

Socioeconomic Gradients in Sexually Transmitted Diseases: A Geographic Information System–Based Analysis of Poverty, Race/Ethnicity, and Gonorrhea Rates in California, 2004–2006

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Socioeconomic disparities in health make significant contributions to patterns of morbidity and mortality in the United States.^{1–4} Socioeconomic status (SES) can directly affect access to health care and is often strongly correlated with behavioral patterns and community attributes that profoundly influence health risks and outcomes. Although the elimination of these inequalities is a fundamental objective of many public health initiatives,⁵ quantifying and monitoring socioeconomic disparities in health is hampered by the paucity of socioeconomic data in most public health surveillance systems.

The use of area-based socioeconomic measures offers a means to link case-based surveillance data with census-based information on associated populations and communities.^{6,7} Case residential address data are assigned a latitude and longitude (geocoded), and these coordinates are then used to map geocoded cases and associate them with census tracts and the socioeconomic data collected within them as part of the decennial US Census. Thus, area-based socioeconomic measures provide estimates of the SES of individual geocoded cases, as well as direct measures of socioeconomic attributes of the communities in which they reside.⁶

Sexually transmitted diseases (STDs) have long been of interest to public health practitioners concerned with socioeconomic disparities in health outcomes,^{8,9} and they represent an ideal focus for geocoding-based studies of such variation. Relative to other infectious and chronic diseases, the geographic ubiquity and high incidence of STDs should allow socioeconomic disparities in infection rates to be readily quantified and accurately mapped. Analyses of data from Massachusetts, Rhode Island, and Virginia found significant positive relationships between rates of STDs and “percent below

Objectives. We quantified the relationship between gonorrheal infection rates in California and a measure of poverty status and investigated how this relationship and the spatial dispersion of cases varied among the 4 dominant racial/ethnic groups in the state.

Methods. We geocoded gonorrhea cases reported in California between 2004 and 2006, and estimated the poverty status of each case by using the percentage of residents living below poverty in the census tract of residence. We calculated infection rates for African American, Asian, Hispanic, and White cases in each of 4 poverty strata. We mapped cases to visualize the patterns of spatial dispersion associated with each race/ethnicity–poverty combination.

Results. There was a strong positive relationship between poverty and infection, but racial/ethnic disparities in infection, driven by a disproportionate level of gonorrhea among African Americans, eclipsed this differential. The degree of spatial aggregation varied substantially among groups and was especially pronounced for African Americans with gonorrhea in the highest poverty category.

Conclusions. Prevention efforts should target low-income neighborhood “hot spots” to reach the largest numbers of cases, particularly among African Americans. (*Am J Public Health.* 2010;100:1060–1067. doi:10.2105/AJPH.2009.172965)

poverty,” a census-based measure of SES.^{10,11} A number of other geocoding-based studies of socioeconomic variation in STDs produced similar findings,^{12–14} but these were limited in their geographic breadth as they examined data from only large cities.

Pronounced racial/ethnic heterogeneity in STDs has also been documented,^{15–19} but because it is caused in part by disparities in SES among groups, the relative contributions of race/ethnicity and poverty to STD epidemiology remain unclear. Analyses that consider these relationships simultaneously across broader spatial scales, incorporating more cases with a collectively greater diversity of communities and racial/ethnic–socioeconomic combinations, are needed to more accurately and precisely quantify the influence of SES and race/ethnicity on patterns of STDs.

We undertook a geocoding-based social gradient analysis by using gonorrhea incidence data collected over a 3-year period in California at a time when gonorrhea rates were increasing for the first time in decades.²⁰ The objectives of our study were (1) to quantify the relationship between infection rates and a measure of poverty status, (2) to assess whether and how this relationship varied among the 4 dominant racial/ethnic groups in the state, and (3) to examine variation in patterns of spatial dispersion of gonorrhea cases among racial/ethnic–poverty combinations by mapping geocoded cases, in order to better target gonorrhea prevention efforts.

