Measuring Socioeconomic Status/Position in Studies of Racial/Ethnic Disparities: Maternal and Infant Health

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SYNOPSIS

Objective. Theoretical and empiric considerations raise concerns about how socioeconomic status/position (abbreviated here as SES) is often measured in health research. The authors aimed to guide the use of two common socioeconomic indicators, education and income, in studies of racial/ethnic disparities in low birthweight, delayed prenatal care, unintended pregnancy, and breastfeeding intention.

Methods. Data from a statewide postpartum survey in California (*N* = 10,055) were linked to birth certificates. Overall and by race/ethnicity, the authors examined: (*a*) correlations among several measures of education and income; (*b*) associations between each SES measure and health indicator; and (*c*) racial/ethnic disparities in the health indicators "adjusting" for different SES measures.

Results. Education-income correlations were moderate and varied by race/ethnicity. Racial/ethnic associations with the health indicators varied by SES measure, how SES was specified, and by health indicator.

Conclusions. Conclusions about the role of race/ethnicity could vary with how SES is measured. Education is not an acceptable proxy for income in studies of ethnically diverse populations of childbearing women. SES measures generally should be outcome- and population-specific, and chosen on explicit conceptual grounds; researchers should test multiple theoretically appropriate measures and consider how conclusions might vary with how SES is measured. Researchers should recognize the difficulty of measuring SES and interpret findings accordingly.

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Reducing disparities in health status and health care between racial/ethnic groups has recently become a major focus of interest in the United States. In the past few years, the US Department of Health and Human Services has launched major initiatives in this area,[1] including the Healthy People 2010 goal of eliminating "health disparities among different segments of the population"[2] and activities at the National Institutes of Health supporting research to better understand racial/ethnic disparities in health.[3] Although the explicit focus on understanding and reducing racial/ethnic disparities is relatively new, results from epidemiologic and clinical studies have for a long time been reported separately by racial/ethnic group.[4,5] Unfortunately, however, adequate information to describe social factors, most notably socioeconomic status/position (abbreviated here as SES), has generally been unavailable or extremely limited in such studies.[4–7] By SES, we mean both absolute and relative levels of wealth and the power and prestige closely associated with wealth, which may be reflected in measures of income, accumulated economic assets, occupational status, and educational attainment, among other measures. The extent to which socioeconomic factors contribute to observed health disparities between racial/ethnic groups is difficult to assess without adequate measurement of SES. Health disparities between racial/ethnic groups, observed without adequate controls for SES, often have been interpreted—explicitly or implicitly—as reflecting inherent biological and/or "cultural" differences.[7,8]

It is encouraging that current initiatives to reduce racial/ethnic disparities rest on the assumption that such disparities are not immutable. However, we are concerned that the prevailing state of the art with respect to SES measurement in health-related research is fraught with serious problems that could substantially limit understanding of the nature of racial/ethnic disparities and consequent application of findings in effective policies to reduce the gaps.

Conceptual and methodological considerations lead to a number of concerns about SES measurement in studies of racial/ethnic disparities in health. Although the terms "socioeconomic status," "socioeconomic position," and "social class" are found throughout the health literature, they are rarely defined. Various factors have been used to reflect these concepts, including income, educational attainment, accumulated economic assets, occupation, marital status, and insurance coverage, and these factors have been measured in diverse ways. In the United States, educational attainment or income (when data are available) is used most often, frequently alone and without consideration of whether the measure(s) selected adequately capture(s) the socioeconomic factors most likely to influence the outcome of interest in light of the most plausible causal pathways. Justification is rarely provided for the socioeconomic measure selected, how and when it is measured, or its interpretation.

