–33.6]	6.1 [4.7–7.9]	19.5 [17.2–21.9]	18.1 [16.1–20.3]	15.5 [13.2–18.2]

Table 1: Survey weighted descriptive statistics of characteristics of people living with HIV 15 years or older by country (PHIA) (Percent, 95 % CI).

PLHIV excluded people who did not test for HIV or received indeterminate HIV test results — Results had fewer than 25 observations and were suppressed ___ dataset had no variable ‡ Estimate based on 25–49 observations and should be interpreted with caution. Lesotho, we combined the population living in peri-urban areas with rural areas. Ethiopia survey was conducted in urban areas and was not representative of the whole country. We classified rural for population size <50,000 and urban for population size >50,000. The following observations were missing and excluded from the analysis because they were less than 2% of the sample: 1 in Cote d'Ivoire, 11 in Ethiopia, 4 in Rwanda, 7 Cameroun, 52 in Tanzania and 6 in Uganda. Quintiles Q1 - Poorest Q2, Q3, Q4, Q5 Richest.

Figure 1 depicts the achievement of the 90–90–90 target by country, broken down by wealth quintile. The light blue bars represent HIV-positive status awareness, the dark blue bars represent access to ART, and the darker blue bars represent HIV viral load suppression. The disparities in HIV-positive status awareness were greatest in Cameroun between PLHIV (40.1% [29.6%–51.5%]) in quintile 1, versus (61.9% [54.7%–68.6%]) in quintile 2; Zambia, 79.4% [75.9%–82.5%] in quintile 5, versus in quintiles 1–4, and Namibia, 88.5% [85.1%–91.2%] in quintile 1 versus 80.4% [75.8%–84.3%] in quintile 4. Access to ART was 81.6% [73.9%–87.5%] in quintile 1, versus 90.9% [88.2%–93.1%] in quintile 5 in Zambia (Figure 1). Namibia achieved the first 90 among PLHIV in quintiles 1–3, Eswatini in quintiles 1–2, Rwanda in quintiles 3–4, and Ethiopia in quintile 2. Ten countries attained the second 90 across all wealth quintiles 1–5, and four countries achieved the third 90 across all quintiles 1–5 (Figure 1).

Figure 2 shows the socioeconomic inequalities among PLHIV in achieving the 90–90–90 target by country, using the concentration curves. Small but significant socioeconomic inequality was observed among PLHIV in achieving the 90 target components in 11 of 12 countries. No significant inequalities in achieving the 90–90–90 target were observed among PLHIV in Rwanda (Figure 1).

Table 2 displays the CIX, which summarizes the information from the concentration curves for each 90-target component for adult PLHIV, adult men (MLHIV) and women (WLHIV), and adolescents living with HIV (ALHIV). Table 2 also displays a cumulative CIX for HIV viral load suppression across adult PLHIV rather than a CIX conditional on each step in the 90 cascades. In five countries, the CIX for HIV-positive status awareness for at least one population group was positive (pro-rich) (Côte d’Ivoire, Tanzania, Zambia, Uganda, and Malawi) and in five countries (Côte d’Ivoire, Ethiopia, Malawi, Namibia, and Eswatini) negative (pro-poor). Among the pro-rich CIX, the lowest was CIX = 0.16 ($p < 0.05$) in Tanzania for PLHIV, and the highest was CIX = 0.378 ($p < 0.1$) in Côte d’Ivoire for ALHIV. Among the pro-poor CIX, the lowest was CIX = -0.074 ($p < 0.05$) for PLHIV in Eswatini, and the highest was CIX = -0.192 ($p < 0.05$) for WLHIV in Ethiopia.

Five countries (Cameroun, Tanzania, Uganda, Malawi, and Zambia) displayed pro-rich CIX, for accessing ART, ranging from CIX = 0.119 ($p < 0.05$) among PLHIV in Zambia to CIX = 0.774 ($p < 0.1$) among ALHIV in Cameroun. Four countries (Tanzania, Zimbabwe, Lesotho and Eswatini) displayed pro-poor CIX, ranging from CIX = -0.076 ($p < 0.10$) among PLHIV in Zimbabwe to CIX = -0.203 ($p < 0.05$) among WLHIV in Tanzania.

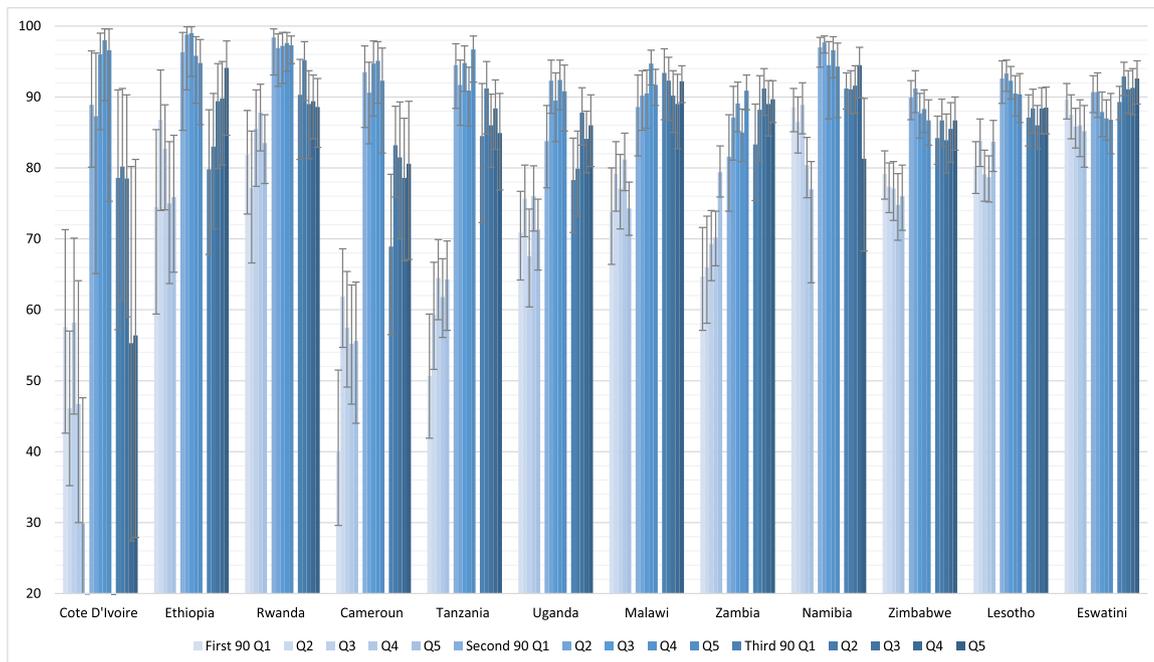


Figure 1. Distribution of awareness of HIV positive status, access to ART, and HIV viral load suppression by wealth quintile and country (percentage, 95% CI) (PHIA 2015–2018). Q1 – (Poorest wealth quintile), Q2, Q3, Q4, Q5 (Richest wealth quintile) indicate quintiles of wealth distribution in each country.