METHODS

We analyzed gonorrhea case-based surveillance data (age, gender, race/ethnicity, and

address) reported to the California Department of Public Health's STD Control Branch between 2004 and 2006.¹⁸ Using SAS version 9.1 (SAS Institute Inc, Cary, NC), we assigned each case to 1 of 5 address categories: (1) incomplete (address field blank or containing insufficient information to permit geocoding), (2) nonresidential (address corresponding to location other than the patient's permanent residence [e.g., health clinics, detention facilities]), (3) PO Box, (4) homeless (when explicitly identified as such), and (5) potentially geocodable (address information that appeared sufficient to permit geocoding to a residential address). We then validated and standardized addresses of all potentially geocodable cases according to US Postal Service address data and abbreviations with the software ZP4 (Semaphor Corp, Nipomo, CA).

Once addresses were standardized, we geocoded and associated addresses with census tracts by using the Tables Address Geocoder application created by the California Department of Public Health's Environmental Health Investigations Branch (http://www.ehib.org/geocoding_tool.jsp). We used the Tables Address Geocoder to apply 5 different address locator algorithms, sequentially in the following order, to geocode each address: TeleAtlas Points (2006), TeleAtlas Streets (2006), Navteq Streets (2006), GDT Streets (2005), and Tiger Streets (2005). An address was considered successfully matched when its Tables Address Geocoder-generated match score, analogous to the match score generated by geocoding in ArcGIS version 9.2 (ESRI, Redlands, CA), was at least 80.

Quantifying Socioeconomic Levels of Census Tracts

We used data on census tract population size and the number of people living below poverty, collected as part of the 2000 US Census,²¹ to estimate the socioeconomic profile of each census tract in California. The area-based socioeconomic measure percent below poverty⁷ was calculated as the quotient of the number of people in a tract living below the federal poverty line and the population of that tract (summary file 3, table 87).²¹ Each tract was assigned to 1 of 4 poverty categories on the basis of its percent below poverty values (<10%, 10% to 19.99%, 20% to 29.99%, and ≥30% of residents living below poverty). We chose cut points for these

categories on the basis of quartiles of the full data set so that the number of cases in each category was roughly equal. Federal guidelines designate any region where 20% or more of the population is below the US poverty line as a "poverty area."²² We did not assign a percent below poverty value to census tracts in which poverty information had been collected from fewer than 60% of the residents because these are usually areas where a high percentage of the population is institutionalized (e.g., incarcerated) and therefore not representative of the state's general population.

Calculating Infection Rates

The outcomes of interest were the mean infection rate for each of the 4 racial/ethnic groups, 4 poverty categories, and 16 racial/ethnic-poverty combinations. Geocoded cases assigned to census tracts constituted numerator data for the calculation of infection rates (cases per 100 000 persons). An appreciable number of cases lacked race/ethnicity information and could therefore not be used directly in calculations of race/ethnicity-specific infection rates. To retain these cases in the data set we calculated rates with numerator data weighted for missing race/ethnicity. For each poverty category, we used the percentage of cases for which race/ethnicity was known as a weighting coefficient, and the inverse of this percentage was multiplied by the number of known cases in each of the 4 major racial/ethnic groups (Asians, African Americans, Hispanics, and Whites) to generate a weighted number of cases. Denominator data for rate calculations included the total population and the number of individuals who self-identified as Asian only, Black or African American only, Hispanic or Latino, and White only in each census tract (summary file 1, table 8).²¹

We used contingency tables analyses to compare men and women, and the 4 racial/ethnic groups in terms of the proportion of potentially geocodable cases relative to the number of cases in the 4 other address categories combined. We calculated confidence intervals (CIs) for rates with the exact Poisson method and we calculated rate ratios with the median-unbiased estimation (midp) method, both implemented in the EpiTools package (Center for Infectious Diseases and Emergency

Readiness, Berkeley, CA) in R (R Foundation for Statistical Computing, Vienna, Austria). We used ArcGIS version 9.2 to generate maps that showed the distribution of cases by poverty category and race/ethnicity. We quantitatively compared the degree of spatial aggregation among cases associated with each of the 16 racial/ethnic-poverty combinations by using Ripley *K*-function²³ analysis performed in R.

