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ASSOCIATIONS BETWEEN POPULATION DENSITY AND CLINICAL AND SOCIODEMOGRAPHIC FACTORS IN WOMEN LIVING WITH HIV IN THE SOUTHERN UNITED STATES

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Abstract

To explore the associations of urbanicity with clinical/behavioral outcomes and sociodemographic factors among women living with HIV in the Southern United States, 523 participants of the Women's Interagency HIV Study were classified into population density quartiles. Rural-Urban Commuting Area codes revealed that 7% resided in areas where >30% commute to urban areas,

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2% resided in small towns or rural areas, and 91% resided in varying densities of urban areas. Although women in lower density, mostly suburban areas reported higher socioeconomic indicators such as advanced education and greater annual household income, larger proportions of women in the lowest density quartile (compared to those in more dense and urban areas) perceived discrimination in health care settings and agreed with several internalized HIV stigma scale items. Women in the lower quartiles had higher CD4 counts, while those in the lowest quartile were more likely to have a suppressed HIV viral load, report being employed, and not report a history of drug use or current heavy alcohol use. More research is needed to understand the interplay between population density and mechanisms contributing to HIV control as well as increased internalized stigma and perceived discrimination, along with how to target interventions (including for stigma alleviation) to improve outcomes for individuals with HIV across urban, suburban, and rural areas.

Keywords

population density; Southern US; stigma; clinical outcomes

INTRODUCTION

Dramatic changes have occurred in the long-term health and lifespan of those living with HIV in the United States (US); individuals are now considered to be living with a controllable chronic disease given appropriate medications and utilization of care. Factors associated with the largest impacts on health outcomes have been identified as social determinants of health, such as poverty, race, access to care, insurance, housing, and social support (Brewer et al., 2018; Duke Center for Health Policy and Inequalities Research (CHPIR), 2011) – all of them affecting many other chronic illness trajectories in addition to HIV disease.

While the incidence of HIV/AIDS was initially highest in the Northern and Western urban areas of the US, this has changed over the past decade, as the more rural Southeastern US states now report greater numbers of individuals newly diagnosed and living with HIV (Reif, Geonnotti, & Whetten, 2006; Reif et al., 2015; Reif, Safley, McAllaster, Wilson, & Whetten, 2017). The South has the highest rates of new HIV diagnoses, including eight of the ten states and all ten metropolitan statistical areas with the highest incidence rates. In addition, the South accounts for the highest HIV case-fatality rates in the US (Hanna et al., 2013).

While the South contains many rural counties, it also contains large urban areas, and individuals with HIV in the South live in areas from the highly metropolitan to the highly rural (Kalichman, Katner, Banas, & Kalichman, 2017). Studies examining the impacts of urban and rural environments on health have shown that persons living with HIV in more rural settings are likely to experience a number of disadvantaging factors: (a) social isolation (Phillips, Moneyham, Thomas, Gunther, & Vyavaharkar, 2011), (b) limited education (Reif, Whetten, Ostermann, & Raper, 2006), (c) a higher risk for depression (Uphold, Rane, Reid, & Tomar, 2005), (d) less utilization of primary care, HIV care, and mental health services due to decreased service availability as well as transportation issues (Konkle-Parker, Erlen, & Dubbert, 2007; Pathman, Ricketts, & Konrad, 2006; Reif, Golin, & Smith, 2005; Reif,

Whetten, et al., 2006; Schafer et al., 2017; Williams, Amico, & Konkle-Parker, 2011), (e) later presentation to HIV care (Lopes, Eron, Mugavero, Miller, & Napravnik, 2017), (f) worse retention in care (Nelson et al., 2018; Ohl et al., 2013; Ohl et al., 2010; Sheehan et al., 2017; Wilson et al., 2011), (g) difficulty coping with the disease (Kempf et al., 2010; Konkle-Parker et al., 2007; Vyavaharkar et al., 2007), and (h) worse outcomes related to cervical cancer screening, sexually transmitted disease (STD) prevalence, and contraception use (Yabroff et al., 2005). However, findings have not been consistent in every study of rural and urban persons living with HIV, including those from a urban/rural comparison of the HIV care cascade in South Carolina that revealed no apparent differences (Edun, Iyer, Albrecht, & Weissman, 2017), and many of these studies have been conducted primarily in men.