The light blue bars represent HIV-positive status awareness (First 90), the dark blue bars represent access to ART (Second 90), and the darker blue bars represent HIV viral load suppression (Third 90).

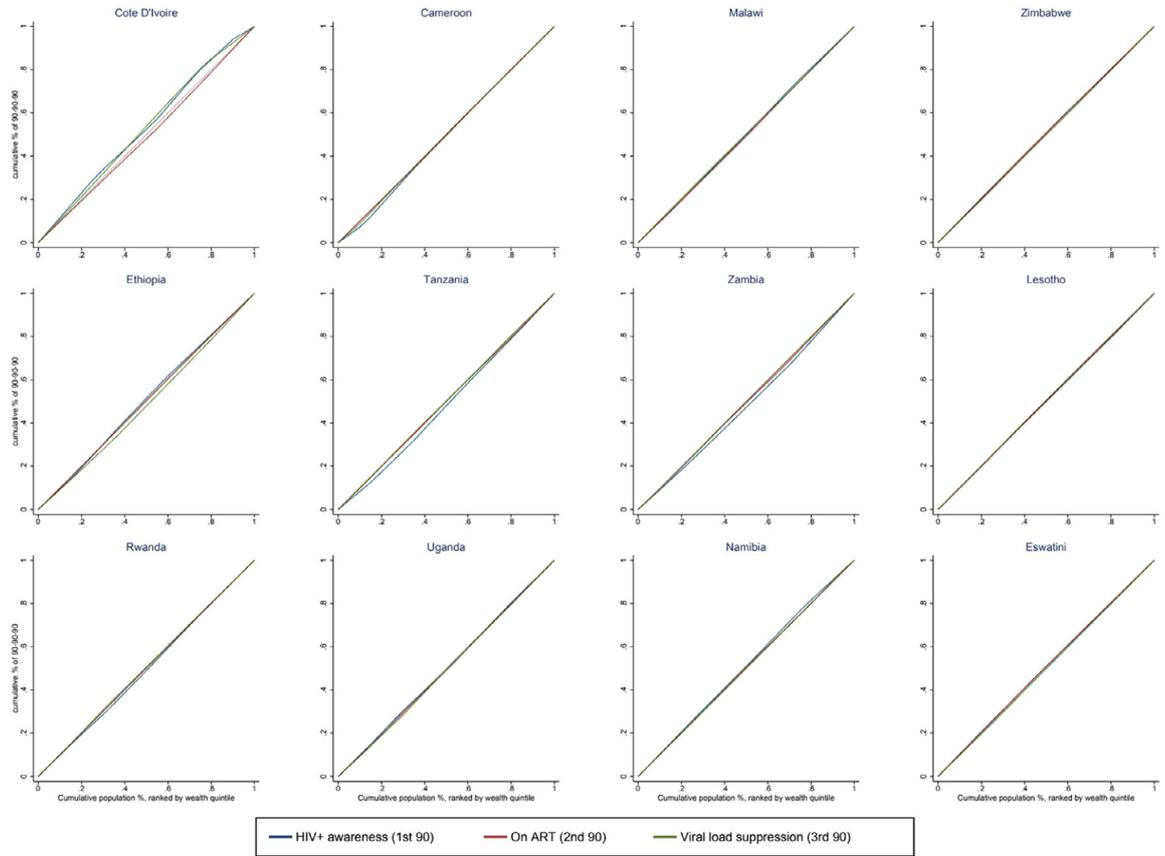


Figure 2. Concentration curves for awareness of HIV positive status, access to ART and viral suppression by countries (PHIA 2015-2018). Blue— Awareness of HIV positive status; red— Access to ART green— HIV viral load suppression —Line of equality.

Three countries (Ethiopia, Uganda, and Lesotho) displayed pro-rich CIX in HIV viral load suppression ranging from CIX = 0.089 ($p < 0.1$) among PLHIV in Uganda to CIX < 0.275 ($p < 0.01$) among WLHIV in Ethiopia (Table 2). Three countries (Tanzania, Uganda, and Zambia) reported pro-rich and three countries (Côte d'Ivoire, Namibia, and Eswatini) pro-poor inequalities for the cumulative CIX for HIV viral load suppression. Six countries did not show significant inequalities in the cumulative CIX (last row of Table 2).

Table 3 shows factors associated with the achievement of the 90–90–90 target. Compared to PLHIV 15 to 24 years old, older age (i.e., 25–34, 35–44, 45–54, or 55 years+) was associated with two or three of the 90s in all 12 countries. Being female compared to being male was associated with an awareness of HIV-positive status in all 12 countries, access to ART in five countries and viral load suppression in eight countries.

Being employed compared to being unemployed was associated with achieving the 90s in 7 of 12 countries, ranging from changes in probabilities of –10.4% ($p < 0.01$) in Tanzania for awareness of HIV-positive status to –2.6% ($p < 0.05$) for access to ART in Malawi and

for HIV viral suppression in Ethiopia (8.8% ($p < 0.01$)). Food insecurity compared to food security was associated with a probability decrease in access to ART in Ethiopia (–7.9%, $p < 0.05$), Uganda (–3.9%, $p < 0.05$) and Namibia (–3.8%, $p < 0.01$) and HIV viral load suppression in Lesotho (–3.3%, $p < 0.05$). It was associated with probability increase in the awareness of HIV-positive status in Zambia (4.3%, $p < 0.05$) and Lesotho (3.2%, $p < 0.05$) and access to ART in Eswatini (3.3%, $p < 0.05$).

