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OPEN

Understanding the pathways leading to socioeconomic inequalities in HIV testing uptake in 18 sub-Saharan African countries

Pearl Anne Ante-Testard[a,b], Mohamed Hamidouche[a,b], Bénédicte Apouey[c], Rachel Baggaley[d], Joseph Larmarange[e], Tarik Benmarhnia[f], Laura Temime[a,b] and Kévin Jean[a,b,g]

Objective: To better understand the different pathways linking socioeconomic position and HIV testing uptake in 18 sub-Saharan African countries.

Design: We used cross-sectional population-based surveys between 2010 and 2018.

Methods: Using a potential outcomes framework and the product method, we decomposed the total effect linking wealth and recent (<12 months) HIV testing into direct effects, and indirect effects, via *internal* (related to individual's ability to perceive need for and to seek care) or *external* (ability to reach, pay for and engage in healthcare) mediators to calculate the proportion mediated (PM) by each mediator.

Results: High levels of inequalities were observed in nine and 15 countries among women and men, respectively. The mediator indirect effect varied greatly across countries. The PM tended to be higher for internal than for external mediators. For instance, among women, HIV-related knowledge was estimated to mediate up to 12.1% of inequalities in Côte d'Ivoire; and up to 31.5% for positive attitudes towards people with HIV (PWH) in Senegal. For the four external mediators, the PM was systematically below 7%. Similar findings were found when repeating analyses on men for the internal mediators, with higher PM by attitudes towards PWH (up to 39.9% in Senegal).

Conclusions: Our findings suggest that wealth-related inequalities in HIV testing may be mediated by internal more than external characteristics, with important variability across countries. Overall, the important heterogeneities in the pathways of wealth-related inequalities in HIV testing illustrate that addressing inequalities requires tailored efforts and upstream interventions.

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Introduction

HIV continues to affect many lives globally especially in sub-Saharan Africa (SSA), which accounts for 67% of people with HIV (PWH) in 2020 [1] making HIV prevention and treatment essential, particularly in this region. HIV testing has played a crucial role in the prevention and management of HIV/AIDS as the entry point that links individuals to prevention and treatment services.

Routine offer of HIV testing in health settings, such as antenatal clinics was recommended by the World Health Organization in 2007 [2], which changed the profiles of testing users and increased uptake in HIV testing [3]. However, in spite of the significant progress in reducing HIV incidence over the past decade in SSA, HIV incidence has not declined sufficiently to reach the UNAIDS 90–90–90 fast-track goals by 2020 and the Sustainable Development Goal of ending the AIDS epidemic by 2030 [4]. A modelling study that investigated the progress towards the first 90 (90% of PWH will know their status) found that 84% of PWH in SSA knew their status by 2020, with proportions consistently lower in Western and Central Africa (WCA, 67% and 70%, respectively) than in Eastern and Southern Africa (ESA, 86% and 90%, respectively) [5]. These still left a gap of around 3.8 million PWH left undiagnosed in SSA [5].

Health inequalities that favour the wealthiest subgroups have also persisted in most SSA countries, especially in WCA [6]. Studies found that people with higher socioeconomic position (SEP) were associated with better knowledge of HIV status and were more likely to seek testing [7–13]. Potential drivers of these inequalities include knowledge on HIV, stigma, distance to care and cost of services, among many others. A study found that cost of services and physical distance between health facilities were the most significant supply-side barriers in accessing obstetric care in SSA [14]. We hypothesize these drivers to also be important barriers in the uptake of HIV testing. Documenting such mechanisms can be useful in understanding the role of each factor in driving such inequalities.

Despite the literature in socioeconomic inequalities in HIV testing, few studies have explored their possible underlying mechanisms. Such studies are timely to help better orientate testing strategies in order to reach the first 95 of the 2030 UNAIDS 95–95–95 targets and to ensure 'no one is left behind'. In this study, we analysed population-based surveys to understand mediating factors linking SEP and HIV testing uptake at the individual level.

Methods

Data and study design

We analysed data from the Demographic and Health Surveys (DHS) conducted between 2010 and 2018 to understand the role of different mediating factors in the pathway between SEP and recent (<12 months) HIV testing uptake.

The DHS are publicly available nationally representative population-based surveys, conducted regularly in low- and middle-income countries (LMIC), collecting data on a wide range of objective and self-reported health indicators including data on HIV/AIDS, using a two-stage sampling design [15]. All women aged 15–49 years are all eligible in all households and, in some surveys, men aged 15–54/59 from a sub-sample are also eligible to participate (https://dhsprogram.com/). Those who consented are interviewed face-to-face by trained interviewers using a standardized questionnaire that includes items on different socio-demographic characteristics, maternal and reproductive health, and HIV-related questions [15].