Theoretical considerations suggest that conclusions regarding racial/ethnic disparities might vary depending on the particular socioeconomic factor used to reflect SES and on when and how that factor is measured. In theory, inadequate control for SES could result from not fully capturing the construct, from measurement error, and/or from the way in which the SES variables are coded. A considerable body of empirical literature also indicates that the associations between SES and health outcomes can vary with both the socioeconomic measure and the health indicator being examined.[9-14] Parker et al. used data from the nationally representative 1988 National Maternal and Infant Health Survey to look at SES measures in relation to three maternal and child health outcomes: low birthweight, small-for-gestational-age, and preterm birth.[14] They found that among both "black" and "white" postpartum women, family poverty status, maternal education, paternal education, maternal occupation, and paternal occupation were generally not highly correlated. Although each SES measure was associated with low birthweight for both groups of women, significant associations with SES measures were not consistently found for small-for-gestational-age and preterm birth. Gazmararian et al. used 1990–1991 population-based data on "white" postpartum women from four states participating in the Centers for Disease Control and Prevention (CDC) Pregnancy Risk Assessment and Monitoring System to examine three health-related behavioral outcomes (smoking during pregnancy, delayed or no prenatal care, and unintended pregnancy) in relation to five SES measures (maternal education, family poverty status, Medicaid enrollment, WIC participation, and residential crowding).[13] Like Parker et al., they observed modest correlations among the SES measures and found that the magnitude of the associations between the SES measures and the outcomes varied across both SES and outcome measures. These observations are consistent with a multidimensional construct of SES that is widely accepted among social scientists and social epidemiologists.[9,15–21] Despite prevailing social science theory and substantial epidemiologic evidence that SES is multidimensional, however, the health literature is replete with studies, including studies of racial/ethnic disparities, that claim to have examined SES when they have used only a single or inadequate measure(s).

Lack of clarity about how to measure and interpret SES not only makes it difficult to study socioeconomic disparities in health in ways that are useful to inform policies to reduce those gaps; it also makes it difficult to interpret results of studies that attempt to adjust for socioeconomic influences on health while examining the influence of other factors, such as race or ethnic group.[22] The present study focuses on the SES measures used most frequently in the US literature—education and income—and considers them in relation to four important health indicators—low birthweight, delayed prenatal care, unintended pregnancy, and breastfeeding intention—to provide guidance for the measurement and interpretation of SES in studies of racial/ethnic disparities. A specific objective was to use data from a large and ethnically diverse, statewide-representative population-based survey to examine empirically whether the SES factor selected (education or income) and the manner of specifying it (e.g., maternal education vs paternal education; household income vs the ratio of household income to the federal poverty level vs household income divided by family size; continuous vs grouped variable) could affect conclusions regarding racial/ethnic disparities in these health indicators.

We chose four maternal and child health indicators of importance across the life cycle, as indicated by inclusion of relevant objectives for each in Healthy People 2010.[2] Ample literature documents the adverse consequences of low birthweight,[23] unintended pregnancy,[24] and failure to breastfeed.[25,26] With regard to delayed prenatal care, while the ideal content and number of prenatal care visits are controversial, few would question the importance of at least one prenatal care visit during the first three months of pregnancy for timely risk assessment and intervention.

METHODS

We matched birth certificate data with data from the Access to Maternity Care (ATM) study, a large statewide survey of the California maternity population.[27–30] ATM data were collected through structured face-to-face interviews conducted in English or Spanish with 10,165 postpartum women during their delivery stays at 19 California hospitals from August 1994 through July 1995. The survey included detailed questions on socioeconomic and demographic characteristics, prenatal care utilization, and other factors related to pregnancy and childbirth. Participating hospitals were randomly selected from eight strata defined according to their delivery population characteristics, based on 1991 statewide birth certificate data. Women at the sampled hospitals were eligible to be interviewed if they had live births during the hospital stay, spoke English or Spanish, were at least 15 years old (and legally emancipated if younger than 18), and were not incarcerated during pregnancy; they were ineligible if nursing staff believed being interviewed would interfere with their care. Eighty-six percent of eligible women who were approached participated in the study. The overall weighted sample appeared representative of the statewide delivery population.[27] The final sample of 10,055 excluded 33 women who had received all of their prenatal care outside of California, 69 women with unreported race/ethnicity, and eight women who reported a racial or ethnic group other than African American, Asian/Pacific Islander, European/Middle Eastern, Latina, or American Indian/Alaskan Native. The survey methodology has been reported elsewhere,[27–30] and a detailed technical appendix is available on request.