Stigma is thought to be an important driver of health care utilization and related outcomes among people with HIV. Prior studies have examined its relationship with urbanicity among persons living with HIV in the US, yielding contrasting evidence. One analysis of men and women in Georgia found that the magnitude of internalized stigma was greater in less densely populated communities (Kalichman, Katner, Banas, & Kalichman, 2017). Another found that while community size was not related to negative self-image, it was related to one aspect of perceived stigma (disclosure concerns), but differently for men and women (Gonzalez, Miller, Solomon, Bunn, & Cassidy, 2009). Specifically, women reported more disclosure concerns than men; these concerns were especially salient for women living in more rural areas. Among men and women in North Carolina, urban/rural location significantly contributed to variance for total stigma, disclosure concerns, and concerns with public attitudes, but not for personalized stigma or negative self-image (Costelloe et al., 2015).

Further understanding is needed on how geographical environment (ranging from highly urban to less urban) impacts health outcomes in women, as their experiences may differ from those of men. We sought to describe how sociodemographic factors and clinical outcomes are associated with levels of urbanicity. A greater understanding of how urbanicity impacts the behaviors, perceptions, and health of people with HIV will assist in identifying barriers to care and developing interventions to improve clinical and other outcomes in both more and less urban areas.

METHODS

The Women's Interagency HIV Study (WIHS) was a prospective, longitudinal cohort study that explored the impact of HIV infection among women between 1994 and 2020. The original sites were located in Washington DC, New York City (Bronx and Brooklyn), Chicago, Los Angeles, and San Francisco. In 2013, four new Southern sites in North Carolina, Georgia, Florida, and Alabama/Mississippi were added to more accurately reflect the contemporary HIV epidemic in the US. While recruitment procedures have varied across four enrollment waves, women were often referred from clinics or community organizations; those eligible for inclusion were generally women living with HIV (WLWH) or with high HIV risk drug use or sexual behaviors between 25–60 years of age (details in Adimora et al., 2018; Bacon et al., 2005; Barkan et al., 1998). Analyses for this paper were limited to

WLWH from the Southern sites (n=523), since the original sites exclusively included highly urban participants.

Data used for this cross-sectional analysis were collected at the Southern site pre-baseline (screening) and baseline WIHS visits between 2013 and 2015. Demographic variables included self-reported age, education level (<high school, high school graduation or some college, college completion or above), annual household income (≤$18,000, $18,001-$36,000, >$36,000), current employment status (yes/no, regardless of the number of hours per week), race/ethnicity (White non-Hispanic, African-American non-Hispanic, Hispanic, other), and health insurance (yes/no). Participant characteristics collected at baseline included a) drug/alcohol use based on self-report of ever using illicit drugs or currently drinking more than seven drinks per week (yes/no); b) lifetime history of STDs, including gonorrhea, syphilis, chlamydia, pelvic inflammatory disease, trichomoniasis, and genital herpes or warts (yes/no); c) depressive symptoms using the Center for Epidemiologic Studies Depression Scale (Devins & Orme, 1985) (yes/no, yes if score ≥16); d) lifetime history of sexual abuse (yes/no, “At any time in your life, has anyone ever pressured or forced you to have sexual contact? By sexual contact I mean them touching your sexual parts, you touching their sexual parts, or sexual intercourse); e) lifetime history of domestic abuse (yes/no, “Have you ever experienced serious physical violence (physical harm by another person)? By that I mean were you ever hurt by a person using an object or were you ever slapped, hit, punched, or kicked?); f) emotional and tangible social support from the Medical Outcomes Study Social Support Scale (Sherbourne & Stewart, 1991) (range: 1–5); g) food insecurity using the USDA Household Food Security Survey (United States Department of Agriculture Economic Research Service) over the previous six months (very low, low, marginal, high); h) internalized HIV stigma based on the valid and reliable 7-question “negative self-image” subscale of the HIV Stigma Scale, with score as the average of each question measured on a scale of 1–4 and “4” representing higher stigma (Bunn, Solomon, Miller, & Forehand, 2007); i) perceived discrimination in health care settings using a question drawn from the validated Discrimination Scale (Heckman, Somlai, Kalichman, Franzoi, & Kelly, 1998); and j) health literacy using the Newest Vital Sign Health Literacy Scale (adequate literacy: >4, possible limited literacy: 3–4, high likely limited literacy: 1–2) (Weiss et al., 2005).

