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Evaluating the relationship between driving commute time and distance to HIV testing sites and late HIV diagnosis in Atlanta, Georgia

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An abstract of
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Abstract

Evaluating the relationship between driving commute time and distance to HIV testing sites and late HIV diagnosis in Atlanta, Georgia

By Andrew Durkin

Ending the HIV epidemic in the United States is dependent on early diagnosis, prompt linkage to care, and viral load suppression which benefits the individual and decreases the risk of HIV transmission. While long commute time and distance to HIV services have been shown to be barriers to accessing HIV services, there is limited research assessing the effects of commute time and distance to HIV testing on late HIV diagnoses in metropolitan areas. The goal of this thesis was to evaluate the relationships between driving commute time and distance to HIV testing locations and late HIV diagnoses in Atlanta, Georgia. Data from 2013-2018 on late HIV diagnoses in Atlanta, defined as individuals 13 years and older diagnosed with stage 3 HIV within 3 months of initial HIV diagnoses, were accessed through AIDSVu. The driving commute time and distance from a geometric centroid of each Atlanta zip code tabulation area (ZCTA) to the nearest HIV testing location were calculated on ArcGIS Online. Descriptive analyses and choropleth maps were used to describe the driving commute time and distance to HIV testing locations and late HIV diagnoses across ZCTAs. Unadjusted and adjusted linear regression was used to assess the associations between driving commute time and distance to HIV testing locations and late HIV diagnoses across ZCTAs. In adjusted analyses, poverty was selected as a covariate. Additionally, linear regression was performed after stratifying the dataset by poverty. Across the 99 ZCTAs included in the analysis, there were 101 HIV testing locations and the mean percentage of late HIV diagnoses was 23%. The mean distance was 4.14 miles and the mean driving commute time was 8.26 minutes. Driving commute time to HIV testing locations was not associated with late HIV diagnoses in unadjusted and adjusted models. Poverty confounded the relationship between driving distance to HIV testing locations and late HIV diagnoses. Driving commute time and distance to HIV testing locations were not significantly associated with late HIV diagnoses in Atlanta, Georgia. This analysis suggests the importance of examining socioeconomic factors when observing spatial relationships between HIV testing services and HIV-related outcomes.

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TABLE OF CONTENTS

INTRODUCTION

In the United States, approximately 38,000 individuals are diagnosed with HIV each year, most of whom live in metropolitan areas (CDC, 2021b). The Centers for Disease Control and Prevention (CDC) report that fewer than 40% of people living in the United States have ever had an HIV test (CDC, 2019). Of those living with HIV in the United States, 76% have received some care and 58% were retained in care (CDC, 2021a). Overall, 66% of individuals living with HIV were virally suppressed (CDC, 2021a).

In the United States, key behaviors driving the HIV epidemic are male-to-male sexual contact and sharing injection drug equipment. Approximately 65% of new HIV diagnoses are attributable to male-male sex, and another 7% of new HIV diagnoses are attributable to injection drug (CDC, 2021b). Racial/ethnic people are disproportionately affected by HIV: Black/African American people account for 42% of new diagnoses, and Hispanic/Latino people account for 29% of new diagnoses (CDC, 2021b).

The US South has the highest number of people living with HIV (CDC, 2021b). In 2019, the rate of HIV infection in the US South was 378.7 out every 100,000 people (CDC, 2021b). In total, 76% of the 19,396 individuals diagnosed with HIV in the South lived in urban areas in 2018 (CDC, 2021b). Further, in 2019 there were 37,244 people living with HIV in Atlanta, Georgia (GA) with 1,529 people being newly diagnosed (Sullivan et al., 2020).

HIV testing is a vital prevention and treatment tool and interventions are needed to increase HIV testing in the United States (Li et al., 2019). The CDC reports that for every 100 people living with

HIV in the United States, 87 have been diagnosed and know their HIV status (CDC, 2021a). Increasing access to HIV testing would help prevent late HIV diagnosis, improve HIV linkage to care and treatment, and reduce adverse HIV-related outcomes and forward HIV transmission (Patel et al., 2020).

