Economic Deprivation and AIDS Incidence in Massachusetts

ABSTRACT

Objectives. This study quantified AIDS incidence in Massachusetts in relation to economic deprivation.

Methods. Using 1990 census block-group data, 1990 census population counts, and AIDS surveillance registry data for the years 1988 through 1994, we generated yearly and cumulative AIDS incidence data for the state of Massachusetts stratified by sex and by neighborhood measures of economic position for the total, Black, Hispanic, and White populations.

Results. Incidence of AIDS increased with economic deprivation, with the magnitude of these trends varying by both race/ethnicity and sex. The cumulative incidence of AIDS in the total population was nearly 7 times higher among persons in block-groups where 40% or more of the population was below the poverty line (362 per 100 000) than among persons in block-groups where less than 2% of the population was below poverty (53 per 100 000).

Conclusions. Observing patterns of disease burden in relation to neighborhood levels of economic well-being elucidates further the role of poverty as a population-level determinant of disease burden. Public health agencies and researchers can use readily available census data to describe neighborhood-level socioeconomic conditions. Such knowledge expands options for disease prevention and increases the visibility of economic inequality as an underlying cause of AIDS. (*Am J Public Health*. 2000;90:1064–1073)

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In the United States, public health agencies collect and report national and state AIDS surveillance data with reference to race/ethnicity, sex, age, and mode of transmission.[1,2] Conspicuously absent are data on economic conditions,[3] even though several US studies have reported that HIV infection occurs disproportionately and increasingly among the poor[4–10] and 4 studies have documented the incidence of AIDS or HIV in relation to economic deprivation.[11–14] Three of these studies provided AIDS incidence data stratified by economic level for 3 cities (Philadelphia, Pa,[11] Newark, NJ,[12] and Los Angeles, Calif[13]), while the fourth analyzed economic disparities in HIV seroprevalence among newborns in New York State.[14] Thus, 20 years into the AIDS epidemic, there exist few data in the United States empirically quantifying links between economic deprivation and incidence of AIDS. In light of research on causal links between poverty and risk of HIV infection, however, such data could have important ramifications for guiding and evaluating AIDS prevention initiatives and programs and allocation of resources.[1,3,6,8–10]

Building on the limited extant research, we sought to quantify AIDS incidence in relation to economic deprivation in the state of Massachusetts, which presently ranks midway in the quartile of states with the second-highest incidence of AIDS.[2] An additional objective was to extend this description by examining economic disparities in AIDS incidence in relation to both race/ethnicity and sex. To overcome the absence of socioeconomic data in AIDS surveillance records, we used the same strategy employed by the prior 3 studies on economic deprivation and AIDS incidence: that of categorizing AIDS cases and individuals in the total population in terms of the economic characteristics of each person's residential neighborhood.[11–13] This approach permits determining and comparing population-based incidence rates among persons residing in neighborhoods with greater and lesser economic deprivation.[3,15,16] Whereas the prior 3 studies used area-based socioeconomic measures at the zip code (average population = 25 000) and census tract (average population = 4000) level, we used data from a smaller, more economically homogeneous level, the census block-group (average population = 1000).[15,16]

Methods

Study Population

The study base comprised all 6.3 million people included in the 1990 US census as residents of Massachusetts, of whom 86.0% were designated as White, 4.7% as Black, 4.4% as Hispanic, 2.2% as Asian/ Pacific Islander, 0.2% as American Indian, and 2.4% as "other." We assumed that all in-state Massachusetts AIDS reports included in this study originated from this at-risk population.

AIDS cases. We included all incident cases of AIDS reported to the Massachusetts Department of Public Health by the state's HIV/AIDS Reporting System between January 1, 1988, and December 31, 1994. The

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HIV/AIDS Reporting System uses the standard Centers for Disease Control and Prevention (CDC) case report form and defines an incident case of AIDS as a unique first report of diagnosis of an AIDS-defining condition, using the AIDS case definitions of the CDC.[11,12] In light of the CDC's 1987 revision of the AIDS case definition,[17] we restricted the study time period to include only cases diagnosed after December 31, 1987, and we extended the study to include all subsequent calendar years for which entry of AIDS data was complete (through 1994, as of the time our study was conducted). In addition to date of diagnosis, AIDS case records included information on age at diagnosis, sex, race/ethnicity, mode of transmission, and residential address at time of diagnosis.

Between January 1, 1988, and December 31, 1994, the surveillance system documented 8874 incident AIDS cases in Massachusetts. Of these cases, 13 of the persons resided in nonprison institutions, 335 were in prisons, 204 were homeless, and 9 lived out of state. Of the remaining 8313 persons with AIDS who were domiciled residents, we were able to geocode 8059 (96.9%) to the census block-group level, using MapInfo Pro version 4.0 (MapInfo Corporation, Troy, NY). The geocoded address was recorded at the time of diagnosis and/or at the time of the initial case report, or, if the address at diagnosis could not be established, an address from 5 years before or 2 years after diagnosis was used. Among geocoded cases, we restricted analyses to the Black non-Hispanic, Hispanic, and White non-Hispanic populations (n = 7994), since small numbers precluded meaningful analysis of data for other racial/ethnic groups (Table 1).

Census block-group socioeconomic measures. To characterize neighborhood socioeconomic conditions, we employed census block-group socioeconomic measures.[15,16,18] We obtained census block-group data from Summary Tape File 3A for the 1990 US census.[18] In 1990, Massachusetts contained 5603 block-groups, with an average population size of 1074 people (SE = 8.9; median = 956).