Country sample was based on convenience sampling (with data available as of February 2021) that was slightly extended from a previous study [6]. In total, we analysed 10 WCA countries (Burkina Faso, Cameroon, Congo DR, Côte d'Ivoire, Guinea, Liberia, Mali, Niger, Senegal and Sierra Leone) and eight ESA countries (Ethiopia, Kenya, Lesotho, Malawi, Rwanda, Tanzania, Zambia and Zimbabwe).

The national implementing agencies and research institutes that conducted the surveys were responsible for ethical clearance which ensured informed consent from the participants prior to their involvement and guaranteed confidentiality of information [16].

Variables

Socioeconomic position

We defined participant SEP based on the DHS wealth index, a composite measure of household wealth based on living standards such as household assets and characteristics [17]. More specifically, we used the relative wealth rank of the participants in the country-specific cumulative distribution of the wealth index score, a continuous variable ranging from 0 to 1. We compared the predicted outcomes between the richest and the poorest individuals in the wealth distribution.

Outcome variable

The outcome of interest was the self-report of recent (<12 months) HIV testing.

Mediators

We selected six potential individual-level mediators available in the DHS that we hypothesized to be in the pathway between wealth and recent HIV testing based on

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the literature. We categorized these mediators into two categories based on a principal component analysis for women (Figure S1, Supplemental Digital Content, http://links.lww.com/QAD/C570).

The first category of mediators referred to the individual's ability to perceive the need for and to seek care [18] (i.e. HIV-related knowledge and positive attitudes towards PWH). The second category included factors that characterize the ability to reach, pay for, and engage in healthcare [18] (i.e. reporting no distance-related problem to seek care, reporting no money-related problem to seek care, no permission needed from spouse/partner to seek a doctor and no/single difficulty in seeking care). For simplicity, we labelled the first category *internal* and the second category *external* characteristics to the participants. External mediators were only available for women in the DHS except in Tanzania.

All mediators were coded as binary variables with favourable responses coded as 1. Complete descriptions of these variables and how they were constructed can be found in Table S1, Supplemental Digital Content, http://links.lww.com/QAD/C570.

Confounders

The confounders that we identified a priori were age (15–24, 25–34, 35 and above), type of residence (urban and rural) and family situation (in a union, single and widowed/separated).

Statistical analysis

Firstly, we estimated country- and sex-specific percentages of reporting favourable levels of the mediators and recent HIV testing while accounting for survey design and sampling weights. We also calculated the proportions of the mediators at favourable levels between the richest and poorest quintiles.

Secondly, we fitted multivariable modified Poisson regressions adjusting for confounders and accounting for survey design to compute the inequalities and mediated effects [19]. We estimated the wealth-related inequalities in recent HIV testing by estimating the total effect (TE) of wealth on recent testing using Eq. (1).

$$P(recentHIVtesting) = f(wealthrank, confounders) \quad \text{[Equation 1]}$$

Outcome model:

$$P(recentHIVtesting) = f(wealthrank, mediator, EMinteraction, confounders)$$

$$where\ EM = exposure\text{-}mediator. \quad \text{[Equation 2]}$$

Mediator model:

$$P(mediator) = f(wealthrank, confounders) \quad \text{[Equation 3]}$$

Thirdly, we applied different outcome and mediator models (Eqs. (2) and (3)) using the product method based on the potential outcomes framework [20,21] to explore different pathways linking wealth and recent HIV testing through the internal and external mediators. We explored each mediator separately and assumed that they do not influence one another in the analysis. We considered four assumptions in this analysis: no unmeasured exposure – outcome confounding, no unmeasured mediator – outcome confounding, no unmeasured exposure – mediator confounding, and none of the mediator – outcome confounder is itself affected by the exposure [22]. Figure 1 shows the Directed Acyclic Graph (DAG) of the pathways that we explored.

Lastly, we estimated the proportion mediated (PM, in %) by each mediator. The PM is the proportion of the TE of the exposure on the outcome that is mediated. The PM captures how important the pathway is through the mediator in explaining the observed effect of the exposure on the outcome (i.e. TE) [23]. To calculate the PM, we decomposed the TE of wealth on recent HIV testing into the controlled direct effect (CDE) and the natural indirect effect (NIE) (Fig. 1) using coefficients from the outcome and mediator models (Text S1, Supplemental Digital Content, http://links.lww.com/QAD/C570). The CDE is the effect of the exposure on the outcome, while the mediator is set to a pre-specified level uniformly over the entire population [21]. Here, we pre-specified the level of the mediator to a favourable level. The NIE represents the change in the outcome when SEP is held constant and the mediator changes to what it would have been for a change in the other SEP category [21,24]. We also accounted for the EM interaction in our outcome models (Eq. 2) when it was statistically significant (P-value < 0.05) to calculate for these effect estimates [21]. We used the formula based on Valeri and VanderWeele to calculate for such effects (Text S1, Supplemental Digital Content, http://links.lww.com/QAD/C570). We bootstrapped the 95% confidence interval (CI) with 1000 replications. Considering the low rate of missing data (Table S2, Supplemental Digital Content, http://links.lww.com/QAD/C570), we conducted a complete-case analysis.

