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ZIP Code Correlates of HIV-Testing: A Multi-level Analysis in Los Angeles

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In this study we examine how individuals' residential areas relate to their HIV-testing, regardless of individuals' characteristics. Data from a 1999 random probability sample of Los Angeles (LA) County adults ($n = 5475$) was used to conduct a multi-level analysis of HIV-testing among respondents in (1) all 233 ZIP codes and (2) the subset of regions with higher rates of higher-risk sex. Results showed that HIV-testing rates varied across individuals' residential ZIP codes. Throughout LA and in higher-risk regions, residents of areas containing concentrations of African Americans were more likely to test for HIV than residents of White or Latino areas, regardless of individuals' own race/ethnicity or the number of AIDS cases or testing sites in ZIP codes. However, residents of Latino areas were no more likely to test than residents of White areas. This is a concern because of increasing rates of HIV-infection among Latinos. We conclude that opportunities exist to increase testing in Latino higher-risk areas.

KEY WORDS: contextual; HIV/AIDS; service utilization; geography; Multi-level.

INTRODUCTION

An estimated 40,000 persons become infected with HIV in the United States annually and recent reports show that the number of persons living with HIV (PLH) is increasing (CDC, 2000; Jaffe, 2003). Although testing is considered one of the most cost-effective ways to decrease HIV transmission (Creese *et al.*, 2002), many PLH do not test and are unaware of their statuses (Glynn and Rhodes, 2005). To understand HIV-testing impediments, most studies focus on individuals' characteristics, ignoring characteristics of individuals' residential areas. Four studies have examined variations in HIV-testing across geographic regions and two explored a possible regional characteristic associated with that variance, leaving many compelling regional characteristics unexamined (CDC, 2003a; Los Angeles Public Health Assessment Unit, 2001; Fennema *et al.*, 2000; Leaver *et al.*, 2004). HIV-testing has been associated with having a test site conveniently nearby, prevention program availability or residing in areas with more AIDS cases (CDC, 2003a; Leaver *et al.*, 2004; Speilberg *et al.*, 2001).

A bivariate analysis of a 1997 sample of Los Angeles (LA) County residents showed variations in HIV-testing across eight health service areas, without exploring reasons for that variation or adjusting for individuals' characteristics (Los Angeles Public Health Assessment Unit, 2001). This study, using data for 1999, attempts to understand which particular characteristics of residential areas affect regional testing rates, over and above the characteristics of the individuals living in the area. LA County is a widely diverse area with the second largest cumulative

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number of AIDS cases of any metropolitan area in the United States (CDC, 2004).

HIV testing is a function both of individuals' behaviors and their residential contexts. There are at least two ways to conceive of the influence of residential areas on testing. First, they may offer residents more opportunities for sex with higher-risk partners if they contain more: unmarried residents, persons having higher-risk sex, or persons with HIV/AIDS, (including gay males or Latinos and African Americans because they disproportionately are affected by HIV/AIDS) (CDC, 2003b). Individuals acting on those opportunities may perceive themselves at higher-risk for HIV and, subsequently, may be more likely to test. Second, residential areas also could represent structural-level phenomena affecting testing, such as a greater number of convenient and publicly funded test sites. Finally, predominately Latino or African American areas or areas with higher AIDS prevalence could be proxies for increased outreach efforts by HIV prevention organizations. They also would represent increased awareness about HIV/AIDS.

This paper is important for understanding HIV-testing decisions because it documents the role of residential contexts over and above individuals' risk and demographic factors. Identifying residential characteristics correlated with low testing rates, particularly in higher-risk areas, is potentially important to public health agencies which can use these insights to direct enhanced HIV-testing outreach efforts to areas that are likely to lag in testing.