TABLE 1—Distributional Characteristics of 8059 Geocoded AIDS Cases in Massachusetts, 1988–1994

Characteristic	% Geocoded	Geocoded Cases (n = 8059) n	%
Sex			
Women	93.8	1519	18.8
Men	81.1	6540	81.2
Race/ethnicity			
American Indian	71.4	5	0.1
Asian	100.0	32	0.4
Black	88.6	1786	22.2
Hispanic	86.3	1343	16.7
White	93.0	4865	60.4
Unknown	93.3	28	0.3
Age, y			
<20[a]	89.1	143	1.8
20–29	89.8	1385	17.2
30–39	90.7	3975	49.3
≥40	91.6	2556	31.7
CDC-assigned mode of transmission			
Women and girls (n = 1519)			
Injected drugs	91.2	737	48.5
Sex with men	97.5	506	33.3
Transfusion	94.4	51	3.4
Pediatric	95.1	58	3.8
Unknown	94.4	167	11.0
Men and boys (n = 6540)			
Sex with men	95.8	3480	53.2
Injected drugs	80.2	1835	28.1
Sex with men and injected drugs	91.1	328	5.0
Sex with women	89.0	186	2.8
Transfusion	93.8	166	2.5
Pediatric	87.2	68	1.0
Unknown	93.9	477	7.3

Note. CDC = Centers for Disease Control and Prevention.
[a]Includes 133 children (aged 12 years and younger) and 26 adolescents (aged 13–19 years).

Using the census data, we constructed numerous measures of neighborhood socioeconomic conditions, assessed in relation to absolute and relative poverty and wealth, crowding, education, and occupational class.[15,16] Specific measures pertained to (1) poverty (percentage of people living below the poverty line, which was set at $12 674 for a family of 4 in the 1990 census; according to federal guidelines, a "poverty area" is one where 20% or more of residents live below the poverty line and an "extreme poverty area" is one where 40% or more of residents live below the poverty line[18,19]); (2) high income (percentage of households with an annual household income of at least $150 000, the highest income category reported by the US census[18]); (3) ratio of lower-income households (<$20 000) to higher-income households (≥$60 000); (4) population density (number of persons per square mile); (5) crowding (percentage of households with more than 1 person/room); (6) education (percentage of adults 25 years and older who had not completed high school); and (7) working class (percentage of persons employed in nonsupervisory occupations, as determined by a previously validated block-group class measure[15,16]). Because these diverse indicators revealed comparable patterns of AIDS incidence in relation to economic deprivation and advantage (data available upon request), we present results for only 3 indicators: (1) poverty, (2) population density, and (3) high income, conceptualized as a measure of wealth. Data on these indicators were available for 98% of the state's population.

Statistical Analysis

Constructing numerators and denominators stratified by block-group socioeconomic measures. Numerators consisted of geocoded AIDS cases whose individual records were linked to the selected block-group measures characterizing socioeconomic conditions in the case's block-group. For each calendar year, we tallied the number of cases, stratified by race/ethnicity and sex, who lived in block-groups with the specified socioeconomic characteristics (e.g., White women who lived in block-groups where fewer than 2% of residents were below the poverty line).

Denominators of incidence rates reflected the combined number of person-years of residents in block-groups sharing a particular economic condition for each calendar year from 1988 to 1994. Block-group population counts by sex were directly available for Hispanics from Summary Tape File 3A.[18] For Blacks and Whites, counts by sex did not distinguish between persons of Hispanic and

non-Hispanic origin[18]; we therefore estimated the number of non-Hispanic Blacks and Whites by (1) calculating, for each block-group, the proportion of White and Black persons of non-Hispanic origin and (2) multiplying these proportions by each group's sex and age distribution within the block-group.[16] We then summed across all block-groups in the catchment area within the same economic stratum to obtain denominator data stratified by race/ethnicity (Black non-Hispanic, Hispanic, White non-Hispanic), sex (women, men), and block-group economic position (measures pertaining to poverty, population density, and wealth).

Calculating incidence rates and cumulative incidence. For each calendar year 1988 through 1994, we estimated annual incidence rates. To estimate 7-year cumulative incidence (as an estimate of absolute risk), and to account for changes in incidence over the study period within each sex-racial/ethnic population and block-group level of economic deprivation, we used the formula[20]

$$1 - e^{\uparrow}\left[-\sum_{1998}^{1994} IR\right],$$

where e is the base in the natural logarithm system and is approximately equal to the value 2.71828. *IR* represents the annual incidence rates. The ratios of estimates for cumulative incidence at the extremes of economic distributions and 95% confidence intervals are presented for the total Massachusetts population (Table 2). We also present estimates of absolute difference in risk between extremes of the economic distributions. For these estimates, the standard errors were minute (approximately 0.0001 excess cases per 100 000 persons), and confidence intervals are therefore not presented.

Estimates of trend. We estimated trends in cumulative incidence (with interval estimation) across the social gradient constructed for each socioeconomic measure, using least squares linear regression to derive estimates of sex- and race/ethnicity-specific β coefficients to evaluate the hypothesis of increasing AIDS incidence in relation to increasing deprivation. To simplify comparisons of the public health impact of economic conditions across subpopulations in this and other studies, we visually depict these trends by using figures with untransformed scales (Table 2 and Figure 2).[21]

Results

To assess the incidence of AIDS in relation to block-group socioeconomic conditions, we first describe the socioeconomic distribution of the AIDS cases and of the total Massachusetts population and then present annual and cumulative incidence rates stratified by the poverty, population density, and wealth block-group measures, both for the total population and for the total population additionally stratified by race/ethnicity and sex.

Sociodemographic Characteristics of AIDS Cases and of Massachusetts Population

Among the 8059 geocoded and 815 non-geocoded AIDS cases as recorded in the AIDS surveillance system, persons with non-geocodable addresses were more likely to be men, to be Black or Hispanic, and to have "injection drug use" assigned as their mode of HIV acquisition (Table 1). Socioeconomic characteristics of the AIDS cases and of the 1990 Massachusetts population differed considerably in terms of the block-group measures of poverty, population density, and wealth (Table 2). Thus, most of the Massachusetts population resided in block-groups where less than 10% of the population was below the poverty line, population density was fewer than 5000 people per square mile, and at least 2% of the population had household incomes of $150 000 or more. By contrast, in most of the AIDS cases in the state, the person lived in block-groups where at least 10% of the population was below the poverty line, population density exceeded 10 000 people per square mile, and fewer

TABLE 2—Economic Gradients in Incidence of AIDS in Total Massachusetts Population, 1988–1994

