Connecting Race and Place: A County-Level Analysis of White, Black, and Hispanic HIV Prevalence, Poverty, and Level of Urbanization

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Objectives. We evaluated the role of poverty in racial/ethnic disparities in HIV prevalence across levels of urbanization.

Methods. Using national HIV surveillance data from the year 2009, we constructed negative binomial models, stratified by urbanization, with an outcome of race-specific, county-level HIV prevalence rates and covariates of race/ethnicity, poverty, and other publicly available data. We estimated model-based Black–White and Hispanic–White prevalence rate ratios (PRRs) across levels of urbanization and poverty.

Results. We observed racial/ethnic disparities for all strata of urbanization across 1111 included counties. Poverty was associated with HIV prevalence only in major metropolitan counties. At the same level of urbanization, Black–White and Hispanic–White PRRs were not statistically different from 1.0 at high poverty rates (Black–White PRR = 1.0, 95% confidence interval [CI] = 0.4, 2.9; Hispanic–White PRR = 0.4, 95% CI = 0.1, 1.6). In nonurban counties, racial/ethnic disparities remained after we controlled for poverty.

Conclusions. The association between HIV prevalence and poverty varies by level of urbanization. HIV prevention interventions should be tailored to this understanding. Reducing racial/ethnic disparities will require multifactorial interventions linking social factors with sexual networks and individual risks. (*Am J Public Health.* 2014;104: e77–e84. doi:10.2105/AJPH.2014.301997)

Within the United States, disparities in diagnosed HIV prevalence among the 3 major racial/ethnic groups (White, Black, and Hispanic) are striking. At the end of 2009, 43% of people living with an HIV diagnosis were Black, 35% White, and 19% Hispanic.[1] Concurrently, Blacks constituted only 12% of the population, non-Hispanic Whites 65%, and Hispanics 16%.[2] In the 46 states with confidential name-based HIV reporting since at least January 2007, the estimated diagnosed HIV prevalence rate at the end of 2009 was 952 per 100 000 people among Blacks (near the threshold for a generalized epidemic),[1] 320 per 100 000 among Hispanics, and 144 per 100 000 among Whites; compared with Whites, therefore, Blacks and Hispanics were respectively 6.6 times and 2.2 times more likely to be living with an HIV diagnosis.

A number of mechanisms, primarily structural and social factors, have been proposed to explain these stark racial/ethnic disparities in HIV prevalence.[3,4] Structural factors, such as oppression and mistrust in government, may hinder receptivity to prevention outreach and increase HIV prevalence.[3] Social constructs (e.g., homophobia and HIV stigma) may discourage open discussion of risk behaviors and limit HIV testing and treatment. Additionally, limited access to health care resources has been identified as a key driver of racial/ethnic health disparities.[5] Finally, Black men are more likely than White men to be both incarcerated and infected with HIV while incarcerated.[6,7] All of these factors are, in turn, associated with poverty.[8] However, specific relationships among these multiple factors and racial/ethnic HIV prevalence disparities, and variation of these relationships across levels of urbanization, are not well understood.

Previous analyses of national surveillance and survey data in the United States have focused on associations between HIV prevalence rates, poverty, and race exclusively in urban areas, finding no disparities in poverty-adjusted HIV prevalence rates among heterosexuals in urban settings.[9,10] Furthermore, among heterosexuals living in US urban areas with high AIDS prevalence, HIV prevalence rates among those living at or below the poverty line were 2.2 times as high as rates among those living above the poverty line.[10] A more recent analysis of US surveillance data confirmed the complex associations between demographics, social determinants of health, and AIDS diagnosis rates.[8]

However, variation in these factors across the urban–rural continuum may limit generalizability of these findings to nonurban settings, where similar research is lacking. In 2009, the proportions of Black and Hispanic Americans living in poverty were roughly twice that of White Americans.[11] For all races/ethnicities, the proportion living in poverty is greater in rural areas than in urban areas.[12] Additionally, rural areas, with lower HIV prevalence, are more likely to be medically underserved, with reduced access to HIV care and treatment.[13]

In the context of these complex sociodemographic associations, previously observed associations in the United States between poverty and racial/ethnic disparities in HIV may differ outside of urban areas. Therefore, using publicly available county-level data, we first describe the association between poverty and HIV prevalence by race/ethnicity across levels of urbanization. We subsequently examine racial/ethnic disparities in HIV prevalence across levels of urbanization, after controlling for poverty. We hypothesized that, in all strata of urbanization, poverty-adjusted Black–White and Hispanic–White HIV prevalence rate ratios (PRRs) would statistically differ from 1.0.