To focus on settings in which wealth-related inequalities were substantial before decomposing the TE into CDE and NIE to calculate the PM, we established a cut-off based on the TE, with a prevalence ratio (PR) $\geq$1.5. All analyses were conducted using R version 4.0.3 (R Foundation for Statistical Computing, Vienna, Austria).

Sensitivity analysis

We repeated the analysis among women while excluding those who had recent birth in the past year. We also conducted an additional analysis using joint-mediators

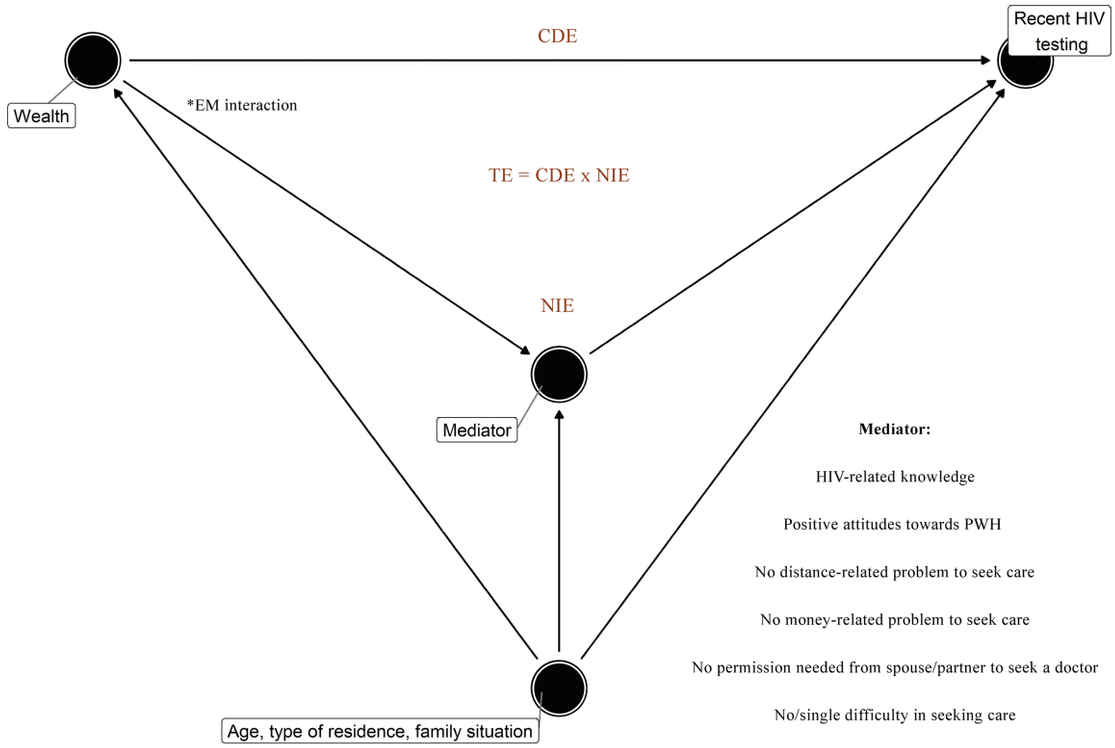


Fig. 1. DAG illustrating the pathway between wealth and recent (<12 months) HIV testing through each mediator while adjusting for confounders (i.e., age, type of residence and family situation) and exposure-mediator interaction when statistically significant (*P*-value <0.05) (*). The TE of wealth on recent HIV testing could be disentangled into the CDE and the NIE. CDE, controlled direct effect; EM, exposure-mediator; NIE, natural indirect effect; TE, total effect; PWH, people with HIV.

approach to check for the identification assumption related to the mediators influencing each other [25].

Results

Characteristics of study population

Data were collected from 392 044 participants, 261 935 female and 130 109 male participants. Table 1 and Table S3, Supplemental Digital Content, http://links.lww.com/QAD/C570 illustrate the survey and participants characteristics. Overall, 93–100% of eligible women were successfully interviewed, and 86–100% of men (Table S3, Supplemental Digital Content, http://links.lww.com/QAD/C570).