Block-Group Characteristic	Cases, n	Population in 1990	Risk per 10^5	Relative Incidence[a] (95% Confidence Interval)	Excess No. of Cases[a] per 10^5	Estimate of Trend[b] (95% Confidence Interval)
People living below federal poverty line, %				6.88 (6.20, 7.64)	309	69.25 (67.43, 71.07)
0–1.9	633	1 201 946	52.65			
2–4.9	1039	1 687 124	61.57			
5–9.9	1375	1 487 492	92.38			
10–19.9	2089	1 024 428	203.71			
20–39.9	2117	667 388	316.69			
40–100	792	218 334	362.08			
Population density, people/sq mile				9.23 (8.43, 10.11)	333	84.87 (83.01, 86.74)
0–999	611	1 509 285	40.47			
1000–4999	1512	2 120 452	73.96			
5000–9999	1281	1 990 071	9.76			
10 000–24 999	2692	1 174 348	256.70			
25 000+	1954	497 169	373.47			
Households with annual income ≥$150 000, %				0.40 (0.37, 0.44)	–106	–32.05 (–30.35, –33.76)
0–1.9	4405	2 515 045	175.00			
2–4.9	1796	1 695 578	105.86			
5–9.9	1246	1 218 648	102.19			
10–100	593	854 497	69.38			

[a]Relative incidence and excess number of cases are comparisons of cumulative incidence of AIDS in populations living in the poorest and most crowded neighborhoods relative to populations living in the wealthiest and most spacious neighborhoods.
[b]Estimate of trend is β coefficient for linear trend, quantifying the number of additional (or decremental when negative) cases at each descending level of a socioeconomic gradient.

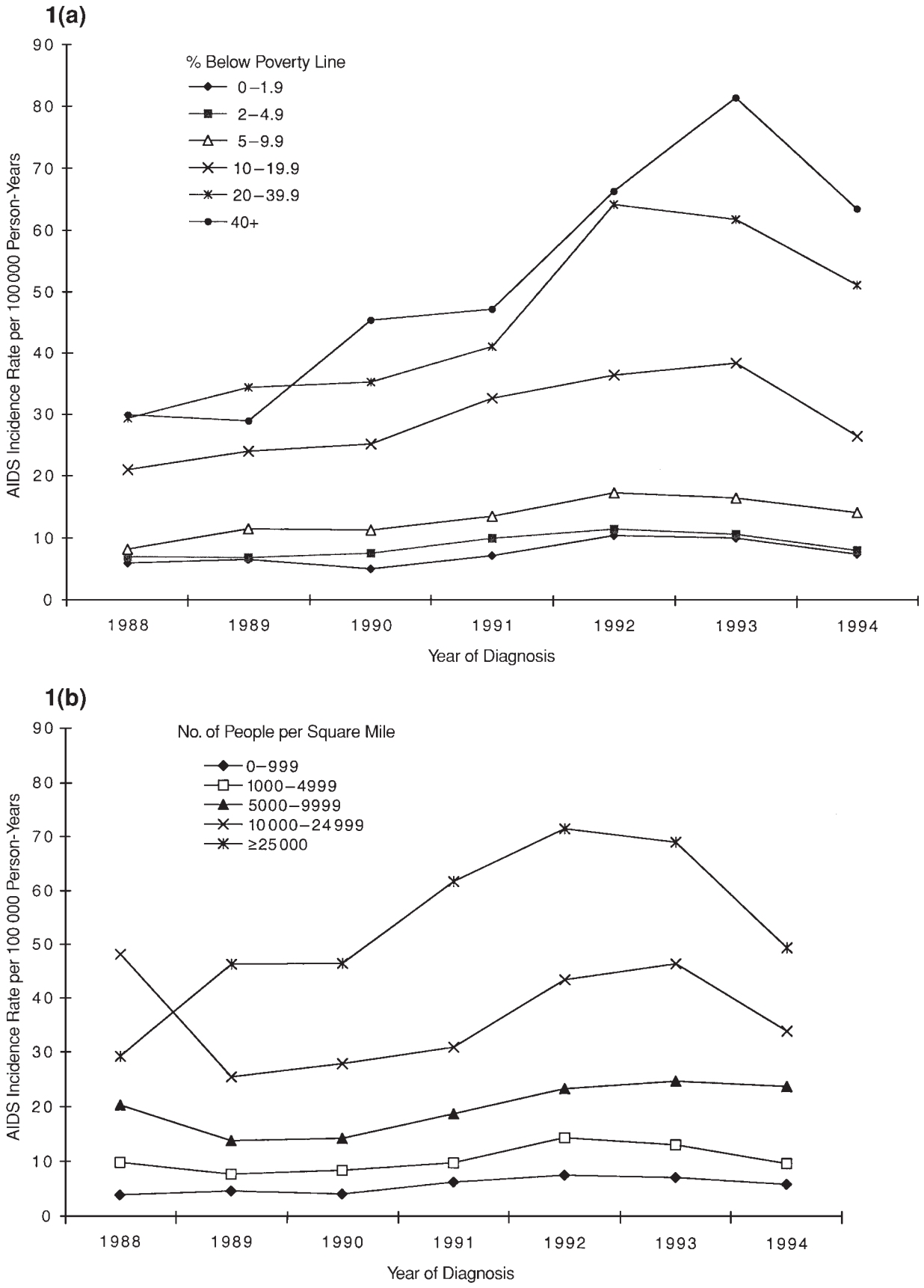


FIGURE 1—AIDS incidence rates, by year of diagnosis, in total Massachusetts population, 1988–1994, in relation to percentage of people living below the poverty line (a) and to population density (b).