Clinical outcomes included suppressed HIV viral load (yes/no, yes if <200 copies/mL), CD4 count, CD4 category (≥200, <200), abnormal cervical screening result or treatment for a gynecologic condition in the past six months (yes/no), HIV medication high adherence in the past six months among WLWH receiving antiretroviral therapy (yes/no, yes if medications taken ≥95% of the time), and missed HIV care in the past six months among WLWH in care (yes/no).

INCLUSION CRITERIA AND CLASSIFICATION OF PARTICIPANT URBANICITY

Starting in 2013, home addresses were collected confidentially at each site for all WIHS women to allow for geospatial analyses; enrollees at Southern sites were both living with HIV and who consented to geocoding were eligible for this analysis (n=566). Of these 566 women, 43 were excluded from these analyses due to missing home address information: 26

due to unstable housing conditions, 12 for not providing an address, and 5 for providing an address that could not be matched, resulting in a final sample of 523 women.

Address data were geocoded using ArcGIS; latitude and longitude of addresses were matched to census block tracts with each participant assigned a corresponding Federal Information Processing Standard (FIPS) code. By linking FIPS codes at the census tract level to population density data from the 2010–2014 5-year American Community Survey (U.S. Census Bureau), an ongoing general household survey (U.S. Census Bureau, 2008), we created a variable representing the census tract population density (expressed as persons per square mile) for each participant included in the analysis.

The census tract population densities of the analytic population were then divided into quartiles, with women being classified into one of four categorical population density strata ranging from least urban (lowest quartile) to most urban (highest quartile). The median population density ranged from 528 persons per square mile (interquartile range [IQR]: 120, 997) in the lowest quartile to 6753 (IQR: 5111, 9190) in the highest quartile. The decision to use population density quartiles to represent urbanicity was driven by the reality that very few women were classified as “rural” when defined using two alternative measures, 2010 Rural-Urban Commuting Area (RUCA) codes (WWAMI Rural Health Research Center) and the proportion of persons in a participant’s census tract living in a rural area according to the 2010 decennial census (U.S. Census Bureau).

RUCA codes define census tract rural/urban status based on population size, urbanization, and commuting patterns (WWAMI Rural Health Research Center). According to RUCA codes, in the lowest population density quartile, 47% of study participants resided in metropolitan urbanized areas and 17% resided in micropolitan cores (small cities) where most people live and work, resulting in about 64% who could be classified as “urban,” though the population densities of the census tracts where these “urban” participants lived were considerably less than those of participants in higher quartiles. Approximately 26% resided in areas where at least 30% commute to a metropolitan or micropolitan area (suburbs), and 10% resided in small towns or rural/other areas. In the next two higher population density quartiles, 97% and 98% respectively resided in metropolitan areas, and 3% and 2% resided in small cities where most people live and work. In the most urban quartile, 100% resided in highly populated metropolitan urbanized areas.

DATA ANALYSES

Frequency distributions were calculated for categorical characteristics, and medians and IQRs were calculated for continuous variables. For dichotomous variables, such as employment, drug/alcohol use, history of sexual abuse, history of domestic abuse, depressive symptoms, etc., proportions were compared using the Wilcoxon rank-sum test. For ordinal categorical variables, such as education level, annual household income, food insecurity category, etc., and for continuous variables, such as age, CD4 count, etc., Spearman’s rank correlation coefficient (Spearman’s rho) was used to assess the correlation between variables and population density quartiles. For race/ethnicity and state where the WIHS site was located, the Chi square test was used.

We also estimated adjusted mean differences and risk ratios (aRRs), with 95% confidence intervals (CIs), between population density quartiles and each clinical outcome via linear and modified Poisson regression, respectively, accounting for clustering by census tract and controlling for factors posited to potentially confound the quartile/outcome relationships (see Table 2 footnote). All analyses were conducted in SAS version 9.4 (SAS Institute Inc., Cary, North Carolina, US).

