Intersectional forces of rising urban inequality and the global AIDS pandemic: A retrospective analysis

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This analysis determines how the intersection of increased urban growth and poverty have impacted HIV incidence and prevalence, given the need to address a growing HIV inequality globally. It is a retrospective analysis using combined data from five publicly available, population-level datasets to determine city- and within-urban countrywide estimates of 95-95-95 global HIV treatment targets, prevalence, and incidence rates from 2015 to 2019.

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The Global Council on Inequality, AIDS and Pandemics set up by the Joint United Nations Programme on HIV and AIDS gathers and analyzes evidence to better understand precisely how inequalities at national and gathers and analyzes evidence to better understand precisely how inequalities at national and international levels drive pandemics, including AIDS, and how pandemics fuel inequalities. The Global Council's background papers are circulated for discussion and feedback purposes only. They have not yet been peer-reviewed. Kindly direct feedback to the main Author.

ABSTRACT

Objective: To determine how the intersection of increased urban growth and poverty has impacted HIV incidence and prevalence, given the need to address a growing HIV inequality globally.

Design: Retrospective analysis using combined data from five publicly available, population-level datasets to determine city- and within-urban countrywide estimates of 95-95-95 global treatment targets, prevalence, and incidence rates from 2015 to 2019.

Setting: For city-level estimates, we analyzed combined data from: Fast-Track City (FTC), SINAN from Brazil, and UNAIDS Naomi-Spectrum. Countrywide estimates of HIV prevalence in the urban poorest versus non-poorest since 2012 were compiled from Population-Based HIV Impact Assessment surveys (PHIA) in 12 countries and Demographic and Health Surveys (DHS) in 28 countries.

Results: We found that HIV prevalence is generally higher in urban areas than rural areas, and highest among the urban poorest. This factor ultimately results in national estimates of HIV masking nuances in HIV inequalities between the urban rich and poor. Specifically, national and city-level HIV estimates mask inequalities within and between cities, with secondary cities often having higher HIV prevalence and incidence rates than capital cities and large urban areas.

Conclusion: The urban divide between the poor and rich is a key driver of HIV inequality, often with poorer outcomes in smaller cities than their larger counterparts. Interventions tailored to cities, and particularly those considering local nuances in sub-populations (e.g., different genders, ages, roles), are necessary to reduce HIV inequality. Focused HIV programming accounting for structural drivers of inequalities between urban poor and non-poor populations such as inequalities in wealth, education, employment, and housing, are crucial to closing gaps driving HIV inequalities globally.

INTRODUCTION

Approximately 56% of the world's population currently lives in urban areas and that proportion is expected to increase to 68% by 2050.[1] Ninety percent of projected urban growth will be in African and Asian cities alone, with a disproportionate increase amongst the poorest.[1] The SARS-CoV-2 pandemic has accelerated this trajectory, both by increasing the number of people who are newly poor.[2,3] Cities also remain the center of the HIV pandemic globally, with a single city accounting for up to 30% of a country's HIV burden in some cases.[4] This pattern has emerged despite the many advantages cities have in offering cost-effective HIV service infrastructure and resources.[5] Understanding the intersectional forces of rising urban inequality with the global HIV pandemic is crucial to reaching the 95-95-95 targets and ending the global HIV epidemic by 2030, as set forth by the latest UNAIDS Global AIDS Strategy 2021-2026.[6]

Historically, HIV prevalence was associated with higher wealth, but recent findings have indicated that this association has weakened over time and that urbanicity is a confounding factor.[7] The determinants of socioeconomic inequalities in the global HIV pandemic are poorly understood. However, previous studies in sub-Saharan Africa have found that inequality is often a more important risk factor for HIV prevalence than wealth at the aggregate level,[8] and data clearly support the impact of intersectional forces of economic inequality on other marginalized identities and social positions globally.[9] In 2021, key populations such as men who have sex with men, people who inject drugs, transgender people, and sex workers and their clients accounted for 70% of HIV infections globally.[10]

Geographic factors, such as urban residence, also factor prominently. Prior research using the Demographic Health Survey (DHS) and AIDS Indicator Surveys to measure inequalities in

HIV prevalence in 24 countries in sub-Saharan Africa suggested that HIV is more prevalent among relatively wealthier countries and individuals within the region.[11] However, within urban areas in countries such as Uganda, Kenya, Zimbabwe and Swaziland, HIV was more prevalent among the poor.

