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Disparities in HIV Linkage and Receipt of Care within Atlanta

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Disparities in HIV Linkage and Receipt of Care within Atlanta

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B.S., Tuskegee University, 2016
M.D., Meharry Medical College, 2020

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An abstract of
A thesis submitted to the Faculty of the
Rollins School of Public Health of Emory University in
partial fulfillment of the requirements for the degree of
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Abstract

Disparities in HIV Linkage and Receipt of Care within Atlanta

By Eric Johnson, M.D.

Background

HIV has posed a significant public health threat in the United States for over forty years. Atlanta, Georgia, one of the largest metropolitan areas in the South, is at the epicenter of new HIV diagnoses in the region. Although Black/African American individuals make up 33% of Atlanta's population, they account for 69% of new HIV diagnoses annually. Linkage to care (LTC) and receipt of care (ROC), following diagnosis, are critical steps in HIV management.

Objective

This study aimed to evaluate associations between LTC and ROC outcomes and key social determinants of health (SDOH) at the zip-code level in Atlanta, with a focus on racial disparities in LTC and ROC.

Methods

Zip code level HIV and SDOH data were sourced from the AIDSVu 2022 Atlanta dataset. LTC was defined as HIV intervention within a month of diagnosis and ROC defined as HIV intervention in the given year. Using unadjusted and adjusted linear regression and negative binomial regression, we measured the association between zip code level SDOH and zip code level LTC/ROC percentages and counts, respectively, stratified by race (Black, White, and Total).

Results

The LTC and ROC analyses included 61 and 145 zip codes, respectively. 77.1% Black and 82.1% White populations diagnosed with HIV were linked to care; 77.7% and 81.6%, respectively, received care. Linear regression showed that among Black cases, higher severe housing burden and greater median household income were significantly associated with higher LTC (housing burden 1.48%, $p = 0.0025$; household income 0.0002%, $p = 0.0321$). Negative binomial models showed that people in a zip code with less than a high school education was associated with 7.0% (Black) and 5.1% (White) lower LTC cases, and 8.75% (Black) and 5.2% (White) lower ROC cases.

Conclusions

Zip code level education-related social determinants of health were strongly associated with reduced HIV linkage to and receipt of care, particularly among African American populations. Other SDOH factors, such as income and housing burden, showed less consistent effects. With some findings displaying no significant effects at all. Further research is needed to refine analysis and address structural barriers to HIV care, especially for marginalized groups in the Southern U.S.

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Table of Contents

Introduction

HIV has posed a significant public health threat to the United States population for over forty years. The Southern U.S. is the most affected region of the country: as of 2023, the South accounted for 51% of new HIV cases (20,188 cases) in the U.S.(6). Nationally, 38% of new HIV diagnoses are in Black/African American individuals (14,754 cases); of these 48% were in the South. Black/African Americans are the racial/ethnic group with the highest rate of new HIV diagnoses in the country (2,5).

Atlanta, Georgia, one of the largest metropolitan areas in the South with nearly six million people, is at the epicenter of new HIV diagnoses in the South (3,5). Georgia itself is the state with the highest incidence of HIV and HIV-associated mortality in the country (5). As of 2022, there were over 43,000 people in Atlanta living with HIV. Black/African-American people represent 33% of the population in Atlanta, yet account for 69% of new diagnoses of HIV each year (2). This high incidence can potentially be attributed to a wide variety of factors including socioeconomic factors, stigma towards HIV, reduced healthcare access, and reduced HIV pre-exposure prophylaxis (PrEP) use rates, among others (4,12,18,19).

Following HIV diagnosis, linkage to care and receipt of care are critically important. Not only does receiving HIV care improve treatment outcomes for patients, but efficient linkage to care works to reduce HIV transmission to other people at risk (15). National statistics suggest that 81.6% of patients are linked to care within a month after diagnosis, while 75.6% are retained in care for a year after their diagnosis (2). In comparison, Atlanta statistics have shown that 78.0% are linked to care within a month of diagnosis, while 78.2% are retained in care within the year of their diagnosis (2).

Black/African Americans, particularly those living in the South, face numerous barriers to linkage and the receipt of HIV care. Previous studies have suggested that many African Americans with HIV deal with barriers like active and systemic discrimination which impede effective prevention and treatment (7,10). This is especially relevant, since it has been shown that black men who have sex with men (MSM) are linked to care at lower rates than other demographics (13,15). Policy choices, like the refusal for the state to utilize Medicaid expansions through the Affordable Care Act (ACA), have prevented notable improvements to HIV care linkage for these populations (9). Also of note, the southern U.S. has a high concentration of the nation's black population, and with it, many social and religious norms shaped by religious institutions such as the "black church"(8). Notably, aspects of homophobia and discomfort discussing sexual health within these institutions may contribute to HIV risk and should be carefully considered (8). All of these factors, and others, each collectively contribute to the environment in Atlanta in which HIV prevention, linkage, and receipt of care continue to be persistent issues in need of further investigation.