METHODS

To evaluate racial/ethnic variation in the associations between poverty and HIV prevalence at different levels of urbanization, we

used publicly available data to statistically model county-level, race-specific HIV prevalence rates. We obtained county-level estimated case counts of Black, White, and Hispanic persons aged 13 years and older living with an HIV infection diagnosis as of December 31, 2009, from AIDSVu.org, an interactive online map of HIV prevalence in the United States.[14] The analysis includes HIV surveillance data reported by state departments of health (on the basis of address at diagnosis) to the Centers for Disease Control and Prevention (CDC) through June 2011. The CDC adjusted these data for reporting delays and missing risk-factor information, but not for incomplete reporting. The CDC then provided aggregate estimated county-level data to AIDSVu.org. Prevalence denominators are 2009 US Census Bureau race-specific population estimates for each county.[15] Our analysis included counties meeting the following criteria: the number of estimated diagnosed prevalent race-specific cases was 5 or more; the race-specific population was at least 1000 persons; the county was located within the 46 states that had confidential name-based HIV infection reporting since at least January 2007; data were available for the White population and at least 1 other race/ethnicity; and the CDC was authorized by the given state to release aggregate estimated case counts for individual racial/ethnic groups. The CDC implements the first 2 criteria to protect the confidentiality of persons included in the case data.

In our analysis, we measured county-level, race-specific poverty as the percentage of the given race living in poverty. We defined county-level urbanization using the urbanization classification of the National Center for Health Statistics.[16] This categorization includes 6 levels based on a county's population and proximity to metropolitan areas (Table 1). To maintain consistency with the data source, we use the term "level of urbanization" to refer to this measure. We included other publicly available, county-level potential confounders because of previously documented associations with HIV prevalence.[4,6,13,23] These factors were estimates of per capita health expenditures and estimates of population proportions of drug use, men who have sex with men, health insurance coverage, and correctional populations (Table 1).

We calculated observed race-specific HIV prevalence rates and Black–White and Hispanic–White PRRs for each level of urbanization by summing cases and populations for included counties. We compared race-specific distributions of HIV cases by level of urbanization using the χ^2 test. We performed negative binomial regressions, stratified by urbanization, to examine unadjusted associations between individual potential confounders and HIV prevalence rates.[24]

Given the overdispersion of the outcome, we used negative binomial (rather than Poisson) regressions in this analysis. We constructed 2 sets of stratified negative binomial models; 1 set included Black and White populations and the other included Hispanic and White populations. We modeled county-level, race/ethnicity-specific HIV case counts as a function of poverty, race (as an indicator variable representing the race/ethnicity of the outcome), potential confounders (Table 1), and log-race-specific population (as the offset). The models accounted for potential differences in the associations between HIV prevalence and poverty by race/ethnicity using a poverty–race interaction term; they also accounted for potential differences in all associations across levels of urbanization through stratification. We conducted model selection using a hierarchical backward elimination strategy.[25] This strategy assessed interaction and then assessed all possible subsets of measured confounders. Using the fully specified model as the gold

TABLE 1—Data Sources Used in the Model of HIV Prevalence

Variable	Data Source	Comments
Poverty	2005–2009 American Community Survey (ACS) 5-y estimates[17]	Percentage of the race living in poverty.
Urbanicity	2006 National Center for Health Statistics urban–rural classification scheme for counties[16]	This categorization defines counties on the basis of size and proximity to metropolitan areas. The 6 categories are central counties of metropolitan areas of ≥ 1 million people (large central metro), fringe counties of metropolitan areas of ≥ 1 million people (large fringe metro), counties in metropolitan areas of 250 000–999 999 people (medium metro), counties in metropolitan areas of 50 000–249 999 people (small metro), micropolitan counties, and noncore counties.
Drug use	2006–2008 National Surveys on Drug Use and Health, substate estimates from the Substance Abuse and Mental Health Services Administration[18]	Percentage of population aged ≥ 12 y who used an illicit drug other than marijuana in past month. Each county within the defined substate region was assigned the same value.
Population of men who have sex with men	2005–2009 ACS 5-y estimates[19]	Percentage of male–male unmarried partner households.
Health insurance coverage	2009 Small Area Health Insurance Estimates[20]	Percentage of the population < 65 y lacking health insurance.
Correctional population	2010 United States Decennial Census[21]	Percentage of the county population in federal or state prisons.
Health care expenditures	2009–2010 Health Resources and Services Administration Area Resource File[22]	Per capita hospital expenditures.

standard, we considered that any subset of confounders that changed the measure of association of interest by less than 10% also controlled for confounding. The final model subsequently used this subset of confounders. With this method, no other set of confounders adequately controlled for confounding, and all listed confounders and the poverty–race interaction term were retained in the final model.