RESULTS

Of the 98 355 cases of gonorrhea reported in California between 2004 and 2006, case counts and the distribution of cases among the 5 address categories were similar among years (Appendix 1, available as a supplement to the online version of this article at <http://www.ajph.org>). Across years there were more cases among males (53.6%) than among females (46.0%), and the distribution of cases varied among the 4 racial/ethnic groups, with African Americans disproportionately represented (26.1% of cases) followed by Hispanics (20.6%), Whites (17.4%), and Asians (2.4%; Appendix 1).

The majority of cases were classified as having addresses that were potentially geocodable (mean across years=84.5%) or incomplete (12.2%). None of the remaining 3 address categories accounted for more than 2% of the total cases (homeless=0.3%; PO Box=1.4%; nonresidential=1.7%; Appendix 1). The percentage of cases with potentially geocodable addresses was significantly higher than expected among females (85.9%) compared with males (83.6%; $\chi^2_1=101.7$; $P<.001$), and there were statistically significant differences in this proportion when the 4 largest racial/ethnic groups were compared ($\chi^2_3=266.6$; $P<.001$). The largest deviations were a lower proportion of potentially geocodable cases among Whites (88.8%) and a higher proportion among African Americans (93.3%).

Overall, 80.7% of all cases were successfully geocoded (Appendix 1). The percent of cases geocoded was 79.8% for males, 82.0% for females, 89.5% for African Americans, 86.9% for Asians and Hispanics, and 84.9% for Whites. The proportion of potentially geocodable cases that were successfully geocoded was at least 95% for each year, gender, and racial/ethnic group. Whereas only 0.4% of all cases

were missing gender information, 32.5% were missing data on race/ethnicity. Of these, 95.1% were successfully geocoded and their race/ethnicity estimated with the aforementioned weighting procedure.

Of the 7049 census tracts in California, available data on resident poverty were sufficient to classify 6941 (98.5%) into 1 of the 4 poverty categories (Table 1). Forty-seven percent of tracts were assigned to the <10% of residents living below poverty category, 28.5% were in the 10% to 19.99% category, 14.2% were in the 20% to 29.99% category, and 10.4% were in the ≥30% category. Tracts in the highest poverty category were geographically concentrated in urban centers (e.g., San Francisco, Los Angeles, San Diego) and along a north-south transect spanning the San Joaquin Valley, an urbanized corridor in the central part of the state bisected by 2 major highways that connect large metropolitan areas in northern and southern California (Appendix

2, available as a supplement to the online version of this article at <http://www.ajph.org>).

Poverty, Race/Ethnicity, and Infection Rates

Overall, there was a strong positive relationship between poverty and infection. The infection rate among census tracts in the highest poverty category (191.9 per 100 000 persons) was 4.6 times higher (95% CI=4.4, 4.7) than was the rate in the lowest poverty category (42.0 per 100 000 persons; Table 2). There was a large disparity between the magnitude of the rate associated with African Americans and those of the other racial/ethnic groups. The overall rate among African Americans (392.7 per 100 000 persons) was 6.4 times higher (95% CI=6.2, 6.5) than was the rate associated with the next closest group (Hispanics; 61.7 per 100 000 persons) and 10.9 times higher (95% CI=10.5, 11.3) than was the rate among Whites (36.1 per 100 000 persons), which was the group with the largest population.