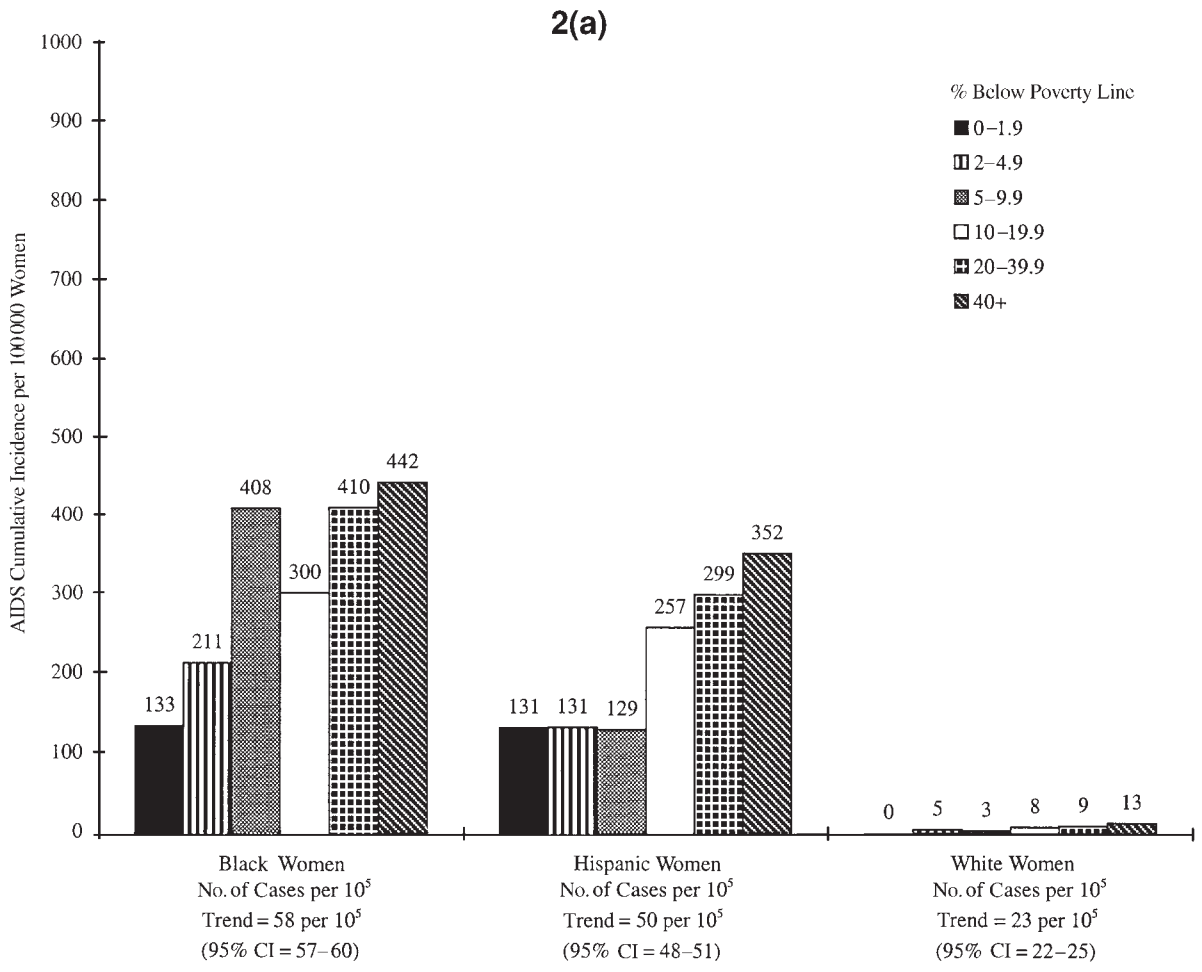
than 2% of households had incomes of $150 000 or more.

Cumulative Incidence of AIDS in Relation to Block-Group Socioeconomic Measures: Total Population

Overall, cumulative incidence of AIDS for the total Massachusetts population for 1988 to 1994 equaled 128 cases per 100 000 persons. During this time period, yearly incidence (Figure 1) and cumulative incidence (Table 2) showed monotonic patterns of increasing AIDS occurrence with decreasing economic resources and increasing population density. Thus, the cumulative incidence of AIDS in the total population was nearly 7 times higher among persons in block-groups where 40% or more of the population was below the poverty line (362 per 100 000) than among persons in block-groups where less than 2% of the population was below the poverty line (53 per 100 000). For population density, cumulative incidence rates ranged from 40 per 100 000 among persons in the least densely populated block-groups (<1000 persons/square mile) to 373 per 100 000 among those in the most densely populated block-groups (≥25 000 persons/square mile). As a demonstration of a protective effect of neighborhood wealth, cumulative incidence was 69 cases per 100 000 among persons living in block-groups where at least 10% of households had annual incomes of $150 000 or more but was 175 per 100 000 among those in block-groups where fewer than 2% of households had incomes of $150 000 or more.

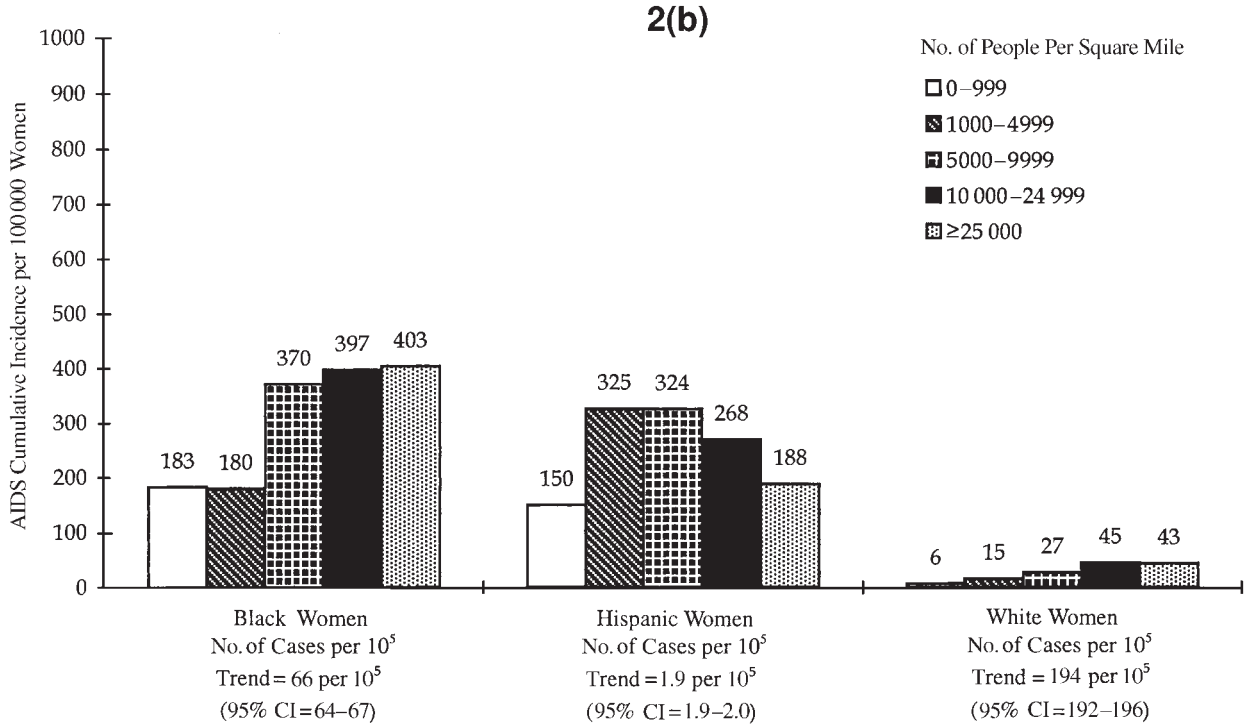
Combined Impact of Socioeconomic Position, Race/Ethnicity, and Sex on Cumulative Incidence of AIDS

