THE LIMITS OF HEALTH SURVEYS FOR CONTEXTUAL OR MULTI-LEVEL ANALYSIS

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White Americans and Americans of African descent occupy strikingly different positions in American society. While there is great diversity within these populations typical or average values for a wide range of statistics describing these populations differ substantially.[1, 2] For instance, at almost all ages African Americans have higher mortality rates than white Americans and consequently lower life expectancy.[3, 4] Because of this pattern, in public health, epidemiology and medical sociology race has become one of the standard bases for dividing the US population.[4-6] While, the approaches to explaining health differences between white and African-Americans are diverse the dominant perspectives in these disciplines have looked to differences in individual characteristics including differences in education, income, family organization, work history, and personal habits such as smoking, drinking and consumer tastes.[7, 8] In most, but not all, of these areas African-Americans are at higher risk compared to whites. African-American women, for instance, are more likely than white women to be over-weight but are less likely to have ever smoked cigarettes.[4]

Some authors have speculated about the possible roles of racism and the legacy of slavery in explaining these differences.[9-12] These concepts, however, are difficult to operationalize within the context of survey research and limited progress has been made in applying them.[13] Some authors have proposed that genetic differences might underlie the socioeconomic and health differences,[14] but genetic explanations have been soundly criticized.[8, 12, 15-17]

Yet other authors have sought to explain differential health outcomes between white and African-Americans with differences in their socioeconomic status (SES). Studies in this vein have found that for some health outcomes the application of statistical controls for SES, variables like education or income, eliminates the differences between white and African-Americans. Nevertheless, for many outcome variables even after the application of statistical controls there remains a residual difference between white and African-Americans.[4, 5] Some authors have argued that the commonly used measures do not adequately control for SES differences between white and African-Americans and have sought additional measures.[6, 10, 18] Recently, furthermore, several researchers have begun to develop more complex theories relating social and economic conditions to health status.[7, 19-21] Although they have many reasons for seeking more complex explanations in socioeconomic factors, many of these researchers share an interest in neighborhood qualities or what are sometimes called contextual or multilevel effects.[22-24] Recent progress in developing statistical techniques and software for multi-level or hierarchical modeling has provided a new methodological foundation for these studies.[25-27] However, despite improved statistical techniques, contextual or multi-level analyses of racial differences in health are still faced with challenges and limitations. One of these is that race and contextual measures of socioeconomic status are

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confounded. It is the purpose of this paper to explore the source and extent of this confounding in health surveys.

Karen Brewster[28] makes a clear presentation of the problem in a study of the role of neighborhood characteristics in determining race differences in the nonmarital sexual activity of adolescents. She used individual level data from the 1982 National Survey of Family Growth (NSFG) matched with contextual data from a variety of sources, most importantly the Bureau of the Census. She proposed to include variables in her analyses only if "the median for one race fell within the bounds of the twentieth and eightieth percentiles of the other race."(p. 411) In exploratory analyses she found that, "the number and type of contextual characteristics that can be tested empirically are limited by the extent of the race differentiation apparent in [the sample].. No indicators of household structure, poverty, welfare dependence, or the norms governing marital unions met this criteria." (p. 411)

Although Brewster's selection of the 20th and 80th percentiles is a subjective and somewhat arbitrary decision on her part, the need for some standard follows from the design of her study.[28] That design, a quasi-experiment in which study groups act as their own controls, is quite common in social research.[29, 30] Whether survey data are cross-sectional like the NSFG or longitudinal, in multivariate analysis it is assumed that there are no exogenous variables systematically related to the dependent variable which are not in the model. Failure to include any such variable may lead to specification error in model parameter estimates. If there are excluded variables systematically related to the independent variables there is also the possibility of selection bias. Selection bias results when an excluded variable is related to both the assignment of cases to analytic groups and to the independent variable. A common defense against selection bias is the application of statistical controls; that is, the inclusion in models of variables intended to statistically match up analytic groups on variables for which they might systematically differ.[10, 12, 28-30] However, when the distributions of the control variables are as different as the distributions of SES variables within American whites are from those within African-Americans, it becomes very difficult to believe that the control variables are sufficient to protect against selection biases. There must be more complex causes determining these distributions.[10, 12, 28-30]