We utilized data from publicly available, population-level, datasets to examine HIV incidence and prevalence variability at the intersection of urbanity and poverty, and to answer the following research questions: What is the variation in HIV incidence and prevalence across large and smaller urban areas globally? What is the variation in HIV incidence and prevalence within urban areas between urban poor and non-poor?

METHODS

We performed a retrospective analysis using combined data from five publicly available, population-level datasets to determine city- and within-urban countrywide estimates of prevalence and incidence rates (from 2015 to 2019). For city-level estimates, we analyzed combined data for 222 cities across UNAIDS-defined regions where we had data for >10 cities. Resulting regions included: Eastern and Southern Africa (98 cities); West and Central Africa (83 cities); Latin America and the Caribbean (18 cities); and Western and Central Europe, and North America (23 cities). City-level data sources included: Fast-Track City (FTC) database with incidence and prevalence directly reported by city authorities (primarily surveillance data), SINAN with directly reported prevalence from Brazilian city authorities, and UNAIDS Naomi-Spectrum sub-national modeled estimates in Africa. The Naomi-Spectrum estimates are produced by administrative units, so we used administrative unit estimates where they were geographically aligned with city boundaries. UNAIDS Global AIDS Monitoring and AHEAD database from the United States were also considered but not included because cities either had a more recent direct estimate from FTC or SINAN, or a more recent modeled estimate in Naomi-Spectrum. Countrywide estimates of HIV prevalence in the urban poorest versus non-poorest (since 2012) were compiled from Population-Based HIV Impact Assessment surveys (PHIA) in 12 countries and DHS in 28 countries.

Statistical methods

City prevalence and incidence indicators were spatially joined to city boundaries from the Functional Urban Areas dataset by the European Commission and mapped.[12] The Naomi-Spectrum estimates modeled by administrative units were matched to Functional Urban Area boundaries in a Geographic Information System using visual inspection. The Functional Urban Areas dataset included population estimates for 2015, which were used to classify cities by population size based on Dijkstra et al 2021,[13] and whether it was a capital city, as follows: capital/extra-large (>5 million); large (1 million-5 million); medium (250,000-1 million); and small (<250,000). We refer to capital cities and cities with more than 5 million people as "major cities," and all other cities as "secondary cities." Prevalence and incidence rates were compared across city types within regions (where we had data for at least 50 cities) using the t-test statistic, and p-values less than 0.1 were interpreted as indicating a potential difference.

To understand within-city disparities, HIV prevalence estimates were calculated from PHIA and DHS survey data sets by urban "slum" and urban non-"slum" households. Incidence data were not available in a majority of these surveys, and thus are not reported in this analysis.

"Slum" households are defined by UN-Habitat as lacking improved water, improved sanitation, durable floor, or sufficient space.[14] Although "slum" households are not necessarily located in areas with informal settlement, this asset-based definition is a strong proxy of the urban poorest and populations living in the most deprived areas of cities. The “slum” household definition is an absolute measure of poverty that is measured with the same assets consistently across countries and over time.