The goal of this study was to further evaluate HIV linkage to care and receipt of HIV care within Atlanta. Specifically, potential disparities by race were evaluated for linkage to care and receipt of care data and their relationship to select social determinants of health (SDOH) factors.

Methods

Data Source

The data source for this analysis was AIDSVu, an online mapping tool and data repository that contains multi-level deidentified data on HIV incidence, prevalence, linkage to care, receipt of care, and viral suppression for open use (19). Zip code-level data is available at national, regional, state, county, and city levels for HIV positive individuals aged 13 and older. Data is provided to AIDSVu by primary sources such as: Centers for Disease Control and Prevention (CDC), local and state health departments, as well as American Community Survey (ACS) from the U.S. Census Bureau.

This study used the 2022 Atlanta, GA dataset, the most recent year of data available (2). This data set included zip code level HIV linkage to care data, receipt of care data, social determinants of health data (SDOH), and a general city profile data set. Zip codes included in the dataset were those within the Atlanta metropolitan statistical area (MSA) (19).

Exposures

The primary exposure variables used within this study were five social determinants of health variables (SDOH). The SDOH variables for this study were defined by AIDSVu. These included percent living in poverty, median household income, percent living with severe housing cost burden, percent with less than a high school education, and the Gini coefficient; all were measured at the zip code level. Poverty was defined as percent living below the federal poverty line (19,20). Percent living with severe housing cost burden was defined as the percent of renters and owners paying above 50% of their income on their housing costs (19). Percent with less than a high school education was defined as people aged 25 and above without a high school degree or its equivalent(19). The Gini coefficient is a measure of income inequality, which is a ratio scored within a range of 0 for full equality to 1 for full inequality (19).

Outcomes

The primary outcomes of this study were the zip code level percentages and counts of patients meeting criteria for linkage to care (LTC) and receipt of care (ROC). LTC was defined as a CD4 or HIV viral load measured within one month following new diagnosis. LTC was reported for 2018-2022. Zip code count data from this dataset was based on a person's zip code at the time of HIV diagnosis.

Receipt of care (ROC) was defined as a CD4 or HIV viral load measured within six months of new HIV diagnosis. In contrast to LTC, this variable was only reported for 2022. Patients were attributed to zip codes based on their most recent known addresses as of 2022. ROC percentage values were calculated using a numerator that included individuals diagnosed with HIV by the end of 2022, still alive in 2022, who have either a CD4 or HIV viral load within the year (19). The denominator included all 13-year-old cases or older who were living with HIV as of 2022, excluding new diagnosed cases from that year.

Data Analysis

Descriptive statistics were used to compare demographic and SDOH characteristics. To evaluate the association of race and linkage to care/receipt of care within zip codes, we performed unadjusted and adjusted linear and negative binomial regressions. Linear regression was used to measure the association between SDOH and the percentage of patients linked to care or who received care within a zip code. Negative binomial regression was used to measure the association between SDOH and the count of patients linked to care or who received care within a zip code. Negative binomial regression was used in place of Poisson regression to correct for high deviance within the final models identified with Poisson regression. Regression analyses were completed using SDOH variables as exposure variables, first individually and then in a complete model using all SDOH variables. Independent variable selection for the final models was determined using backwards elimination and collinearity testing. Utilizing these methods, the Gini coefficient was removed from the final model due to not meeting the significance threshold in backwards elimination ($p<0.05$). The variable percent living in poverty was initially selected for removal as well, but was retained due to its importance to the research question and as a social determinant of health.

We additionally conducted a sensitivity analysis where we included the Gini coefficient as a covariate in the negative binomial models. This study was deemed exempt from IRB approval by the Institutional Review Board of Emory University. All analyses were completed in SAS 9.4 (Cary, NC).

Results

Demographics/Characteristics

The linkage to care (LTC) group consisted of 61 total zip code observations after model selection and data cleaning. Table 1 shows summary statistics for the multiple LTC variables, including the outcome variables and exposure variables. Out of the included sample for this model, an average of 77.8% those diagnosed with HIV were linked to care (Table 1). When stratified by race, an average of 77.1% and 82.1% were linked to care for Black and White populations within included zip codes respectively (Table 1). The mean percent living with severe housing cost burden was 15% across zip codes, however, the range was 6.4% to 29.4% (Table 1). A mean of 11.8% of people across all zip codes lived in poverty, while a mean of 8.5% of people across zip codes had less than a high school education (Table 1). The average median household income for the included zip codes was $86,440 (Table 1). Notably, median household incomes ranged from $32,374 to $162,808 (Table 1).