RESULTS

A total of 523 WLWH met the inclusion criteria for this analysis; baseline characteristics are detailed in Table 1. Over three-quarters of WLWH (85%) reported taking their HIV medications as prescribed at least 95% of the time in the last six months and 87% reported not missing an HIV care appointment in the past six months. Baseline median CD4 count was 554 cells/μL (IQR: 357–784), with 76% demonstrating HIV viral load suppression (<200 copies/mL). Twenty-one percent of women agreed that they felt discriminated against in a health care setting because of their HIV status. Internalized stigma, with a median score of 2.1 (IQR: 1.6–2.6), was measured by seven questions: 24% “agreed” or “strongly agreed” that having HIV made them feel like a bad person, 34% that having HIV made them feel that they are not as good as others, 36% that having HIV made them feel unclean, 36% that having HIV was disgusting, 47% that people’s attitudes about HIV made them feel worse about themselves, and 46% that they felt guilty because they had HIV. Only 36% endorsed that they never felt ashamed of having HIV.

As shown in Table 1, and in Table 2 for abnormal cervical screening result or treatment for a gynecologic condition, HIV medication high adherence, and missed HIV care (all null aRRs), there were no differences in the distribution of population density quartiles for these and the majority of examined factors, including age, history of sexual abuse, history of domestic abuse, food insecurity, depressive symptoms, health literacy, social support, health insurance, STD history, and CD4 count category. Women living in lower population density quartiles reported higher levels of education ($\rho = -0.111$; $p<0.05$) and had higher annual household incomes ($\rho = -0.090$; $p<0.05$). Race/ethnicity ($X^2 = 26.49$, $p<0.01$) and state where the WIHS site was located ($X^2 = 250.57$, $p<0.001$) differed by population density quartile, with the lowest quartile having greater proportions of white non-Hispanic women (16% vs. 6–9%) and women at North Carolina (45% vs. 15–27%) and Mississippi (29% vs. 2–20%) sites than other quartiles. Population density quartiles differed by levels of employment ($z = -2.495$; $p<0.05$) and history of drug use or current heavy alcohol use ($z = -3.369$, $p<0.001$); 35–40% of women were employed in the lower quartiles vs. 24–25% in the highest quartiles, and 52% of women in the lowest quartile had drug use history or current heavy drinking vs. 66–79% of women in higher quartiles.

Women in lower population density quartiles were more likely to have higher CD4 counts ($\rho = -0.116$, $p<0.01$), with adjusted mean differences in cells/μL for 3rd lowest and highest quartiles vs. lowest quartile: −119.59 (95% CI: −197.51 - −41.67) and −97.43 (95% CI: −176.58 - −18.27), respectively (Table 2). Quartiles differed by levels of viral suppression ($z = 3.084$, $p<0.01$), with 85% of women suppressed in the lowest quartile (vs. 69–75%), and aRRs (compared to the lowest quartile) ranging from 0.76 (95% CI: 0.66–0.88) for the

highest quartile to 0.83 (95% CI: 0.74–0.93) for the 2nd lowest quartile (Table 2). In addition, while internalized stigma scores were not different across quartiles ($\rho = -0.052$, $p=0.24$; minimal adjusted mean differences in Table 2), quartiles differed by levels of two specific internalized stigma elements: (1) feeling not as good as others because of having HIV ($z = -2.016$, $p<0.05$), and (2) feeling worse about herself due to people's attitudes about HIV ($z = -2.686$, $p<0.01$). The proportion of women "agreeing" in the lowest quartile was 34% (vs. 17–25%) for (1) and 47% (vs. 33–40%) for (2). Internalized stigma was significantly correlated with depression ($\rho = 0.34$, $p<0.001$), where higher internalized stigma was associated with depressive symptoms. Quartiles differed ($z = -2.762$, $p<0.01$) by levels of another aspect of stigma, perceived discrimination in health care settings, with 23% "agreeing" in the lowest quartile (vs. 12–20%).

DISCUSSION

The aim of this analysis was to compare WLWH residing in lower vs. higher population density areas of the Southern US with regards to sociodemographic characteristics and clinical and behavioral outcomes. Women from lower population density quartiles reported higher education and income levels, consistent with the higher proportion reporting employment in the lowest quartile. Women living in lower population density quartiles were more likely to have higher CD4 counts, and those in the lowest quartile were more likely to be virally suppressed and less likely to report a history of drug use or current heavy alcohol consumption than those in other quartiles. The proportions of women agreeing with several aspects of HIV stigma, including perception of discrimination in health care settings and two elements of internalized stigma (not feeling as good as others, and feeling worse about herself due to people's attitudes about HIV/AIDS) differed by population density quartile; for example, more women in the lowest quartile felt HIV-related discrimination in health care settings than women in the highest quartile. Results from descriptive and adjusted (multivariable regression) analyses were similar, which supports the robustness of findings and suggests that the other factors included in models were not solely responsible for the noted associations between population density and outcomes.