METHODS

Sample

The LA County Health Survey (LACHS) was a population-based telephone survey administered in 1999 and 2000 to LA County residents ages 18 and older. Of those contacted by random-digit dialing, 8354 completed the survey, producing a 55% response rate. The survey was given in English, Spanish, Cantonese, Mandarin, Korean, and Vietnamese. Additional details of the survey are found elsewhere (L.A. Public Health Assessment Unit, 2001). The sample used in this analysis included only persons responding to the survey item asking if they had tested for HIV or AIDS in the past two years (persons ages 65 and older were not asked this question ($n = 1041$) and 120 reported to not know or did not respond). Persons having little choice in whether or not they tested were excluded from the analysis because this paper focuses on how contextual factors might affect individuals' decisions to test for HIV. Persons excluded were those testing because of a job or an insurance requirement ($n = 294$) or they were donating blood ($n = 221$) or receiving prenatal care ($n = 452$). Women receiving prenatal care were excluded because the contextual factors that may influence women's decisions to test (i.e., the hospital setting, the physician or nurse) are not available in the data used.

Residential areas were defined as ZIP codes. Using this geographic unit allowed a multi-level analysis to be conducted because most ZIP codes contained a sufficient number of respondents (Maas and Hox, 2002). Using smaller geographic regions such as census tracts would have prevented stable, accurate estimates from being obtained. Thus, the sample excluded persons not providing ZIP codes or cross streets from which ZIP codes could be derived ($n = 751$). There were no differences between those with and without ZIP codes on their individual-level characteristics except those without ZIP codes were slightly younger. The final sample contained 5475 persons nested in 233 ZIP codes.

From this sample, a higher-risk subset was derived—persons in ZIP codes with greater proportions of respondents reporting higher-risk sex behaviors. Higher-risk sex behaviors were defined as in the past year, not always using condoms and having more than one sex partner. It included only sexual behaviors because we lacked illicit drug use data. However, injection drug use is the sole exposure risk for only 5.1% of LA County's living AIDS cases. (L.A. County Department of Health Services HIV Epidemiology Program, 2005). To obtain this higher-risk subset, smaller, contiguous ZIP codes were merged to create larger regions having at least 30 respondents. Using these larger regions reduced the standard errors of proportions of respondents reporting higher-risk sex behaviors. (The central limit theorem was used as a rough guide in selecting $n = 30$ as the minimum number of respondents for a region, although a binomial distribution was estimated.) Of 233 ZIP codes, 190 ZIP codes were merged with others that were similar on the two characteristics determined to be most related to the geographic variation in testing, producing 80 larger regions. Forty-three ZIP codes already contained 30 or more respondents and were left un-merged, resulting in a total of 123 regions.

Regions' characteristics were derived by taking the weighted average of the ZIP codes comprising them. Using this "region" data, we created the "higher-risk" subset for analysis by selecting regions having proportions of residents reporting higher-risk sex that were one standard deviation (0.080) above the mean (0.138), ($n_{\text{region}} = 20$, $n_{\text{respondent}} = 928$).

Variables

The dependent variable was whether or not individuals tested for HIV in the past two years. We controlled for eleven individual-level variables to help isolate the contextual effects, as shown in Table I (definitions are footnoted). Ten contextual (ZIP code- or region-level) factors were examined. (Census-derived measures actually were based on ZIP Census Tract Areas (ZCTAs), which are geographic areas, which, according to the U.S. Census, "in most instances equals the ZIP Code for an area," U.S. Census Bureau.) The three main explanatory ZIP code-level variables of interest were: cumulative number of AIDS cases in 1999, number of publicly funded HIV test sites, and racial/ethnic composition. Table I notes their sources. Publicly funded sites include some hospitals and community, non-profit, and family planning clinics. (The latter account for 17% of LA County women's HIV tests in the previous 2 years (L.A. County Department of Health Services, 2004). Although private medical offices offer HIV-testing, their geographic location should have little impact on decisions to test due to their relative ubiquity. Additionally, examining publicly funded sites is important because it might provide guidance for public health agencies about the impact of the placement of the sites they fund on testing behavior.