We calculated model-based prevalence rates for each race/ethnicity and PRRs and 95% confidence intervals for Blacks and Hispanics (compared with Whites) for each level of urbanization at 10%, 20%, and 30% poverty. Selection of these values of poverty permitted calculation of adjusted prevalence rates and PRRs because of the inclusion of the poverty–race interaction term in the model. We chose these values for poverty on the basis of the US federal definition of a poverty area (≥ 20% of the population with incomes below the poverty line) and the observed ranges of race-specific poverty.[26] We compared poverty-adjusted PRRs across strata of urbanization using Wald tests. We used a nominal type I error rate of 0.05. We performed all analyses with SAS version 9.3 (SAS Institute, Cary, NC).

RESULTS

We included a total of 1111 counties (34% of US counties) in the analysis (Figure A, available as a supplement to this article at http://www.ajph.org). We included 1037 counties (representing an estimated 540 615 diagnosed HIV cases) in the model for Black and White populations (Table 2) and 643 counties (representing an estimated 368 704 diagnosed HIV cases) in the model for Hispanic and White populations (Table 3). At the end of 2009, in the 46 states with confidential, name-based reporting since at least 2007, the CDC estimated that there were 273 800 White, 335 798 Black, and 151 130 Hispanic Americans living with HIV.[1] Therefore, in these 46 states, Black–White models included 89% of the estimated prevalent Black and White HIV cases and Hispanic–White models included 87% of the estimated prevalent Hispanic and White cases.

We included counties from all US Census Bureau regions. Although only 46% of all counties in the United States are in the South, most included counties in both models were in the South (66% for the Black–White model, 51% for the Hispanic–White model). Combined, the South and Northeast regions, which together represent 53% of all counties and 66% of all estimated prevalent diagnosed cases, contributed most cases to each model (72% for the Black–White model, 62% for the Hispanic–White model).[1]

We included counties from all levels of urbanization (Table A). Counties in the most urban category (large central metro) included 57% of cases in the Black–White models and 64% of cases in the Hispanic–White models. For all races/ethnicities, poverty rates increased with decreasing urbanization, except for large fringe metro counties, which had the lowest poverty rates (Tables 2 and 3).

Crude diagnosed HIV prevalence rates for each race/ethnicity significantly differed across levels of urbanization ($P < .001$ for each race/ethnicity) (Figure B). We observed the highest prevalence rates for all 3 races (except that among Hispanics in noncore counties) in large central metro counties. Additionally, we observed racial/ethnic disparities in HIV prevalence across all levels of urbanization. Black–White prevalence rate differences were highest in large central metro counties (1220 per 100 000 population). Hispanic–White prevalence rate differences were highest in noncore counties (704 per 100 000 population). However, although observed Black–White and Hispanic–White HIV PRRs were greater than 1.0 across all strata of urbanization (PRR range = 3.9–9.1 and 1.5–7.0, respectively), we observed the lowest PRRs in large central metro counties (PRR = 4.0 and 1.5 for Black–White and Hispanic–White, respectively; Tables 2 and 3). At each level of urbanization, observed Hispanic–White disparities were lower than Black–White disparities.

TABLE 2—Descriptive Statistics, Observed Prevalence Rates, and Observed Prevalence Rate Ratios (PRRs) for Counties Included in Black–White Models, Aggregated by Level of Urbanization: United States, 2009

	Black				White				
Level of Urbanization	Cases, No. (%)[a]	Population, No. (%)	Observed Prevalence Rate[b]	% Poverty, Mean (SD)[c]	Cases, No. (%)[a]	Population, No. (%)	Observed Prevalence Rate[b]	% Poverty, Mean (SD)[c]	Observed PRR
Large central metro	171 496 (57)	10 562 760 (43)	1624	24.8 (6.2)	134 045 (57)	33 185 754 (28)	404	8.5 (2.5)	4.0
Large fringe metro	50 419 (17)	5 072 003 (21)	994	20.1 (10.1)	41 778 (18)	31 677 663 (27)	132	7.6 (3.4)	7.5
Medium metro	47 132 (16)	4 752 163 (19)	992	27.0 (8.4)	39 502 (17)	29 044 768 (25)	136	9.9 (2.9)	7.3
Small metro	14 570 (5)	1 847 792 (7)	789	30.5 (10.0)	11 601 (5)	11 912 386 (10)	97	11.8 (4.2)	8.1
Micropolitan	13 990 (5)	1 726 128 (7)	811	33.3 (11.1)	8083 (3)	9 031 035 (8)	90	13.4 (4.0)	9.1
Noncore	5832 (2)	714 082 (3)	817	33.6 (13.9)	2167 (1)	2 290 277 (2)	95	13.8 (3.6)	8.6
Total	303 439 (100)	24 674 928 (100)	1230	11.1 (4.3)	237 176 (100)	117 141 883 (100)	203	28.6 (11.6)	6.1