Health indicators

For the present study, we used four indicators of maternal and infant health: low birthweight (< 2,500 grams), delayed prenatal care (no care or care initiated after the first trimester), unintended pregnancy (not trying to get pregnant just before the pregnancy among women who gave birth), and lack of breastfeeding intention (not intending to breastfeed when interviewed immediately postpartum, a good marker of breastfeeding initiation).[31,32] Information on birthweight was obtained from birth certificates; the data on the other health indicators were based on respondents' self-reports.

Race/ethnicity

Race/ethnicity was conceptualized as reflecting the large geographic region of a woman's family origin, which could influence her experiences and/or her responses to them. Race/ethnicity was self-reported and categorized into five mutually exclusive groups: African American, Asian/Pacific Islander, European/Middle Eastern, Latina, and American Indian/Alaskan Native.[27,29]

Socioeconomic measures

We examined several measures each of income and education, which we conceptualized as two related but different *dimensions* of SES; other dimensions such as occupational status and ownership of wealth were not measured in the ATM survey. Information on occupation is included in birth certificate data but was not included in the survey. We elected not to use the occupational information after discovering that about half of the sample had maternal occupation listed only as "homemaker" and about one-fourth of records

lacked information on paternal occupation. Different *specifications* of education and income refer to different detailed ways of specifying their measurement, e.g., describing maternal, paternal, or household education or using continuous versus categorical measurement. All income information came from the survey; we specified it in five different ways. Information on education came from both the survey and birth certificates; we specified it in six different ways. The specifications of income and education are displayed in Figure 1. The results from the multivariate models for income divided by family size and paternal education are not reported but are available on request.

Other variables

We also studied maternal age (in years) and parity (first birth, 2–4 births, 5 or more births), both from survey data; age and parity could potentially confound observed associations between the socioeconomic measures and the maternal and infant health indicators.

Analytic approach

We used SAS software[33] to examine correlations among multiple measures of education and income at the individual or household level. We used SUDAAN software[34] to estimate the distribution of each health indicator by each socioeconomic measure and to construct regression models. Overall and for each racial/ethnic group, we constructed unadjusted logistic regression models for associations between each socioeconomic measure and each health indicator. Finally, we developed multivariate models using different measures of education and income primarily to explore the associations of race/ethnicity with the four health indicators while "controlling" for the potential confounding effects of age, parity, and the socioeconomic factors. We examined odds ratios and 95% confidence intervals generated by these models.

For the categorical variables, the reference group was always the most privileged social group. To account for the different sampling probabilities of women

Figure 1. Specifications of income and education used in present study, Access to Maternity Care (ATM) survey data and birth certificate data

Income specifications	
Poverty level	Before-tax annual income in dollars from all sources, as reported by the ATM respondent, divided by family size, in categories defined by percentage of the federal poverty level
Income	Midpoint of the range chosen by the ATM respondent as best reflecting her family's before-tax annual income in dollars
Income quartiles	Income (defined above), grouped as quartiles
Income divided by family size	Income (defined above), divided by family size
Income divided by family size quartiles	Income (defined above), divided by family size, grouped as quartiles
Education specifications	
Maternal education	
Continuous	Number of completed years, as recorded on birth certificate
Categorical	Highest completed level of education, as reported by the ATM respondent, grouped into categories based on credentials
Paternal education	
Continuous	Number of completed years, as recorded on birth certificate
Categorical	Number of completed years, as recorded on birth certificate, grouped into categories based on credentials
Household education	
Continuous	From birth certificate: highest number of completed years of either parent or of one parent if the other parent's information not listed
Categorical	Highest parental education level or highest level of one parent if the other parent's information not listed; from ATM self-reports for mothers or estimated from birth certificates for fathers; grouped into categories based on credentials

in the study, all estimates were calculated using sample weights. The weighting factors were based on sampling probabilities and on the insurance coverage and ethnic distributions observed in 1994 statewide birth certificate data. The analyses of low birthweight included singleton births only (99% of all births). Chi-square tests were used to judge the fit of the nested multivariate models.[35]