To proxy areas that might be perceived as being at higher risk for HIV transmission, we obtained three additional ZIP code-level variables from the 2000 Census: (1) percentage of single adults; (2) percent of male same-sex partner households; and (3) the proportion of respondents having higher risk sex behaviors. Five additional neighborhood characteristics from 2000 Census data were examined: (1) median household income, (2) education and (3) unemployment rate; (4) residential stability (being in the same household as 5 years prior) representing social networks; and (5) percentage of non-English speakers representing language barriers to care. Finally, for the comparisons of geographic areas that were rather ethnically/racially homogenous, we use the term "predominately," which was defined as one standard deviation above the mean percentage, with one exception. Few (1.5%, results not shown) Asians lived in predominately African Americans ZIP codes. In this case only, we defined "predominately" as any percentage above the mean.

Data Analyses

A descriptive univariate analysis of persons in the sample was first conducted. A series of hierarchical models were then built on which multilevel logistic regression analysis was conducted using MLwiN to estimate geographic variation in individuals' likelihood of testing for HIV, controlling for individual-level factors (Rabash, 2001). Essentially, ZIP code-specific regression intercepts were estimated and subsequently tested to determine if they varied. If so, the ZIP code characteristics associated with that variation were estimated.

The first model included no covariates and was simply used to detect geographic variation in HIV-testing across ZIP codes. The second model added eleven individual-level covariates. The third model added the three ZIP code-level factors hypothesized to be related to the geographic variation in HIV-testing: the number of test sites, the number of AIDS cases and the racial/ethnic composition. The final model added the seven remaining ZIP codes factors enumerated above. ZIP code-level variables were grand mean centered and individual-level variables were entered as deviations from ZIP code means, so intercepts were interpreted as the mean testing probability for the average ZIP code. Empirical Bayes estimates were produced for ZIP codes' varying intercepts to adjust for their differential number of respondents.

These steps were first conducted among the entire sample ($n_{\text{ZIP code}} = 233$, $n_{\text{respondent}} = 5475$) and then replicated on the region data set ($n_{\text{region}} = 123$, $n_{\text{respondent}} = 5475$) adding the final contextual variable of interest—region-level proportion of higher-risk residents. Finally, we repeated the entire analysis using the subset of higher-risk regions ($n_{\text{region}} = 20$, $n_{\text{respondent}} = 928$).

Full iterative generalized least-squares methods were used for the full sample and residual (or restricted) methods were used for the higher-risk subset, which is appropriate when fewer clusters (regions, here) are present (Goldstein, 1995). Second-order penalized or predictive quasi-likelihood (PQL)

Table I. Description of Weighted and Unweighted Sample ($n = 5475$)

Variable	Weighted % or mean (range)	Unweighted % or mean (range)
Individual-level		
Marital status (%)		
Unmarried, not living together	49	46
Unmarried, living together	8	8
Married	43	46
Female (%)	47	56
Age	39 (18–62)	38 (18–64)
College educated (%)	25	28
Race/ethnicity (%)		
Latino	32	33
African American	10	10
Asian/Pacific Islander	12	9
Other	4	4
Non-English speaker (%)[a]	28	26
Annual household income[b]	$41,301 (0–$75,000)	$43,398 (0–$75,000)
Having a regular source of medical care (%)	74	76
Insurance status (%)		
Private	61	63
Public	6	6
None	33	31
Employed (%)	72	71
Having "risky" sexual behaviors (%)[c]	13	11
ZIP code-level		
# Cumulative 1999 AIDS cases[d]	203(0–2259)	199 (0–2353)
# Publicly-funded test sites[e]	0.88 (0–7)	0.87 (0–7)
% of adults in the ZIP code who are[f]		
Latino	44 (1.5–95)	43 (3–97)
African American	9 (0.00–88)	10 (0.04–86)
Asian-Pacific Islander	12 (0.01–60)	12 (0.08–64)
Other	3 (0.0–11)	3 (0.1–12)
% of adults in the ZIP code who are unmarried[g]	57 (30–79)	56 (30–78)
% of adults in the ZIP code who are college educated	23 (0–72)	23 (2–70)
% of adults in the ZIP code who are non-English speaking	17 (2–54)	16 (1–51)
Mean household income	$42,927 ($14,632-$105,998)	$43,786 ($14,847-$101,328)
Unemployment rate (%)[h]	5.1 (1.3–9.9	5.1 (1.5–10.1)
% of residences that are stable[i]	49 (33–75)	48 (32–72)
% of households with male same-sex partners	0.48 (0–5.0)	0.47 (0–5.0)