Another way of putting this problem is to say that the race and SES variables are confounded. The variance of one is so much in common with the variance of the other that their effects cannot be separated. This means that even after the application of statistical controls, there is still residual confounding.[6]

Brewster's[28] demonstration that race and contextual SES measures are confounded in the 1982 NSFG raises questions about other surveys, and about the relationship between the surveys and the US society they are designed to represent. In this paper we addresses these questions by replicating her results with two other national surveys, the National Health Interview Survey (NHIS) and the Third National Health and Nutrition Examination Survey (NHANES 3).   Both of these surveys are larger than the 1982 NSFG both in the number of respondents and in the number of primary sampling units. Because two of the underlying stratification mechanisms which link race and health in the United States are racial and economic segregation,[23, 31-33] we assess the degree of racial and economic segregation within the samples and compare the results to the 1990

US Census. Then we review the degree of confounding between race and socioeconomic status, and discuss the implications for analyses of these surveys.

Methods

 The NHIS is an annual survey of households. Data are collected in personal interviews by staff of the Bureau of the Census. The sample is representative of the civilian, non-institutionalized, population of the US. Each year from 1985 to 1994 used the same basic design. For the first stage of sampling the primary sampling units (PSUs) were counties, groups of small contiguous counties, or metropolitan areas; 198 primary sampling units were selected. Within PSUs there were two sampling frames, an area frame based on enumeration districts from the 1980 Census and a list frame of building permits. Within segments drawn from the area frame, clusters of 8 households were selected. In 1990 there were 48,680 households sampled in the NHIS of which 95.5 percent were interviewed. These households contained 119,631 persons.[34, 35] In order to improve estimates for African-Americans this population was over-sampled. The over-sampling was achieved by stratifying enumeration districts within PSUs which were between 5 and 50 percent African-American in such a way that there was a higher sampling rate in enumeration districts which had a higher proportion of African-Americans.[34]

The NHANES 3 sample is also representative of the civilian non-institutionalized population of the US. Data were collected not only in personal interviews in households but also with interviews, examinations and physical measurement in mobile examination centers. In the NHANES 3 sample design most PSUs were counties, but some were groups of small counties. Eighty-one PSUs were selected. In the first half of the survey, 1988-1991, households were sampled from both an area frame of units defined in the 1980 Census and a list frame of building permits. For the second half, 1992-1994, only an area frame from the 1990 Census was used. The NHANES 3 sample was designed to be approximately 40 percent white and 30 percent each African- and Mexican-American. This distribution was obtained by stratifying PSUs by the size of these population groups, by stratifying segments within PSUs, and by screening households within segments. Within PSUs the stratification was by the density of Mexican-Americans because sub-groups of Mexican-Americans were expected to be rarest.[36] In the NHANES 3 interviews were completed with 33,919 persons, 86 percent of the identified sample.[37]

Because the mid-point of the NHANES 3 is 1991 and 1990 NHIS data are used in this analysis, it is reasonable to compare the samples with the 1990 US Census. Although the Census has broader coverage of the US population than the surveys the error introduced is probably small compared to other errors in measurement. Census data were obtained from a Summary Tape File 3a.[38]

Household records for the NHIS and the NHANES 3 were coded into 1990 Census geography to the block-group level. For the second half of the NHANES 3 1990 Census geographic codes were obtained from the sampling. For the first half of that survey household addresses were coded using a commercial address coding program and the results edited with segment maps from the field work. More than 99 percent of the households were coded. For the NHIS the Bureau of the Census was able to translate 1980 geographic codes for some area frame households into 1990 codes, about 60 percent of all households, and also provided probability-based assignments

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of codes for about 30 percent. Street addresses for residences in this 30 percent and from the list frame were coded with the commercial program and then edited using the known clustering of households in the sample design. This method produced codes more accurate than the probability assignments for more than one quarter of the sample households. This leaves about 12 percent of the households with codes assigned on a probability basis and about 3 percent without codes.

In addition to this small amount of data missing because households were not coded to Census geography, there were additional losses due to item non-response on other items used in this analysis. In particular, there are higher levels of non-response for the poverty status items in the NHANES 3 and NHIS. Values for missing data for this item were imputed in the Census.