Being educated rather than uneducated was associated with reduced probabilities of achieving the 90s in six countries and increased probabilities in six countries, ranging from –16.4% ($p < 0.05$) in Cameroon to 8.0% ($p < 0.1$) in Lesotho for HIV viral load suppression. Compared with PLHIV who had no education, the probability for being aware of HIV-positive status was 6.7% ($p < 0.05$), 11.9% ($p < 0.01$) and 20.1% ($p < 0.1$) for PLHIV with primary, secondary, and higher-level education in Rwanda. It was 12.0% ($p < 0.1$) and 16.8% ($p < 0.05$) for PLHIV with secondary, and higher level of education in Cameroon, and 7.8% ($p < 0.01$) and –10.7% ($p < 0.05$) for PLHIV with primary education

	Cote d'Ivoire	Ethiopia	Rwanda	Cameroon	Tanzania	Uganda	Malawi	Zambia	Namibia	Zimbabwe	Lesotho	Eswatini
Awareness of HIV positive status												
PLHIV 15 years+	-0.121 [443] 0.11	-0.055 [603] 0.49	0.065 [931] 0.24	0.033 [973] 0.57	0.085 [1779] 0.03	0.011 [1760] 0.76	-0.005 [2213] 0.90	0.139 [2394] < 0.001	-0.128 [2430] 0.01	-0.042 [3498] 0.15	0.004 [3185] 0.87	-0.076 [2985] 0.03
MLHIV	-0.008 [139] 0.95	0.133 [122] 0.38	0.100 [299] 0.22	0.043 [289] 0.56	0.072 [551] 0.28	0.101 [570] 0.05	0.100 [710] 0.08	0.185 [749] < 0.001	-0.091 [747] 0.14	-0.050 [1215] 0.24	0.043 [1015] 0.30	-0.024 [964] 0.64
WLHIV	-0.161 [304] 0.08	-0.192 [408] 0.02	0.030 [632] 0.59	0.030 [684] 0.67	0.065 [1228] 0.15	-0.061 [1190] 0.20	-0.091 [1503] 0.05	0.109 [1645] 0.002	-0.149 [1683] 0.02	-0.041 [2283] 0.22	-0.054 [2170] 0.12	-0.125 [2021] 0.01
ALHIV	0.378 [38] † 0.06	—	-0.019 [103] 0.89	0.027 [124] 0.86	-0.048 [107] 0.68	0.053 [229] 0.52	-0.079 [213] 0.42	0.035 [283] 0.61	-0.173 [240] 0.13	-0.047 [344] 0.49	0.033 [329] 0.62	-0.147 [333] 0.04
Accessing ART												
PLHIV 15 years +	0.278 [224] 0.13	-0.184 [485] 0.36	-0.041 [787] 0.72	0.052 [528] 0.68	0.042 [1100] 0.62	0.102 [1297] 0.10	0.093 [1718] 0.12	0.101 [1751] 0.02	-0.113 [2134] 0.22	-0.072 [2786] 0.09	-0.078 [2631] 0.10	-0.093 [2640] 0.02
MLHIV	0.535 [62] 0.13	-0.788 [110] 0.28	-0.148 [243] 0.44	-0.012 [148] 0.95	0.268 [297] 0.03	0.227 [388] 0.02	0.230 [509] 0.02	0.220 [524], 0.01	-0.120 [606] 0.43	-0.028 [913] 0.73	0.017 [785] 0.83	-0.166 [794] 0.03
WLHIV	0.153 [162] 0.46	-0.122 [375] 0.54	0.021 [544] 0.89	0.071 [380] 0.64	-0.203 [803] 0.03	0.001 [909] 0.98	-0.011 [1209] 0.89	0.039 [1227] 0.45	-0.100 [1528] 0.29	-0.100 [1873] 0.02	-0.144 [1846] 0.02	-0.065 [1846] 0.14
ALHIV	—	—	-0.261 [71] 0.22	0.774 [28] † 0.07	-0.310 [77] 0.24	0.087 [110], 0.73	0.207 [121] 0.22	0.193 [134] 0.17	0.090 [179] 0.65	0.133 [210] 0.29	-0.105 [227] 0.4871	-0.166 [245] 0.18
HIV viral load suppression												
PLHIV 15 years+	-0.213 [207] 0.09	0.240 [471] 0.01	-0.074 [765] 0.32	0.023 [492] 0.76	-0.025 [1025] 0.70	0.089 [1177] 0.08	-0.034 [1563] 0.56	0.048 [1541] 0.35	-0.007 [2059] 0.90	0.025 [2494] 0.48	0.019 [2429] 0.6252	0.052 [2359] 0.24
MLHIV	-0.247 [57] 0.26	0.067 [108] 0.74	-0.087 [235] 0.44	0.168 [139] 0.20	-0.003 [267] 0.98	0.174 [339] 0.06	-0.043 [454] 0.63	0.060 [464] 0.48	0.037 [579] 0.71	0.044 [816] 0.45	0.029 [721] 0.6623	0.0125 [722] 0.88
WLHIV	-0.172 [150] 0.20	0.275 [363] 0.01	-0.065 [530] 0.52	-0.035 [353] 0.72	-0.058 [687] 0.50	0.044 [838] 0.41	-0.018 [1109] 0.80	0.048 [1077] 0.44	-0.029 [1480] 0.68	0.008 [1678] 0.86	0.012 [1708] 0.7817	0.074 [1637] 0.19
ALHIV	—	—	0.044 [67] 0.88	—	-0.281 [70] 0.25	0.225 [101] 0.05	-0.202 [106] 0.13	-0.154 [110] 0.23	0.054 [175] 0.67	-0.018 [185] 0.87	0.206 [208] 0.03	0.162 [212] 0.10
PLHIV 15 years +a	-0.125 [416] 0.09	0.096 [600] 0.15	0.016 [931], 0.72	0.039 [945], 0.45	0.069 [1779] 0.04	0.077 [1760] 0.01	0.024 [2213] 0.46	0.116 [2394] <0.0001	-0.076 [2430], 0.04	-0.029 [3498] 0.19	-0.002 [3185] 0.93	-0.050 [2985] 0.04

Table 2: Survey weighted Wagstaff normalised concentration indices of people living with HIV 15 years or older by sex, adolescents aged 15-24 years for the 90-90-90s by country (PHIA 2015-2018) CIX, [sample size], p value.