Variable	Mean	Median	Std Dev
Percent Linked to Care (All Races)	77.8	78.1	7.5
Number of Cases Linked to Care (All Races)	55.1	37.0	46.9
Percent Linked to Care (Black)	77.1	77.3	11.6
Number of Cases Linked to Care (Black)	36.2	21.0	40.4
Percent Linked to Care (White)	82.1	83.3	15.9
Number of Cases Linked to Care (White)	8.6	7.0	5.7
Percent Living with Severe Housing Cost Burden (All Races)	15.0	14.8	5.0
Percent Living in Poverty (All Races)	11.8	9.7	6.8
Percent with Less than a High School Education (All Races)	8.5	7.8	5.2
Median Household Income ($) (All Races)	$86440.5	$84973.0	$25942.2

Table 1.

Descriptive Statistics for Linkage to Care and Zip Code Level Social Determinants of Health in Atlanta, AIDSVu Atlanta Dataset, 2022

Variable	Mean	Median	Std Dev
Percent That Received Care (All Races)	79.1	79.1	5.1
Number of Cases That Received Care (All Races)	202.6	135.0	206.9
Percent That Received Care (Black)	77.7	78.2	6.3
Number of Cases That Received Care (Black)	139.1	80.0	172.1
Percent That Received Care (White)	81.6	82.4	8.8
Number of Cases That Received Care (White)	32.2	21.0	38.1
Percent Living with Severe Housing Cost Burden (All Races)	14.2	13.6	5.0
Percent Living in Poverty (All Races)	11.4	9.7	6.2
Percent with Less than a High School Education (All Races)	9.3	8.4	5.6
Median Household Income ($) (All Races)	$85557.4	$80697.0	$26750.5

Table 2.

Descriptive Statistics for Receipt of Care and Zip Code Level Social Determinants of Health in Atlanta, AIDSVu Atlanta Dataset, 2022

The receipt of care (ROC) group consisted of 145 zip code observations after model selection. Table 2 similarly displays summary statistics for key variables related to ROC, including both outcome and exposure variables. Across zip codes, a mean of 79.1% of new HIV diagnoses received HIV care (Table 2). A mean of 77.7% of the Black population received care (Table 2). A mean of 81.6% of the White population received care (Table 2). The mean percent living with severe housing cost burden was 14.2% across zip codes (Table 2). Additionally, a mean of 11.4% people across zip codes were living in poverty and 9.3% had less than a high school education across zip codes (Table 2).

Linear Regression: Linkage to Care Models (LTC)

Variable	Total Percent Estimate (SE)	p-value	Black Percent Estimate (SE)	p-value	White Percent Estimate (SE)	p-value
Percent with Severe Housing Cost Burden	0.75 (0.31)	0.0196	1.48 (0.47)	0.0025	-0.84 (0.69)	0.2284
Percent Living in Poverty	-0.09 (0.25)	0.7160	-0.61 (0.37)	0.1090	1.13 (0.55)	0.0437
Percent with Less than a High School Education	0.26 (0.27)	0.3447	0.37 (0.41)	0.3703	-0.19 (0.60)	0.7459
Median Household Income	0.00018 (0.00007)	0.0092	0.00022 (0.00010)	0.0321	0.00017 (0.00015)	0.2496

Table 3.

Linear Regression Associations Between HIV Linkage to Care and Social Determinants of Health by Race in Atlanta, AIDSVu Atlanta Dataset, 2022

For the Total percentage model, LTC for all patients was 0.75% higher, for every 1% increase in zip code level rates of severe housing cost burden (β=0.74610,p=0.0196) (Table 3). Among Black patients, a 1% increase in the percent of people with severe housing cost burden in a zip code was associated with 1.48% higher linkage to care (p=0.0025), while a $1 increase in the median household income in a zip code was associated with 0.0002% higher linkage to care (p=0.0321) (Table 3). The percent of people living in poverty and the percent of people with less than a high school education in a zip code were not statistically significantly associated with linkage to care for Black people. Among White HIV diagnosis, a 1% increase the percent of people living in poverty in a zip code was associated with a

1.13% higher linkage to care (p=0.0437) (Table 3). No other zip code level social determinants of health were statistically significant for White patients.

Linear Regression: Receipt of Care Models (ROC)

Variable	Total Percent Estimate (SE)	p-value	Black Percent Estimate (SE)	p-value	White Percent Estimate (SE)	p-value
Percent with Severe Housing Cost Burden	-0.27 (0.13)	0.0363	-0.08 (0.16)	0.6176	-0.26 (0.22)	0.2513
Percent Living in Poverty	-0.12 (0.13)	0.3328	-0.22 (0.16)	0.1770	0.04 (0.23)	0.8465
Percent with Less than a High School Education	-0.10 (0.10)	0.3520	-0.00 (0.13)	0.9729	-0.27 (0.18)	0.1467
Median Household Income	-0.00006 (0.00003)	0.0167	-0.00007 (0.00003)	0.0500	-0.00007 (0.00005)	0.1300

Table 4.