Existing literature has been contradictory on the associations between population density and health outcomes. We found that greater proportions of women in lower population density areas experienced certain aspects of internalized HIV stigma (consistent with Gonzalez, Miller, Solomon, Bunn, & Cassidy, 2009; and Costelloe et al., 2015) and discrimination in health care settings, perhaps partially due to common stereotypes about people living with HIV and different sexual norms in those environments. In addition, living in an area with lower population density may translate to an increased sense of isolation due to fewer opportunities to engage with other WLWH. Our finding of no difference in the overall internalized stigma score across quartiles was both similar to (Gonzalez, Miller, Solomon, Bunn, & Cassidy, 2009; Costelloe et al., 2015) and contrasting (Kalichman, Katner, Banas, & Kalichman, 2017) past research, providing evidence that the relationship between stigma and urbanicity likely varies by context. Additional studies are needed in specific geographical locations and population subsets in order to better characterize the pathways through which stigma manifests.

Similarly, while it has been previously reported that people living in more rural areas have worse viral suppression (Nwangwu-Ike, Saduvala, Watson, Panneer, & Oster, 2019), other studies revealed no differences (Edun, Iyer, Albrecht, & Weissman, 2017) or the opposite relationship (Sheehan et al., 2017). We noted that women in the lowest quartile were more likely to be virally suppressed, consistent with the finding of higher CD4 counts in lower quartiles. This may be due to the fact that women living in the lowest quartile in the WIHS were primarily suburban rather than truly rural. In our sample, suburban women were likely to be better resourced, as reflected by their higher reported education, household income, and employment. Our work provides needed insight on differences between WLWH in highly urban and less urban (including suburban and some rural) areas, information that is sparse in the literature yet relevant to understanding the domestic HIV epidemic.

LIMITATIONS

There is a great deal of inconsistency in the literature about the measurement of rural and urban areas and the way those should be defined (Weissman et al., 2015). A limitation of this analysis is that the number of truly rural participants, as defined by RUCA codes, was small. However, the differences in population densities between our quartiles were great, with the second quartile having nearly four times the median population per square mile than the first (lowest population density) quartile, and the fourth quartile having more than ten times the median population density than the first quartile. These findings highlight the range of urbanicity represented in our sample and the importance of exploring this variation.

Other limitations include the use of only one item to measure discrimination in health care settings (other questions were not asked of participants), and the fact that the 8% of WIHS women who did not consent to geocoding may have differed from those who did consent. It is important to note that women enrolled in our study were willing and able to travel to urban WIHS research sites every six months over many years, and thus may not be reflective of most rural or suburban WLWH in the South or nationally. It is unclear how this might have impacted the results of our study, as women from both lower and higher population densities enrolled in the WIHS may be better resourced and less transient than typical WLWH, and this may have resulted in our findings not being generalizable to all US or Southern WLWH. Regardless, the WIHS represents a large, high quality sample of WLWH in the Southern US.

CONCLUSION

Collectively, our findings indicate a need for studying the relationships between stigma, adherence, and clinical outcomes across the continuum of urbanicity, including in areas and populations that are truly rural by definition. Many outcomes were similar between WLWH in different population density areas, though the number of truly rural women in this sample was small. Perceptions of discrimination in health care settings and certain elements of internalized stigma were greater among women in the lowest population density quartile, though this did not appear to affect the key clinical outcomes of CD4 count and HIV viral suppression.

Additional analyses are needed to examine if internalized stigma and perceived discrimination impacted HIV clinical outcomes, including longitudinal explorations of whether the relationships between population density and outcomes among WLWH are maintained in the setting of persistent perceptions of internalized stigma and discrimination. Along with exploring the resiliency mechanisms that allowed women in lower population density areas to attain adequate HIV control despite more commonly perceiving discrimination and certain elements of internalized stigma, future studies should explore how to target interventions (including for stigma alleviation) to improve outcomes for individuals with HIV across the urbanicity continuum.