[a]Non-English speakers = those completing surveys in languages other than English.
[b]Exact household income was not collected. Possible responses categories were: 1 = "less than $10,000", 2 = $10,000–$20,000; 3 = $20,000–$30,000; 4 = $30,000–$40,000; 5 = $40,000–$50,000; 6 = $50,000-$75,000; 7 = "over $75,000". Category midpoints were assigned to each person.
[c]Risky sex = in last year, not always wearing condoms and having >one partner.
[d]Obtained from the L.A. County Office of AIDS Programs and Policy.
[e]Obtained from L.A. County Department of Health Services (2004), AIDS Project Los Angeles (2004), and the L.A. Regional Family Planning Council, Inc. (2004).
[f]Data for this and the following seven variables were obtained from the 2000 Census.
[g]% Unmarried = among those age 15+ years.
[h]Unemployment rate = among those age 16+ years in the labor force.
[i]Residential stability = % of persons age 5+ years who no longer live at their residence of 5 years prior.

methods were used for all estimations (Goldstein and Rabash, 1996). *T*-tests estimated the significance of individual- and ZIP-code-level covariates. For covariates comprised of several terms, Wald statistics having chi-square distributions were used as global tests of significance. They also estimated the significance of the variance components (the amount of variation in testing or slopes across ZIP codes). No evidence of potential model misspecification was found. Sampling weights were included in all analyses to adjust for differential rates of survey participation. The weights were designed using selected

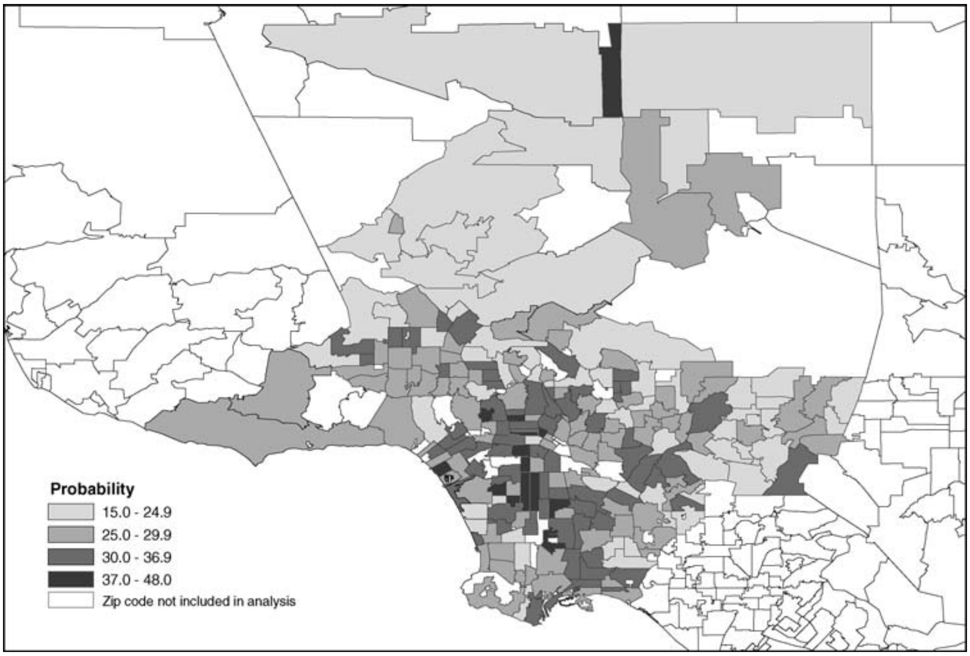

Fig. 1. Probability of HIV testing by Los Angeles neighborhoods probability.

demographic variables in the 1998 LA County population census projections.