Late HIV diagnosis is defined as acquired immunodeficiency syndrome (AIDS; stage 3 HIV) diagnosis within three months of initial HIV diagnosis (Sullivan et al., 2020). In the United States, among individuals living with HIV, the estimated median interval from HIV infection to HIV diagnosis was 3 years (Dailey et al., 2017). Surveillance data show 1 in 4 people had been living with HIV for 7 years or longer at time of diagnosis (CDC, 2015). Even in geographic areas where HIV testing is widely accessible, 1 in 5 persons with HIV have advanced disease at the time of diagnosis (Hall et al., 2016). Most late HIV diagnoses are among people living in metropolitan areas (Hall et al., 2016). For example, in Atlanta, GA a total of 288 people received late HIV diagnosis in 2019 which represented 18.8% of the new HIV diagnoses in the year (Sullivan et al., 2020).

There are differences in late HIV diagnosis by gender, age, race/ethnicity, sexual orientation, and drug use history. Diagnosis delays are longer for males with a median of 3.1 years compared to females with a median of 2.4 years (CDC, 2015; Dailey et al., 2017). Older people have longer delays with people 55 years or older having a median time of 4.5 years compared to 2.4 years among individuals 13-24 years old (CDC, 2015; Dailey et al., 2017). The median time of infection to diagnosis is lowest among White persons at 2 years followed by Black/African American and Hispanic/Latino persons at 3 years, Native American persons at 3.5 years, and Asian persons at 4 years (CDC, 2015; Dailey et al., 2017). Risk groups analysis shows that heterosexual females and females who inject drugs have the lowest median time from HIV infection to diagnosis at 2.5 years

(CDC, 2015; Dailey et al., 2017). These risk groups are followed by gay and bisexual males and males who inject drugs at 3 years and heterosexual males at 5 years from initial infection to diagnosis (CDC, 2015; Dailey et al., 2017).

Late HIV diagnosis is an important indicator of the quality of HIV service delivery (Valdiserri et al., 2013). Individuals with late HIV diagnoses face challenges responding to antiretroviral treatment (ART), have a higher mortality risk, and are at increased risk for forward HIV transmission (Dailey et al., 2017). Early HIV detection must be improved as approximately 40% of ongoing transmission is transmitted by people unaware of their HIV infection (Dailey et al., 2017).

In 2006, the CDC recommended routine HIV screening in healthcare settings for persons between 13 and 64 years old (HHS, 2006). However, limited routine HIV screening remains an issue and contributes to late HIV diagnosis in the United States (Rizza et al., 2012; Sullivan et al., 2021). Barriers to HIV screening in the United States include HIV stigma, limited medical care access, low income, low education, and low transportation access (Rueda et al., 2016; Sullivan et al., 2021). Further, access to HIV testing services is impacted by social determinants of health and health inequities including poverty and lack of access to health insurance (Sullivan et al., 2021).

Long commute time and distance have been shown to be barriers to accessing HIV services in the United States (Dasgupta et al., 2015; Goswami et al., 2016; Siegler et al., 2019). However, there are limited analyses examining whether commute time and distance to HIV testing services is associated with late HIV diagnoses in large metropolitan areas (Arbona & Barro, 2020; Cope et al., 2016). The goal of this manuscript is to evaluate the relationship between driving commute time and distance to HIV testing sites and late HIV diagnosis in Atlanta, GA which is a high HIV prevalence metropolitan area located in the south. This analysis will help inform HIV prevention strategies to increase HIV testing access and uptake and improve the allocation of resources to address gaps in services (Arbona & Barro, 2020; Siegler et al., 2019).

METHODS

Data sources

Five-year late HIV diagnosis percentage data were accessed through AIDSVu (Atlanta_AIDSVu_DownloadableDataset_2018-1.xlsx (live.com)) (Sullivan et al., 2020). Zip code tabulation areas (ZCTA) shapefiles were downloaded from the Georgia Association of Regional Commissions on March 15, 2022 (https://opendata.atlantaregional.com/datasets/GARC::zip-codes/about). HIV testing locations were obtained from CDC's National Prevention Information Network, Customizable Data Feed downloaded on March 31, 2022 (https://npin.cdc.gov/). ArcGIS Online (Esri, Redlands, CA) was the data source for street level data which was used to collect driving distance in miles and driving commute time in minutes. These data were downloaded on April 11, 2022 (https://www.esri.com). Poverty and racial demographic data were accessed through AIDSVu (Sullivan et al., 2020). These data were obtained from the U.S. Census Bureau's 2010 census (Atlanta_AIDSVu_DownloadableDataset_2018-1.xlsx (live.com)).