When data were simultaneously stratified by both poverty and race/ethnicity, rates among African Americans were considerably higher than they were among any of the other racial/ethnic groups irrespective of poverty category (Figure 1). For example, the rate among African Americans in the highest poverty category (823.2 per 100 000 persons) was 6.0 times higher (95% CI=5.5, 6.5) than was the rate among Whites (136.7 per 100 000 persons) in the same poverty category. This racial/ethnic differential eclipsed in magnitude the disparities attributed to poverty. The rate among African Americans in the lowest poverty category (268.1 per 100 000 persons) was 2.0 to 5.9 times higher (95% CI=1.8, 7.2) than were rates for any of the other 3 racial/ethnic groups in the highest poverty category. We repeated these comparisons with unweighted rates (excluding cases with unknown race/ethnicity), and the results were qualitatively identical to those detailed before.

TABLE 1—Number of Geocoded Gonorrhea Cases, Total Number of Census Tracts, Number of Census Tracts in Each Poverty Category With Reported Gonorrhea Cases, and Population Counts, by Race and Poverty Category: California, 2004–2006

	<10% of Residents Living Below Poverty Line	10%–19.99% of Residents Living Below Poverty Line	20%–29.99% of Residents Living Below Poverty Line	≥30% of Residents Living Below Poverty Line	Residents Unassigned to Poverty Category	Total
No. of geocoded cases	19 209	23 862	16 925	19 026	331	79 353
African Americans	2 941	5 790	5 743	8 486	56	23 016
Asians	836	596	315	277	17	2 041
Hispanics	2 986	5 433	4 426	4 699	86	17 630
Whites	5 748	4 922	2 216	1 560	90	14 536
Other known races	242	243	134	126	7	752
Unknown	6 456	6 878	4 091	3 878	75	21 378
No. of census tracts	3 259	1 975	986	721	108	7 049
No. of census tracts with ≥1 case of gonorrhea	2 919	1 872	953	714	75	6 533
With ≥1 African American cases	1 089	1 043	594	554	36	3 316
With ≥1 Asian case	559	397	195	183	13	1 347
With ≥1 Hispanic case	1 379	1 407	832	663	34	4 315
With ≥1 White case	1 948	1 329	610	434	39	4 360
With ≥1 case among other known races	217	196	115	93	7	628
With ≥1 case among unknown races	2 076	1 438	753	591	34	4 892
Population	15 240 238	9 890 103	4 951 416	3 305 092	484 799	33 871 648
African Americans	550 755	647 656	472 049	431 577	79 889	2 181 926
Asians	1 980 594	963 921	407 511	256 582	40 252	3 648 860
Hispanics	2 539 241	3 595 350	2 653 477	2 040 548	137 940	10 966 556
Whites	9 590 616	4 289 747	1 249 323	477 736	209 368	15 816 790
Other known races	135 437	121 765	54 197	35 709	7 293	354 401

Notes. Case counts reflect gonorrhea cases reported to the California Department of Public Health STD Control Branch between 2004 and 2006. Census tract and population count data for California were collected as part of the 2000 US Census and obtained from the US Census Bureau.

TABLE 2—Weighted Gonorrhea Infection Rates Per 100 000 Population Per Year, by Race and Poverty Category: California, 2004–2006

% of Residents Living Below Poverty Line	African American, Rate (95% CI)	Asian, Rate (95% CI)	Hispanic, Rate (95% CI)	White, Rate (95% CI)	Total, Rate (95% CI)
<10	268.11 (254.43, 281.78)	21.19 (19.17, 23.22)	59.04 (56.05, 62.03)	30.09 (28.99, 31.19)	42.01 (40.98, 43.04)
10–19.99	418.68 (402.92, 434.44)	28.96 (25.56, 32.35)	70.77 (68.02, 73.52)	53.75 (51.54, 55.93)	80.42 (78.66, 82.19)
20–29.99	534.81 (513.94, 555.67)	33.98 (28.32, 39.64)	73.32 (70.07, 76.58)	77.97 (73.08, 82.87)	113.94 (110.97, 116.91)
≥30	823.22 (796.15, 850.29)	45.20 (36.97, 53.42)	96.41 (92.15, 100.67)	136.71 (126.23, 147.20)	191.89 (187.16, 196.61)
Total	392.68 (384.37, 401.00)	21.45 (19.95, 22.95)	61.67 (60.20, 63.14)	36.07 (35.14, 37.01)	96.79 (95.74, 97.84)

Note. CI = confidence interval. Gonorrhea rates were calculated using case counts weighted for missing race/ethnicity data. Weighted rates and 95% CIs are calculated within each racial/ethnic group or among the 4 racial/ethnic or poverty category totals by the exact Poisson method. Population count data for California were collected as part of the 2000 US Census and obtained from the US Census Bureau.