RESULTS

Descriptive statistics are presented in Table I for the individual- and ZIP-code-level variables. When comparing the analysis sample's weighted statistics with those of the entire sample (or the LA County population), the analysis sample was slightly younger than the entire sample as expected (results not shown). Results of examining the variation in mean probabilities of HIV-testing across 233 ZIP codes are presented in a LA County map, Figure 1. ZIP codes varied greatly in their residents' mean probabilities of testing in the previous two years, using a model containing no covariates. Although 27% of LA residents tested on average, this percentage ranged from 15 to 48% across ZIP codes, ZIP code-level variance component = 0.205; standard error = 0.041; chi-square [1 *df*] = 24.72, $p < .001$.

Table II presents the results that focus on the ZIP code-level influences on testing probabilities, controlling for eleven individual-level factors shown at the bottom of the table. The first column of Table II shows that, regardless of one's own characteristics, living in ZIP codes having more AIDS cases or areas having higher percentages of African Americans increased one's likelihood to test for HIV whereas the number of test sites did not. The second column shows results from the full model, which included the only other ZIP code characteristic that was found significantly related to testing, the percentage of unmarried residents. Persons in areas having higher percentages of unmarried residents, regardless of their own marital status, were more likely to test than residents elsewhere. Residents of areas with higher percentages of African Americans were more likely to test than residents with higher percentages of whites. When we instead used an area's percentage of Latino residents as the reference group, we found residents of areas with higher percentages of African Americans were more likely to test, OR = 1.2, 95% confidence interval, CI = 1.1, 1.3, than residents of predominately Latino areas. However, the testing odds in predominately Latino areas did not differ from those in predominantly White areas, OR = 1.0, 95% CI = 0.9, 1.0. Additionally, when the percentage of unmarried residents was introduced in the model, the number of AIDS cases was no longer associated with testing (the two variables are correlated at $r = .53$).

Given limited resources, it is important to focus HIV prevention efforts where they could have the greatest impact—where concentrations of residents at higher risk for HIV live. Thus, we repeated

Table II. Multilevel Logistic Regression Results: Individuals' Mean Likelihoods of HIV-Testing in the Previous 2 Years ($n = 5475$)

	Model 1: Using 3 hypothesized ZIP code-level factors			Model 2: Adding other related ZIP code-level factors		
	Coeff	OR (95% CI)	Test[a]	Coeff	OR (95% CI)	Test
Intercept	−1.090			−1.100		
ZIP code-level variables[b]						
Cumulative # AIDS cases[c]	0.533	1.7 (1.3, 2.3)	$t = 3.6$**	0.070	1.1 (0.8, 1.5)	$t = 0.4$
# HIV test sites	0.002	1.0 (0.9, 1.1)	$t = 0.1$	−0.022	1.0 (0.9, 1.1)	$t = 0.6$
% of adults in ZIP who are[d]			$\chi^2 = 43.810$, 4*df****			$\chi^2 = 43.810$, 4*df***
% White	1.0			1.0		
% African American	0.185	1.2 (1.1, 1.3)	$t = 6.2$***	0.122	1.1 (1.1, 1.2)	$t = 3.9$***
% Latino	0.039	1.0 (1.0, 1.1)	$t = 1.6$	0.009	1.0 (1.0, 1.1)	$t = 0.4$
% Asian/Pacific Islander	−0.016	1.0 (0.9, 1.0)	$t = 0.4$	−0.010	1.0 (0.9, 1.1)	$t = 0.3$
% Other	0.348	1.4 (1.0, 2.0)	$t = 1.1$	0.208	1.2 (0.7, 2.2)	$t = 0.7$
% Unmarried[d]				0.334	1.4 (1.2, 1.6)	$t = 5.2$***
Variance components[e]		Coeff. (95% CI) chi-square			Coeff. (95% CI) chi-square	
Intercept	0.122	(0.053, 0.191)	12.468, 1*df***	0.083	(0.024, 0.142)	7.593, 1*df**