In many of the countries, female and male participants lived in rural areas (except in Côte d'Ivoire, Cameroon and Liberia among both sex, and in Senegal among males). They were either married or cohabitating except in Cameroon, Senegal and Lesotho where most males were single (Table S3, Supplemental Digital Content, http://links.lww.com/QAD/C570).

Table 1 shows that around 18–45% of the female participants and 17–40% of the male participants had comprehensive HIV-related knowledge in ESA countries compared to 1–32% and 13–26% among female and male participants, respectively, in WCA countries. Moreover, the proportion of participants with positive attitudes towards PWH was lower in WCA countries (around 15–57% among females and 18–51% males) compared to ESA countries (about 36–84% among females and 45–86% among males). In terms of the external variables, most women reported no external-related problems except in Burkina Faso, Côte d'Ivoire, Cameroon, Congo DR, Guinea, Niger and Sierra Leone in WCA (majority of women reported money-related problems in seeking care), and in Ethiopia and Malawi in ESA (majority of women reported distance-related and money-related problems). Most female participants did not need spousal/partner permission to seek a doctor in all countries.

Self-reported recent HIV testing uptake among female and male participants in WCA was lowest in Niger (8.4 and 2.7%, respectively) and highest in Cameroon (40 and 35%, respectively). Meanwhile in ESA, uptake among women and men was lowest in Ethiopia (21.2 and 19.7%, respectively) and highest in Kenya (67.9 and 57.5%, respectively).

Socioeconomic inequalities in HIV Testing

Figure 2 illustrates that the richest were more likely to have comprehensive HIV-related knowledge, have

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Table 1. Survey and population characteristics, by country and sex.

Western-Central Africa	BFA (Burkina Faso)		CIV (Côte d'Ivoire)		CMR (Cameroon)		COD (Congo DR)		GNA (Guinea)		LIB (Liberia)		MLI (Mali)		NIG (Niger)		SEN (Senegal)		SLE (Sierra Leone)	
Survey year	2010		2011–2012		2018		2013–2014		2018		2013		2018		2012		2017		2013	
Sex	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M
N	17 087	7307	10 060	5135	14 677	6978	18 827	8656	10 874	4117	9239	4118	10 519	4618	11 160	3928	16 787	6977	16 658	7262
Internal mediators																				
HIV-related knowledge (%)	23.3	21.5	14.5	13.2	32.4	25.8	11.8	13.8	14.6	18.9	1.3	17.1	15.8	16.3	10.0	13.9	16.2	21.2	21.9	14.0
Positive attitudes towards PWH (%)	32.8	38.7	47.3	46.3	57.0	51.2	33.6	40.2	15.4	17.5	33.6	37.5	29.5	34.0	18.3	24.9	34.2	30.0	34.7	33.0
External mediators																				
No distance-related problem to seek care (%)	56.4	–	60.3	–	60.3	–	61.1	–	53.9	–	59.9	–	71.5	–	57.1	–	77.9	–	61.4	–
No money-related problem to seek care (%)	28.2	–	33.0	–	32.7	–	31.4	–	39.9	–	53.1	–	59.5	–	40.1	–	55.3	–	32.9	–
No permission needed to seek a doctor (%)	78.9	–	75.6	–	65.4	–	67.3	–	70.5	–	92.2	–	72.9	–	78.9	–	93.4	–	82.5	–
No/single difficulty in seeking care (%)[†]	56.6	–	56.7	–	53.5	–	54.1	–	54.2	–	70.6	–	68.1	–	59.2	–	80.4	–	59.7	–
Recent (<12 months) HIV testing (%)	11.8	8.6	15.4	9.9	40.0	35.0	9.1	7.6	9.4	5.9	21.6	13.7	9.2	4.9	8.4	2.7	13.0	6.3	17.6	8.2