Statistical significance * $p < 0.1$ ** $p < 0.05$ *** $p < 0.01$ rounded off to the nearest second decimal — Results had fewer than 25 observations and were suppressed † Estimate based on 25–49 persons/observations and should be interpreted with caution. Concentration Index - CIX rounded off to the nearest third decimal point. ^aPLHIV with viral load suppression as a proportion of all PLHIV. All PLHIV – All people living with HIV MLHIV – Men living with HIV WLHIV – Women living with HIV ALHIV – Adolescents living with HIV

	Côte d'Ivoire			Ethiopia			Rwanda			Cameroun			Tanzania			Uganda		
	1 st 90	2 nd 90	3 rd 90	1 st 90	2 nd 90	3 rd 90	1 st 90	2 nd 90	3 rd 90	1 st 90	2 nd 90	3 rd 90	1 st 90	2 nd 90	3 rd 90	1 st 90	2 nd 90	3 rd 90
Age years 25–34 ref:																		
15–24	20.0**	-29.3	7.7	8.3	-57.5	9.4*	5.5	-0.5	-0.5	31.3***	-1.3	-3.1	2.5	-1.4	5.6	15.5***	-2.9	5.9
35–44	24.3**	-20.6	18.2	11.2**	-56	11.3**	18.0***	3.0	5.5	46.9***	5.6	8.1	17.20***	3.9	4.4	31.5***	-3.0	8.9**
45–54	27.0***	-8.4	30.5**	17.0***	-50.6	15.3***	20.0***	3.9*	5.1	47.3***	9.1	9.3	24.0***	8.6**	6.7	34.3***	4.2	17.3***
55+	24.5**	-3.9	31.9**	20.6**	-55.6	15.0*	23.8***	4.1	2.4	55.0***	4.8	23.8**	13.7***	12.3***	10.0**	33.6***	6.6	10.3**
Sex Female ref:																		
Male	13.0***	7.4	13.9**	11.4***	-1.4	0.1	7.1***	1.3	7.0***	11.7***	-3.2	-1.3	11.9***	6.1***	7.6***	14.3***	4.5***	5.9**
Urban ref: rural	1.1	-8.4	-23.2**	-5.2	-2.3	-1.9	8.6**	-1	5.9*	-4.1	-1.6	-3.2	4.1	-0.3	2.3	-1.6	-1.7	2.7
Employed ref:	1.4	4.5	4.7	-3.4	-0.4	8.8***	-3.8	-0.4	-3.4	0.1	-5.1*	-1	-10.4***	-6.1***	3.2	2.5	-0.3	2
unemployed																		
Food insecure ref:																		
Secure	—	—	—	1.2	-7.9**	-5.4	0.3	2	-3.1	2.9	-0.7	6	3.6	0.6	-3.2	-1.7	-3.9**	0.2
Household size 1-3 ref:																		
7+	-6.8	7.0	2.1	-3.9	-0.4	0.8	3.7	0.6	-0.3	-2	-2.2	-3.1	5.3**	5.0***	-3.9	-2.4	4.1**	-0.10%
4 to 6	3.9	12.6*	-7	-14.3***	1.9	-3.5	7.2**	-0.5	0.9	1.7	1.5	-6	4	3.6	-5.2	-5.0*	1.4	2.4
Education Primary ref:	-7.7	5.3	-11.3*	-5.9	5.6	2.3	6.7**	-4.0	-0.8	6.3	-1.7	-16.4**	7.8***	-0.6	-0.3	0.2	-2.5	0.6
not educated																		
Secondary	-1.7	1.4	3.2	2.1	2.1	0.5	11.9***	-3.5	-4.7	12.0*	-2.4	-12.1	5.8	1.8	4.7	0.3	-7.4**	-0.9
Higher	12.3	-	-	-3.3	11	20	20.1*	-	-	16.8**	-2.2	-5.7	17.1*	-1.0	3.8	5.5	-10.1***	1.3
Wealth Q2 ref:																		
Q1	-8.9	2.6	1.3	13.7**	5.3	2.8	-7.5*	-1.2	5.5	17.3***	-0.7	16.5**	5.7	-0.4	6.8	9.6**	6.5**	1.6
Q3	-0.3	11.1	2	9.2*	2.6	8.3*	0.6	-1.0	-0.6	16.0***	4.6	16.4**	9.8***	2.4	-0.2	4.0	4.2	9.1***
Q4	-8.4	18.5	-21.8*	5.2	-3.9	10.9**	-0.1	-0.3	-1.8	15.7**	6.5	14.7	7.1	-1.2	2.3	11.0**	7.3**	3.7
Q5	-26.9**	-0.1	-36.3**	6.6	-6.8	21.5***	-7.2	1.5	-8.2*	17.0**	6.2	17.3*	15.0***	4.6	-1.00%	6.2	7.7*	4.4
N	443	160	203	595	280	471	931	767	745	973	517	481	1.778	1031	1003	1760	1297	1.177