In order to summarize the level of segregation in the samples and the Census and render them comparable we calculated D statistics, the most commonly used measure of segregation.[39] The formula for D is:

$$D = \sum_{i=1}^{n} \left[t_i |p_i - P| / 2TP(1 - P) \right]$$

where the capital letters refer to the total population and the small letters the local units, T and t are total populations, P and p are the proportion one group is of the total, and there are n local units indexed by i. This statistic is a measure of the evenness of the mixture of two populations across sub-areas of a whole; its value is 0 when the mixture is uniform and 1 when there is complete segregation. In the tables the D statistics are multiplied by 100. Evenness is the most important dimension of segregation and for blacks in the US it is a good over-all measure of segregation.[40] One interpretation of the D statistic is that it represents the proportion of members of one group that would have to change the sub-area in which they live in order to make the mixture across the whole area uniform. Significantly for this study the D statistic is insensitive to either the relative sizes of the populations or the number of sub-units over which it is calculated.[39] These statistics were calculated to measure the segregation of non-Hispanic African-Americans from non-Hispanic white Americans. For economy, these groups are often referred to in what follows as blacks and whites. In calculating the D statistics the presence of Hispanic Americans was ignored; this is one limitation of this study. By analogy with the categories black and white, D statistics were also calculated to measure the segregation of the poor from the not-poor. Because the samples are national samples and do not represent all sub-units of the US territory it was necessary to group the data; in each instance the distribution of block-groups and tracts was divided into deciles.

Several area measures of SES were considered in this study: median household income, percent of population age 25 or over with 16 or more years of education, percent poor, percent of households with interest, dividend, or rent income, percent of persons age 16 or over in the labor force, and percent of youths neither in school nor at work. Because similar results were obtained from the first four of these variables an index combining them was constructed from the first principal component of their data matrix. SES index scores for units that would be considered advantaged are negative while those that would be considered disadvantaged are positive.

Results

Table 1 presents D statistics, calculated over four levels of Census geography, for the residential segregation of African-Americans from non-Hispanic whites. As one must expect, in larger units of geography, the populations are more diverse and the D statistics are lower. At 27 the D statistic for the Census at the state level measures the uneven distribution of the Blacks over the US regions and throughout the states. At the level of Census tract it is 72 and at the level of block group it is even higher at 76. The D statistics for the surveys are, perhaps not surprisingly and reassuringly, generally similar to those of the Census. Upon closer inspection, however, D statistics for the NHIS 1990 are seen to be consistently larger than those from the Census, and those for the NHANES 3 are seen to be consistently smaller. In the case of the NHIS this may be due to the over-sampling of areas with large numbers of blacks within PSUs. Consistent with this explanation the differences between the NHIS sample and the Census are uniformly smaller for the weighted than the unweighted data, and at the block group level the value of D for the NHIS is even one less than the Census value. After the survey data are weighted, the statistics from the NHIS are closer to those from the Census than are those from the NHANES 3. This is not surprising given the larger number of PSUs in the NHIS.

Table 1. Racial segregation of non-Hispanic blacks and whites in the NHANES 3, the NHIS 1990 and the US Census 1990: D statistics for the distribution of non-Hispanic blacks and whites over area units classified by percent of area population black

	Unweighted		Weighted		1990 Census
	NHANES 3	NHIS 1990	NHANES 3	NHIS 1990	
State	25	30	26	30	27
County	45	54	45	51	48
Tract	71	77	70	73	72
Block group	73	79	72	75	76

The extent of segregation when the D statistic is 76 and the effects of over-sampling may be seen in Table 2. According to the 1990 Census 43 percent of white Americans live in block-groups with virtually no African-Americans; and 19 percent of African-Americans live in block groups less than 2 percent white.

Table 2. Percent distribution of blacks and whites in the 1990 NHIS and Census by percent of block group black

Percent black	1990 NHIS sample		1990 Census	
	Black	White	Black	White
Total	100.00	100.00	100.00	100.00
< 0.24	1.31	45.01	.01	42.91
0.24 - 1.20	.48	11.07	.52	11.35
1.21 - 3.37	1.46	14.45	2.01	14.23
3.38 - 7.23	2.58	10.58	3.81	11.16
7.24 - 13.25	3.71	7.05	5.43	7.72
13.26 - 52.7	17.99	9.60	26.09	10.87
52.8 - 77.9	14.47	1.40	15.35	1.30
78.0 - 92.1	15.06	.40	12.79	.33
92.2 - 98.4	17.59	.24	14.80	.10
98.5 - 100	25.34	.21	19.19	.01