Eastern-Southern Africa	ETH (Ethiopia)		KEN (Kenya)		LES (Lesotho)		MWI (Malawi)		RWA (Rwanda)		TNZ (Tanzania)		ZBW (Zimbabwe)		ZMB (Zambia)	
Survey year	2016		2014		2014		2015–2016		2014–2015		2011–2012		2015		2018	
Sex	F	M	F	M	F	M	F	M	F	M	F	M	F	M	F	M
N	15 683	12 688	31 079[§]	12 819	6621	2931	24 562	7478	13 497	6217	10 967	8352	9955	8396	13 683	12 132
Internal mediators																
HIV-related knowledge (%)	18.3	27.0	28.6	23.7	27.0	16.5	35.6	31.5	44.8	40.3	30.5	25.5	44.6	34.9	33.7	24.9
Positive attitudes towards PWH (%)	35.5	44.5	73.0	77.7	84.4	71.6	80.5	85.0	83.4	86.4	59.1	64.8	77.2	78.8	70.7	75.1
External mediators																
No distance-related problem to seek care (%)	49.7	–	77.3	–	74.5	–	44.4	–	78.4	–	–	–	66.7	–	71.2	–
No money-related problem to seek care (%)	45.2	–	63.3	–	72.7	–	47.2	–	50.7	–	–	–	57.0	–	79.5	–
No permission needed to seek a doctor (%)	67.9	–	94.0	–	96.4	–	83.6	–	97.3	–	–	–	94.7	–	96.2	–
No/ single difficulty in seeking care (%)[†]	55.1	–	82.0	–	84.9	–	56.2	–	82.8	–	–	–	76.4	–	85.2	–
Recent (<12 months) HIV testing (%)	21.2	19.7	67.9	57.5	59.1	37.9	44.4	42.3	39.7	36.9	32.5	27.7	49.3	36.8	65.4	53.4

F, female; M, male; *N*, total number. PWH, people with HIV.
[†]A ioint mediator of no distance-related to seek care, no money-related to seek care and no permission needed to seek a doctor.
[§]All version: 31 079; long version: 14 741, short version: 16 338.

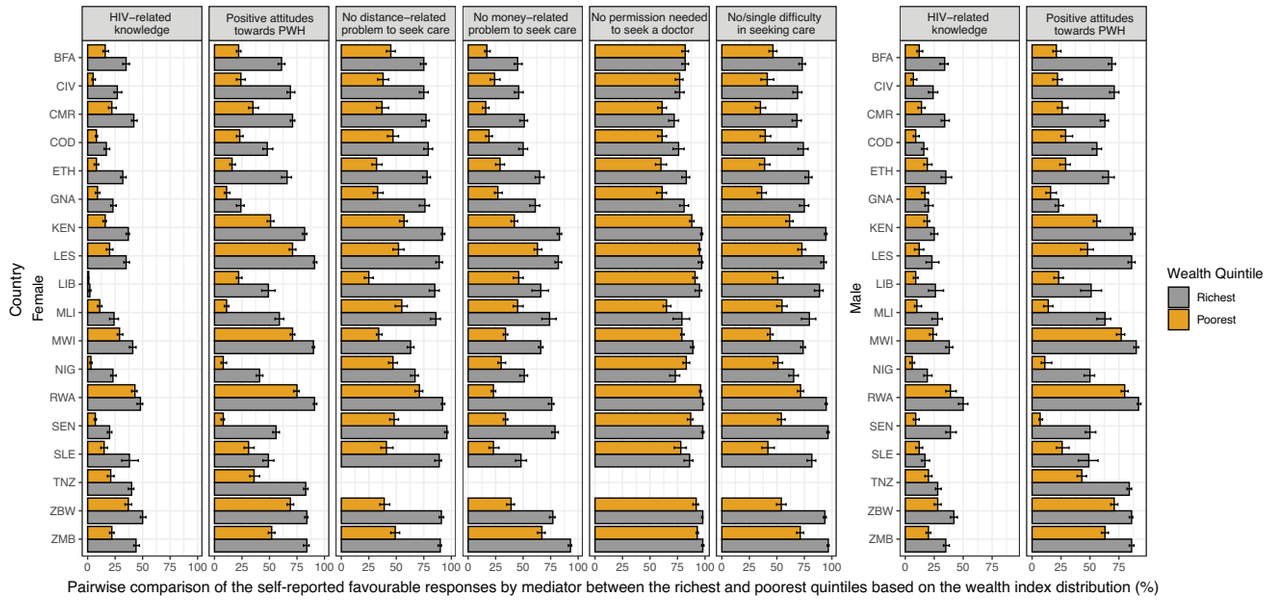


Fig. 2. Path from wealth to mediator – proportion of the richest and poorest participants who self-reported favourable levels of the mediator in 18 sub-Saharan African countries, stratified by sex. External mediators were not available among women in Tanzania in the DHS. Refer to Table 1 for full country names. PWH, people with HIV.

positive attitudes towards PWH and were less likely to report problems external to the participants. We also observed different magnitudes across countries and mediators.

Table 2. Total effect of wealth on recent HIV testing – adjusted prevalence ratios of recent HIV testing between the richest and poorest participants (stratified by sex), while accounting for confounders.