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Table 1:

Baseline characteristics of Women's Interagency HIV Study participants living with HIV in the Southern United States, by population density quartile and overall (n=523)

Characteristic	Category	Lowest density	2nd lowest density	3rd lowest density	Highest density	Total	Statistic*	*p*-value
Age in years		43 (35–50)	45 (36–51)	46 (37–52)	45 (38–51)	44 (36–51)	ρ = 0.071	0.103
Education level	Less than high school	34 (26%)	38 (29%)	41 (31%)	51 (39%)	164 (31%)	ρ = −0.111	0.011
	High school graduation or some college	84 (65%)	86 (66%)	77 (58%)	76 (58%)	323 (62%)		
	College completion or above	12 (9%)	7 (5%)	14 (11%)	3 (2%)	36 (7%)		
Annual household income	≤$18,000	88 (68%)	91 (69%)	89 (67%)	103 (79%)	371 (71%)	ρ = −0.090	0.039
	$18,001–$36,000	28 (22%)	31 (24%)	32 (24%)	24 (18%)	115 (22%)		
	>$36,000	14 (11%)	9 (7%)	11 (8%)	3 (2%)	37 (7%)		
Employed	No	46 (35%)	52 (40%)	32 (24%)	33 (25%)	163 (31%)	$z = -2.495$	0.013
Race/ethnicity	White non-Hispanic	21 (16%)	9 (7%)	12 (9%)	7 (6%)	49 (9%)	$X^2 = 26.49$	0.002
	Hispanic	6 (5%)	4 (3%)	4 (8%)	17 (13%)	31 (6%)		
	African American non-Hispanic	100 (77%)	116 (89%)	114 (86%)	104 (80%)	434 (83%)		
	Other	3 (2%)	2 (1%)	2 (2%)	2 (2%)	9 (2%)		
Health insurance		106 (82%)	113 (86%)	108 (82%)	115 (88%)	442 (85%)	$z = -1.143$	0.253
History of drug use or current heavy alcohol use		67 (52%)	87 (66%)	104 (79%)	91 (70%)	349 (67%)	$z = -3.669$	<0.001
Among drug users in past six months (15%), times used drugs in past six months		2–3/week (<1/week - 4–6/week)	<1/week (<1/month - 2–3/week)	1/week (<1/week - 1/day)	1/week (<1/month - 4–6/week)	1/week (<1/month - 2–3/week)	ρ = 0.028	0.806
Among alcohol drinkers in past six months (53%), number of alcoholic drinks per week in past six months		1.2 (0.3–6.0)	1.8 (0.4–6.0)	3.5 (0.7–13.6)	4.0 (0.9–12.0)	2.7 (0.5–10.0)	ρ = 0.193	0.001
Gynecological abnormality		17 (13%)	24 (18%)	20 (15%)	20 (15%)	81 (15%)	$z = 0.260$	0.795