RESULTS

Sociodemographic characteristics of the sample

Table 1 displays the sociodemographic characteristics of the sample, overall and by racial/ethnic group. As noted, the data in Table 1 were weighted to represent the 1994 maternity population in California. Three-fourths of the women were ages 20 to 34 years. The African American and Latina women appeared to be younger than the other racial/ethnic groups. About one-third of the women had just delivered their first births, although the proportion appeared to vary somewhat by racial/ethnic group. Just under half of the women were foreign born; large majorities of both Asian/Pacific Islanders and Latinas were born outside the US. Almost one-third of the women had not completed high school, and nearly two-thirds had incomes below 200% of the poverty level. The distributions of educational level and poverty level appeared to vary

Table 1. Selected characteristics[a] of the study sample (N = 10,055 respondents to the Access to Maternity Care survey)

	All	*African American*	*American Indian/Alaskan Native*	*Asian/Pacific Islander*	*European/ Middle Eastern*	*Latina*
	N = *10,055*	n = *1,096*	n = *55*	n = *753*	n = *2,543*	n = *5,608*
Characteristic	*Weighted percent*	*Weighted percent*	*Weighted percent*	*Weighted percent*	*Weighted percent*	*Weighted percent*
Age						
≤ 17 years	2.4	2.2	2.2	2.3	0.9	3.5
18-19 years	8.2	14.6	9.3	3.6	4.9	10.6
20-34 years	76.8	72.4	75.4	76.4	76.6	77.7
≥ 35 years	12.6	10.8	13.1	17.7	17.6	8.2
Parity						
1st live birth	35.8	30.5	31.7	37.9	43.7	30.5
2nd–4th live birth	58.8	65.1	60.7	58.5	54.0	61.4
≥ 5th birth	5.4	4.4	7.6	3.6	2.3	8.1
Immigration status						
US-born	51.5	92.1	93.2	17.3	87.8	26.1
Foreign-born	48.5	7.9	6.8	82.7	12.2	73.9
Level of maternal education						
Some high school or less	30.1	16.3	33.1	5.6	11.0	51.1
Completed high school or GED	31.3	34.6	31.0	27.7	31.5	31.4
Some college	23.8	36.9	27.6	29.6	32.5	14.3
Completed college or more	14.8	12.3	8.3	37.1	25.0	3.2
Poverty level[b]						
0–100%	45.0	57.2	60.9	30.8	21.9	63.0
101%–200%	18.1	15.5	18.6	14.4	15.7	20.9
201%–300%	11.9	10.3	10.8	13.6	20.6	5.6
301%–400%	8.5	6.2	5.4	13.5	14.3	3.7
≥ 401%	13.2	8.2	4.4	25.8	25.5	2.4
Missing data	3.2	2.7	0.0	1.8	2.1	4.4

[a]Weighted

[b]See Figure 1 for definition

substantially by racial/ethnic group: Asian/Pacific Islanders and European/Middle Easterners appeared to have higher education and income levels than each of the other three groups. Latinas had the lowest education and income levels: more than 80% had no schooling beyond high school, and almost 85% had incomes below 200% of the poverty level.

Income also appeared to vary across racial/ethnic groups within a given level of maternal education (data not shown). Asian/Pacific Islanders and European/Middle Easterners had higher average income levels at each level of education than each of the other groups. For example, among women who had not completed high school, European/Middle Eastern women had incomes more than three times those of African Americans and two times those of Latinas (data not shown).