Mean prevalence estimates were calculated by “slum”/non- “slum” household type applying sampling weights specific to individuals interviewed about HIV in each survey, and plotted by country and region. Statistical analysis was conducted using SAS Enterprise Guide,[15] STATA 17,[16] and Python.[17] Spatial data management, analysis, and mapping were performed in ArcGIS 10.8.[18]

RESULTS

The maps in **Figure 1** underscore the importance of disaggregating HIV indicators beyond national to the city-scale where there is large variability in prevalence and incidence rates. In Tanzania, for example, the Naomi-Spectrum model estimated a prevalence of 0.8% and incidence of 25 cases per 100,000 people in Zanzibar City (population 700,000), 9.0% prevalence and 242/100,000 incidence in Makambako (population 70,000), and 3.9% prevalence and 116/100,000 incidence in Dar es Salaam (population 5.6 million). Similar disparities were observed across cities in Ethiopia, Ghana, and other countries. We found that capital cities and other major cities (i.e., 5 million or more population) did not always experience the greatest HIV burden; in many cases large secondary cities (i.e., 1 - 5 million population) had similar or higher HIV prevalence and incidence rates, though these patterns differ by region.

In Eastern and Southern Africa (ESA), the mean prevalence of HIV in major cities was 6.5% on average compared with 11.8% in large cities ($p<0.05$), but no differences in mean prevalence were detected between major cities and secondary cities with fewer than 1 million residents (medium: 4.9%, $p>=0.1$; small: 4.6%, $p>=0.1$) (**Table 1**). Mean HIV incidence followed a similar pattern in this region with 247 cases per 100,000 in major cities and a higher, but not statistically different rate, in large cities (314/100,000, $p>=0.1$). Unlike the prevalence pattern, however, incidence rates were lower in secondary cities of less than 1 million people compared with major cities (medium: 127/100,000, $p<0.1$; small: 131/100,000, $p<0.1$) (**Table 1**).

In West and Central Africa (WCA), no statistical differences were detected in HIV prevalence or incidence in major versus secondary cities of any size (**Table 1**), though several secondary cities had similar incidence and prevalence as major cities. Mean prevalence was 1.57% in major cities, compared to 1.44% ($p>=0.1$) in large cities, 1.03% ($p>=0.1$) in medium cities, and 1.65% ($p>=0.1$) in small cities. However, comparatively lower levels of HIV infection in this region make differences more difficult to detect. We did not perform statistical comparisons among cities in Latin America and the Caribbean or in Western and Central Europe and North America because we had data on relatively few cities, and levels of HIV infection are relatively lower in these regions; however, mean prevalence and incidence across city types do not vary widely (**Table 1**). While it is known that key population epidemics, for example among sex workers, people who inject drugs, and men who have sex with men, account for large segments of the HIV epidemic in many of these cities,[10] analysis of subpopulation epidemics is outside the scope of this analysis.

Figure 1. HIV prevalence and incidence since 2015, by city

Sources: Naomi-Spectrum model estimates (81% of prevalence, and 91% of incidence data), Fast-Track Cities direct reports (13% of prevalence, and 9% of incidence data), SINAN direct reports (6% of prevalence data).