Characteristic	Category	Lowest density	2nd lowest density	3rd lowest density	Highest density	Total	Statistic*	*p*-value
Lifetime history of sexually transmitted disease		75 (58%)	100 (76%)	100 (76%)	87 (67%)	362 (65%)	$z = -1.494$	0.135
Lifetime history of sexual abuse		40 (31%)	51 (40%)	49 (39%)	36 (29%)	176 (34%)	$z = -0.403$	0.687
Lifetime history of domestic abuse		41 (32%)	43 (34%)	40 (32%)	40 (31%)	165 (32%)	$z = -0.183$	0.855
Center for Epidemiological Studies Depression Scale Score		14 (7–26)	12 (5–21)	13 (6–20)	15 (6–25)	14 (6–23)	$\rho = -0.002$	0.968
Depressive symptoms		44 (34%)	36 (27%)	30 (23%)	43 (33%)	153 (29%)	$z = -0.399$	0.690
Food insecurity score		2 (0–6)	1 (0–4)	1 (0–4)	1 (0–5)	1 (0–4)	$\rho = -0.044$	0.311
Food insecurity category	High	55 (42%)	62 (47%)	59 (45%)	60 (47%)	236 (45%)	$\rho = -0.045$	0.303
	Marginal	23 (18%)	18 (14%)	28 (21%)	27 (21%)	96 (18%)		
	Low	22 (17%)	31 (24%)	22 (17%)	20 (16%)	95 (18%)		
	Very low	30 (23%)	20 (15%)	23 (17%)	22 (17%)	95 (18%)		
Emotional support		4.0 (3.0–5.0)	4.0 (3.0–4.9)	4.0 (3.0–5.0)	4.2 (3.3–5.0)	4.0 (3.0–5.0)	$\rho = 0.033$	0.463
Tangible support		4.1 (3.1–5.0)	4.3 (3.3–5.0)	4.1 (3.4–5.0)	4.3 (3.1–5.0)	4.3 (3.1–5.0)	$\rho = 0.003$	0.951
Total social support		4.1 (3.1–4.9)	4.2 (3.1–4.9)	4.1 (3.4–5.0)	4.4 (2.9–5.0)	4.1 (3.2–4.9)	$\rho = 0.028$	0.532
Health literacy	High likely limited	16 (12%)	6 (5%)	14 (11%)	2 (2%)	38 (7%)	$\rho = -0.002$	0.980
	Possible limited	26 (20%)	13 (10%)	11 (8%)	5 (4%)	55 (11%)		
	Adequate	54 (42%)	33 (25%)	27 (20%)	13 (10%)	127 (24%)		
	Missing	34 (26%)	79 (60%)	80 (61%)	110 (85%)	303 (58%)		
“I feel discriminated against in health care settings because of my HIV status”		30 (23%)	26 (20%)	18 (14%)	15 (12%)	89 (21%)	$z = -2.762$	0.006
Internalized stigma score		2.3 (1.6–2.9)	2.1 (1.6–2.7)	2.1 (1.4–2.4)	2.1 (1.7.2.6)	2.1 (1.6–2.6)	$\rho = -0.052$	0.240
“Having HIV/AIDS makes me feel that I’m a bad person”		30 (24%)	28 (22%)	20 (15%)	23 (18%)	101 (19%)	$z = -1.460$	0.144
“I feel I’m not as good as others because I have HIV/AIDS”		44 (34%)	31 (24%)	23 (17%)	32 (25%)	130 (25%)	$z = -2.016$	0.044
“Having HIV/AIDS makes me feel unclean”		47 (36%)	41 (32%)	29 (22%)	38 (29%)	155 (30%)	$z = -1.688$	0.092
“Having HIV/AIDS is disgusting to me”		47 (36%)	47 (36%)	30 (23%)	41 (32%)	165 (32%)	$z = -1.492$	0.136
“People’s attitudes about HIV/AIDS make me feel worse about myself”		61 (47%)	52 (40%)	43 (33%)	42 (33%)	198 (38%)	$z = -2.686$	0.007

Characteristic	Category	Lowest density	2nd lowest density	3rd lowest density	Highest density	Total	Statistic*	*p*-value
"I feel guilty because I have HIV/AIDS"		59 (46%)	52 (40%)	39 (30%)	50 (39%)	200 (39%)	$z = -1.631$	0.103
"I never feel ashamed of having HIV/AIDS"		46 (36%)	48 (37%)	54 (42%)	54 (42%)	202 (39%)	$z = 1.209$	0.227
Missed HIV care in past six months		17 (14%)	15 (12%)	16 (13%)	19 (15%)	67 (13%)	$z = 0.420$	0.674
HIV medication high adherence		103 (86%)	91 (85%)	94 (85%)	84 (85%)	372 (85%)	$z = 0.229$	0.819
HIV viral load suppression (<200 copies/mL)		112 (86%)	97 (74%)	96 (73%)	90 (69%)	395 (76%)	$z = 3.084$	0.002
CD4 count (cells/μL)		643 (409–877)	543 (335–806)	506 (324–729)	524 (369–739)	554 (357–784)	$\rho = -0.116$	0.008
CD4 count ≥200 cells/μL		122 (94%)	113 (86%)	122 (92%)	112 (86%)	469 (90%)	$z = 1.243$	0.107
State of Women's Interagency HIV Study site	Alabama	18 (14%)	23 (18%)	22 (17%)	9 (7%)	72 (14%)	$X^2 = 250.57$	<0.001
	Florida	1 (1%)	2 (2%)	2 (2%)	60 (46%)	65 (12%)		
	Georgia	14 (11%)	54 (41%)	55 (42%)	40 (31%)	163 (31%)		
	Mississippi	38 (29%)	17 (13%)	26 (20%)	2 (2%)	83 (16%)		
	North Carolina	59 (45%)	35 (27%)	27 (20%)	19 (15%)	140 (27%)		

Values are N (%) or median (interquartile range).