	Adjusted PR (95% confidence interval) *P*(recent HIV testing) = *f*(wealth rank, confounders)	
Country	Female	Male
BFA	**2.74 (2.09 – 3.58)**	**14.97 (9.12 – 24.57)**
CIV	**3.39 (2.53 – 4.52)**	**8.93 (5.27 – 15.15)**
CMR	**2.68 (2.33 – 3.07)**	**3.95 (3.23 – 4.83)**
COD	**12.14 (7.34 – 20.08)**	**15.30 (8.67 – 26.98)**
ETH	**3.97 (3.14 – 5.01)**	**3.89 (3.00 – 5.05)**
GNA	**10.63 (6.57 – 17.19)**	**11.27 (4.93 – 25.74)**
KEN	*1.30 (1.23 – 1.37)*	**1.59 (1.47 – 1.71)**
LES	*0.90 (0.82 – 0.99)*	**1.61 (1.30 – 2.00)**
LIB	1.21 (0.99 – 1.47)	**2.92 (1.94 – 4.38)**
MLI	**11.17 (7.08 – 17.63)**	**6.16 (2.14 – 17.72)**
MWI	*1.10 (1.04 – 1.17)*	*1.13 (1.01 – 1.26)*
NIG	**4.82 (3.23 – 7.17)**	**46.04 (10.47 – 202.43)**
RWA	1.08 (0.99 – 1.19)	0.93 (0.80 – 1.07)
SEN	**1.62 (1.30 – 2.01)**	**3.08 (1.75 – 5.44)**
SLE	*1.35 (1.07 – 1.70)*	**2.58 (1.45 – 4.61)**
TNZ	*1.44 (1.27 – 1.65)*	**1.68 (1.42 – 1.99)**
ZBW	1.13 (1.00 – 1.28)	*1.37 (1.16 – 1.63)*
ZMB	*1.13 (1.04 – 1.23)*	**1.51 (1.37 – 1.66)**

PR, prevalence ratio; *P*, probability; *f*, function of. Bold fonts indicate that the model is statistically significant and eligible (PR ≥ 1.5), italic indicates that the model is statistically significant but ineligible, and normal fonts indicate that the model is not statistically significant. Refer to Table 1 for full country names.

Table 2 shows the TE of wealth on recent HIV testing which was the effect estimate we used to measure wealth-related inequalities. We estimated the adjusted PRs of recent testing between the richest and the poorest participants while accounting for confounders. Applying the cut-off of PR ≥1.5 led us to keep nine countries for women and 15 countries for men in our final mediation analyses. Levels of wealth-related inequalities vary greatly by country and sex with pro-rich inequalities in HIV testing in most countries. Inequalities tended to be higher among men than women.

Wealth-related inequalities were markedly observed in WCA countries. Among women, the highest inequalities were in Congo DR where the prevalence of recent testing among the richest women was 12.14 (95% CI 7.34–20.08) times greater than among the poorest women. Meanwhile in men, the highest inequality was in Niger where the prevalence of testing among the richest men was 46.04 (10.47–202.43) times greater than among the poorest men.

Mediated effects

Pathways from wealth to each mediator based on Fig. 1 were explored (Table S4, Supplemental Digital Content, http://links.lww.com/QAD/C570). Among the eligible models in Table 2 (i.e., with substantial inequalities), we observed that wealth was associated with majority of the mediators except for HIV-related knowledge among men in Sierra Leone, positive attitudes towards PWH among men in Guinea and no spousal/partner permission needed to seek a doctor in Burkina Faso, Côte d'Ivoire,

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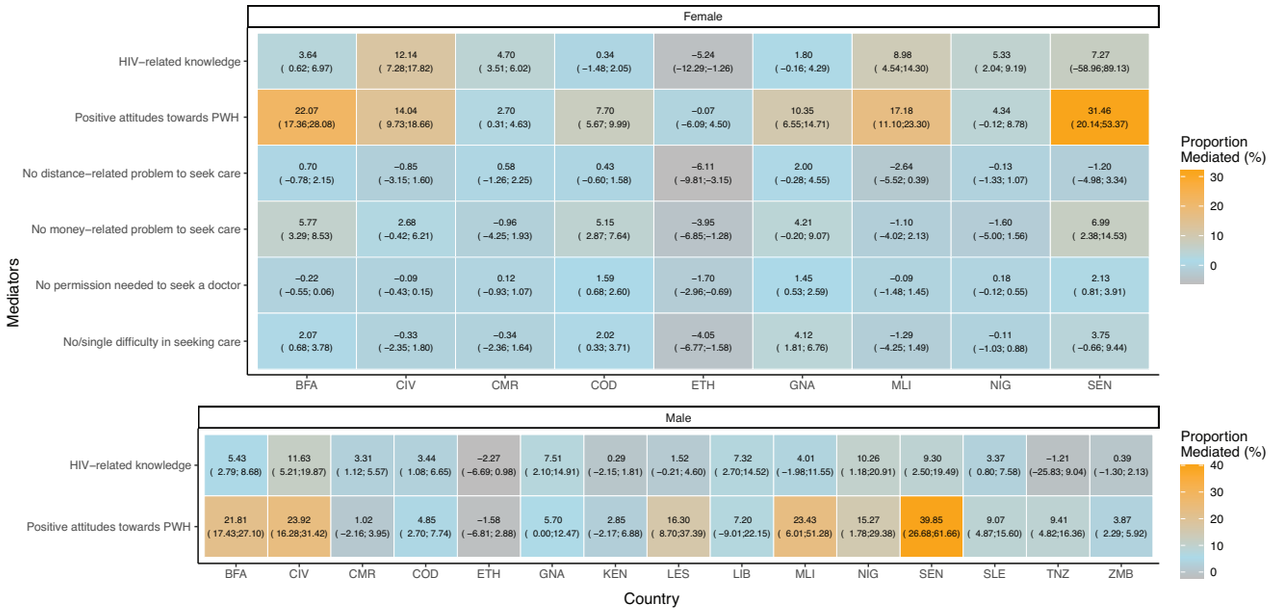