[a]Eleven individual-level factors were included in all models. In the final model, the ORs for dichotomous or categorical variables were: race/ethnicity* = African American (1.8)***, Latino (1.4)*, Asian/Pacific Islander (0.5)***, other race/ethnicity (1.9)*; employed (0.8) *; female (1.0); insurance status* = uninsured (0.8)*, publicly insured (1.2); marital status*** = single (1.6)***, living together (1.2)***; non-English speaker (1.0); regular source of medical care (1.5)**; risky sex behaviors (2.1)***; and college educated (0.9). The ORs for continuous variables were age (0.7)*** and annual household income (1.0). The OR for age can be interpreted as, for every year increase in the average adult's age, their odds of testing decreases by 30%.
[b]Global chi-square tests were used for variables comprised of several terms and t-tests were used for individual terms.
[c]Statistics represent those for the average person in the average LA County ZIP code because individual-level variables were centered within ZIP codes and ZIP code-level variables were grand mean centered.
[d]This continuous variable is presented in terms of 10s (10 AIDS cases or 10 percentage points). Thus the AIDS cases' OR of 1.7 can be interpreted as, for every increase of 10 AIDS cases in the average ZIP code, the odds of residents' testing increase by 70%.
[e]Coeff.: coefficient, OR: odds ratio, CI: confidence interval, *SE*: standard error, *df*: degrees of freedom *$p < .05$, **$p < .001$, ***$p < .0001$.

the analysis presented in Table II for the subsample of individuals living in regions identified as "higher risk" by aggregating individual responses to the region level. Examining only the higher risk regions, residents had a 31% probability of testing during the prior two years. The probability slightly, but not significantly, varied across regions, ZIP code level variance component = 0.148, standard error = 0.088. As with the analysis reported in Table II, regardless of residents' characteristics, residents of regions having higher percentages of African Americans were more likely to test than residents of areas that were predominantly White, OR = 1.3, 95% CI = 1.1, 1.6, or predominantly Latino, OR = 1.2, 95% CI = 1.1, 1.5. In the higher risk subsample, the percentage of unmarried persons in the region did not significantly relate to testing probability.

We used the final model to estimate the testing probabilities for people of various ethnicities who lived in a "predominately" African American neighborhood. African Americans living in a predominantly African American neighborhood are estimated to have a 65% probability of testing, for Latinos living in such neighborhoods the probability is 56%, for Asians 24% and for Whites, 47%. However, only 27% of Latinos living in a predominantly Latino neighborhood, 8% of Asians living in an Asian neighborhood, and 27% of Whites living in a white neighborhood would be predicted to test. Likewise, unmarried residents of neighborhoods where single people predominate had a 51% probability of testing whereas unmarried persons living elsewhere had a 23% testing probability.

DISCUSSION

LA County residents' mean probability of voluntary HIV-testing in the previous two years was 27%, in concordance with national studies (Anderson *et al.*, 2000). However, this probability varied across ZIP codes. Additionally, among higher-risk regions, testing rates appeared higher (31%).