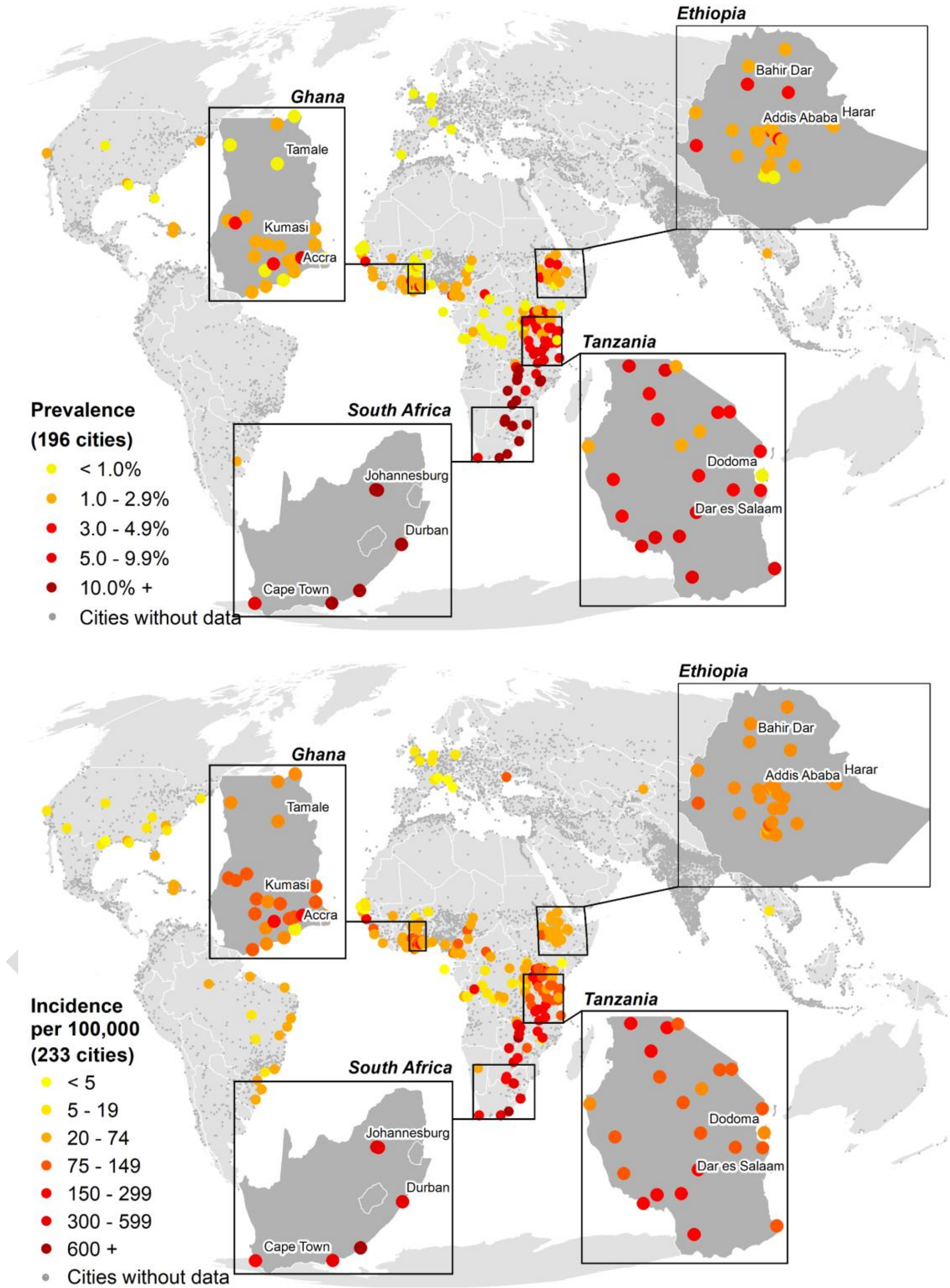


Table 1. City prevalence and incidence by city population and region

	Prevalence					Incidence					Interpretation
City type	**N**	**Mean**	**SD**	**t-test**		**N**	**Mean**	**SD**	**t-test**		
Africa - Eastern & Southern	97	5.34	4.54			97	156	213			
Capital/XL (5M+)	14	6.54	4.36	Ref.		14	247	451	Ref.		A similar proportion of people are living with HIV (prevalence) in small- and medium-sized as capital/XL cities, and large cities have the largest proportion of people living with HIV (greater than capital/XL cities). Additionally, more people are testing positive (incidence) in large, XL, and capital cities than in small- or medium-sized cities.
Large (1M-5M)	5	11.76	4.74	5.22	*	5	314	135	67		
Medium (250k-1M)	26	4.92	4.71	-1.62		26	127	147	-120	†	
Small (<250k)	52	4.62	4.04	-1.92		52	131	126	-116	†	
Africa - West & Central	81	1.45	1.09			83	50	49			
Capital/XL (5M+)	20	1.57	1.08	Ref.		20	51	66	Ref.		Prevalence and incidence rates are not substantially different in capital/XL cities than smaller non-capital cities, though a larger sample size of cities may be needed to detect differences.
Large (1M-5M)	10	1.44	0.88	-0.13		10	52	32	<1		
Medium (250k-1M)	20	1.03	0.83	-0.54		22	31	24	-21		
Small (<250k)	31	1.65	1.27	0.08		31	64	51	12		
Latin America & Caribbean	5	1.50	0.38			17	34	14			
Capital/XL (5M+)	2	1.60	0.56	N/A		3	25	2	N/A		Insufficient sample size to evaluate differences across city types.
Large (1M-5M)	0	--	--			7	37	19			
Medium (250k-1M)	2	1.60	0.28			5	35	10			
Small (<250k)	1	1.10	--			2	33	19			
West & Central Europe, North America	12	0.68	0.44			22	14	10			
Capital/XL (5M+)	4	0.68	0.32	N/A		5	18	13	N/A		Insufficient sample size to evaluate differences across city types.
Large (1M-5M)	4	0.44	0.22			7	12	6			
Medium (250k-1M)	4	0.93	0.64			8	15	10			
Small (<250k)	0	--	--			2	10	10			