The differences in D statistics between the NHIS and the NHANES on the one hand and the Census on the other is reflected in the distributions of blacks and whites over these categories. The greater segregation in the NHIS sample is seen where the percent of blacks is smaller in the NHIS than in the Census for every mixture category up to 78 percent black. The proportions of blacks living in block-groups that have a high proportion of whites and the proportions of whites living in block-groups that have a high proportion of blacks is, by definition, very small. But, based on these very small denominators,

the relative differences between the survey and the Census are large; the proportion of black persons in the NHIS sample living in block groups that are between 1.20 and 52.7 percent black is 31 percent less than the proportion in the Census. In the Census, 37 percent of blacks live in block groups in this range of the distribution of percent of block group black.

The level of economic segregation of blacks from whites is lower than the level of segregation by race; D statistics for the segregation of blacks from whites over an index of SES in Table 3 are substantially lower than those in Table 1. At the block group level the D statistic for economic segregation is only 43 compared with 76 for racial segregation. At least at the tract and block group level of geography economic segregation, as with racial segregation, is greater in the 1990 NHIS sample than in the Census, and in the NHANES 3 sample it is lower. Also similarly, the statistical weights correct some of the difference with the NHIS and move the D statistics for the sample toward the Census. Only 22 percent of blacks live in block groups with SES scores above the median according to the Census, but blacks in this category make up only 17 percent of the NHIS sample, 24 percent less. At the same time the portion of blacks in the NHIS sample living in block groups in the lowest decile of the distribution of SES is 22 percent greater than in the Census.

Table 3. Economic segregation of blacks and whites in the NHANES 3, the NHIS 1990 and the US Census 1990: D statistics of Non-Hispanic blacks and whites distributed over deciles of an index of SES					
	Unweighted		Weighted		1990 Census
	NHANES 3	NHIS 1990	NHANES 3	NHIS 1990	
State	13	14	16	15	14
County	21	20	22	18	16
Tract	39	52	39	46	43
Block group	40	51	41	45	43

The segregation of the poor, regardless of race, from the not-poor, as measured by D statistics in Table 4, is only slightly less than the economic segregation of the races. This form of economic segregation in the NHIS and NHANES samples has the same relationship to segregation in the Census as racial segregation by race and by SES. That is, the NHIS sample is more segregated than the Census and the statistical weights only partly reduce the difference, and the NHANES 3 sample is less segregated than the Census. At the block group level the D statistic for economic segregation of the poor from the not-poor is 39 in the Census. For the NHIS the unweighted statistic is 42, but with weighting is reduced to 40. In the NHANES both the unweighted and the weighted D statistics are 36.

Table 4. Economic segregation of poor and not-poor in the NHANES 3, the NHIS 1990 and the US Census 1990: D statistics of poor and not-poor distributed over deciles of an index of SES					
	Unweighted		Weighted		1990 Census
	NHANES 3	NHIS 1990	NHANES 3	NHIS 1990	
State	11	16	12	16	11
County	15	21	16	21	18
Tract	35	41	36	38	35
Block group	36	42	36	40	39

The increase in racial and economic segregation in the NHIS over the Census is small, but it has an interesting consequence – a larger proportion of the poor in the NHIS live in areas with more blacks than in the Census. After dividing the poor into two groups, one living in block groups where blacks are under-represented and one in block groups where blacks are over-represented, an estimated 45.2 percent of the poor live in blocks where blacks are over-represented according to the NHIS compared with 41.9 percent according to the Census.

Turning now to the distribution of the index of SES among African-Americans and white Americans, Table 5 presents selected quantiles of the index for these groups. The statistics in this table for the NHIS and the NHANES were estimated with weighted data. The distributions of both whites and blacks over the SES of their block groups of residence in both surveys is very similar to the distributions in the Census. The largest difference is between the NHANES and the Census for blacks; the distribution of blacks by this measure of SES is shifted slightly at both ends towards advantage, the negative end of the SES index. Comparing blacks to whites reveals the large difference in the socioeconomic status of these groups. The median SES index score for blacks (0.77 in the Census) is near the 90th percentile for whites (0.79 in the Census). The median for whites (-.29, Census) is between the 10th and 20th percentiles for blacks; it is, more precisely, approximately equal to the 15th percentile (.30).