Population patterns of socioeconomic gradients in cumulative incidence of AIDS were evident across racial/ethnic and sex subgroups, but they varied in both steepness and monotonicity. Among both women (Figure 2a–c) and men (Figure 2d–f), monotonic patterns were most evident and consistent among the Black and White populations. Only for 1 block-group measure, high income, were



Note. CI = confidence interval.

FIGURE 2—Cumulative AIDS incidence per 100 000 people and estimates of trend in Massachusetts, 1988–1994: for women (non-Hispanic Black, Hispanic, non-Hispanic White) in relation to percentage of women living below poverty line (a), population density (b), and percentage of households with incomes of $150 000 or more (c) and for men (non-Hispanic Black, Hispanic, non-Hispanic White) in relation to percentage of men living below poverty line (d), population density (e), and percentage of households with incomes of $150 000 or more (f).



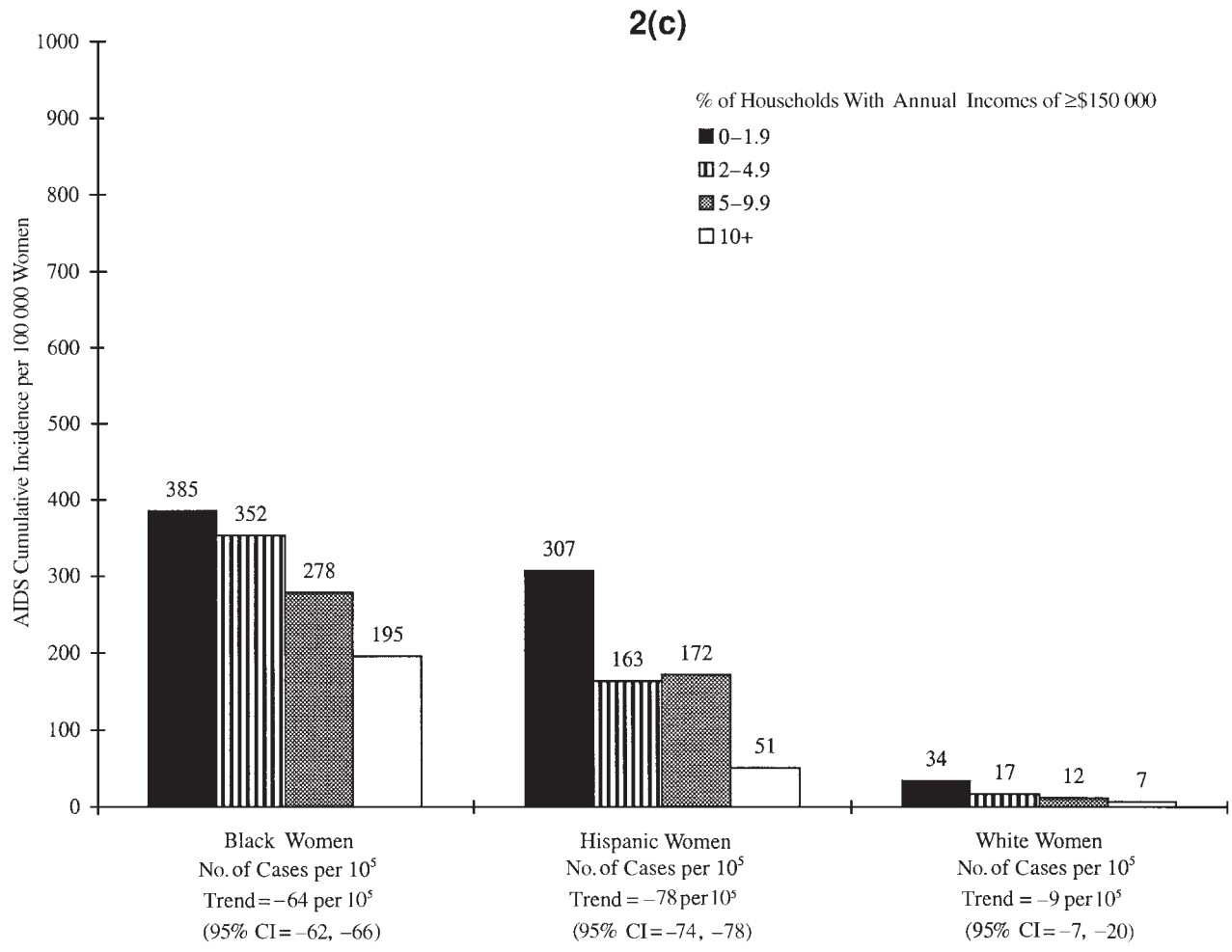
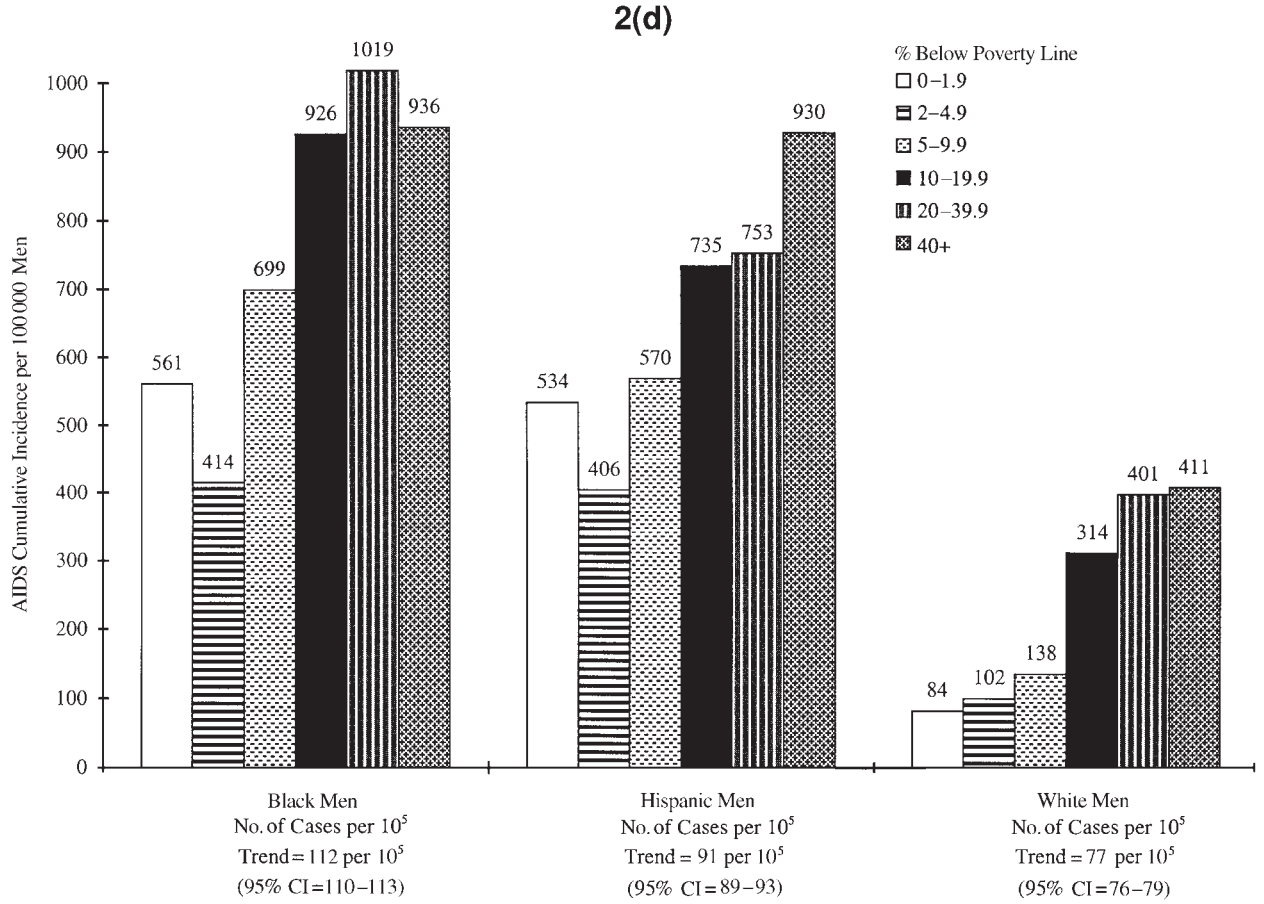
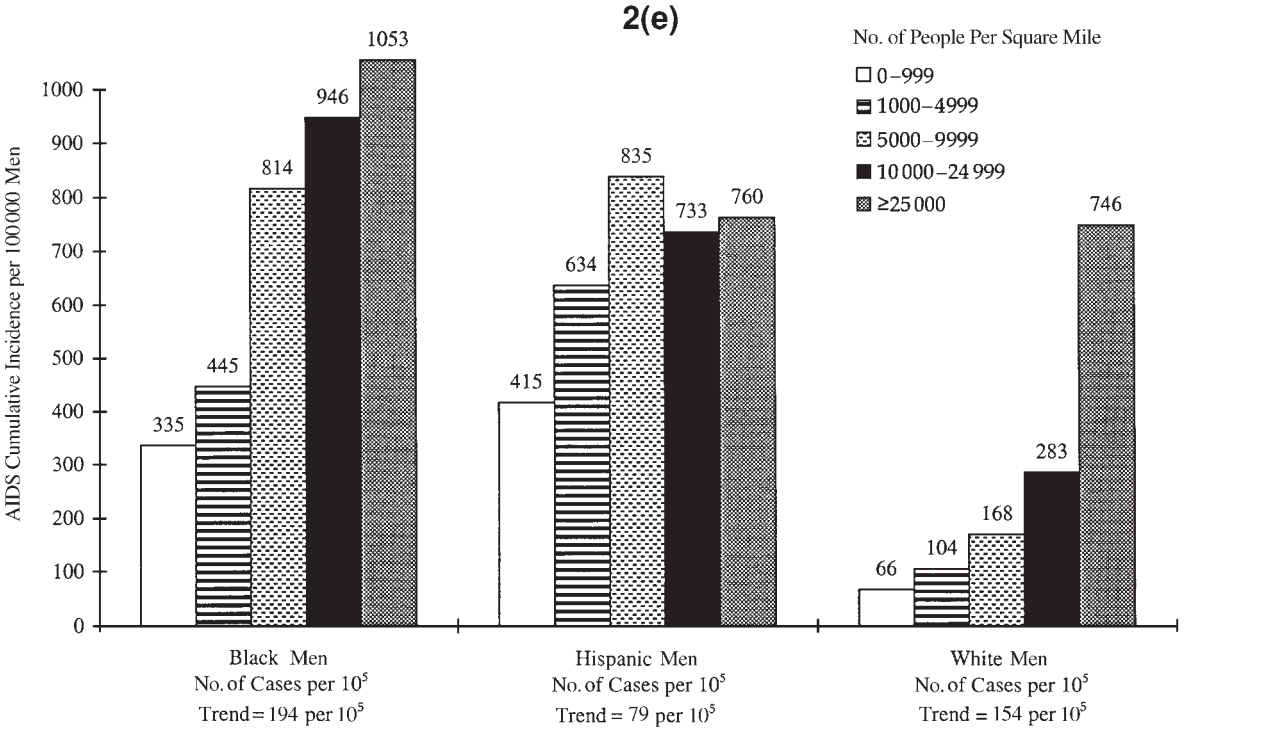