Note. Counties are from the 46 states with confidential name-based HIV infection reporting since at least January 2007 that met the inclusion criteria.
[a]Cases represent the estimated number of persons aged 13 years and older living with a diagnosis of HIV infection at the end of 2009.
[b]Prevalence rate per 100 000.
[c]Mean percentage of poverty represents the mean race-specific poverty of all counties within the given stratum of urbanization included in the analysis.

TABLE 3—Descriptive Statistics, Observed Prevalence Rates, and Observed Prevalence Rate Ratios (PRRs) for Counties Included in Hispanic–White Models, Aggregated by Level of Urbanization: United States, 2009

	Hispanic				White				
Level of Urbanization	Cases, No. (%)[a]	Population, No. (%)	Observed Prevalence Rate[b]	% Poverty, Mean (SD)[c]	Cases, No. (%)[a]	Population, No. (%)	Observed Prevalence Rate[b]	% Poverty, Mean (SD)[c]	Observed PRR
Large central metro	100 079 (71)	16 691 022 (54)	600	25.0 (6.2)	134 045 (59)	33 185 754 (32)	404	8.5 (2.5)	1.5
Large fringe metro	16 799 (12)	5 298 809 (17)	317	19.0 (9.9)	39 630 (17)	28 368 809 (27)	140	6.9 (2.9)	2.3
Medium metro	16 397 (12)	5 920 105 (19)	277	26.0 (7.8)	37 393 (16)	26 257 078 (25)	142	9.5 (2.6)	1.9
Small metro	3690 (3)	1 892 266 (6)	195	28.4 (9.9)	10 203 (5)	10 242 782 (10)	100	11.5 (4.3)	2.0
Micropolitan	2921 (2)	861 784 (3)	339	28.3 (15.1)	5857 (3)	5 861 301 (6)	100	12.0 (3.4)	3.4
Noncore	741 (1)	90 242 (0)	821	28.9 (11.6)	951 (0)	814 015 (1)	117	13.2 (3.4)	7.0
Total	140 626 (100)	30 754 228 (100)	457	25.6 (11.1)	228 078 (100)	104 729 739 (100)	218	9.9 (3.8)	2.1

Note. Counties are from the 46 states with confidential name-based HIV infection reporting since at least January 2007 that met the inclusion criteria.
[a]Cases represent the estimated number of persons aged 13 years and older living with a diagnosis of HIV infection at the end of 2009.
[b]Prevalence rate per 100 000.
[c]Mean percentage of poverty represents the mean race-specific poverty of all counties within the given stratum of urbanization included in the analysis.

At all levels of urbanization for both Blacks and Whites (except that of Whites in large central metro and medium metro counties), associations between poverty and HIV prevalence were statistically insignificant (Table 4). Although the adjusted association between poverty and HIV prevalence for Blacks was statistically different from that for Whites in the most urban counties (the PRR for a 10%

TABLE 4—Estimated Adjusted Prevalence Rate Ratios for All Variables Included in the Black–White and Hispanic–White Negative Binomial Models: United States, 2009