Key: * $p<0.05$, † $p<0.1$

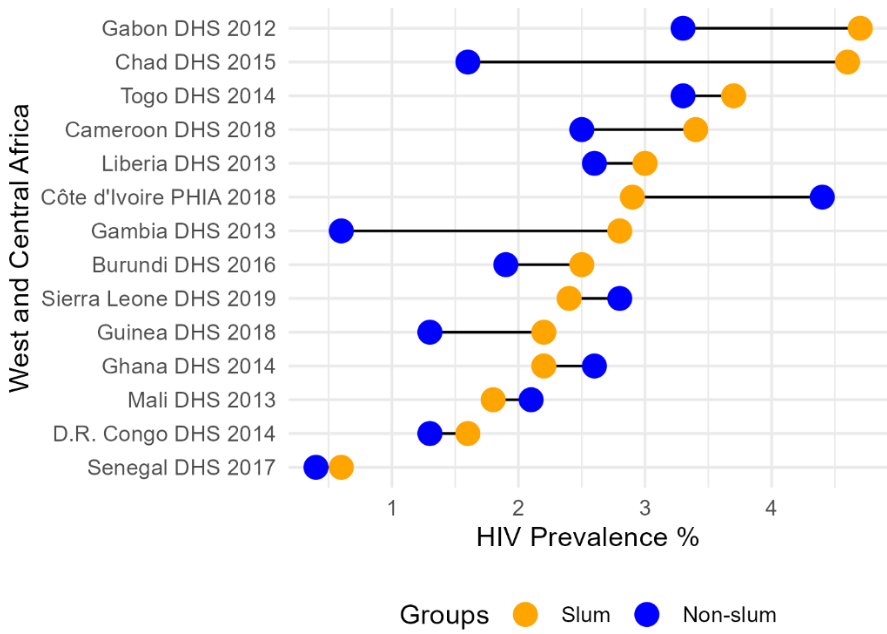
Note: The regions of "Asia & Pacific" and "Eastern Europe & Central Asia" are not reported because we had prevalence and/or incidence data for only two cities in each region. The following countries had a large number of cities in the analysis which might influence results: US (13), Tanzania (23), Kenya (13), Ghana (24), Ethiopia (28), DR Congo (21), Cameroon (12), and Brazil (13).

Within urban areas, we found that HIV prevalence is higher among the urban poorest compared to urban non-poor counterparts. **Figures 2-4** show HIV prevalence across four regions of the world where DHS or PHIA data are available since 2012. Countries are ordered from largest to smallest disparity in HIV prevalence between urban "slum" and non-"slum" dwellers. The disparity in HIV prevalence between the urban “slum” and non- “slum” dwellers remained high in ESA reflecting the HIV epidemiology in the area.

Gaps between rich and poor are far larger in some countries than in others (e.g., South Africa has twice as many “slum” dwellers living with HIV as non-“slum” dwellers - see **Table 1**). Overall, the trend is towards the highest HIV prevalence being amongst the urban poorest. This factor ultimately results in national estimates of HIV masking nuances in HIV inequalities between the urban rich and poor.