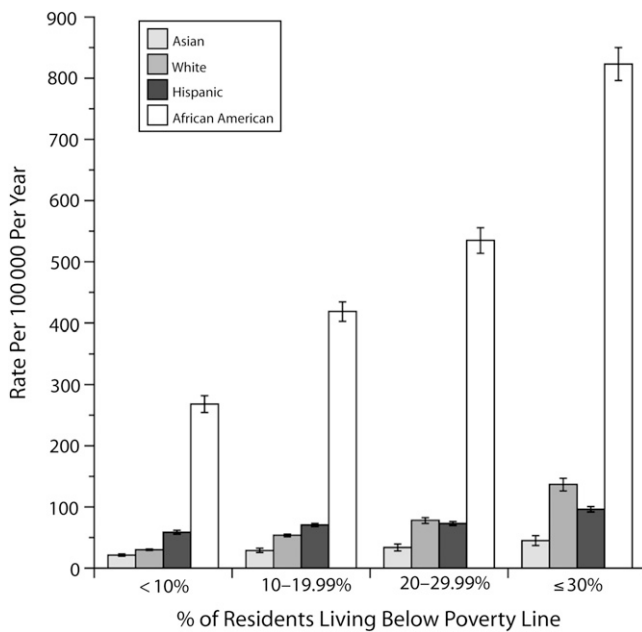
Geographic Distribution and Aggregation of Cases

Mapping of geocoded cases illustrated a striking pattern of spatial aggregation of gonorrhea infection across California (Figure 2). This was partially a consequence of the fact that as community poverty increased, fewer census tracts were associated with each poverty stratum. In the lowest poverty category, 19 209 (24.2%) of the total geocoded cases were distributed among 2919 census tracts, which represented 44.7% of the total number of tracts in the state with at least 1 gonorrhea case

(Table 1). The mean (\pm SE) number of cases in the lowest poverty census tracts was 2.9 ± 0.1 per tract per year (among tracts with at least 1 case in a given year). In contrast, a roughly equal number of cases in the highest poverty category (19 026, or 24.0% of all geocoded cases) were concentrated in just 714 census tracts, representing 10.9% of the total number of tracts in the state with at least 1 associated case of gonorrhea in a given year. The mean (\pm SE) number of cases in these highest poverty tracts was 9.4 ± 0.1 cases per tract per year. These highest poverty tracts and the

associated cases were aggregated primarily in or near San Francisco, Los Angeles, San Diego, Sacramento, and the San Joaquin Valley (Figure 2).

This pattern of spatial aggregation was especially pronounced for African Americans, the racial/ethnic group with the highest number of cases and the only group characterized by a strong positive relationship between number of cases and community poverty (Table 1). The number of African American cases in the highest poverty category ($n=8486$) was far higher than was the number associated with any other race/ethnicity–poverty combination. These high-poverty African American cases, representing 36.9% of geocoded African American cases and 10.69% of all geocoded cases across the state, were concentrated in just 554 census tracts with at least 1 gonorrhea case reported, or 8.5% of such census tracts (Table 1; Table 3; Figure 2). The mean annual African American case density in these tracts was 6.3 ± 0.2 cases. Results of the Ripley *K*-function analysis provided quantitative evidence that African American cases associated with the highest poverty category exhibited by far the greatest degree of spatial aggregation relative to cases in the other 15 racial/ethnic–poverty combinations (Appendix 3, available as a supplement to the online version of this article at <http://www.ajph.org>).