Linear Regression Associations Between HIV Receipt of Care and Social Determinants of Health by Race in Atlanta, AIDSVu Atlanta Dataset, 2022

For the linear regression of receipt of care (ROC) models, only the model that included the total population produced statistically significant results. A 1% increase in the percentage of individuals living with severe housing cost burden in a zip code was associated with 0.27% lower ROC (β=-0.026612,p=0.0363) (Table 4). A one-dollar increase in median household income for a zip code was associated with 0.00006% lower ROC (β=-0.00006371,p=0.0167) (Table 4). The other variables were not statistically significant, although median household income for the Black population just narrowly missed the cutoff for significance (p=0.0500) (Table 4).

Collinearity Testing: Linkage to Care (LTC)

Collinearity testing of variables was completed by assessing variance inflation factor (VIF) and condition index. For each model for linkage to care, the VIF for all variables were <4. The condition index was gathered for each variable and were at most 28.53, suggesting at most moderate collinearity present.

Collinearity Testing: Receipt of Care

For each model for receipt of care, the VIF for all variables were <4, suggesting multicollinearity was not a major factor for these variables. The condition index was also gathered for all interactions. At most, the condition index was 22.86, again suggesting a moderate collinearity present between the variables percent with less than a high school education, median household income, and the intercept. Ultimately, the degree of collinearity found was not high enough to necessitate removal of any variable.

Binomial Regression: Individual Variable Models

When all cases were included, a 1% increase in the percent of people in a zip code with severe housing cost burden was associated with 9.5% higher LTC (Table 5). Similarly, a 1% increase in percent living in poverty was associated with 6.9% higher LTC (Table 5). There was no statistically significant association between the percent of people with less than a high school education in a zip code and the count of cases linked to care.

Among Black patients, for every 1% increase in the number of people with severe housing cost burden in a zip code , there was associated 12.7% higher linkage to care (p=<.0001). For every 1% increase in the percent of people living in poverty in a zip code, there was 9.6% higher LTC (p=<.0001). The association between the percent of people in a zip code with less than a high school education and LTC rates for Black patients trended towards significance (p=0.0831).

Among White cases, for a 1% increase in percent with less than a high school education, there was 2.85% lower LTC across zip codes (p=0.0316) (Table 5). There was no statistically significant association between percent with severe housing cost burden, percent living in poverty, median household income and linkage to care for White cases.

Variables	Outcome Group	Estimate (SE)	IRR (exp(β))	Change in Outcome	95% CI	p-value
Percent with Severe Housing Cost Burden	Total Cases	0.0908 (0.0164)	1.0951	+9.5%	0.0586 - 0.1230	<.0001
Percent Living in Poverty	Total Cases	0.0665 (0.0135)	1.0688	+6.9%	0.0401 - 0.0930	<.0001
Percent with Less than a High School Education	Total Cases	0.0234 (0.0184)	1.0237	+2.4%	-0.0128 - 0.0595	0.2054
Percent with Severe Housing Cost Burden	Black Cases	0.1193 (0.0197)	1.1267	+12.7%	0.0806 - 0.1580	<.0001
Percent Living in Poverty	Black Cases	0.0913 (0.0166)	1.0956	+9.6%	0.0588 - 0.1239	<.0001
Percent with Less than a High School Education	Black Cases	0.0412 (0.0238)	1.0420	+4.2%	-0.0054 - 0.0877	0.0831
Percent with Severe Housing Cost Burden	White Cases	0.0127 (0.0151)	1.0128	+1.3%	-0.0168 - 0.0423	0.3984
Percent Living in Poverty	White Cases	0.0134 (0.0112)	1.0135	+1.4%	-0.0085 - 0.0353	0.2293
Percent with Less than a High School Education	White Cases	-0.0289 (0.0134)	0.9715	−2.9%	-0.0553 - (-)0.0025	0.0316

Table 5.

Individual Binomial Regression Associations Between Linkage to Care and Social Determinants of Health Across Zip Codes in Atlanta, AIDSVu Atlanta Dataset, 2022

When all cases were included, for every 1% increase in percent with severe housing cost burden, there was 13.8% higher ROC for Total cases across zip codes (p=<0.001) (Table 6). For every 1% increase in percent living in poverty, there was 8.9% higher ROC for Total cases across zip codes (p=<0.001) (Table 6).

Among Black patients, for every 1% increase in percentage with severe housing cost burden, there was 16.9% higher associated ROC for Black cases across zip codes (p<0.001) (Table 6). With a 1% increase in percent living in poverty, there was a 11.8% higher ROC for Black cases (p<0.001) (Table 6).