Correlations among different measures of education and income

Table 2 shows that the two SES dimensions examined, income and education, were moderately correlated in the full sample regardless of the SES measure employed; for example, the correlation between poverty level and maternal education reported in the ATM survey was 0.58. These correlations appeared to vary by racial/ethnic group, with the lowest correlations seen among Latinas, for whom the correlation between poverty level and maternal education was only 0.34. Correlations between the different income measures were generally strong and were consistent across racial/ethnic groups. Similarly, maternal education as self-reported on the survey and as recorded on the birth certificate were strongly correlated, as were maternal or paternal education and household education. Maternal and paternal education were only moderately correlated with each other in the sample overall and within each racial/ethnic group.

Unadjusted associations between the health indicators and measures of education and income (not shown)

In the overall sample, at least one measure of each of the SES dimensions (education and income) was significantly associated with each health indicator; in general, lower levels of education and income were positively associated with low birthweight, delayed prenatal care, unintended pregnancy, and lack of intention to breastfeed. The direction of the associations did not appear to vary substantially by racial/ethnic group. In general, however, the magnitude and/or the statistical significance of the associations did appear to vary by the SES dimension, by specification of the SES variables, by health indicator, and by racial/ethnic group. For example, education was significantly associated with lack of breastfeeding intention among Latinas, but income was not. Each of the categorical measures of education was significantly associated with delayed prenatal care among African Americans, but the corresponding continuous measures were not. The odds ratios associated with education were higher for delayed prenatal care and lack of breastfeeding intention than for low birthweight and unintended pregnancy, and income was significantly associated with low birthweight among African Americans, but not among any other racial/ethnic group.

In summary, the patterns revealed that the unadjusted socioeconomic associations were dependent not only on the SES measure (considering both dimension and specification) but also on the health indicator and racial/ethnic group of interest (not shown; available on request).

Multivariate results

Tables 3 through 6 describe the associations between race/ethnicity and each health indicator adjusted for age, parity, and different measures of education and income. To simplify the presentation of the findings, confidence intervals, the odds ratios for age and parity, and the results for income divided by family size and paternal education are not shown; the results for income divided by family size and paternal education supported the conclusions reached based on the results displayed.

Low birthweight. When we examined associations between race/ethnicity and low birthweight, we found that only the odds ratios for Latinas varied according to the education or income measure included in the model (Table 3). Irrespective of which measure of education or income was included, we found that African American women were about three times and Asian women about two times as likely to deliver a low birthweight baby as European/Middle Eastern women, after adjustment for age, parity, and the education or income measure(s) selected. However, adjustment for poverty level produced nonsignificant differences in low birthweight for Latinas compared with European/Middle Eastern women. Almost no significant associations between low birthweight and income or education were found in the models.

Delayed prenatal care. Significant associations between racial/ethnic groups and delayed prenatal care (Table 4) depended on the SES dimension and/or the specified measure used for adjusting, except for African Americans. For African American women, the observed likeli-