	Adjusted Prevalence Rate Ratio (95% Confidence Interval)						
Level of Urbanization	Poverty for Blacks or Hispanics[a]	Poverty for Whites[a]	Correctional Population[b]	Male–Male Households[c]	Drug Use[d]	% Uninsured[e]	Health Care Expenditures[f]
Black–White models							
Large central metro	0.9 (0.8, 1.1)	1.8 (1.1, 3.0)	3.9 (1.0, 14.5)	1.1 (1.1, 1.2)	0.8 (0.7, 1.0)	1.3 (1.1, 1.5)	1.0 (1.0, 1.1)
Large fringe metro	1.0 (0.9, 1.1)	1.1 (0.9, 1.5)	1.7 (1.5, 1.9)	1.2 (1.1, 1.2)	0.8 (0.7, 0.9)	1.2 (1.1, 1.3)	1.0* (1.0, 1.0)
Medium metro	0.9 (0.9, 1.0)	0.8* (0.6, 1.0)	1.2 (1.1, 1.3)	1.1 (1.1, 1.2)	1.0 (0.9, 1.1)	1.1 (1.1, 1.3)	1.1 (1.1, 1.1)
Small metro	1.0 (0.9, 1.1)	1.0 (0.8, 1.2)	1.3 (1.2, 1.4)	1.0 (1.0, 1.1)	1.1 (1.0, 1.2)	1.3 (1.1, 1.4)	1.1* (1.0, 1.1)
Micropolitan	1.0 (0.9, 1.1)	0.8 (0.7, 1.0)	1.3 (1.2, 1.4)	1.1* (1.0, 1.1)	1.0 (1.0, 1.1)	1.1 (1.0, 1.2)	1.1* (1.0, 1.1)
Noncore	1.0 (0.9, 1.0)	0.9 (0.7, 1.2)	1.2 (1.2, 1.3)	1.0 (1.0, 1.0)	1.1 (1.0, 1.3)	0.8* (0.7, 1.0)	1.0 (0.9, 1.1)
Hispanic–White models							
Large central metro	1.1 (0.8, 1.4)	1.9* (1.0, 3.7)	6.5 (1.3, 33.0)	1.1 (1.1, 1.2)	0.8* (0.7, 1.0)	1.1 (0.9, 1.3)	1.0 (1.0, 1.1)
Large fringe metro	1.4 (1.3, 1.6)	1.6* (1.0, 2.5)	2.5 (1.9, 3.3)	1.1 (1.1, 1.2)	0.7 (0.6, 0.8)	0.9 (0.7, 1.0)	1.0* (1.0, 1.0)
Medium metro	1.0 (0.9, 1.2)	0.9 (0.6, 1.3)	1.5 (1.1, 2.0)	1.1* (1.0, 1.2)	1.0 (0.9, 1.1)	0.8 (0.7, 0.9)	1.1 (1.1, 1.2)
Small metro	1.1 (0.9, 1.2)	1.1 (0.8, 1.6)	1.5 (1.3, 1.7)	1.0 (1.0, 1.1)	0.9 (0.8, 1.1)	0.7 (0.6, 0.8)	1.0 (1.0, 1.1)
Micropolitan	1.3 (1.1, 1.4)	1.5 (1.0, 2.4)	1.5 (1.3, 1.6)	1.2 (1.1, 1.2)	0.9 (0.7, 1.1)	0.6 (0.5, 0.7)	1.0 (0.9, 1.1)
Noncore	1.2 (1.0, 1.5)	1.9 (1.0, 3.6)	1.4 (1.2, 1.6)	1.0 (0.9, 1.2)	1.2 (0.8, 1.7)	0.3 (0.2, 0.5)	0.8 (0.6, 1.0)

[a]Prevalence rate ratio (PRR) for a 10% increase in poverty, controlling for all other variables.
[b]PRR for a 5% increase in the percentage of the population living in correctional institutions, controlling for all other variables.
[c]PRR for a 0.1% increase in the percentage of male–male households, controlling for all other variables.
[d]PRR for a 1% increase in the percentage reporting drug use, controlling for all other variables.
[e]PRR for a 10% increase in the percentage uninsured, controlling for all other variables.
[f]PRR for a $1000 increase in per capita health care expenditures, controlling for all other variables.
*$P < .05$. Confidence interval for the PRR does not include the null, despite rounding to 1.0.

increase in poverty was 0.9 [95% confidence interval (CI) = 0.8, 1.1] for Blacks and 1.8 [95% CI = 1.1, 3.0] for Whites), the associations within all other strata were statistically equivalent (Table 4). Associations between confounders and HIV prevalence also differed by level of urbanization (Table 4).

After adjustment for poverty and the other covariates, model-derived Black–White PRRs in large central metro counties were not significantly different from 1.0 when evaluated at 30% poverty (PRR = 1.0 [95% CI = 0.4, 2.9]), but were significantly greater than 1.0 when evaluated at 10% and 20% poverty (PRR = 3.9 [95% CI = 2.8, 5.5] and 2.0 [95% CI = 1.1, 3.6], respectively; Table 5; Figure C). Within this single strata of urbanization, this trend in PRRs across poverty was statistically significant ($P < .01$). For all other poverty levels and levels of urbanization, adjusted Black–White PRRs were significantly greater than 1.0. Adjusted PRRs in large central metro counties were significantly less than those for all other levels of urbanization ($P < .001$ for each comparison), but adjusted PRRs were statistically similar for all other pairs of levels of urbanization.