Among White cases, for every 1% increase in percent with severe housing cost burden, there was 4.8% higher ROC for White cases (p=0.0015) (Table 6). For every 1% increase in percentage with less than a high school education, there was 4.6% lower ROC for White cases across zip codes (p=<0.005) (Table 6).

Variables	Outcome Group	Estimate (SE)	IRR (exp(β))	Change in Outcome	95% CI	p-value
Percent with Severe Housing Cost Burden	Total Cases	0.1290 (0.0128)	1.1377	+13.8%	0.1039 - 0.1541	<.0001
Percent Living in Poverty	Total Cases	0.0849 (0.0117)	1.0886	+8.9%	0.0618 - 0.1079	<.0001
Percent with Less than a High School Education	Total Cases	0.0123 (0.0139)	1.0124	+1.2%	-0.0149 - 0.0395	0.376
Percent with Severe Housing Cost Burden	Black Cases	0.1565 (0.0153)	1.1693	+16.9%	0.1264 - 0.1865	<.0001
Percent Living in Poverty	Black Cases	0.1113 (0.0142)	1.1178	+11.8%	0.0835 - 0.1391	<.0001
Percent with Less than a High School Education	Black Cases	0.0272 (0.0177)	1.0276	+2.8%	-0.0075 - 0.0619	0.1246
Percent with Severe Housing Cost Burden	White Cases	0.0473 (0.0149)	1.0484	+4.8%	0.0181 - 0.0765	0.0015
Percent Living in Poverty	White Cases	0.0149 (0.0118)	1.0150	+1.5%	-0.0082 - 0.0380	0.206
Percent with Less than a High School Education	White Cases	-0.0467 (0.0110)	0.9544	−4.6%	-0.0682 – (-)0.0252	<.0001

Table 6.

Individual Binomial Regression Associations Between Receipt of Care and Social Determinants of Health Across Zip Codes in Atlanta, AIDSVu Atlanta Dataset, 2022

Binomial Regression: Final Linkage to Care Models

When all cases were included, for every 1% increase in percent with less than a high school education, there was 4.5% (β=-0.0458, CI=-0.0845, -0.0070, p=0.0205) lower LTC for Total cases (Table 7).

Among Black patients, for every 1% increase in percent with less than a high school education, there was 7.0% (β=-0.0724, CI=-0.1174, -0.0273, p=0.0016) lower LTC for Black cases (Table 7).

Among White patients, for every 1% increase in percent living in poverty there was 4.9% (β=0.0476, CI=0.0107, 0.0845, p=0.0114) higher LTC for White cases (Table 7). For every 1% increase in the percent with less than a high school education, there was 5.1% (β=-0.0520, CI=-0.0895, -0.0146, p=0.0065) lower LTC for white cases (Table 7).

Variables	Outcome Group	Estimate (SE)	IRR (exp(β))	Change in Outcome	95% CI	p-value
Percent with Severe Housing Cost Burden	Total Cases	0.0288 (0.0269)	1.0292	+2.9%	-0.0239 - 0.0815	0.2843
Percent Living in Poverty	Total Cases	0.0308 (0.0218)	1.0313	+3.1%	-0.0119 - 0.0735	0.1571
Percent with Less than a High School Education	Total Cases	-0.0458 (0.0198)	0.9552	−4.5%	-0.0845 - (-)0.0070	0.0205
Percent with Severe Housing Cost Burden	Black Cases	0.0160 (0.0312)	1.0161	+1.6%	-0.0451 - 0.0771	0.6077
Percent Living in Poverty	Black Cases	0.0412 (0.0251)	1.0420	+4.2%	-0.0079 - 0.0904	0.1003
Percent with Less than a High School Education	Black Cases	-0.0724 (0.0230)	0.9302	−6.98%	-0.1174 – (-)0.0273	0.0016
Percent with Severe Housing Cost Burden	White Cases	-0.0184 (0.0229)	0.9818	−1.8%	-0.0633 - 0.0265	0.4219
Percent Living in Poverty	White Cases	0.0476 (0.0188)	1.0488	+4.9%	0.0107 - 0.0845	0.0114
Percent with Less than a High School Education	White Cases	-0.0520 (0.0191)	0.9493	−5.1%	-0.0895 - (-)0.0146	0.0065

Table 7.

Final Model Binomial Regression Associations Between Linkage to Care and Social Determinants of Health Across Zip Codes in Atlanta, AIDSVu Atlanta Dataset, 2022

Binomial Regression: Final Receipt of Care Models

When all cases were included, for every 1% increase to percent living with severe housing cost burden, there was 10.7% (β=0.1015, CI=0.0647, 0.1383, p=<0.0001) higher ROC for Total cases (Table 8). With every 1% increase in percent with less than a high

school education, there was 6.8% (β=-0.0702, CI=-0.0964, -0.0440, p=<0.0001) lower ROC for Total cases (Table 8).