	Malawi			Zambia			Namibia			Zimbabwe			Lesotho			Eswatini		
	1 st 90	2 nd 90	3 rd 90	1 st 90	2 nd 90	3 rd 90	1 st 90	2 nd 90	3 rd 90	1 st 90	2 nd 90	3 rd 90	1 st 90	2 nd 90	3 rd 90	1 st 90	2 nd 90	3 rd 90
Age years 25–34 ref:																		
15–24	13.81***	2.2	9.5***	15.7***	-1.6	10.8***	5.1**	-2.4	0.3	7.2***	-3.5*	-2.0	7.0***	-0.9	4.9**	10.8***	0.7	7.0**
35–44	25.2***	6.3**	6.7***	29.8***	5.0*	12.7***	13.5***	-1.5	5.8**	20.7***	1.5	0.5	18.2***	1.5	11.0***	17.1***	6.1***	10.2***
45–54	28.1***	7.9***	9.6***	32.3***	12.1***	14.8***	21.6***	-1.4	6.2***	23.7***	8.7***	9.3***	24.5***	5.1**	13.2***	21.0***	3.9*	15.3***
55+	26.8***	8.2**	8.7***	29.7***	14.0**	39.4***	24.4***	0.6	9.8***	18.0***	13.2***	13.9***	20.1***	12.0***	20.2***	19.6***	11.9***	16.3***
Sex Female ref: Male	9.8***	4.5***	2.6	6.9***	0.2	3.7**	9.3***	2.3***	2.9**	9.2***	2.2*	6.2***	9.1***	1.3	0.9	11.7***	-1.6	3.5**
Urban ref: rural	-3.2	-1.8	-2.8	5.4**	0.8	-2.7	1.5	1.2	-0.1	-3.5	-1.0	-1.2	3.0*	-0.1	-2.8	-3.6***	0.4	0.6
Employed ref:	-3.9**	-2.6**	-1.4	-3.1	-2.6	-2	-3.7***	-0.8	-0.6	-3.9***	-0.7	1.4	-5.3***	-1.2	-0.9	-0.6	-3.9***	0.2
unemployed																		
Food insecure ref:																		
Secure	—	—	—	4.3**	0.1	-1	0.3	-3.8***	-0.9	—	—	—	3.2**	0.2	-3.3**	2.0	3.3**	0.9
Household size 1-3 ref:																		
7+	-0.2	-4.1**	-1	4.2**	3.5*	-2.3	-2.8*	-1.9*	-2.4	2.2	0.4	-1.7	2.9*	0.2	2.6*	3.2**	-1.1	-3.8**
4 to 6	-1.1	-2.0	-1.1	3.6	-1.2	-0.3	1.2	-2.8***	1.6	-2.5	3.3*	-0.9	0.1	0.3	1.4	2.3	-0.2	-2.1
Education Primary ref:	3.5	-0.1	1.5	-10.7**	4.9	5.3	2.1	-1.6	1	5.1	-2.1	-1.5	-1.8	-4.3	4.7*	0.7	-4.3	-1.5
not educated																		
Secondary	1.7	0.2	3.6	-8.4	4.8	6.3*	-0.9	-3.8*	-0.2	3.1	-3.0	1.8	-1.6	-3.2	5.2*	-0.4	-6.7*	-1.2

Table 3 (Continued)

Higher Wealth Q2 ref:	Malawi			Zambia			Namibia			Zimbabwe			Lesotho			Eswatini		
	1st 90	2nd 90	3rd 90	1st 90	2nd 90	3rd 90	1st 90	2nd 90	3rd 90	1st 90	2nd 90	3rd 90	1st 90	2nd 90	3rd 90	1st 90	2nd 90	3rd 90
	6.5	7.9	2.1	-1.7	5.3	2.5	8.6	-6.2**	1.8	-1.5	-1.6	-1.6	2	-0.9	8.0*	-3.0	-6.6*	1.2
4.5	1.5	-1.3	4.1	3.9	4.9	0.5	1.6	-0.4	-0.9	2.3	4.3*	2.5	2.5	0.9	-0.8	1.1	3.3**	
1.1	1.5	-3.4	4.8	6.5**	9.6***	6.0**	-0.3	-0.1	0.7	-1.1	0.5	0.5	2.3	0.1	-2.2	-1.0	0.5	
5.0	7.4***	-3.7	5.6	3.0	9.0**	-1.6	1.0	3.9	-0.1	-0.5	2.6	-0.5	0.8	2	0.3	-1.0	1	
0.1	6.1**	0.2	12.7***	8.7**	10.3**	-5.6*	-1.1	-6.9**	1.3	-2.9	3.6	2.8	0.1	0.8	0.7	-0.3	1.7	
N	2.213	1.718	1.563	2394	1751	2430	2134	2059	3.498	2.786	2.494	3185	2631	2429	2985	2640	2359	

Table 3: Factors associated with the 90–90–90s among PLHIV 15 years+ by country - Generalized linear model GLM binomial logit link marginal effects - probabilities.

Generalized linear model GLM binomial logit link marginal effects: coefficients in percentage, rounded off to one decimal point. 1 = Reference. P-values rounded off to two significant figures. Statistical significance levels: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$ — Missing variable in the data set. Quintiles: Q1 - Poorest; Q2- Q3; Q4- Q5 Richest. Each regression included variables for zone- region- district or province dummy to control for variation in HIV services depending on whether the country had a zone- region- province or district variable. Percentage change in probabilities of association of a factor with a given 90 compared to the reference variable.

in Tanzania and Zambia. Compared with those with no education, the probability of accessing ART was lower (-3.8% , $p < 0.1$) and -6.2% , $p < 0.05$) for PLHIV with a secondary, and higher level of education only in Namibia. When compared to PLHIV with no education, the chances of achieving HIV viral load suppression were higher for educated PLHIV in Lesotho, but lower for peers with a primary level of education in Côte d’Ivoire and Cameroun, and those with a secondary or higher level of education in Eswatini. In Uganda, it was lower for PLHIV with a secondary level of education (-7.4% , $p < 0.05$) but higher for PLHIV with a higher level of education 10.1% ($p < 0.05$). No differences were noted in probabilities of achieving the 90s between PLHIV with no education and those with education in Ethiopia, Malawi, and Zimbabwe.

Belonging to a household in the wealth quintiles 2–5 compared to households in quintile 1 was associated with a higher or lower likelihood of achieving the 90s in all countries studied, except in Zimbabwe. In Côte d’Ivoire, PLHIV from the poorest households had a lower likelihood of being aware of their HIV status: -26.9% ($p < 0.05$) for PLHIV in quintile 5, and for HIV viral load suppression the probabilities were -21.8% ($p < 0.1$) and -36.3% ($p = 0.05$) for PLHIV from households in quintiles 4 and 5. They were also lower in Rwanda, -7.5% ($p < 0.1$) for PLHIV from quintile 2 for the awareness of HIV-positive status, and -8.2% ($p = 0.1$) for PLHIV in quintile 5 for HIV viral load suppression. There were no differences in the probability of access to ART between PLHIV from the poorest and wealthier households in nine of 12 countries surveyed (Table 3).

Table 4 shows the results of the decomposition of factors contributing to socioeconomic inequalities in each step of the 90’s CIX. The rural–urban residence contribution to inequalities in awareness of HIV-positive status ranged from -4.4% in Namibia to -69.2% in Cameroun. Education ranged from 1.9% in Côte d’Ivoire to 90.1% in Cameroun for the awareness of HIV-positive status; and wealth contributed to inequalities in achieving the 90s ranging from -2.7% in Eswatini for awareness of HIV-positive status to 33.5% in Côte d’Ivoire; for HIV viral load suppression.