For both the entire sample of LA ZIP codes and higher-risk regions, residents of predominately African Americans areas were more likely to test than residents of White or Latino areas, regardless of their own race/ethnicity or any of ten other characteristics. It could be that because HIV/AIDS disproportionately affects African Americans (CDC, 2003b), residents of neighborhoods with more African Americans may be more aware of the risk of HIV due to increased knowledge of local acquaintances who are infected; this awareness may lead to testing. Alternatively, prevention outreach efforts may be targeting the geographic areas where more African Americans reside than elsewhere.

Residents of areas with a large percentage of single people also were more likely to test than residents of married areas, regardless of their own marital statuses. They may perceive themselves at higher risk for HIV due to more opportunities to meet new sex partners (bars and clubs) relative to areas where married residents predominate.

It is interesting to note that two measures of perceived risk—a region's percentage of African Americans and the percentage of unmarried adults, appear to be more strongly related to HIV testing rates than documented risk, as measured by cumulative numbers of AIDS cases. In the subset of areas identified as having higher sexual risk, the percentage of unmarried individuals provided no additional predictive power. We also found no relationship between the number of publicly funded test sites in an area and testing, once individual characteristics and two region level variables (percent African American and percent unmarried) were controlled for.

This study has a number of limitations. Survey weights accounted for the likely underrepresentation of homeless persons or those without telephones in this telephone-administered survey. Also, respondents reported higher rates of HIV-testing relative to some other surveys. However, there is no reason to believe that testing rates would not uniformly be distributed across ZIP codes. Additionally, the survey's response rate was somewhat lower than that in national health studies; however, sample averages for key variables are similar to those found elsewhere (Simon *et al.,* 2001).

The "higher-risk" definition may be rather crude and understate risk due to respondents' unwillingness to report risk-taking behaviors. Alternatively, our measure may over-state risk because it does not allow for strategic use of condoms by persons with multiple partners. Nonetheless, individuals' higher-risk behaviors predicted HIV-testing in this study, providing support for the validity of the measure. Further, the measure included only sexual behaviors because we lacked illicit drug use data. This might be a minor issue because injection drug use is the sole exposure risk for only 5.1% LA County's AIDS cases (LA County Department of Health HIV Epidemiology Program, 2004). Unique features of LA, such as the concentration of AIDS cases among gay or bisexual men, also may limit the generalizability to other US ZIP codes. Admittedly, we could have chosen another definition of "higher-risk regions" than what we used—one standard deviation above the mean. However, as with the derivation of any dichotomous variable from a continuous measure, the cut off point is somewhat arbitrary and can produce varied results depending on the cut-off. Finally, all ZIP code level analyses share a weakness in that the Census data is based on ZCTAs but the geographic area on which the data are mapped are ZIP codes. ZIP codes and ZCTAs in most instances encompass the same areas, but sometimes the overlap is not exact as ZIP codes boundaries change over time.

This research also has the strength of going beyond analyzing individuals' characteristics to examine ZIP code-level correlates of HIV-testing. It identified ZIP code characteristics related to testing, among all and higher-risk areas. The results suggest that even among areas with greater prevalence of higher-risk behaviors, HIV-testing rates are relatively low in White and Latino ZIP codes. Public health officials in LA and elsewhere can use this information to re-examine their current efforts in White and Latino higher-risk ZIP codes. Although frequent testing may contribute to reinforce or riskier behavior, testing remains an important prevention effort, especially for those one fourth of HIV-positive persons who are unaware of their status.

The evidence presented here suggests that demand factors for testing, such as perceived risk for HIV, may have a greater effect on HIV testing than the "supply" factors, such as test sites. We conclude that simply increasing the number of HIV-testing sites will not, by itself, be sufficient. The "build it and they will come" adage appears not to apply to HIV-testing sites. Rather, public health officials might want to examine the testing messages and outreach efforts occurring in African American areas for guidance on possible interventions to increase testing elsewhere. Additional research, perhaps qualitative, also might address this issue. The potential mechanisms leading to increased testing might involve social marketing efforts, social networks, or other factors such as routine HIV-testing practices, as was recently advocated by the CDC (CDC, 2003b).

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