Among Black cases, for every 1% increase to percent living with severe housing cost burden, there was 10.2% (β=0.0972, CI=0.0543, 0.1400, p=<.0001) higher ROC for Black cases (Table 8). For every 1% increase in percent with less than a high school education, there was 8.7% (β=-0.0915, CI=-0.1221, -0.0609, p=<.0001) lower ROC for Black cases (Table 8).

Among White cases, for every 1% increase in percent living with severe housing cost burden, there was 6.5% (β=0.0.0632, CI=0.0262, 0.1003, p=0.0008) higher ROC for White cases (Table 8). For a 1% increase in percent with less than a high school education, there was 5.2% (β=-0.0536, CI=-0.0819, -0.0253, p=0.0002) lower ROC for White cases (Table 8).

Variables	Outcome Group	Estimate (SE)	IRR (exp(β))	Change in Outcome	95% CI	p-value
Percent with Severe Housing Cost Burden	Total Cases	0.1015 (0.0188)	1.1068	+10.7%	0.0647 - 0.1383	<.0001
Percent Living in Poverty	Total Cases	0.0201 (0.0187)	1.0203	+2.0%	-0.0166 - 0.0567	0.2833
Percent with Less than a High School Education	Total Cases	-0.0702 (0.0134)	0.9323	−6.8%	-0.0964 - (-)0.0440	<.0001
Percent with Severe Housing Cost Burden	Black Cases	0.0972 (0.0219)	1.1021	+10.2%	0.0543 - 0.1400	<.0001
Percent Living in Poverty	Black Cases	0.0222 (0.0216)	1.0225	+2.3%	-0.0200 - 0.0645	0.3021
Percent with Less than a High School Education	Black Cases	-0.0915 (0.0156)	0.9125	−8.8%	-0.1221 - (-)0.0609	<.0001
Percent with Severe Housing Cost Burden	White Cases	0.0632 (0.0189)	1.0653	+6.5%	0.0262 - 0.1003	0.0008
Percent Living in Poverty	White Cases	0.0364 (0.0200)	1.0370	+3.7%	-0.0028 - 0.0756	0.0691
Percent with Less than a High School Education	White Cases	-0.0536 (0.0145)	0.9478	−5.2%	-0.0819 - (-)0.0253	0.0002

Table 8.

Final Model Binomial Regression Associations Between Receipt of Care and Social Determinants of Health Across Zip Codes in Atlanta, AIDSVu Atlanta Dataset, 2022

Sensitivity Analysis: Both models

The linkage to care for Total cases model showed two main changes with sensitivity analysis. Percent living in poverty became statistically significant, showing 275.1% higher LTC for every percent increase (p=0.0004). Along with this, the estimate for median household income was not statistically significant in the sensitivity analysis (p=0.1713). For

LTC for Black cases, the sensitivity analysis including the Gini coefficient in the model, did not significantly change the results of the negative binomial regressions.

For receipt of care for Total cases model, there were multiple changes present. Percent living with severe housing cost burden was no longer statistically significant (p=0.1521). Percent living in poverty became significant, with a notably higher association with ROC for Total cases (β=7.5082, p=0.0001). Among Black cases, notable changes included percent living with severe housing cost burden no longer being significant (p=0.208), and percent living in poverty becoming significant while displaying a strong positive association with the ROC for Black cases (β=5.8936, p=0.0002). With the receipt of care for White cases model, the most notable change found was that percent living with severe housing cost burden lost its statistical significance (p=0.4955). For the other variables, the sensitivity analysis did not significantly change the results of the binomial regressions.

Discussion

Overall, this analysis of 2022 HIV care data from Atlanta revealed distinct patterns by race and HIV care stage. Linkage to care (LTC) models showed mixed results. Having less than a high school education was associated with decreased LTC for both Black and White populations at a zip code level, with a stronger association for Black cases. Also, housing cost burden and poverty were not significant predictors for Black individuals, which was unexpected. In contrast, receipt of care (ROC) demonstrated more associations with SDOH factors. Having less than a high school education predicted reduced ROC for both groups, again with stronger effect for Black cases. Notably, higher housing cost burden was associated with increased ROC in both racial groups across zip codes, an unexpected finding that may reflect broader social implications.

The linear regression results showed that increases in LTC were associated with a higher percentage of individuals with a severe housing cost burden at the zip code level, both among Black patients and in the total sample. While unexpected, this suggests that current efforts to immediately link patients to care could be working, as the population is still able to be linked with care despite financial barriers. This may also be a result of other social factors, that were unmeasured and not focused on within this study. An association was also found with Black and the Total population regarding median household income, as they both had a positive association with LTC, although to a smaller degree. This showed a subtle increase of LTC when income is increased.