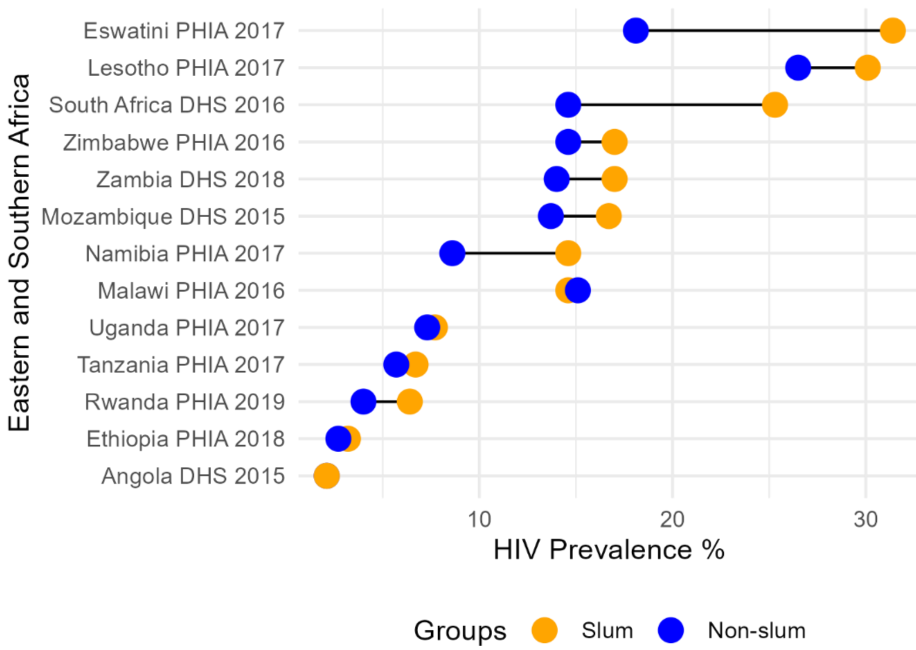
In WCA, comparison of HIV prevalence for “slum” and non-“slum” populations showed higher HIV prevalence in “slums” compared to non-“slum” in 8 out of 13 countries (62%): Chad, Gambia, Gabon, Guinea, Togo, Liberia, DR Congo and Senegal. However, we found a different trend for Côte d’Ivoire, Cameroon, Ghana, Sierra Leone, and Mali where non-“slum” populations seem to have higher prevalence than “slum” populations. Senegal showed a narrower variation in HIV prevalence estimates between the groups.

Figure 2: Prevalence of HIV in West and Central Africa by setting (urban "slum" and non- "slum")



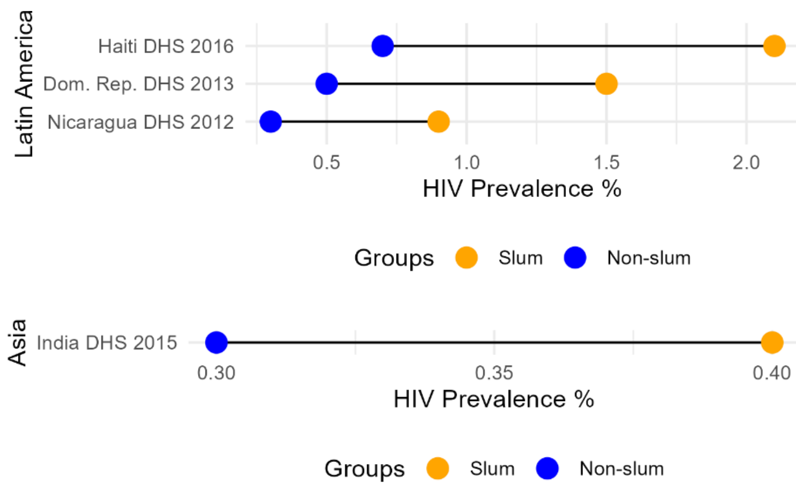
In ESA, most countries except for Namibia and Malawi had higher HIV prevalence among "slum" compared to non- "slum" populations. Meanwhile, in Burundi, Ethiopia, Malawi and Uganda, "slum" and non- "slum" populations had similar HIV prevalence rates. Burundi, Ethiopia, Uganda and Angola had smaller differences in HIV prevalence between "slum" and non- "slum" groups. Overall, narrower differences in HIV prevalence were observed across economic groups in East African countries whereas disparities were greater in Southern African countries.