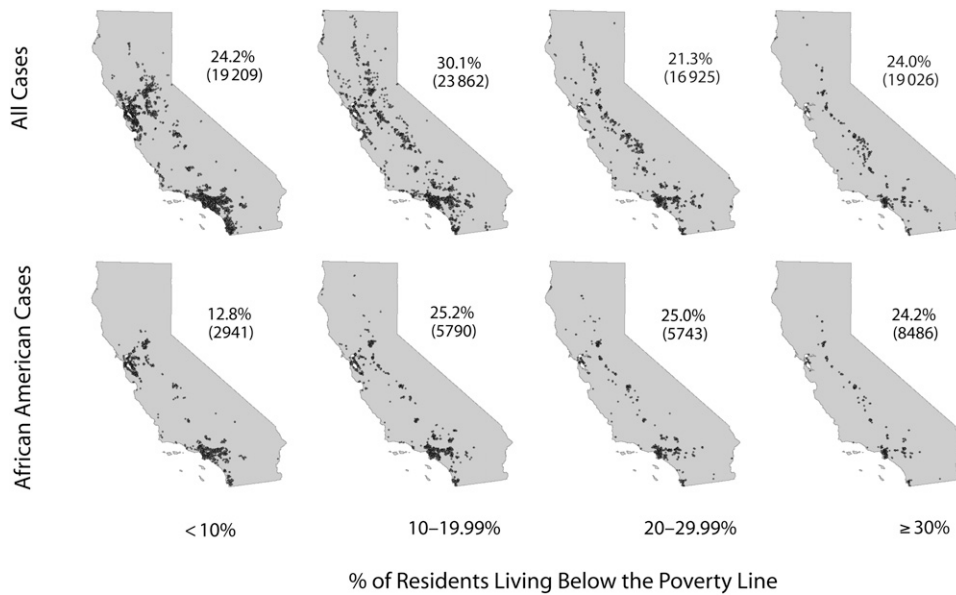


Note. Gonorrhea rates were calculated using case counts weighted for race/ethnicity. Error bars show 95% confidence intervals calculated with the exact Poisson method. Census tract and population count data for California were collected as part of the 2000 US Census and obtained from the US Census Bureau.

FIGURE 1—Gonorrhea infection rates, by race/ethnicity and percentage of census tract residents living below the poverty line: California, 2004–2006.

DISCUSSION

Our analyses documented strong gradients in gonorrhea rates by poverty status and independently by racial/ethnic group, with African Americans having the highest gonorrhea rates at all levels of poverty. Rates of infection



Note. The percentage of cases within each poverty level category and raw case counts upon which these values are based (in parentheses) are displayed to the right of each map. Census tract and population count data for California were collected as part of the 2000 US Census and obtained from the US Census Bureau.

FIGURE 2—Spatial distribution of geocoded gonorrhea cases across census tracts among all California residents and among African Americans, by the percentage of residents living below the poverty line: California, 2004–2006.

were positively related to the percent of census tract residents living below the poverty line, with the average rate in tracts with at least 30% of residents below poverty more than 4.5 times

the rate in tracts for which the poverty fraction was less than 10%. Similar relationships have been documented in other states,^{10,11,24} but our study is by far one of the largest geocoding-based

assessments of SES-related trends in the epidemiology of an STD—in terms of geographic area, total population, and number of cases—conducted in the United States to date.

TABLE 3—Gonorrhea Cases Presented as a Percentage of Total California Gonorrhea Cases and of Total State Population, by Race and Poverty Category: California, 2004–2006

	<10% of Residents Living Below Poverty Line	10%–19.99% of Residents Living Below Poverty Line	20%–29.99% of Residents Living Below Poverty Line	≥30% of Residents Living Below Poverty Line	Total
African American					
% of cases	3.71	7.30	7.24	10.69	38.81
% of population	1.63	1.91	1.39	1.27	6.44
Asian					
% of cases	1.05	0.75	0.40	0.35	3.60
% of population	5.85	2.85	1.20	0.76	10.77
Hispanic					
% of cases	3.76	6.85	5.58	5.92	30.08
% of population	7.50	10.61	7.83	6.02	32.38
White					
% of cases	7.24	6.20	2.79	1.97	25.78
% of population	28.31	12.66	3.69	1.41	46.70
Total					
% of cases	24.21	30.07	21.33	23.98	
% of population	44.99	29.20	14.62	9.76	

Note. Percentages of gonorrhea cases were calculated using case counts weighted for missing race/ethnicity data. Population count data for California were collected as part of the 2000 US Census and obtained from the US Census Bureau.