Table 5. Percentiles of the population distributions of Non-Hispanic white and African-Americans by an index of socioeconomic status of their block group of residence: NHIS 1990, NHANES 3, and 1990 US Census						
SES Quantile	NHANES 3		NHIS 1990		1990 US Census	
	White	Black	White	Black	White	Black
10th	-1.47	-.61	-1.41	-.57	-1.39	-.55
20th	-1.31	-.17	-1.03	-.10	-1.04	-.11
25th	-.99	0.00	-.89	0.10	-.89	.07
Median	-.27	0.75	-.32	0.83	-.29	.77
75th	.30	1.43	.25	1.53	.28	1.49
80th	.44	1.59	.38	1.70	.42	1.66
90th	.82	2.02	.75	2.12	.79	2.13

Discussion

This research began with the purpose of assessing the degree to which race and contextual measures of socioeconomic status were confounded . Brewster[28] concluded that race and measures of poverty were confounded in the 1982 National Survey of Family Growth. This research has found that race and SES are also confounded in the 1990 National Health Interview Survey and the Third National Health and Nutrition Examination Survey. In each of these surveys median values of measures of SES for white and African-Americans each lie outside the margins of the 20th and 80th percentiles of the other group's distribution recommended by Brewser.[28] This is not, however, a problem with the surveys; the surveys accurately represent the SES distributions of white and African-Americans as measured in the Census.

Some analytical strategies have been proposed that in some circumstances compensate for selectivity problems. Berk[41] suggested the use of probit models to compensate for selection bias against cases in one tail of a distribution. This, however, is not the problem with these contextual

variables; the distributions of the socioeconomic variables in the samples resemble those in the population very closely. Lieberson[42] suggested the use of ridit models. Ridits compare relative positions within groups by transforming, in this case, index scores of SES into locations on a cumulative percentile scale. As he suggests, this might be meaningful in certain carefully constructed theoretical contexts. However, outside of these contexts it is apparent that in any model simultaneously containing race and contextual measures of SES these variables will have substantial variance in common. A conservative strategy might be to consider race on the one hand and SES and context on the other as alternative explanations and compare models containing one or the other, but not both. A more adventurous strategy might be to define an instrumental variable for race that has the effect of SES removed. Such a variable might be constructed from a logistic regression of race on indicators of SES; the result of the regression would be an equation predicting a probability of membership in a racial category and the instrumental variable would be actual minus predicted probability of category membership.

Either one of these strategies, however, requires adopting a theoretical position, and it is in theory that the only real solution to this problem lies.[29, 43] Several authors have recently argued for a more theoretical approach than has been common in studies of the relationships among, race, social class, and health.[10-12, 43] The first step, they argue, is to approach race as a predictor or confounder of SES. In this perspective racial differences reflect not only differences in SES but also ill-effects of individuals' stressful experiences of discrimination and of disadvantage that results from systematic processes of exclusion and racist ideology that supports them. The proposals, above, either to model race and SES as alternatives or to consider a residual race variable after removing SES effects, are modest steps consonant with these approaches.

There are potential explanations alternative to SES -- characteristics of ethnic groups such as migration and cultural factors, for instance.[15, 44] The new OMB standards for collecting data on race and ethnicity recognize that membership in racial and ethnic groups is a matter of self-identification, and that some individuals might consider themselves to be members of more than one group.[45] There is, of course, a literature on ethnic groups and acculturation too enormous to review here. The significant point for this discussion is that we have few concepts and measures of ethnic groups' identities and participation that we can include in federal surveys. It would be interesting to go beyond the new OMB standard to define and measure what it means to people to be members of race or ethnic groups, how people participate in these groups, and to describe the groups in sufficient detail to identify characteristics of them, characteristics that could be measured independently of membership, that might produce the observed differences in health.

Finally it must be realized that whatever methodological strategies are adopted or theoretical refinements made, the empirical basis of the confounding of contextual measures of SES and race in the NHIS and the NHANES is the segregation of American society. At this level these surveys are case studies with a sample size of one. The surveys are designed to produce statistics which can be generalized to describe the US non-institutionalized civilian population. Multi-national comparative designs are a different research strategy for finding an explanation for racial differences in health, one requiring quite different data.[46] In comparative research the confounding of race and SES in the United States might be overcome with studies including other societies where the social distribution of races or the social attitudes towards races were different.