Table 2. Correlations between measures of income and education

	Measure						
Measure	*1*	*2*	*3*	*4*	*5*	*6*	*7*
All (*N* = 10,055)							
1. Poverty level[a]	1.00						
2. Income[b]	0.95	1.00					
3. Income divided by family size[b]	0.97	0.95	1.00				
4. Maternal education[a,c]	0.58	0.55	0.59	1.00			
5. Maternal education[a,d]	0.58	0.56	0.60	0.86	1.00		
6. Paternal education[a]	0.54	0.54	0.57	0.61	0.68	1.00	
7. Household education[a]	0.59	0.56	0.60	0.88	0.81	0.83	1.00
African American (*n* = 1,096)							
1. Poverty level[a]	1.00						
2. Income[b]	0.95	1.00					
3. Income divided by family size[b]	0.97	0.92	1.00				
4. Maternal education[a,c]	0.55	0.37	0.42	1.00			
5. Maternal education[a,d]	0.51	0.36	0.39	0.85	1.00		
6. Paternal education[a]	0.46	0.45	0.42	0.53	0.57	1.00	
7. Household education[a]	0.56	0.41	0.43	0.90	0.75	0.72	1.00
American Indian/Alaskan Native (*n* = 55)							
1. Poverty level[a]	1.00						
2. Income[b]	0.94	1.00					
3. Income divided by family size[b]	0.96	0.88	1.00				
4. Maternal education[a,c]	0.54	0.34	0.45	1.00			
5. Maternal education[a,d]	0.53	0.44	0.50	0.96	1.00		
6. Paternal education[a]	0.59	0.69	0.65	0.68	0.69	1.00	
7. Household education[a]	0.68	0.64	0.66	0.87	0.85	0.86	1.00
Asian/Pacific Islander (*n* = 753)							
1. Poverty level[a]	1.00						
2. Income[b]	0.95	1.00					
3. Income divided by family size[b]	0.97	0.94	1.00				
4. Maternal education[a,c]	0.51	0.36	0.37	1.00			
5. Maternal education[a,d]	0.59	0.41	0.43	0.82	1.00		
6. Paternal education[a]	0.51	0.38	0.39	0.54	0.63	1.00	
7. Household education[a]	0.55	0.38	0.38	0.87	0.79	0.77	1.00
European/Middle Eastern (*n* = 2,543)							
1. Poverty level[a]	1.00						
2. Income[b]	0.94	1.00					
3. Income divided by family size[b]	0.97	0.94	1.00				
4. Maternal education[a,c]	0.53	0.47	0.48	1.00			
5. Maternal education[a,d]	0.51	0.46	0.48	0.86	1.00		
6. Paternal education[a]	0.46	0.44	0.43	0.52	0.58	1.00	
7. Household education[a]	0.55	0.49	0.50	0.84	0.76	0.80	1.00
Latina (*n* = 5,608)							
1. Poverty level[a]	1.00						
2. Income[b]	0.87	1.00					
3. Income divided by family size[b]	0.89	0.93	1.00				
4. Maternal education[a,c]	0.34	0.27	0.37	1.00			
5. Maternal education[a,d]	0.36	0.29	0.39	0.76	1.00		
6. Paternal education[a]	0.31	0.28	0.36	0.43	0.55	1.00	
7. Household education[a]	0.34	0.28	0.37	0.82	0.71	0.76	1.00

[a]Categorical

[b]Continuous

[c]From ATM Survey data

[d]From birth certificates

Table 3. Adjusted associations between race/ethnicity and low birthweight

	Logistic regression model								
Variable	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*
Race/ethnicity[a]									
African American	3.08[b]	2.85[b]	2.94[b]	3.09[b]	3.05[b]	3.13[b]	3.07[b]	2.98[b]	2.87[b]
Asian/Pacific Islander	2.05[c]	1.97[c]	2.46[c]	2.06[c]	2.02[c]	2.13[c]	2.04[c]	2.12[b]	2.01[c]
Latina	1.86[d]	1.67	2.07[c]	1.71[d]	2.01[c]	1.97[c]	1.92[c]	2.02[c]	1.80[d]
European/Middle Eastern	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Poverty level									
Missing data		0.60							0.60
≤ 100%		1.19							1.19
101%–200%		1.35							1.30
201%–300%		0.79							0.74
301%–400%		0.73							0.71
≥ 401%		1.00							1.00
Income (log transformed, per $1,000)			0.97						
Income									
Missing data				1.02					
First quartile				1.52[d]					
Second quartile				0.94					
Third quartile				1.12					
Fourth quartile				1.00					
Maternal education in years					1.03				
Maternal education in categories									
Less than high school						0.98			0.88
High school graduate or GED						1.31			1.20
Some college						1.11			1.09
College graduate or more						1.00			1.00
Household education in years							1.01		
Household education in categories									
Less than high school								0.85	
High school graduate or GED								1.29	
Some college								1.36	
College graduate or more								1.00	

NOTE: All models were adjusted for age (in continuous years) and parity (first birth as reference category, 2–4 births, ≥ 5 births). Confidence intervals and results for income divided by family size and paternal education are not shown for space reasons but are available on request from the authors.