Additionally, we found that high-poverty gonorrhea cases were highly aggregated in a relatively small number of census tracts. This result suggests that targeted prevention efforts in neighborhood “hot spots” could reach large numbers of cases, particularly among African Americans, and that a range of screening programs, prevention outreach, and social marketing activities should be focused in these areas. With the complex relationships among STD rates, race/ethnicity, poverty, and related socioeconomic-related factors (e.g., access to medical care, education, unemployment, incarceration, racism), results of our analyses support control efforts that are collaborative and involve partners operating in a number of domains rather than efforts that are focused on the biomedical prevention “silo” alone.

We also found evidence for striking racial/ethnic disparities in gonorrhea infection rates that eclipsed in magnitude the disparities attributable to poverty. The overall rate among African Americans was between 6.4 and 18.3 times higher than were rates for the other 3 racial/ethnic groups examined, and rates among African Americans in the lowest poverty stratum were double the highest rate among the other 3 racial/ethnic groups in the highest poverty stratum. When the overall rate among African Americans was compared with that among Whites, the rate ratio of 10.9 is close to the value of 11.8 calculated for gonorrhea cases in western states of the United States in 2005 as part of a nationwide study of STD disparities in African American communities.¹⁵ Race/ethnicity and socioeconomic status are highly correlated, with African Americans and Hispanics often associated with lower socioeconomic positions relative to Asians and Whites. Similar to a number of other studies that have attempted to decouple the influence of these 2 factors on patterns of STDs, our analyses show that racial/ethnic differences in gonorrhea rates persisted after we stratified or controlled for indicators of poverty.^{12–14,25,26} Because of the disproportionate burden of cases among African Americans, studies and intervention strategies that focus on disease dynamics in this group are critical to reducing both the overall number of cases and the magnitude of racial/ethnic disparities in disease levels.^{15,27}

Although differences in individual behaviors related to exposure, transmission, and

treatment seem likely contributors to racial/ethnic variation in infection rates, findings that show the persistence of racial/ethnic disparities after individual behavior is controlled for^{13,25,26,28} indicate the influence of other factors. The context dependence of individuals within larger sexual networks,²⁹ especially involving partner choice and assortative mating, have been shown to increase infection rates among African Americans by linking peripheral populations with areas of high infection.³⁰ Lower levels of access to or quality of care in these areas are also probably important factors.³¹ Provider behavior could further contribute if clinics used by particular racial/ethnic groups are more likely to perform diagnostic tests and report infection statistics.³² Regardless of the mechanisms by which gonorrhea incidence became higher among African Americans than it did in other racial/ethnic groups, the higher incidence has resulted in disproportionately higher prevalence³³ so that, even if all risk factors equalize, the higher prevalence alone would sustain ongoing higher incidence unless aggressive control measures intervene.

Although the observation of gonorrhea concentration within areas of high poverty and large African American and Hispanic populations was somewhat expected, we were surprised by the degree to which aggregation varied with race/ethnicity and socioeconomic status. This general pattern is consistent with the concept of spatially discrete “core” areas of infection^{34–38} and evidences the context dependence of individual behaviors that is central to sexual network theory^{39–41} and models of within-group mixing, assortative partner selection, and internetwork bridging^{30,42–44} that are often invoked to explain large-scale patterns of sexually transmitted infection.