The results of this study show that the NHIS 1990 and the NHANES 3 samples reflect quite closely the racial and economic segregation in the US, especially after they are weighted.   The NHIS sample is, however, slightly more segregated by race and SES than the Census results, and the NHANES 3 is slightly less so. For the NHIS much of this difference is probably due to the method for over-sampling blacks because weighting uniformly reduces the differences between the sample and the Census. For the NHANES 3 there is no clear explanation; weighting makes little difference. Because the NHANES 3 is a much smaller sample than the NHIS there is a much larger role for sampling variability with this survey. It is interesting to note, however, that one of the goals of that survey was to measure racial and ethnic diversity and in the end the sample is slightly less segregated than the country. These results highlight the difficulty of using cross-sectional national samples to explain differences in health outcomes between white and African-Americans, but given their purposes, and each of these surveys has many purposes, this is only to say that their contribution to this problem may be more to describe rather than to explain race differences.

References

1.   Jaynes GD, Williams RM. A Common Destiny: Blacks and American society. Washington, DC: National Academy Press; 1989.
2.   Harrison RJ, Bennett CE. Racial and ethnic diversity. In: Farley R, ed. *State of the Union: America in the 1990s*. New York: Russell Sage Foundation; 1995.
3.   Elo IT, Preston SH. Estimating African-American mortality from inaccurate data. *Demography*. 1994;31(3):427-58.
4.   NCHS. National Center for Health Statistics. Health, United States, 1998 with Socioeconomic Status and Health Chartbook. Hyattsville, MD: Public Health Service; 1998.
5.   Williams DR, Collins C. US Socioeconomic and racial differences in health: patterns and explanations. *Annu Rev Soc*. 1995;21:349-86.
6.   Kaufman JS, Cooper RS, McGee DL. Socioeconomic status and health in Blacks and Whites: the problem of residual confounding and the resiliency of race. *Epidemiology*. 1997;8(6):621-8.
7.   Link B, Phelan J. Social conditions as fundamental causes of disease. *J Health and Social Behavior*. 1995(extra):80-94.
8.   Muntaner C, Nieto FJ, O'Campo P. Race, social class, and epidemiologic research. *Public Health Policy*. 1997;18(3):261-74.
9.   Cooper R, David R. The biological concept of race and its application to public health and epidemiology. *J Health Politics, Policy and Law*. 1986;11(1):97-116.
10.   Herman AA. Toward a conceptualization of race in epidemiologic research. *Ethnicity and Disease*. 1996;6(Winter/Spring):7-20.
11.   Williams DR. Racism and health: a research agenda. *Ethnicity and Disease*. 1996;6(Winter/Spring):1-6.
12.   LaVeist TA. Why we should continue to study race, but do a better job: an essay on race, racism and health. *Ethnicity and Disease*. 1996;6(Winter/spring):21-9.
13.   Krieger N. Embodying inequality: a review of concepts, measures, and methods for studying health consequences of discrimination. *Internatl J Health Serv*. 1999;299(2):295-352.
14.   Herrnstein RJ, Murray C. *The Bell Curve: intelligence and class structure in American life*. New York: The Free Press; 1994.
15.   Bradby H. Ethnicity: not a black and white issue, a research note. *Sociology of Health and Illness*. 1995;17(3):405-17.
16.   Frasier S. The Bell Curve Wars: race, intelligence, and the future of America. New York: Basic Books; 1995.
17.   Muntaner C, Nieto FJ, O'Campo P. The Bell Curve: on race, social class, and epidemiologic research. *Am J Epidemiology*. 1996;114(6):531-6.
18.   Williams DR, Lavizzo-Mourney R, Warren RC. The concept of race and health status in America. *Public Health Reports*. 1994;109(1):26-41.