Discussion

This is the first study to examine socioeconomic inequalities in the 90–90–90 target among adult PLHIV aged 15 years and older in 12 Sub-Saharan African countries. We identified three major findings with policy implications for meeting the 95–95–95 target: Pro-poor and pro-rich socioeconomic inequalities in achieving the components of the 90–90–90 target were observed in 11 of the 12 countries surveyed. Rwanda had no significant socioeconomic inequalities. In three-quarters of the countries, older age was associated with achieving the 90s, as were greater wealth,

Summary (%)	Côte d'Ivoire			Ethiopia			Rwanda			Cameroun			Tanzania			Uganda			
	1 st 90	2 nd 90	3 rd 90	1 st 90	2 nd 90	3 rd 90	1 st 90	2 nd 90	3 rd 90	1 st 90	2 nd 90	3 rd 90	1 st 90	2 nd 90	3 rd 90	1 st 90	1 st 90	3 rd 90	
CIX	-0.121	0.278	-0.213	-0.055	-0.184	0.240	0.065	-0.041	-0.074	0.033	0.052	0.023	0.085	0.042	-0.025	0.011	0.102	0.089	
Decomposed	66.9	21.7	-16.1	33.8	28.6	17.0	20.2	8.3	10.4	38.1	1.3	-7.5	75.9	0.2	-19.7	116.6	12.7	19.3	
Residual	33.1	78.3	116.1	66.2	71.4	83.0	79.8	91.7	89.6	61.9	98.7	107.5	24.1	99.8	119.7	-16.6	87.3	80.7	
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
Factors' contributions to inequalities (%)																			
Age	-3.0	-0.9	7.1	-7.3	-3.1	1.3	-6.3	1.4	1.3	31.4	1.9	7.9	-1.9	0.3	-0.3	-61.0	-0.5	-2.3	
Sex	8.6	-2.8	13.5	-0.8	-0.4	0.0	0.6	0.1	0.1	-4.9	0.9	0.7	22.5	15.8	-26.7	88.0	0.9	-0.1	
Location (rural urban)	9.1	17.4	-75.1	31.3	3.2	-2.3	39.3	6.6	-22.5	-62.2	-10.6	-55.9	25.8	-2.1	-34.2	-44.4	-4.1	7.8	
Employment status	1.2	-0.2	0.3	2.3	0.0	1.0	0.1	-0.1	-0.8	0.1	-4.8	-2.5	-2.6	-0.4	-1.4	10.7	-0.1	0.9	
Food insecurity	—	—	—	1.2	-1.7	0.8	-0.7	7.8	-7.4	-4.6	0.3	-7.9	-6.1	-1.2	-12.1	11.9	2.0	-0.2	
Household size	0.5	-0.7	-0.8	13.6	-0.1	0.0	-0.8	0.6	-0.3	-5.8	-2.7	11.4	-2.3	-4.2	-11.2	33.8	-1.1	-1.3	
Location (region)	0.4	-3.7	6.2	5.5	20.0	-9.7	0.0	6.8	-2.7	-116.6	-23.3	-92.9	-20.0	-25.4	41.3	-112.8	2.5	6.0	
Education level	-1.9	-0.9	-0.8	-6.7	-2.5	3.8	10.2	-2.5	3.3	90.1	-2.3	53.5	9.1	1.0	-7.7	15.7	-3.7	-1.2	
Wealth quintiles	52.0	13.6	33.5	-5.4	13.0	22.0	-22.3	-12.4	39.3	110.6	41.8	78.1	51.2	16.3	32.6	174.6	16.7	9.5	
Total decomposed	66.9	21.7	-16.1	33.8	28.6	17.0	20.2	8.3	10.4	38.1	1.3	-7.5	75.9	0.2	-19.7	116.6	12.7	19.3	

Summary (%)	Malawi			Zambia			Namibia			Zimbabwe			Lesotho			Eswatini			
	1 st 90	2 nd 90	3 rd 90	1 st 90	2 nd 90	3 rd 90	1 st 90	2 nd 90	3 rd 90	1 st 90	2 nd 90	3 rd 90	1 st 90	2 nd 90	3 rd 90	1 st 90	2 nd 90	3 rd 90	
CIX	-0.005	0.093	-0.034	0.139	0.101	0.048	-0.128	-0.113	-0.007	-0.042	-0.072	0.025	0.004	-0.078	0.0194	-0.076	-0.093	0.052	
Decomposed	149.4	14.8	19.8	51.0	20.9	8.3	16.1	2.3	-54.8	32.4	19.6	26.4	76.9	7.3	-8.0	21.7	19.1	9.6	
Residual	-49.4	85.2	80.2	49.0	79.1	91.7	83.9	97.7	154.8	67.6	80.4	73.6	23.1	92.7	108.0	78.3	80.9	90.4	
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	
Factors' contributions to inequalities (%)																			
Age	-92.9	1.9	-0.8	-1.3	0.2	2.6	-1.5	0.1	-10.0	3.4	2.0	-4.5	-103.2	2.4	-14.1	-3.4	0.3	1.9	
Sex	-13.0	-1.3	3.4	0.2	0.0	-2.2	2.6	0.7	13.8	-4.7	-0.7	4.5	142.8	-0.7	1.6	1.3	-0.2	-0.4	
Location (rural urban)	167.0	-4.0	16.6	24.9	4.0	-29.9	-4.4	-3.5	4.3	35.7	4.8	-17.5	289.4	0.4	-51.3	7.6	-0.7	1.9	
Employment status	30.8	-0.9	1.3	-2.4	-2.6	-4.0	4.9	1.1	13.1	7.3	0.8	4.6	-238.9	2.2	-6.7	1.0	4.9	0.5	
Food insecurity	—	—	—	-2.6	-0.1	1.4	0.1	-2.0	-8.6	—	—	—	-153.4	0.4	29.1	5.1	7.1	-3.7	
Household size	2.6	-0.3	0.5	0.9	0.0	-0.2	0.6	-1.0	11.4	0.1	1.6	3.6	-0.7	0.1	-1.1	3.1	-0.4	4.0	
Location (region)	-44.6	-5.6	5.8	-7.0	-4.0	-12.6	11.8	3.5	-55.0	-3.4	-4.7	-20.2	91.8	5.1	15.7	3.2	0.1	-2.6	
Education level	57.9	2.0	-4.7	5.9	1.4	1.4	1.3	3.1	8.9	3.9	4.2	19.6	60.1	-5.3	3.5	6.4	4.6	5.8	
Wealth quintiles	41.6	23.0	-2.3	32.3	22.0	51.9	0.7	0.4	-32.6	-9.8	11.6	36.3	-11.0	2.7	15.3	-2.7	3.4	2.3	
Total decomposed	149.4	14.8	19.8	51.0	20.9	8.3	16.1	2.3	-54.8	32.4	19.6	26.4	76.9	7.3	-8.0	21.7	19.1	9.6	