By design, the highest and lowest poverty strata considered in our analyses each accounted for about one fourth of the total number of geocoded cases. Despite this parity, the lowest-poverty cases were distributed among 41% of the state’s census tracts, whereas high-poverty cases were aggregated within just 10% of the tracts. This phenomenon was especially pronounced among African Americans. Low-poverty cases, representing 13% of the African American cases and 4% of all cases in the state, occurred within 15% of the state’s tracts, whereas high-poverty cases, accounting

for 37% of African American cases and 11% of all cases statewide, were concentrated in just 8% of all tracts. The high mean annual African American case density in these tracts suggests that the pattern of spatial aggregation among high-poverty cases was driven largely by infection in this racial/ethnic group. These areas of high gonorrhea incidence would seem to be ideal locations for targeted intervention strategies and for studies of disease transmission within sexual networks.^{45,46}

Our analytical approach was not without problems that limit or suggest caution in interpretation of our results. First, more than 15% of cases could not be geocoded and were excluded from our analyses. Among geocoded cases, a higher proportion were female than were male, and there were fewer White and more African American cases geocoded, relative to the proportion for Hispanics and Asians. Although biases could be introduced into our findings as a result, the absolute differences seem too small for their influence to conceivably affect our interpretation of the analyses, particularly the overall relationship between poverty and infection rates.

Second, the use of area-based socioeconomic measures to approximate the socioeconomic status of individual cases may not be precise if variance in regard to the mean socioeconomic status within a spatial area of inference (here, census tract) is large. However, because case-specific data on socioeconomic characteristics are almost never collected as part of public health surveillance, few alternatives are available for studies of the relationship between health outcomes and socioeconomic status. Use of area-based socioeconomic measures should provide a reasonable approximation of such information, but because socioeconomic status is inherently an aggregate measure affected by a multitude of different factors (e.g., income, education, employment, home ownership), identifying a simple but accurate metric with which to quantify it can be difficult. Studies of socioeconomic disparities in a wide array of health conditions (including 3 STDs) found that, relative to a number of other measures of community poverty, the percent below poverty metric appears to be particularly robust in its ability to detect socioeconomic gradients in health outcomes.¹¹ In addition to estimating an individual’s level of poverty, such measures

should accurately represent the socioeconomic features of the neighborhoods and communities in which the individual resides.⁶ The influence of such environmental characteristics on individual health outcomes, and on STDs in particular, has been documented empirically.⁴⁷

Finally, because of our use of year 2000 census data to estimate population sizes for infection rate calculations and the steady rates of population growth in California, it seems probable that our methods slightly overestimated actual rates and may have introduced some small biases between racial/ethnic and poverty groups because of differential growth among populations (e.g., relatively high growth rates among Hispanics). In addition, our method of weighting data to retain cases with unreported race/ethnicity may also have reduced the precision, and perhaps accuracy, of our race-specific rate estimates. There was a slight positive relationship between the proportion of cases of known race/ethnicity and poverty. Although we do not have data to quantify the nature or magnitude of the bias that this may have introduced, it seems likely that it would result in more cases (and a higher weighted rate than expected) at lower poverty levels, making the poverty–infection relationship identified with weighted rates a conservative estimate. The magnitude of the differences we observed among racial/ethnic groups and poverty categories, and the fact that we obtained qualitatively identical results when unweighted rates were compared, suggest that such influences would not have distorted the overall trends sufficiently to alter our conclusions.

Our findings provide strong evidence for pronounced racial/ethnic and socioeconomic variation in rates of sexually transmitted infection in California and highlight the value of spatially explicit analyses for characterizing this heterogeneity and formulating effectively targeted public health interventions. ■

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Contributors

Y.P. Springer collected the data, synthesized analyses, and led the writing. M.C. Samuel and G. Bolan conceptualized the study. M.C. Samuel and Y.P. Springer designed and developed specific study methodologies. All authors helped to interpret findings and review drafts of the article.

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Human Participant Protection

Because these analyses involved only the use of routine surveillance data and publicly available census data, institutional review board approval was not required and was not sought.

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