FIGURE 2—*Continued*





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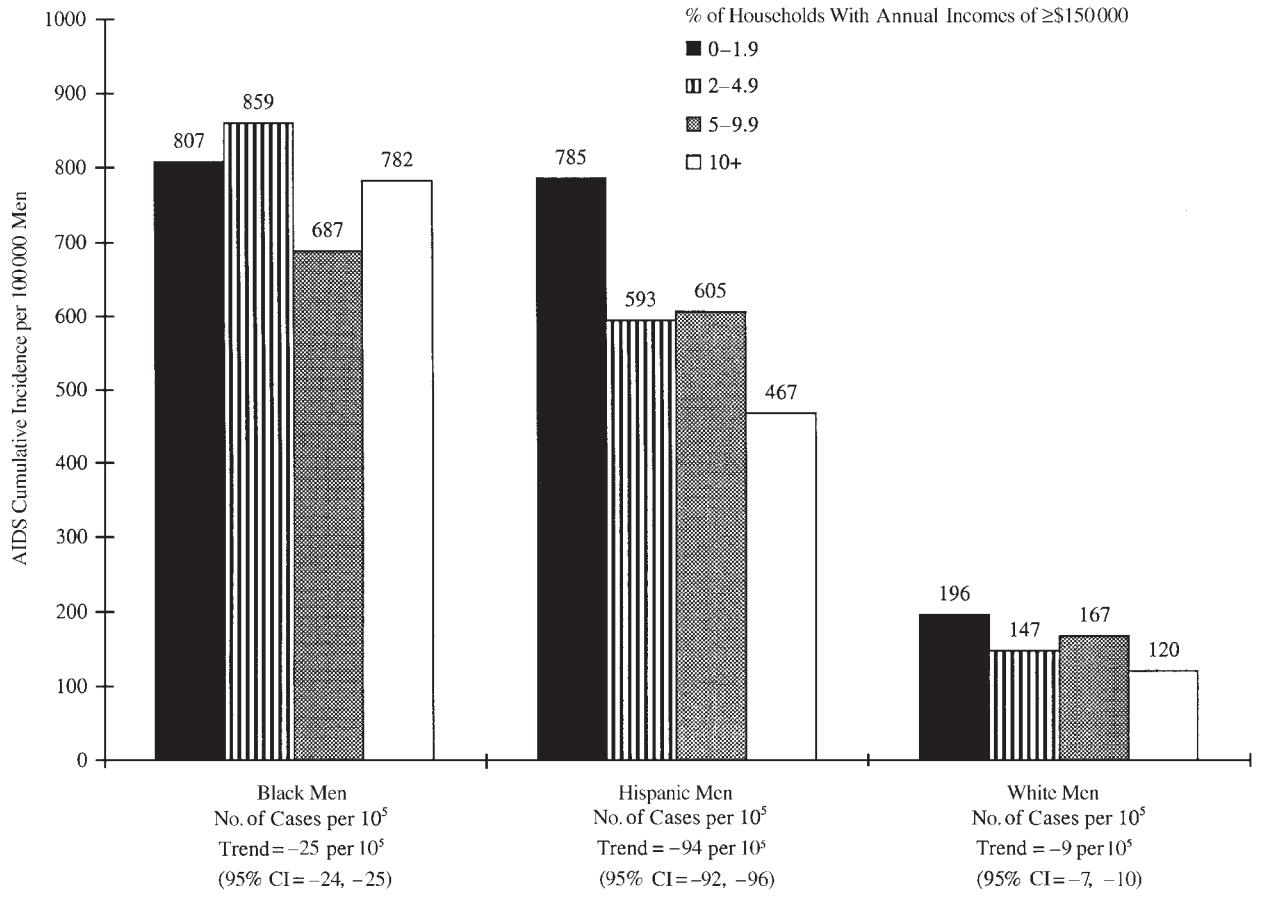

FIGURE 2—*Continued*

economic inequalities in AIDS incidence greater among women than among men, a finding that may reflect elevated risk of AIDS in more affluent gay neighborhoods.

As evidence of the combined impact of socioeconomic position, sex, and race/ethnicity on risk of AIDS, the cumulative incidence among persons living in block-groups where 40% or more of the population was below the poverty line equaled 442 cases per 100 000 among non-Hispanic Black women and 352 per 100 000 among Hispanic women but only 13 per 100 000 among non-Hispanic White women; higher rates among men ranged from 936 per 100 000 among non-Hispanic Black men and 930 per 100 000 among Hispanic men to 411 per 100 000 among non-Hispanic White men. Moreover, the absolute excess risk of AIDS among persons living in these impoverished block-groups, compared with persons living in block-groups where less than 2% of the population was below the poverty line, was 309 cases per 100 000 for non-Hispanic Black women, 221 per 100 000 for Hispanic women, 13 per 100 000 for non-Hispanic White women, 375 per 100 000 for non-Hispanic Black men, 396 per 100 000 for Hispanic men, and 327 per 100 000 for non-Hispanic White men. Finally, cumulative incidence in categories of greatest poverty, greatest population density, and least wealth among White women was always lower than in categories of least poverty, least population density, and most wealth among both non-Hispanic Black and Hispanic women (Figure 2a–c); the same pattern was apparent among the men (Figure 2d–f).

Discussion

Our study provides additional evidence, for the first time at the state level, that neighborhood levels of economic deprivation and population density are powerful determinants of AIDS incidence.[11–14] Between 1988 and 1994, both relative and absolute risk of AIDS increased among persons in Massachusetts living in economically deprived and densely populated block-groups. Compared with those residing in the least poor block-groups, persons residing in the poorest block-groups were burdened with an excess of 309 cases per 100 000; compared with those living in the least densely populated block-groups, those living in the most densely populated block-groups had an excess of 333 cases per 100 000; compared with those living in block-groups with the smallest percentage of high-income households, those living in block-groups with the largest percentage of high-income households had 106 fewer cases per 100 000 (Table 2).

Moreover, because we were able to stratify the data by sex and race/ethnicity, our results provide new evidence of the combined impact of economic deprivation, race/ethnicity, and sex on incidence of AIDS (Figure 2): the highest rates for the state occurred among non-Hispanic Black men living in block-groups with the greatest population density (1053 cases per 100 000), followed by

non-Hispanic Black men and Hispanic men living in the most impoverished block-groups (more than 900 cases per 100 000), while the lowest rates occurred among White women in the least impoverished block-groups (0 cases per 100 000). Whereas government surveillance reports as well as published studies of AIDS incidence typically describe risk in relation to sociodemographic categories of sex and race/ethnicity, our results indicate that these social categories are insufficient to describe the population burden of AIDS; data must additionally be stratified by measures of adverse living conditions.