For most levels of urbanization for both Hispanics and Whites, associations between poverty and HIV prevalence were statistically insignificant. The adjusted associations between poverty and HIV prevalence for Hispanics were statistically equivalent to those of Whites for all levels of urbanization, although the association for Whites was stronger in the most urban counties (the PRR for a 10% increase in poverty was 1.1 [95% CI = 0.8, 1.4] for Hispanics and 1.9 [95% CI = 1.0, 3.7] for Whites; Table 4). Adjusted associations between confounders and HIV prevalence varied by level of urbanization (Table 4).

Adjusted, model-derived Hispanic–White PRRs were not significantly different from 1.0 at 10%, 20%, and 30% poverty in the most urban counties (PRR = 1.4 [95% CI = 0.9, 2.1], 0.8 [95% CI = 0.4, 1.6], and 0.4 [95% CI = 0.1, 1.6], respectively) and at 20% and 30% poverty in large fringe metro counties (PRR = 1.5 [95% CI = 0.8, 2.7] and 1.3 [95% CI = 0.4, 3.5], respectively; Table 5; Figure C). For all other poverty levels and levels of urbanization, poverty-adjusted Hispanic–White PRRs remained significantly greater than 1.0. However, within these (and all other) levels of urbanization, apparent trends in model-based PRRs across poverty levels were statistically nonsignificant. Adjusted PRRs in counties belonging to metropolitan statistical areas with

TABLE 5—Model-Based, Adjusted HIV Prevalence Rates and Prevalence Rate Ratios (PRRs), by Level of Urbanization: United States, 2009

	Model-Based Black-White PRR (95% CI)			Model-Based Hispanic-White PRR (95% CI)		
Level of Urbanization	10% Poverty	20% Poverty	30% Poverty	10% Poverty	20% Poverty	30% Poverty
Large central metro						
PRR	3.9 (2.8, 5.5)	2.0 (1.1, 3.6)	1.0 (0.4, 2.9)	1.4 (0.9, 2.1)	0.8 (0.4, 1.6)	0.4 (0.1, 1.6)
Black or Hispanic prevalence rate	753 (403, 1408)	706 (396, 1257)	661 (365, 1198)	444 (204, 962)	474 (228, 986)	506 (235, 1091)
White prevalence rate	193 (104, 356)	355 (146, 863)	654 (180, 2378)	320 (144, 710)	622 (196, 1977)	1212 (226, 6505)
Large fringe metro						
PRR	7.2 (6.1, 8.5)	6.4 (4.4, 9.2)	5.6 (3.0, 10.6)	1.7 (1.3, 2.2)	1.5 (0.8, 2.7)	1.3 (0.4, 3.5)
Black or Hispanic prevalence rate	704 (446, 1112)	711 (448, 1128)	718 (444, 1158)	724 (390, 1347)	1010 (541, 1886)	1409 (738, 2689)
White prevalence rate	98 (60, 160)	112 (58, 215)	127 (53, 306)	426 (212, 855)	691 (259, 1841)	1120 (290, 4327)
Medium metro						
PRR	7.5 (6.3, 8.9)	9.3 (7.1, 12.2)	11.5 (7.0, 18.8)	2.7 (2.1, 3.5)	3.3 (2.1, 5.2)	3.9 (1.7, 9.1)
Black or Hispanic prevalence rate	407 (279, 592)	383 (268, 548)	361 (253, 515)	379 (222, 647)	390 (232, 656)	402 (237, 683)
White prevalence rate	54 (38, 78)	41 (26, 66)	31 (16, 61)	140 (80, 244)	119 (56, 256)	102 (35, 300)
Small metro						
PRR	8.1 (6.5, 10.0)	8.2 (6.5, 10.4)	8.4 (5.6, 12.7)	3.0 (2.1, 4.2)	2.8 (1.9, 4.1)	2.6 (1.4, 5.0)
Black or Hispanic prevalence rate	326 (193, 551)	321 (197, 524)	316 (198, 505)	610 (258, 1442)	645 (286, 1455)	683 (309, 1511)
White prevalence rate	41 (25, 65)	39 (23, 66)	37 (20, 72)	204 (90, 462)	230 (93, 570)	260 (87, 775)
Micropolitan						
PRR	9.2 (7.6, 11.2)	10.7 (8.9, 12.9)	12.4 (8.9, 17.4)	3.5 (2.5, 4.9)	2.9 (1.9, 4.4)	2.3 (1.0, 5.3)
Black or Hispanic prevalence rate	498 (291, 851)	492 (293, 824)	485 (293, 804)	836 (293, 2385)	1049 (379, 2902)	1317 (483, 3588)
White prevalence rate	54 (33, 90)	46 (27, 79)	39 (21, 73)	236 (84, 667)	366 (119, 1122)	567 (147, 2186)
Noncore						
PRR	9.2 (7.3, 11.7)	9.9 (7.8, 12.5)	10.6 (6.6, 17.0)	7.2 (4.1, 12.6)	4.5 (2.5, 8.0)	2.8 (0.9, 8.6)
Black or Hispanic prevalence rate	772 (398, 1499)	753 (393, 1442)	733 (385, 1397)	3045 (694, 13 369)	3619 (878, 14 921)	4302 (1078, 17 160)
White prevalence rate	84 (44, 158)	76 (38, 154)	69 (29, 163)	424 (98, 1834)	805 (182, 3556)	1527 (263, 8875)