Figure 3: Prevalence of HIV in Eastern and Southern Africa by setting (urban "slum" and non- "slum")



In Latin America, HIV prevalence among "slum" populations was roughly three times higher than non- "slum" populations in Haiti, Dominican Republic, and Nicaragua. In India where we have data from 2015, we also found "slum" populations to have higher HIV prevalence rates compared to non- "slum" populations.

Figure 4: Prevalence of HIV in Latin America and Asia by setting (urban "slum" and non-"slum")



DISCUSSION

In this retrospective study analyzing combined data from five population-level datasets, we found the urban divide between the poor and rich is a key driver of HIV inequality, with a significant trend towards the urban poor ("slum") suffering higher HIV prevalence rates compared to their urban non-poor (non- "slum") counterparts. This phenomena is likely due to structural drivers of inequalities between urban poor and non-poor populations such as inequalities in wealth, education, employment, and housing, which have been well documented to negatively affect HIV outcomes for the poor compared to their richer counterparts including through higher rates of prevalence and mortality, lower testing uptake, and lower levels of HIV knowledge.[19-23] For example, a systematic study on socio-economic differences and HIV/AIDS mortality in sub-

Saharan Africa demonstrated that persons of low socio-economic status defined through income level and education, had over 50% risk of dying from HIV/AIDS.[20] Few studies have additionally demonstrated that HIV further exacerbates the effects of poverty.[19,24] Our study adds to extant literature as one of the first analyses to utilize multiple publicly available cross-national datasets to assess the combined impact of poverty and urbanity on HIV outcomes. It additionally demonstrates that national estimates of HIV mask nuances in HIV inequalities between the urban rich and poor.

Beyond disparities within a given urban setting, our cross-national analyses highlighted similar or worse outcomes in smaller cities (e.g., a population between 1-5 million) than their larger counterparts (e.g., a population of >5 million). Possible explanations of this phenomena could be related to disparities in resources or funding between major and secondary cities; geographical location of Ministries of Health, National AIDS Councils, large academic institutes, and research hospitals driving prioritization of HIV programming; and additional resourcing for capacity building or quicker uptake of innovative programming and interventions in major cities. While the existence of sub-national variations in HIV outcomes (i.e., mortality, incidence, prevalence) have been well established,[25-27] this is the first global analysis to incorporate urbanity and population size to better understand sub-national variations. Our analysis demonstrates that inequalities between cities, particularly major and secondary cities can help inform geographically equitable resourcing and financing towards closing 95-95-95 gaps.

This study has some critical limitations. City datasets used were not perfectly comparable as methodologies differed with a mix of surveillance and modeled data. We accounted for this discrepancy by using surveillance data where possible. The datasets reported data for different years spanning from 2019-2021, with the majority of the data reported in 2021. The cities included in the study were based on availability of data, so we were not able to have a representative number of cities from each region for the regional analysis. Additionally, the following countries had a large number of cities in the analysis which might influence results: United States (13), Tanzania (23), Kenya (13), Ghana (24), Ethiopia (28), Democratic Republic of Congo (21), Cameroon (12), and Brazil (13). Assessment of urban poor vs non-poor included merging two separate data sets, DHS and PHIA, both of which utilize cross sectional survey methodologies with some variations. Both surveys collect HIV self-reported status, which could be an underestimate,[28-30] while other studies have found that self-reporting of HIV seropositivity does provide reasonable estimates.[31]

Poverty can be difficult to define in any context, especially urban contexts where asset ownership does not necessarily reflect vulnerabilities to food, housing, and other insecurities during economic shocks such as accident, illness, job loss, COVID-19 lockdowns/curfews, or food or fuel price fluctuations. Furthermore, in many countries, poverty from censuses and surveys are known to undercount "slum" dwellers and other vulnerable urban residents.[32] In our analysis of household survey data, we used "slum-households," a widely accepted metric of poverty which is based on household assets to assess relative and absolute poverty, though this dataset might have under-represented data on the urban poorest. Previous studies have found that different forms of wealth, for example, wage economy compared to agricultural economy, are differentially associated with HIV infection.[33] The present study does not disaggregate wealth along different dimensions, which may conceal varied effects.