Table 4: Percentage contributions of factors to socioeconomic inequalities in the 90–90–90 among PLHIV by country (PHIA) (%).

Concentration indices are rounded off to the nearest three decimal places. 1 = Reference. — Missing variable in the data set. Each regression included variables for zone, region, district or province dummy to control variation in HIV services depending on whether the data set had a zone, region, province or district variable. Absolute percentage contribution of a factor to observed pro-poor (-) pro rich (+) inequality in a given 90.

employment, and urban residence, each in three or more countries. Living in a city, education, and socioeconomic status all played a role in the observed socioeconomic inequalities.

The first finding was that, except for Rwanda, all surveyed countries had mostly small socioeconomic inequalities favoring PLHIV from either poor or wealthy backgrounds in achieving the 90–90–90 target. Other studies also show that there are mixed results on whether socioeconomic status leads to inequality.^{4,5,9,6,7} A study in Vietnam discovered small socioeconomic inequalities in ART initiation and adherence, concluding that because ART was provided free of charge, PLHIV accessed it with few socioeconomic barrier.⁵ A systematic review in Sub-Saharan African countries and a South African study found that PLHIV from the wealthiest quintile had higher uptake of HIV testing than those from the poorest quintile.^{7,6} In our study, in Cameroun and Zambia, PLHIV from households in the higher wealth quintiles had a higher uptake of HIV testing than their peers from lower wealth quintile households, reinforcing these findings. Our study extends these findings by highlighting that high levels of awareness of HIV positive status among PLHIV from the lowest wealth quintiles is essential for achieving access to ART and HIV viral load suppression target. It found that only Eswatini (89.7% [86.9%–91.9%]), Lesotho (80.3% [76.4%–83.7%]), Namibia (88.5% [85.1%–91.2%]) and Rwanda (81.4% [73.5%–88.1%]) tested $\geq 80\%$ of PLHIV in the poorest quintiles households, and had more than 95% of PLHIV accessing ART and achieving HIV viral load suppression. This result show that the awareness of HIV-positive status by wealth was mixed, suggesting untapped potential for increasing national HIV testing coverages among PLHIV across wealth quintiles.²⁰ Equitable HIV testing covering more than 95% of PLHIV, including PLHIV from households in the poorest quintiles, is essential to meet the 95–95–95 target.

In our study, inequalities in attaining the 90–90–90 target favored PLHIV from wealthy backgrounds in Uganda and Zambia, and PLHIV from poor backgrounds in Namibia and Eswatini. Inequalities in HIV-positive status awareness favored PLHIV from wealthy households in Tanzania, MLHIV from Uganda and Malawi, ALHIV from Côte d'Ivoire, and WLHIV from poor households in Côte d'Ivoire, Ethiopia, and Malawi. One explanation for this disparity is that PLHIV may face different barriers depending on their socioeconomic background.^{21,22} Poor women living with HIV in Ethiopian cities, for example, reported selling antiretroviral drugs to cover ART-related cost.²² In contrast, PLHIV from wealthy backgrounds may have faced barriers to accessing HIV testing and treatment, such as stigma and discrimination, lack of private clinics, and concerns about potential loss of social status and community standing if community members learned about their HIV positive status.²³ Another explanation for

wealth disparities in attaining the 90s could be the World Health Organization (WHO) 2016 recommendation for universal HIV testing and treatment (UTT).²⁴ With this recommendation, WHO removed eligibility requirements for ART, improving access to HIV testing and same-day ART initiation.²⁴ As a result, communities in a trial in four countries (Kenya, South Africa, Uganda, and Zambia) quickly achieved in the 90s between 2012 and 201.²⁵ reducing, but not eliminating, disparities in treatment initiation.²⁶ Interventions to achieve the 95–95–95 target should account for the heterogeneity of inequalities PLHIV face at each step of the care cascade.

Inequalities along each step of the care cascade can also lead to significant differences in outcomes. For instance, in our study, the cumulative CIX of HIV viral load suppression among all PLHIV revealed a significant concentration of inequalities among PLHIV from poor households in six countries. This concentration was not found in the CIX of HIV viral suppression in the sequential 90–90–90 target among PLHIV in Tanzania, Zambia, Namibia, and Eswatini, confirming previous evidence that significant numbers of PLHIV were lost at each step of the 90 cascades.²⁷ More PLHIV, including key populations, may have dropped off at each step of the care cascade. For example, where data were available, MSM had the lowest self-reported awareness of HIV-positive status; access to ART and HIV viral load suppression was lower among key populations than in the general Population.²⁸ Because of stigma and discrimination, key populations may not benefit from their households' socioeconomic ranking in terms of HIV testing, access to ART, and HIV viral suppression. At every step of the care cascades, enhanced adherence counselling, follow-up, and clinical care that accounts for socioeconomic inequalities is required.

Only in Rwanda was achievement of the 90s equitable across PLHIV subpopulation groups and 90–90–90 target components according to our study. One explanation for this equity is that Rwanda achieved universal access to ART, with at least 80% coverage of PLHIV, earlier than the other 11 countries surveyed in this study, in December 2009.²⁹ Another reason is that the country expanded its national Community-Based Health Insurance scheme, covering most of the poor people and those in the informal sector, reducing out-of-pocket payments and catastrophic health expenditure.³⁰ Furthermore, Rwanda was among the top 10 high-performing countries in the world in 2021, and the best in Sub-Saharan Africa after Namibia, in terms of gender equality—economic participation and opportunity, educational attainment, health and survival, and political empowerment for men and women.³¹ Early and rapid achievement of universal access to ART, high gender equality, and large-scale national community-based health insurance coverage may have reduced socioeconomic barriers that PLHIV faced in knowing

their HIV status, accessing ART, and achieving HIV viral load suppression.