In the negative binomial regression models, The LTC models recurrently showed a negative association between LTC and percent in the zip code with less than a high school education, especially within the Black population. For that population, there was a notable (7%) decrease in LTC found with every 1% increase in the population without a high school level education. For the White population, across zip codes, there was an 4.9% increase in LTC for every percent increase in the percent of population living in poverty. This could suggest that despite living in poverty, White counterparts in Atlanta zip codes still have adequate access to immediate HIV care. This could also be the result of negative binomial

regression being more sensitive to the lower instances of White case counts, in comparison to Black cases or Total cases. Each result may have differed from the linear regression results due to negative binomial regression utilizing direct count data instead of percentages, and better accounting for data variance and dispersion as well. Also of note, median household income results for negative binomial models did not produce reliable results, so they were excluded. It was unclear why this only occurred for this specific variable.

Our findings regarding the association between housing cost burden and ROC were unexpected and not in line with previous literature. We found that ROC was more common in zip codes with higher percentages of severe housing cost burden. Prior work has shown that financial burden and housing strain can negatively affect those attempting to attain HIV care (1,16,17). Our findings may be due to an inability to account for urban density within our models, which may noticeably affect what housing burden looks like to individuals within each assessed zip code. Another reason would be that this variable is affected by bias due to the amount of removed zip code observations. With more complete models using the full number of observations across zip codes, there would be much less sensitivity to smaller numbers by race and the results ultimately would be less susceptible to bias.

Overall, this study contributes to the HIV linkage to care and retention in care literature by reinforcing certain expected associations but also showing evidence of other unexpected results. Along with this, as Atlanta continues to be one of the highest incidence and mortality cities for HIV, especially for African-Americans, this study provides more insight into the city' specific disparities faced by Black populations at a zip code level.

This study has several limitations. First, we are limited by the data available in AIDSVu, including being limited to zip code level SDOH. Additionally, AIDSVu has significant missing data due to it being compiled by multiple sources into a public database. The linkage to care data was based on HIV diagnoses from 2018-2022, which includes the COVID-19 pandemic that likely influenced an increase in both missing data and potential changes in the incidence of HIV. LTC and ROC results cannot be directly compared due to the differing timeframes and denominators used for each outcome. Finally, statistical power was likely reduced by the decreased number of ZIP code observations available for analysis, particularly for LTC models. Despite the limitations, previous studies have successfully used AIDSVu data for HIV based descriptive analysis (14).

Conclusion

These findings reveal important associations between social determinants of health (SDOH) and differing levels of HIV care access by race in Atlanta, particularly highlighting the role of educational attainment. Zip code-level disparities were especially pronounced for African American populations, where lower education levels were consistently associated with reduced access to both immediate and ongoing HIV care. In contrast, the influence of other SDOH variables, such as income and housing burden, were less

consistent and warrants further investigation. Future studies should employ refined models and more complete data to better characterize the structural barriers affecting African Americans and other marginalized groups. This work is essential to improving HIV outcomes in one of the nation's most affected metropolitan areas and to addressing the broader social inequities that shape health access.

References

1. Aidala, A. A., Wilson, M. G., Shubert, V., Gogolishvili, D., Globerman, J., Rueda, S., Bozack, A. K., Caban, M., & Rourke, S. B. (2016). Housing Status, Medical Care, and Health Outcomes Among People Living With HIV/AIDS: A Systematic Review. American Journal of Public Health, 106(1), e1-e23. https://doi.org/10.2105/AJPH.2015.302905

2. AIDSVu. (2024). Atlanta, GA city profile overview. https://map.aidsvu.org/profiles/city/atlanta-ga/overview#0-1-Locations

3. AIDSVu. (2024). U.S. national profile overview. https://map.aidsvu.org/profiles/nation/usa/overview#0-1-Locations

4. AIDSVu. (2024, February 7). AIDSVu releases new data highlighting ongoing inequities in PrEP use among Black and Hispanic people and across regions of the country. https://aidsvu.org/news-updates/news-updates-aidsvu-releases-new-data-highlighting-ongoing-inequities-in-prep-use-among-black-and-hispanic-people-and-across-regions-of-the-county/

5. Centers for Disease Control and Prevention. Diagnoses, deaths, and prevalence of HIV in the United States and 6 territories and freely associated states, 2022. HIV Surveillance Report, 2022; vol. 35. http://www.cdc.gov/hiv-data/nhss/hiv-diagnoses-deaths-prevalence.html. Published May 2024.

6. Centers for Disease Control and Prevention. Estimated HIV incidence and prevalence in the United States, 2018-2022. HIV Surveillance Supplemental Report 2024;29(No. 1). https://www.cdc.gov/hiv-data/nhss/estimated-hiv-incidence-and-prevalence.html. Published May 2024.