Fig. 3. Heatmap of the proportion mediated by each mediator in the total effect of wealth on HIV testing, stratified by sex (eligible models). Refer to Table 1 for full country names. PWH, people with HIV.

Liberia and Niger among women (Table S4, Supplemental Digital Content, http://links.lww.com/QAD/C570). The paths from each mediator to HIV testing uptake were also explored (Figure S2 and Table S5, Supplemental Digital Content, http://links.lww.com/QAD/C570). In all eligible countries except Lesotho, all mediators were positively associated with recent testing (Table S5, Supplemental Digital Content, http://links.lww.com/QAD/C570).

There was heterogeneity in the importance and role of each mediator in the pathway between wealth and recent testing across countries and sex groups (Fig. 3). Internal mediators tended to have higher PM compared to external mediators in women, with magnitudes varying across countries. For example, among women, the TE of wealth on recent testing uptake was mediated by positive attitudes towards PWH by 31.46% (20.14–53.37%) in Senegal, but only by 4.34% (−0.12 to 8.78%) in Niger. In other words, we could also say that wealth-related inequality in testing among women in Senegal could be explained by positive attitudes towards PWH by 31.46% (20.14–53.37%). Meanwhile, in Côte d'Ivoire, wealth-related inequalities in testing could be explained by HIV-related knowledge by 12.14% (7.28–17.82%), while in Congo DR by only 0.34% (−1.48 to 2.05%). External mediators tended to have lower PM in majority of the countries except in Burkina Faso, Congo DR, Guinea, and Senegal in which reporting no money-related problem mediated slightly more or almost similarly than HIV-related knowledge.

Among men, positive attitudes towards PWH tended to mediate the TE of wealth on testing more with a range between −1.58% (−6.81 to 2.88%) in Ethiopia and 39.85% (26.68–61.66%) in Senegal than HIV-related knowledge that ranged between −2.27% (−6.69 to 0.98%) in Ethiopia and 11.63% (5.21–19.87%) in Côte d'Ivoire. A negative PM indicates that the CDE and NIE were in opposite direction. Figure S3, Supplemental Digital Content, http://links.lww.com/QAD/C570 shows small reduction in inequality in a few countries after setting each mediator to a favourable level over the entire participants (i.e. CDE).

Sensitivity analysis

When excluding women who had recent birth in the past year in the analysis, findings were nearly consistent but with higher magnitudes of inequalities (Table S6, Supplemental Digital Content, http://links.lww.com/QAD/C570) and PM by each mediator (Figure S4, Supplemental Digital Content, http://links.lww.com/QAD/C570) in most countries. Tanzania was also added to the countries with substantial inequalities. Through the joint-mediators approach, we observed that HIV-related knowledge and attitudes towards PWH do not influence testing independently from each another (Table S7, Supplemental Digital Content, http://links.lww.com/QAD/C570). This also applies to the external mediators.

Discussion

We analysed cross-sectional population-based surveys to assess individual-level drivers of wealth-related inequalities in recent HIV testing through mediation analysis in

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several SSA countries. Richest individuals were more likely to have been recently tested than the poorest with magnitudes varying across countries. The richest were more likely to have a favourable situation regarding the mediators (e.g., better HIV knowledge, lesser stigma towards PWH and lesser problems to seek care) and these mediators were also positively associated with HIV testing. For instance, people having no problem to seek care were also more likely to have been recently tested for HIV. We found no single, strong mediator in the pathway between wealth and recent testing that was consistently strong across countries and sex, but our results show that inequalities were mediated more by internal more than external characteristics. The importance of each mediator varied greatly by country and sex which may depend on several factors such as socioeconomic, epidemiological, donor and political structures of the country.