Additionally, we would be remiss not to acknowledge that HIV inequalities are most prominent among key populations (i.e. men who have sex with men, people who inject drugs, sex workers) and adolescent girls and young women.[10] Despite key populations making up only 5% of the global population, 70% of new infections in 2021 were among key populations and their sexual partners.[10] A key limitation in our study was the inability to assess intersecting vulnerabilities between poverty and key and vulnerable populations due to scarcity in data; a particularly important question given that key and vulnerable populations are often economically marginalized and likely disproportionately represented among the urban poorest.[19,34-36] Although global and national HIV reporting systems, including several of those included in our study, try to encourage tracking and reporting of HIV indicators among key and vulnerable populations, only a very limited number of cities or national HIV surveys actually collect and report these data in urban areas.

There is a large scope for additional research to better map out and understand the contexts for geographical and structural HIV inequalities. Further explorations are required to better understand how spatial inequalities affect HIV prevalence rates within countries to guide HIV interventions and policies; particularly as it relates to the secondary cities that experience equal or greater HIV burden compared to major cities; including nuanced regional differences. In addition, it would be informative to understand intersectional vulnerabilities of key and vulnerable populations in the context of poverty, which requires robust collection of sub-national sub-population data. Lastly, understanding the structural drivers underpinning HIV inequalities between urban poor and non-poor populations can inform other health inequalities (e.g., pandemics, infectious diseases, non-communicable diseases).

CONCLUSION AND POLICY IMPLICATIONS

We examined five publicly available datasets and found that the urban divide between the rich and poor is a key driver of HIV inequality. Additionally, our cross-national analyses highlighted similar or worse outcomes in large secondary cities (e.g., a population between 1-5 million) than their major/capital city counterparts (a population of >5 million or capital cities). Framed within our global efforts to attain the UNAIDS 95-95-95 targets and the goal to end AIDS by 2030, it is critical to understand social, geographical, and structural inequalities that are limiting us from attaining these goals. Focused HIV programming accounting for sub-national variations and structural drivers of inequalities between urban poor and non-poor populations such as inequalities in wealth, education, employment, and housing, are crucial to closing gaps driving HIV inequalities globally.

What is already known on this topic

- There is a global rise in urban growth amongst the poorest in the world and cities remain the epicenter of the global HIV pandemic.
- Sub-national variation in HIV burden has been well documented with some cities faring better than others
- There is a demonstrated link between structural inequalities such as inequalities in education, housing, and income, and inequalities in health outcomes.

What this study adds

- We found that HIV prevalence is higher among the urban poorest compared to urban non-poor counterparts which ultimately results in national estimates of HIV masking nuances in HIV inequalities between the urban rich and poor.
- We found that large secondary cities (1-5 million population) often have equal or greater HIV incidence and prevalence compared to major cities.
- These data provide a framework for focused HIV programming crucial to closing gaps driving HIV inequalities globally.

SUPPLEMENT

Table S1. Comparison of FTC reports vs Naomi-Spectrum estimates in cities with both data sources

City	Country	Prevalence		Incidence	
		FTC	Naomi	FTC	NAOMI
Kinshasa	DR Congo	--	0.6	0.48	17
Accra	Ghana	1.7	1.4	1.1	61
Nairobi	Kenya	6	3.4	--	106
Blantyre	Malawi	17.37	10.6	0.42	221
Lagos	Nigeria	--	0.7	0.49	20
Lusaka	Zambia	--	10.9	1783	322

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