*z=Wilcoxon rank-sum, ρ=Spearman's rho, X^2=chi square.

History of drug use or current heavy alcohol use = ever used injected or non-injected drugs, or more than seven drinks per week in the past six months; gynecologic abnormality = abnormal cervical screening result or treatment for a gynecologic condition in the past six months; sexually transmitted disease = gonorrhea, syphilis, chlamydia, pelvic inflammatory disease, trichomoniasis, and genital herpes or warts; sexual abuse = forced or pressured to have sexual contact; domestic abuse = was threatened to hurt or kill, or prevented from leaving or entering the house, seeing friends, making phone calls, getting or keeping a job, continuing education, or seeking medical attention; depressive symptoms = Center for Epidemiological Studies Depression Scale score ≥16; food insecurity category based on 10 questions of the USDA Household Food Security Survey, to capture the experience of anxiety regarding household food supplies, inadequate quality of food, and/or reduced food intake; tangible and emotional support based on subscales of Medical Outcomes Study Social Support Scale; health literacy category based on correct scores of the Newest Vital Sign; discrimination in a health care setting based on question from Discrimination Scale; internalized stigma score, based on the "negative self-image" subscale of the HIV Stigma Scale, ranges from a score of 1 (low stigma; strongly disagree with all 7 items on the subscale) to 4 (high stigma; strongly agree with all 7 items on the subscale); HIV medication high adherence = medications taken ≥95% of the time in the last six months. Proportions calculated excluding small numbers of participants with missing data, and proportions with HIV medication high adherence and missed HIV care calculated from participants taking antiretroviral medications and participants in HIV care, respectively.

Table 2:

Associations between population density quartiles and clinical outcomes among participants of the Women's Interagency HIV Study living with HIV in the Southern United States

Outcome	Quartile	Estimate	95% Confidence Interval
Gynecologic abnormality	Lowest density	reference	
	2nd lowest density	0.92	0.83–1.01
	3rd lowest density	0.96	0.86–1.06
	Highest density	0.94	0.85–1.04
Did not miss HIV care	Lowest density	reference	
	2nd lowest density	1.00	0.91–1.11
	3rd lowest density	0.99	0.90–1.10
	Highest density	0.99	0.89–1.10
HIV viral load suppression (<200 copies/mL)	Lowest density	reference	
	2nd lowest density	0.83	0.74–0.93
	3rd lowest density	0.81	0.72–0.92
	Highest density	0.76	0.66–0.88
HIV medication high adherence	Lowest density	reference	
	2nd lowest density	0.98	0.88–1.09
	3rd lowest density	0.96	0.87–1.07
	Highest density	0.96	0.86–1.08
Internalized stigma score	Lowest density	reference	
	2nd lowest density	0.02	−0.15 – 0.19
	3rd lowest density	−0.08	−0.26 – 0.10
	Highest density	−0.10	−0.27 – 0.07
CD4 count (cells/μL)	Lowest density	reference	
	2nd lowest density	−61.01	−146.10 – 24.07
	3rd lowest density	−119.59	−197.51 – −41.67
	Highest density	−97.43	−176.58 – −18.27

Estimates are adjusted mean difference via linear regression for Internalized Stigma and CD4 count, and adjusted risk ratios estimated via modified Poisson regression for other outcomes. All models accounted for clustering by census tract and included the following covariates: race/ethnicity (white non-Hispanic, African-American non-Hispanic, Hispanic, other), age (continuous), health insurance (yes/no), employment (yes/no), education level (<high school, high school graduation or some college, college completion or above), and depressive symptoms (yes/no, yes if Center for Epidemiological Studies Depression Scale score ≥16). Internalized stigma score, based on the "negative self-image" subscale of the HIV Stigma Scale, ranges from a score of 1 (low stigma; strongly disagree with all 7 items on the subscale) to 4 (high stigma; strongly agree with all 7 items on the subscale), so a 1-unit score increase is equivalent to changing one's response to all of the 7 items from "agree" to "strongly agree." Gynecologic abnormality = abnormal cervical screening result or treatment for a gynecologic condition in the past six months (yes/no); HIV medication high adherence = medications taken ≥95% of the time in the last six months (yes/no), and did not miss HIV care = no missed HIV care visit in the past six months (yes/no).