Mediation analysis was conducted in countries where substantial levels of pro-rich inequalities were observed, majority of which were WCA countries which is consistent to other studies [6,26]. This is quite expected since most WCA countries' healthcare delivery is through private sectors and often has inadequate decentralization of HIV services [27]. Meanwhile, in ESA, healthcare delivery is mostly based on public and community health efforts incorporated with international donor funding [28]. Participants were also more likely to report having comprehensive HIV-related knowledge and positive attitudes towards PWH in ESA. This could be due to the longer history of HIV programs in this region in response to the higher burden of the epidemic. Inequalities were also found to be higher among men, which could be explained by women having more access to testing through routine offer in antenatal clinics [29].

Based on the findings, attitudes towards PWH play a major role in explaining part of inequalities regardless of the epidemic in a country. Low HIV stigma has been well documented to be associated with higher SEP [30] and higher HIV testing uptake [31]. Stigma has important implications for HIV testing. Due to the negative attitude towards PWH and the fear of being treated similarly, people may refuse to participate in any HIV prevention services despite their knowledge [32]. In turn, high level of HIV-related knowledge was found to reduce stigma [33,34].

Long travel times to reach healthcare in rural areas were found to be an important barrier in reaching high coverage [35] and distance to care was found to affect uptake of facility delivery [36]. However, our findings showed that reporting no distance-related problem in seeking care mediated a lower proportion of the relationship between wealth and recent testing among women. We did not use physical distance itself but the perception that distance would be a problem in seeking care and in some countries like Senegal, HIV services reach the populations through both fixed and mobile strategies [37]. Although magnitude is small, reporting no money-related problem tended to have higher PM in WCA countries which have a widespread policy of user fees for health services [26]. In most countries, married women do not usually need spousal consent legally to access sexual and reproductive health facilities [38] which may explain why no spousal/partner permission to seek a doctor mediate less.

This study has several limitations. First, the issue of temporality due to the use of cross-sectional data, especially for the internal mediators, namely HIV-related knowledge and stigma. Indeed, since counselling goes along with HIV testing in most contexts, we cannot exclude reverse causation between the internal mediators and HIV testing uptake. Some studies caution against mediation analysis when using cross-sectional data, especially when the temporal ordering is not clear [39]. However, both HIV-related knowledge and stigma have been identified by prospective studies and meta-analyses to be associated (positively and negatively, respectively) with uptake of health services, including HIV testing [40,41]. The existing evidence thus supports a causal link between the internal mediators assessed here and HIV testing. Second, while we may have accounted for possible exposure-mediator and exposure-outcome confounding, there may be a residual mediator-outcome confounding that we failed to account for. Third, the lack of the variable risk perception of acquiring HIV in the DHS. It was indeed found to be an important mediator between peer education and HIV testing in key populations [42]. Another limitation is the self-report of HIV testing and mediators. A study, however, showed that the sensitivity of self-reported HIV testing ranged from 96% to 99% with high specificity [43,44]. Despite this, reporting bias may still be present resulting to underreporting of sensitive information such as stigma. Another potential limitation is that inequalities have been measured only through wealth index which carries its own limits. Although it is said to be stable and represents long-term SEP in LMIC, it can only assess relative wealth within a population [45]. For this reason, we did not pool the estimates across countries. Survey years were also different which may have contributed to the heterogeneity in inequality estimates and mediated effects.

Despite the limitations, this study has several strengths. We used large, standardized and nationally representative data, with low rates of missing values. Moreover, to our knowledge, this is the first study to present a comprehensive analysis of mediators in several SSA countries. Importantly, compared to a classic mediation analysis, we used the potential outcomes framework allowing us to account for exposure-mediator interaction.

In conclusion, this study provides a comprehensive analysis of mediating factors that could potentially explain

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wealth-related inequalities in HIV testing in several SSA countries. Our results suggest that inequalities in HIV testing may be explained more by individual internal than external characteristics. The inter-country and sex heterogeneities in the role of the mediators suggest that addressing inequalities would necessitate tailored efforts. Meanwhile, the lack of an identified strong, single mediator across countries illustrate that inequalities may not be addressed by solely acting upon a single factor but must be tackled upstream with social and structural interventions that address the principal causes of inequalities. In this paper, we underline the use of mediation analysis based on the potential outcomes framework in assessing such inequalities. More research is needed to explore other potential mediators and contextual factors. Beyond measuring inequalities in HIV testing, there is a need to understand their drivers to help tailor interventions that could reduce them and 'leave no one behind'.

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Conflicts of interest

There are no conflicts of interest.

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