19. Susser M, Watson W, Hopper K. *Sociology in Medicine, 3rd ed.* New York: Oxford University Press; 1985.
20. Wilkinson RG. *Unhealthy Societies: the afflictions of inequality*. London: Routledge; 1996.
21. Amick BC, Levine S, Tarlov AR, Walsh DC. Society and Health. New York: Oxford University Press; 1995.
22. Robert SA. Community-level socioeconomic status effects on adult health. *J Health and Social Behavior*. 1998;39:18-37.
23. LeClere FB, Rogers RG, Peters KD. Ethnicity and mortality in the United States: individual and community correlates. *Social Forces*. 1997;76(1):169-98.
24. O'Campo P, Gielen AC, Faden R. Violence by male partners against women during the childbearing year: a contextual analysis. *Am J Pub Health*. 1995;85:1092-7.
25. Duncan C, Jones K, Moon G. Context, composition and heterogeneity: using multilevel models in health research. *Soc Sci Med*. 1998;46(1):97-117.
26. Witte JS, Greenland S, Kim L-L. Software for hierarchical modeling of epidemiologic data. *Epidemiology*. 1998;9(5):563-5.
27. Singer JD. Using SAS PROC MIXED to fit multilevel models, hierarchical models, and individual growth models. *J Educational and Behavioral Stat*. 1998;24(4):323-55.
28. Brewster KL. Race differences in sexual activity among adolescent women: the role of neighborhood characteristics. *Am Soc Rev*. 1994;59:408-24.
29. Lieberson S. *Making It Count: the improvement of social research and theory*. Berkeley: University of California Press; 1985.
30. Kaufman JS, Cooper RS. Seekiing causal explanations in social epidemiology. *Am J Epidemiology*. 1999;150(2):113-120.
31. LeClere FB, Rogers RG, Peters KD. Neighborhood social context and racial differences in women's heart disease mortality. *J Health and Social Behavior*. 1998;39:91-107.
32. Massey DS, Shibuya K. Unraveling the tangle of pathology: the effect of spatially concentrated joblessness on the well-being of African Americans. *Soc Sci Research*. 1995;24:352-66.
33. Polednak AP. Segregation, discrimination and mortality in US Blacks. *Ethnicity and Disease*. 1996;6:99-108.
34. Massey JT, Moore TF, Tadros W, Parsons VL. Design and estimation for the National Health Interview Survey, 1985-94. Vital and Health Statistics Series 2 No. 110. Hyattsville, MD: National Center for Health Statistics; 1989: DHHS Publication No. (PHS) 89-1384.
35. Adams PF, Benson V. Current estimates from the National Health Interview Survey, 1990. Vital and Health Statistics Series 10 No. 181. Hyattsville, MD: National Center for Health Statistics; 1991: DHHS Publication No. (PHS) 92-1509.
36. Ezzati TM, Massey JT, Waksberg J, Chu A, Maurer KR. Sample design: Third National Health and Nutrition Examination Survey. Vital and Health Statistics Series 2 No. 113. Hyattsville, MD: National Center for Health Statistics; 1992: DHHS Publication No. (PHS) 92-1387.
37. Mohadjer L, Montaquila J, Waksberg J, et al. Weighting and estimation methodology: National Health and Nutrition Examination Survey 3, executive summary. NHANES III Reference Manual and Reports. CD-ROM . Hyattsville, MD: National Center for Health Statistics, Centers for Disease Control; 1996.
38. Census. Census of Population and Housing, 1990. Summary Tape File 3 on CD-ROM Technical Documentation. Washington: Bureau of the Census, US Department of Commerce; 1992.
39. Massey DS, Denton NA. The dimensions of residential segregation. *Social Forces*. 1988;67(2):281-315.
40. Massey DS, White MJ, Phua V-C. The dimensions of segregation revisited. *Sociological Methods and Research*. 1996;25(2):172-206.
41. Berk RA. An introduction to sample selection bias in sociological data. *Am Soc Rev*. 1983;48:386-98.
42. Lieberson S. A reconsideration of the income differences found between migrants and northern-born blacks. *Am J Sociology*. 1978;83(4):940-66.
43. Muntaner C. Invited commentary: social mechanisms, race, and social epidemiology. *Am J Epidemiology*. 1999;150(2):1-6.
44. Smaje C. The ethnic patterning of health: new directions for theory and research. *Soc of Health and Illness*. 1996;18(2):139-71.
45. OMB. Revisions to the standards for the classification of federal data on race and ethnicity. Washington: Office of Management and Budget; 1997: http://www.access.gpo.gov/su_docs/aces/aces140.html.
46. Kunst A. Cross-national comparisons of socio-economic differences in mortality. *Departmant of Public Health*. Rotterdam: Erasmus University; 1997.