Key variables

Five-year late HIV diagnosis was defined as all individuals 13 years and older diagnosed with HIV infection who were diagnosed with stage 3 HIV (AIDS) within 3 months of initial HIV diagnoses in Atlanta, GA reported between January 1, 2013 - December 31, 2018. These data were analyzed as a percent with the numerator being the number of individuals who were diagnosed with HIV during the five-year time period and were diagnosed with stage 3 HIV (AIDS) within 3 months of initial HIV diagnoses. The denominator was the number of individuals who were newly diagnosed with HIV in the same five-year period.

The driving distance was calculated in miles between each ZCTAs centroid and the closest HIV testing location. Driving distances adhered to road rules specific to cars such as one-way roads and avoiding illegal turns. The driving commute time was calculated in minutes between each ZCTAs centroid and the closest HIV testing location. Driving commute times were based on using historical and live traffic driving speed data and obeyed to road rules specific to cars such as one-way roads and avoiding illegal turns. This driving commute time assumes travel is through a private vehicle.

Poverty data represent the percent of each ZCTA's population living below the federal poverty line in 2018. The numerator was the total amount of people living below the federal poverty line and the denominator was the total population for whom poverty level was determined in each ZCTA.

Data analysis

Data on the average commute time to the nearest HIV testing location and percentage of late HIV diagnoses by ZCTA in Atlanta, GA were depicted in choropleth maps of Atlanta metropolitan ZCTAs. We overlaid maps with available, 5-year cumulative percentage of late HIV diagnoses using ArcGIS 10.8.1 (Esri, Redlands, CA). A geometric centroid of each ZCTA was computed and HIV testing locations within these areas were then identified and overlaid on the map. Latitude and longitude points for both the ZCTA centroids and HIV testing locations were extracted and imported on a street level base map in ArcGIS Online. Driving distance and commute time from the centroid of each ZCTA to the nearest HIV testing location were calculated with street network information using spatial network analysis in ArcGIS Online. This procedure was performed for both driving commute time in minutes and driving distance in miles. The commute times and driving distances were then depicted on maps of late HIV diagnoses by ZCTA. ZCTA-specific proportions of late HIV diagnoses were categorized into quantiles. Descriptive analyses of key variables including exposures and outcomes across ZCTAs were also conducted.

Unadjusted and adjusted linear regression was used to evaluate the relationship between commute time and driving distance to the nearest HIV testing location and late HIV diagnoses across ZCTAs in Atlanta, GA. In adjusted analyses, poverty was selected as a covariate. Additionally, linear regression was performed after stratifying the dataset by poverty.

RESULTS

Of 240 total ZCTAs in the metropolitan Atlanta area, 99 ZCTAs had available late HIV diagnoses data and were included in the observed dataset (Table 1, Figure 1). With all ZCTAs, the population included 41% Black people, 41% White people, 11% Hispanic people, 5% Asian people, and 2% other or not identified. The mean percentage of late HIV diagnoses was 23% of all HIV diagnoses. The number of total HIV testing locations in the 99 ZCTAs was 101. The mean driving distance to the closest HIV testing locations was 4.14 miles with a mean driving commute time of 8.26 minutes. Across the ZCTAs, the mean percentage of population living in poverty was 16%.

Table 1: Key characteristics of zip code tabulation areas by percentage of late diagnoses in Atlanta, Georgia

Percentage of late HIV diagnoses by quantile (2013-2018)	Number of zip code tabulation areas	Mean percentage of population living in poverty (2018)	Mean driving distance to closest HIV testing location (miles)	Mean driving commute time to closest HIV testing location (minutes)
10% - 16%	22	21%	3.08	6.86
17% - 20%	24	17%	4.65	9.19
21% - 24%	20	14%	4.01	8.13
25% - 31%	18	15%	2.89	6.29
32% - 54%	15	10%	6.57	11.38

Figure 1: Map showing commute time to HIV testing sites and percentage of late HIV diagnoses by zip code tabulation area in Atlanta, Georgia