Note. CI = confidence interval. Prevalence rates are per 100 000. Trend in model-based PRR across poverty levels is statistically significant for the large central metro counties in the Black–White model ($P < .01$), but for no other levels of urbanization in either model (as shown by statistical significance of the poverty–race interaction term).

populations greater than 1 million (i.e., those in the 2 highest levels of urbanization) were significantly smaller than adjusted PRRs for all other levels of urbanization ($P < .001$ for each comparison). Pairwise comparisons of adjusted PRRs between all other levels of urbanization were not statistically significant.

DISCUSSION

Using population-based HIV surveillance data, we investigated the relationships between HIV prevalence, race, and poverty across levels of urbanization. The association between individual-level poverty and HIV is well documented in the United States, especially in urban areas.[27–35] For both Blacks and Hispanics, poverty-adjusted HIV PRRs in our study were not statistically different from 1.0 in high-poverty urban counties. However, in low-poverty urban counties and in less-urban settings, severe racial/ethnic HIV disparities remained, even after adjustment for poverty. These results support prior analyses in which poverty mediated racial/ethnic HIV prevalence disparities among heterosexuals in selected high-prevalence, high-poverty US cities, and extend those findings by including prevalent HIV cases resulting from all modes of transmission, from a larger number of urban counties and from nonurban counties.[9,10]

Our findings suggest that the association between HIV prevalence and poverty is not monolithic. For urban areas, where controlling for poverty reduced racial/ethnic disparities, poverty may be a marker for high HIV density and large high-risk populations.[9,27,29,33] In nonurban areas, health insurance coverage and per capita health expenditures were significantly associated with HIV prevalence, whereas poverty was not. Therefore, in the absence of high HIV density or high-risk populations, poverty may be a marker for other factors on the causal pathway between poverty and HIV risk, such as decreased health care resources.[13] In our analysis, the regression coefficients for poverty increased when we removed the 2 health care variables from the models, indicating that the association between poverty and HIV prevalence may be subsumed by the associations with access to care in nonurban counties. Consequently, we posit that poverty may act through 3 pathways, which vary in importance by urbanization: 1 pathway mediated by high HIV density in the community, 1 by the presence of high-risk populations in the community, and 1 by limited access to care.

However, these poverty-mediated pathways alone may not drive racial/ethnic disparities. Even after adjustment for health care factors in nonurban counties, disparities remained. Additional unspecified factors related to race/ethnicity and unrelated to poverty (such as stigma, sexual networks, and coinfection with sexually transmitted diseases) may account for the observed racial/ethnic disparities in county-level HIV prevalence in nonurban areas.[5,16]

The conceptualization of these pathways may guide prevention, with interventions targeting factors that drive the epidemic at specific levels of urbanization. Major urban areas are currently the focus of national HIV prevention strategies. The National HIV/AIDS Strategy calls for greater prevention "in communities where HIV is most heavily concentrated"[36(p8)] and also for a reduction in racial/ethnic disparities.[36] The former recommendation has been advanced through the Enhanced Comprehensive HIV Prevention Planning Project, which targets HIV prevention in the 12 US cities with the highest AIDS prevalence.[37] Our observed lack of racial disparities in high-poverty urban counties may partially reflect the ongoing influence of prevention programs in these counties. However, a reduction in racial/ethnic disparities will also require additional, unique prevention strategies for counties outside of major metropolitan areas (which include 25% of national HIV cases), where disparities are greater than in the most urban counties.