7. Doherty, R., Walsh, J. L., Quinn, K. G., John, S. A. (2022). Association of Race and Other Social Determinants of Health With HIV Pre-Exposure Prophylaxis Use: A County-Level Analysis Using the PrEP-to-Need Ratio. AIDS Education and Prevention, 34(3), 183-194. https://doi.org/10.1521/aeap.2022.34.3.183

8. Foster, P. P., Thomas, M., Lewis, D. (2016). Reverse Migration, the Black Church and Sexual Health: Implications for Building HIV/AIDS Prevention Capacity in the Deep South. AIMS Public Health, 3(2):242-254. https://doi.org/10.3934/publichealth.2016.2.242

9. Gai, Y., & Marthinsen, J. (2019). Medicaid Expansion, HIV Testing, and HIV-Related Risk Behaviors in the United States, 2010-2017. American Journal of Public Health, 109(10), 1404-1412. https://doi.org/10.2105/AJPH.2019.305220

10. Gant, Z., Dailey, A., Wang, S., Johnson Lyons, S., Watson, M., Lee, K., Satcher Johnson, A. (2022). Trends in HIV care outcomes among adults and adolescents in the U.S. South, 2015-2019. Annals of Epidemiology, 71, 15-22. https://doi.org/10.1016/j.annepidem.2022.04.011
11. Henkhaus, M. E., Hussen, S. A., Brown, D. N., Del Rio, C., Fletcher, M. R., Jones, M. D., Marellapudi, A., & Kalokhe, A. S. (2021). Barriers and facilitators to use of a mobile HIV care model to re-engage

and retain out-of-care people living with HIV in Atlanta, Georgia. PLoS ONE, 16(3), e0247328. https://doi.org/10.1371/journal.pone.0247328

12. Hill, M., Smith, J., Elimam, D., Mustafaa, G., Wortley, P., Taylor, B., Harris, O. (2023). Ending the HIV epidemic PrEP equity recommendations from a rapid ethnographic assessment of multilevel PrEP use determinants among young Black gay and bisexual men in Atlanta, GA. PLoS ONE, 18(3), e0283764. https://doi.org/10.1371/journal.pone.0283764

13. Hixson, B. A., Omer, S. B., del Rio, C., Frew, P. M. (2011). Spatial clustering of HIV prevalence in Atlanta, Georgia and population characteristics associated with case concentrations. Journal of Urban Health, 88(1):129-141. https://doi.org/10.1007/s11524-010-9510-0

14. Hood, N., Benbow, N., Jaggi, C., Whitby, S., Sullivan, P. S., & AIDSVu Health Department Collaborators. (2024). AIDSVu Cities' Progress Toward HIV Care Continuum Goals: Cross-Sectional Study. JMIR Public Health and Surveillance, 10, e49381. https://doi.org/10.2196/49381

15. Jeffries, W. L., 4th, Dailey, A. F., Jin, C., Carter, J. W., Jr, & Scales, L. (2020). Trends in Diagnosis of HIV Infection, Linkage to Medical Care, and Viral Suppression Among Men Who Have Sex with Men, by Race/Ethnicity and Age-33 Jurisdictions, United States, 2014-2018. MMWR. Morbidity and Mortality Weekly Report, 69(38), 1337-1342. https://doi.org/10.15585/mmwr.mm6938a1

16. Kalichman, S. C., Cherry, C., Amaral, C., White, D., Kalichman, M. O., Pope, H., Swetsze, C., Jones, M., Macy, R. (2010). Health and treatment implications of food insufficiency among people living with HIV/AIDS, Atlanta, Georgia. Journal of Urban Health, 87(4):631-641. https://doi.org/10.1007/s11524-010-9446-4

17. Latkin, C. A., German, D., Vlahov, D., & Galea, S. (2013). Neighborhoods and HIV: a social ecological approach to prevention and care. The American Psychologist, 68(4), 210-224. https://doi.org/10.1037/a0032704

18. Siegler, A. J., Mouhanna, F., Giler, R. M., Weiss, K., Pembleton, E., Guest, J., Jones, J., Castel, A., Yeung, H., Kramer, M., McCallister, S., & Sullivan, P. S. (2018). The prevalence of pre-exposure prophylaxis use and the pre-exposure prophylaxis-to-need ratio in the fourth quarter of 2017, United States. Annals of Epidemiology, 28(12), 841-849. https://doi.org/10.1016/j.annepidem.2018.06.005

19. Sullivan, P. S., Woodyatt, C., Koski, C., Pembleton, E., McGuinness, P., Taussig, J., Ricca, A., Luisi, N., Mokotoff, E., Benbow, N., Castel, A. D. (2020). A data visualization and dissemination resource to support HIV prevention and care at the local level: analysis and uses of the AIDSVu Public Data Resource. Journal of Medical Internet Research, 22(10), e23173. https://doi.org/10.2196/23173

20. U.S. Census Bureau. (2024). QuickFacts: Atlanta city, Georgia. https://www.census.gov/quickfacts/fact/table/atlantacitygeorgia/PST045224