Possible Sources of Error Affecting Study Results

Interpretation of our findings rests on several assumptions about validity of measures, especially pertaining to block-group measures of socioeconomic position and race/ethnicity. As we discuss below, however, it is unlikely that these study results are exaggerated by measurement error.

First, an unknown proportion of people may have changed residence in the interval between HIV infection and diagnosis of AIDS. Some researchers have suggested that AIDS cases are greater among the poor because deterioration of health leads to poverty,[4] with loss of assets causing relocation to poorer block-groups. Misclassification introduced by using residential address at the time of AIDS report rather than of HIV infection, however, would introduce error in the direction of overestimating economic gradients only among people at risk of losing substantial income or other assets. Among the chronically poor, no such misclassification would occur. Nor would misclassification occur if AIDS cases emerged from neighborhoods with economic conditions similar to those of neighborhoods where HIV infection was first acquired in those cases. Further countering these concerns about the likely direction of causal pathways between economic deprivation and AIDS are (1) a recent Massachusetts study demonstrating that positive HIV tests among persons seeking HIV testing at public clinics were 4 times more frequent among persons living in lower-income zip codes than among persons living in higher-income zip codes[22] and (2) additional US studies documenting newly diagnosed HIV infection disproportionately among the poor, with excess risk linked to poverty most profoundly among women.[4,5,7]

Second, reliance on census block-group socioeconomic measures is unlikely to have inflated estimates of socioeconomic gradients in the incidence of AIDS. In fact, underestimation of these gradients is the more likely bias, for several reasons. First, lack of residential address resulted in exclusion of prisoners and homeless persons, 2 populations known to be at high risk of HIV infection and AIDS.[8,23] Underascertainment of AIDS among medically underserved populations would likewise deflate estimates of relative and absolute risk among the poorest populations. Prior non-AIDS studies have shown that disparities in individuals' health identified via area-based measures resemble or are underestimates of health disparities identified via gradients based on individual- or household-level economic data.[15,16,24,25] Additional contextual research likewise demonstrates that block-group socioeconomic measures are far more than simply proxies for unavailable individual-level economic data; instead, they provide data on how neighborhood conditions themselves affect health, independent of and in conjunction with individual- and household-level socioeconomic resources.[15,16,26]

Third, validity of estimates could be affected by factors differentially compromising classification of and enumeration by race/ethnicity, among numerators and/or denominators. Misclassification by race/ethnicity, documented to occur in AIDS surveillance systems,[27,28] would affect validity most seriously if it had occurred differentially in numerator and denominator data (i.e., AIDS case reporting and US census self-identification) and differentially within social class categories. Regarding the numerator data, a recent reliability study of AIDS surveillance data in Massachusetts noted 99% agreement for sex and 94%, 94%, and 91% agreement for Black, White, and Hispanic race/ethnicity, respectively, comparing surveillance data with information in medical records.[29] A related form of misclassification is use of racial/ethnic categories that are heterogeneous with respect to social meaning, because among the persons in each category there are differences in historical experience of conquest and enslavement, in current refugee and immigrant status, and in country of origin.[8–10,30,31] Heterogeneity pertaining to country of origin and immigrant status, for example, may explain why economic gradients in AIDS incidence were least pronounced among the Hispanic population (Figure 2). Finally, undercounting of populations of color (estimated nationally in the 1990 census to have been between 2% and 12%, depending on race/ethnicity, sex, and age) could lead to overestimation of incidence rates among these populations.[32–34] This marginal inflation of rates due to an undercounted denominator, however, is insufficient to explain the magnitudes of excess AIDS incidence by race/ethnicity that we observed. Notably, however, racial/ethnic disparities apparent within our block-group socioeconomic strata are likely to reflect residual confounding, since Black residents of a wealthy block-group, for example, are likely to be less wealthy than their White counterparts, while White residents of a poor block-group are less likely to be as impoverished as their Black counterparts.[15,35]

Including Socioeconomic Data in AIDS Surveillance Systems

Despite possible biases, our results are compatible with and extend the findings of the 4 published US studies[11–14] and 3 non-US studies (1 Australian,[36] 1 Spanish,[37] and 1 Canadian[38]) quantifying AIDS or HIV incidence in relation to economic resources. Although none of these prior studies reported results stratified by sex, 1 US study, like ours, reported that incidence of AIDS was inversely associated with income in each of 4 racial/ethnic groups: Asian/Pacific Islander, Black, Hispanic, and White.[13] Together, these results indicate that our findings may be generalizable to other states, especially those containing urban populations; future research, however, should address this issue by quantifying AIDS incidence in relation to economic deprivation in additional states, taking into account both rural and urban areas.

In conclusion, our results suggest that public health agencies can feasibly expand AIDS and other disease surveillance systems to include neighborhood-level economic data. When rich descriptions of neighborhood conditions are linked at the block-group level to residential address of HIV/AIDS cases, dynamics of the epidemic in relation to neighborhood economic resources become more visible. Such knowledge can inform HIV prevention initiatives that emphasize social and economic harm reduction at the neighborhood level.[6,8–10] At a time of disturbing trends of increasing geographic concentrations of poverty within the United States,[39] coupled with increasing evidence of poverty as a causal determinant of risk of HIV infection,[8–10] data on AIDS incidence in relation to neighborhood economic conditions strongly suggest that reducing the incidence of AIDS will depend vitally on approaches that promote the growth of social and economic resources in neighborhoods where AIDS is endemic. □

Contributors

S. Zierler and N. Krieger were the principal investigators, conceived the project, and wrote the manuscript. N. Krieger was overall director of the project, and S. Zierler conducted the analyses. Y. Tang, W. Coady, E. Siegfried, A. DeMaria, and J. Auerbach—staff at the Massachusetts Department of Public Health—participated in all phases of data collection, in data analysis decisions, and in the editing of various versions of the manuscript.

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