The complex interrelationships between the factors of interest and the limitations of the analysis, including variable selection and study design, make causal inference impossible. However, the results of our analysis suggest factors that may be considered to reduce disparities. Increased health insurance coverage may address broader associations between HIV prevalence and poverty in nonurban areas by improving access to care.[5,13] The observed null association between poverty and HIV prevalence outside of highly urban counties may indicate that interventions associated with poverty reduction alone may not reduce disparities in all settings of urbanization. In addition to existing behavioral interventions, our analysis supports a multifactorial approach, linking social factors with sexual networks and individual risk behaviors.[4]

Limitations

Limitations of this analysis include those typical of ecological analyses, specifically the ecological fallacy. Because our unit of analysis is the county, we cannot characterize intracounty variability, which may be substantial, and cannot make inferences to individuals within these counties.

Selection of counties for inclusion in the study may also have affected results. Although most included counties were from 2 US Census–defined regions (the South and Northeast), this geographic distribution is similar to that in other national studies of HIV prevalence.[9,10,13] Our analysis also included almost 90% of HIV cases from the 46 states with estimated prevalence data. We attempted to further account for potential selection bias by requiring both analyzed racial/ethnic populations to contribute populations for a given county. Excluded counties had either small race-specific populations (<1000) or few race-specific cases (<5). As a result, at lower levels of urbanization, counties with a low prevalence were excluded, leaving only counties with higher prevalence for inclusion in the analysis. In counties with small case counts, which were concentrated in more rural strata of urbanization, estimates may also have been affected by unstable prevalence rates (i.e., rates generated with case counts of <12).[1] Sensitivity analysis using only stable rates, which reduced the number of more rural counties and, consequently, slightly modified PRR estimates and increased confidence interval width, did not meaningfully change results. Consequently, although our overall conclusions are generalizable at the county level, and possibly to other geographic areas, our estimates are likely biased primarily at the lowest levels of urbanization, with prevalence being overestimated and observed associations between poverty and HIV prevalence rates being biased away from the null at these more rural levels of urbanization.

Our use of both surveillance and census data may have also influenced our results. Although surveillance data provide the best available

estimates of HIV prevalence, these data depend on racial patterns of HIV diagnosis. Because more Black Americans than White Americans have been tested for HIV, racial/ethnic disparities may be overestimated.[38] We also included in the analysis county-level confounders from the US Census. The inclusion of other social determinants of health (e.g., education) was limited by the potential for high collinearity with poverty, resulting in an unstable model. As a result, our estimates may exhibit residual confounding.

Finally, this analysis assumed independence of rates within and between counties. Although accounting for spatial correlation may reduce variance, the exact associations between geographic proximity and county-level HIV prevalence are unstudied.[39] As a result, the effect of excluding spatial correlation is unclear.

Conclusions

Our analysis found differences in the associations between HIV prevalence and poverty by race/ethnicity and urbanization. Although our analysis confirmed the associations between poverty and racial/ethnic disparities in urban areas, the lack of such a relationship in nonurban areas suggests the need for additional research regarding differences between the urban and nonurban HIV epidemic. The proposed series of pathways between poverty and HIV prevalence suggests the need for additional, more nuanced studies of poverty and its relationship to proximate determinants of HIV infection, which are likely to be multiple and to vary by setting.[40] Additionally, as a continuation of county-level analyses, future spatial analyses of HIV prevalence should examine the role of geography in the HIV epidemic, potentially suggesting the geographic range of sexual networks and the influence of urban HIV prevalence on the nonurban epidemic.

This analysis focused on 3 keys factors in the practice of public health: place, race, and poverty. In doing so, it reinforced complex relationships among these factors and identified nuances in their associations with HIV prevalence. We have observed, to the best of our knowledge for the first time, county-level differences in racial/ethnic HIV disparities by level of urbanization. We found that, although poverty may help to explain racial/ethnic HIV disparities in the most urban counties, different factors unrelated to poverty must explain the large disparities in nonurban areas. Additional research is needed to identify factors and confirm causal pathways resulting in these racial/ethnic disparities. ■

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Contributors

All authors contributed to the interpretation of findings and to the writing of the report. A. S. Vaughan and E. Rosenberg performed the analysis. A. S. Vaughan and P. S. Sullivan conceptualized the analysis. A. S. Vaughan wrote the first and final drafts.

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Human Participant Protection

Because this research used only publicly available, county-level data, protocol approval was not required.

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