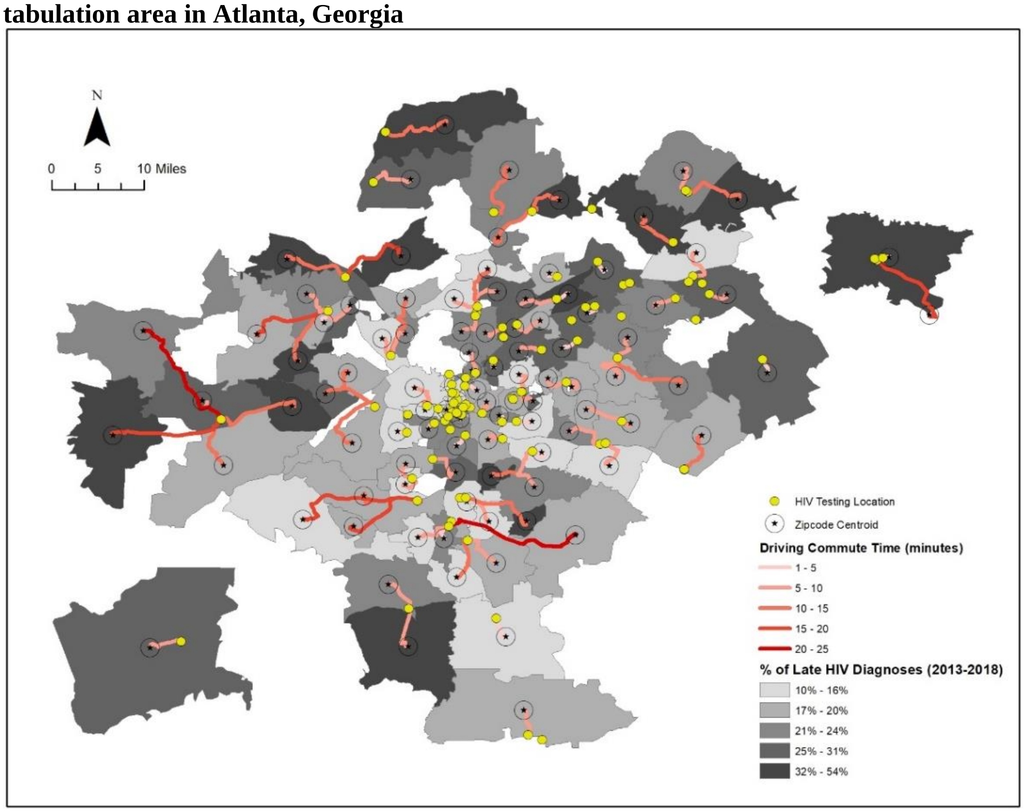
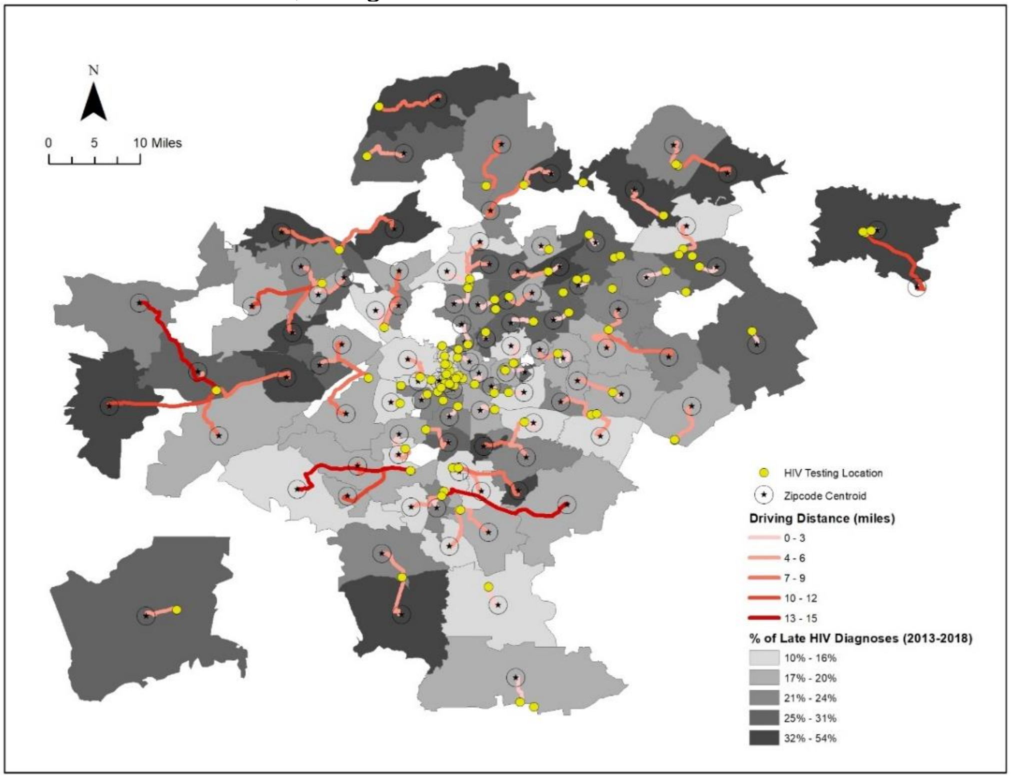