The second finding was that being older, female, residing in urban areas, being employed, food insecure, more educated, and wealthier were associated with the achievement of the 90–90–90 target in nine of the 12 countries studied. This finding is in line with other studies conducted.^{4–6} PLHIV aged 25–34, 35–44, and 45–54 years might have had more extensive networks than those aged 15–24 years in our study,³² related, or not, to their households' socioeconomic status, that they leveraged to know their positive status and access ART better than younger PLHIV. More WLHIV than MLHIV tended to achieve HIV viral load suppression with percentage changes in probabilities, ranging from 3.5% ($p = 0.005$) in Eswatini, to 13.9% ($p = 0.037$) in Tanzania supporting the evidence.^{7,6,8} HIV testing and treatment programs may be leaving behind ALHIV.²⁶ and MLHIV due to the unique socioeconomic inequalities these populations face. HIV testing and treatment programs should address age and gender-related inequalities facing ALHIV and MLHIV in achieving the 90–90–90 target.

Our study found that PLHIV who were employed were less likely to be aware of their HIV-positive status in Ethiopia, Zimbabwe, and Lesotho, to access ART in Tanzania, and to be HIV virally suppressed in Eswatini, supported, by the evidence. In South Africa, being employed was associated with increased awareness of HIV-positive status [7]. In South Africa, Kenya, Uganda, and Nigeria, access to ART or HIV viral load suppression was not associated with employment source 7. Our findings suggest that employed PLHIV in the surveyed countries may have avoided HIV testing or ART access due to HIV-related stigma and discrimination at work. Confidential HIV testing and treatment services in the workplace may be required.

In three countries (Zambia, Lesotho and Eswatini), food insecurity was associated with an increased likelihood of PLHIV being aware of their HIV-positive status, but a decrease in their access to ART and HIV viral load suppression our study found. This finding suggests no evidence that food insecurity impacts PLHIV' awareness of HIV positive status in most countries. However, the finding suggests that in Zambia, Lesotho and Eswatini, in the context of food insecurity, food programs and food incentives integrated in HIV testing and treatment programs can enable PLHIV to know their HIV positive.³³ Food programs may also be useful tools for PLHIV to access ART and achieve HIV viral load suppression in these three countries and in Ethiopia, Namibia, Uganda and Lesotho.

In nine countries, PLHIV with more education were more likely to know their HIV-positive status, access ART, and achieve HIV viral load suppression, but not in Malawi, Zimbabwe, or Eswatini, highlighting the critical role education plays in achieving the 90–90–90

target. Similarly, being from a household in wealth quintiles 2–5 rather relative to quintile 1, was associated with a higher likelihood of achieving the 90s in 9 of the 12 countries but lower in 3 of the 12 countries studied suggesting that wealth plays a role in the achievement of the 90s.

Age, gender, residence in urban areas, employment, food security, higher education, and wealth are all common dimensions of inequalities, as is poverty. The association of these factors with the 90–90–90 target implies that achieving the 95–95–95 target may necessitate stronger synergies with programs aimed at reducing inequality and poverty, such as social protection and cash transfers, particularly during the COVID-19 era. In response to COVID-19, over 3300 social protection measures have been implemented.³⁴ PLHIV are only mentioned in a few³⁴ of these measures. People-centered 95–95–95 target interventions with social protection and action on the social determinants of health are required.²⁰

Our final result is related to the decomposition analysis, which revealed that age, gender, rural-urban residence, education, and wealth all contributed the most to observed socioeconomic inequalities. This finding emphasizes the importance of designing interventions in the 95–95–95 target interventions to reduce inequalities related to rural–urban residence, education, and wealth.

Our research has limitations. We used the wealth index, which is an approximation rather than a precise measure of socioeconomic status. The wealth indices do not compare the wealth of households across subpopulations or countries. Households in higher wealth quintiles should be wealthier, but this is not always the case because models do not fully capture wealthiest.¹⁹ We were unable to determine whether the small inequalities were due to key populations dropping out of the care cascade because key populations may not identify themselves during surveys due to stigma and Discrimination.²⁸ The high residuals in our results indicate that our models did not account for other factors associated with achieving the 90s and accounting for observed inequalities, such as stigma and discrimination, which were not standardized across countries in our study. For example, in the context of UTT in Eswatini, stigma was pervasive and influenced PLHIV engagement with HIV treatment and Care.³⁵ The achievement of the 90–90–90 target may have improved before 2020, the target's deadline, but also hampered by the COVID-19 pandemic. It is unclear how these factors influenced socioeconomic disparities in the 90-90-90s.

Finally, we discovered socioeconomic disparities in achieving the 90s among PLHIV in 11 of the 12 countries studied. Governments should prioritize activities to reduce gender, rural–urban residence, education, and wealth-related inequalities, and measure equity, in their 95–95–95 target plans, and scale up equitable

HIV testing, access to ART, and HIV viral load suppression interventions among PLHIV. More research is needed to understand interventions to reduce socioeconomic inequalities in the 95–95–95 target.

Contributors

DC conceptualized the study and led the data curation. DC and SAA defined the methodology. SAA and DC performed the data analysis. DC, SAA, DG, JE and OK further analyzed the data. DC and SAA visualized the data. DC drafted the manuscript. DC, SAA, DG, JE and OK critically reviewed the manuscript. DC further revised the manuscript. DC, SAA, and DG saw and verified the data. All authors read and agreed to submit the manuscript.

Data sharing statement

The data for this study is publicly available and can be requested at [PHIA Data Manager \(columbia.edu\)](https://phia-data-manager.columbia.edu).

Declaration of interests

David Chipanta works for UNAIDS

All authors declare no conflict of interest.

Acknowledgements

None.

Funding

This study was supported by the Swiss National Science Foundation (grant 202660).

Supplementary materials

Supplementary material associated with this article can be found in the online version at doi:[10.1016/j.eclinm.2022.101652](https://doi.org/10.1016/j.eclinm.2022.101652).

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