Figure 2: Map showing driving distance to HIV testing sites and percentage of late HIV diagnoses by zip code tabulation area in Atlanta, Georgia



In the unadjusted linear regression model for all ZCTAs in the dataset, for every additional mile of driving distance to the nearest HIV testing location, there was a 0.58% increase in late HIV diagnoses (p-value=0.03), (Table 2).

In the unadjusted linear regression model for all ZCTAs in the dataset, for every 1-minute increase in commute time to the nearest HIV testing location, there was a 0.32% increase in late HIV diagnoses; this association was not statistically significant (p-value=0.09), (Table 3). The intercept coefficient showed when commute time was 0 minutes the average late HIV diagnoses was 20.36% (p-value <0.001).

After stratifying by the median of the percentage of population living in poverty (14.1%), 51 ZCTAs were equal to or below the median and 48 ZCTAs were above the median. Results across models were non-significant (Table 2, Table 3).

Table 2: Unadjusted linear regression model of driving distance to the nearest HIV testing location in full sample and stratified by poverty

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95% CI*	*Upper 95% CI*
Driving distance (miles): 99 ZCTAs	0.58	0.27	2.16	0.03	0.05	1.12
Population ≤ 14.1% living in poverty (51 ZCTAs)	0.56	0.41	1.38	0.17	-0.26	1.38
Population > 14.1% living in poverty (48 ZCTAs)	0.33	0.33	0.99	0.33	-0.34	1.00

Table 3: Unadjusted linear regression model of commute time to the nearest HIV testing location in full sample and stratified by poverty

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95% CI*	*Upper 95% CI*
Commute time (minutes): 99 ZCTAs	0.32	0.19	1.68	0.09	-0.06	0.69
Population ≤ 14.1% living in poverty (51 ZCTAs)	0.35	0.28	1.23	0.22	-0.22	0.92
Population > 14.1% living in poverty (48 ZCTAs)	0.06	0.23	0.27	0.79	-0.41	0.53

When linear regression models adjusted for poverty, the associations between both driving distance and commute time and late HIV diagnoses were non-significant (Table 4, Table 5).

Table 4: Adjusted for poverty linear regression model of driving distance to the nearest HIV testing location

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95% CI*	*Upper 95% CI*
Intercept	25.82	2.34	11.03	0.00	21.18	30.47
Driving distance (miles)	0.33	0.28	1.17	0.24	-0.22	0.88
Population % living in poverty	-0.26	0.09	-2.74	0.01	-0.45	-0.07

Table 5: Adjusted for poverty linear regression model of commute time to the nearest HIV testing location

	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95% CI*	*Upper 95% CI*
Intercept	26.38	2.68	9.82	0.00	21.05	31.71
Commute time (minutes)	0.13	0.19	0.66	0.51	-0.26	0.51
Population % living in poverty	-0.28	0.09	-2.90	0.00	-0.47	-0.09

DISCUSSION

Ending the HIV epidemic in the United States is dependent on early diagnosis, prompt linkage to care, and viral load suppression which benefits both the individual and decreases the onward risk of transmission (Fauci et al., 2019). It is critical for the United States' HIV response to address the problem of late HIV diagnoses. Additionally, it is vital to understand and address structural factors that contribute to inequities in the HIV epidemic. Our findings show that commute time to HIV testing locations was not associated with late HIV diagnoses in unadjusted or adjusted models; poverty confounded the relationship between the driving distance to HIV testing locations and late HIV diagnoses. These results can help inform and guide HIV prevention activities that reduce the number of late HIV diagnoses. These activities include increasing mobile HIV testing locations, promoting telehealth services, distributing ride share vouchers to testing locations, and employing mailout self-HIV testing kits. These prevention activities could be targeted to specific geographic areas that have longer distance to HIV services.

Results from the models examining the relationship between driving distance to HIV testing location and late HIV diagnoses found that the association became non-significant when adjusting for poverty. Other studies in North Carolina and Texas found significantly higher rates of late HIV diagnoses in areas with longer distances to testing sites; poverty was not selected as a confounding variable in either study (Arbona & Barro, 2020; Cope et al., 2016). However, as in our study, poverty was shown to be inversely associated with late HIV diagnoses in metropolitan areas in Texas (Arbona & Barro, 2020). Authors suggested that this negative relationship may be a result of enhanced HIV prevention and surveillance efforts targeting high-poverty communities in urban areas, such as National HIV Behavioral Surveillance (Arbona & Barro, 2020). Like other studies have noted, further analyses observing and including socio-economic disparities are needed to better understand how these disparities can be addressed in HIV care and services (Goswami et al., 2016; Sullivan et al., 2021).

In the models examining the relationship between commute time to HIV testing location and late HIV diagnoses, commute time was not significantly associated with late diagnosis in either unadjusted and adjusted models. Although no other studies to date have assessed this relationship, studies similar to ours have examined the relationship between commute time and other HIV-related outcomes. Results from these studies in Atlanta and across the United States showed longer commute times to HIV services were associated with access to care and preexposure prophylaxis (Dasgupta et al., 2015; Sharpe et al., 2022; Siegler et al., 2018). However, these evaluations did not specifically control for poverty. Two of these studies only included men who have sex with men compared to this manuscript observing the general population (Dasgupta et al., 2015). Additionally, one of these studies included public transport systems in the measure of commute time (Dasgupta et al., 2015). Lastly, one of these studies focused on non-urban areas (Sharpe et al., 2022).

In the adjusted model, the relationship between driving distance and late HIV diagnosis became non-significant. There are multiple potential explanations for this finding. Poverty may be acting as a confounder because it may be associated with both driving distance and late HIV diagnosis. This is partially supported by the results of the adjusted model which found that poverty was inversely associated with late HIV diagnosis. Alternatively, poverty may be acting as a proxy measure for other variables that confound the relationship. For example, people living in poverty may be less likely to have health insurance or access to a personal vehicle and less able to take time off work to seek health services due to potential lost wages. Additionally, poverty may be highly correlated with driving distance because people living in poverty may be more likely to live in areas that have lower access to health services.

Our findings are subject to several limitations. First, late HIV diagnoses data were only available for 99 of the 240 total ZCTAs in Atlanta; thus, the results may not reflect the entire Atlanta metropolitan area. Additionally, an analysis using more recent 2020 census data and 2020 5-year late HIV diagnoses would capture a more time sensitive reflection of the observed variables. Secondly, traffic patterns and different times of travel in the day were not accounted for. This could lead to the mean commute time calculated not truly representing the actuality of how long it takes to drive to the closest HIV testing location. Future studies should account for HIV testing service operation hours and higher traffic time periods when calculating commute times. Third, the transport mode in this study was limited to only cars. Considering local context would strengthen this type of analysis. Accounting for specific community transport trends and access such as public transportation would be important to include (Dasgupta et al., 2015). Lastly, this study was based off the assumption that individuals seeking HIV testing locations prefer to access their closest HIV testing location (Cope et al., 2016). This assumption may not be accurate due to HIV stigma. People could prefer to seek services further from their home due to fear of accessing services and being recognized within their community. Additionally, individuals’ routine travel pattern (i.e., commuting to work) may make further HIV testing locations more appealing and accessible.

Understanding whether driving distance and commute time to HIV testing locations are associated with late HIV diagnoses could improve accessibility of HIV testing services and increase early HIV diagnosis rates. Further analysis is needed in a diverse set of large metropolitan areas as geographical differences may influence results. Similar types of studies could also be beneficial in suburban and rural areas where HIV services are less available and accessible. In future analyses, other types of transport and corresponding travel time should also be included such as public transport options (Dasgupta et al., 2015). By conducting additional analyses, HIV testing service location deserts can be identified and inform interventions that help decrease late HIV diagnoses (Sharpe et al., 2022). Lastly, this analysis suggests the importance of examining socioeconomic factors (e.g., poverty, access to health insurance, unemployment) when observing spatial relationships to HIV testing services and HIV-related outcomes.

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