[a]American Indian/Alaskan Natives not included due to small sample size (n = 55)

[b]$p \leq 0.001$

[c]$p \leq 0.01$

[d]$p \leq 0.05$

hood of delayed prenatal care was not statistically different in any model from that of European/Middle Eastern women. Latinas were at significantly greater risk of delayed prenatal care than European/Middle Eastern women after adjustment for income as a continuous variable, but not for income measured in categories. In contrast, the risk of delayed prenatal care was similar for Latinas and European/Middle Eastern women after adjustment for maternal or household education measured in categories, but Latinas were more likely than women in the reference group to have delayed prenatal care after adjustment for maternal or household education measured as continuous variables. SES appeared to be strongly associated with delayed prenatal care, regardless of the income and education measure tested. The magnitude of these associations was greater for income than for education, and both poverty level and maternal education were significantly associated with

Table 4. Adjusted associations between race/ethnicity and delayed prenatal care

	Logistic regression model								
Variable	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*
Race/ethnicity[a]									
African American	1.18	0.73	0.99	0.72	1.23	1.15	1.21	1.09	0.77
Asian/Pacific Islander	2.04	1.88[d]	1.37	1.83[d]	2.66[c]	2.47[c]	2.72[c]	2.41[c]	2.14[d]
Latina	1.71[c]	1.00	1.81[b]	1.10	1.48[c]	1.16	1.49[c]	1.14	0.85
European/Middle Eastern	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Poverty level									
Missing data		7.73[b]							5.77[c]
≤ 100%		11.69[b]							8.24[b]
101%–200%		4.69[b]							3.59[c]
201%–300%		3.04[c]							2.67[d]
301%–400%		1.95							1.76
≥ 401%		1.00							1.00
Income (log transformed, per $1,000)			0.81[b]						
Income									
Missing data				8.35[b]					
First quartile				6.55[b]					
Second quartile				4.14[b]					
Third quartile				2.15[b]					
Fourth quartile				1.00					
Maternal education in years					0.88[b]				
Maternal education in categories									
Less than high school						6.23[b]			3.06[c]
High school graduate or GED						3.63[b]			2.03[c]
Some college						2.12			1.58
College graduate or more						1.00			1.00
Household education in years							0.87[b]		
Household education in categories									
Less than high school								5.46[b]	
High school graduate or GED								3.23[b]	
Some college								1.86[b]	
College graduate or more								1.00	

NOTE: All models were adjusted for age (in continuous years) and parity (first birth as reference category, 2–4 births, ≥ 5 births). Confidence intervals and results for income divided by family size and paternal education are not shown for space reasons but are available on request from the authors.

[a]American Indian/Alaskan Natives not included due to small sample size (n = 55)

[b]$p \leq 0.001$

[c]$p \leq 0.01$

[d]$p \leq 0.05$

delayed prenatal care, although the odds ratios were attenuated, even when both were included in the model.

Unintended pregnancy. Without adjustment for any SES measure, African Americans were at greater risk of unintended pregnancy than European/Middle Eastern women (Table 5, Model A). That higher risk was no longer observed after adjustment for any specification of income, whereas adjustment for maternal education did not appear to make a difference. Few socioeconomic associations were found with unintended pregnancy in the multivariate models.

Lack of intention to breastfeed. Table 6 shows that, in all models, Latinas were more likely than European/Middle Eastern women to intend to breastfeed. No other racial/ethnic differences were found, regardless of which measure of education or income was used for

Table 5. Adjusted associations between race/ethnicity and unintended pregnancy

	Logistic regression model								
Variable	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*
Race/ethnicity[a]									
African American	1.80[d]	1.47	1.42	1.51	1.66[d]	1.80[d]	1.64[c]	1.76[d]	1.48
Asian/Pacific Islander	1.06	0.98	1.19	0.97	1.06	1.10	1.06	1.12	0.99
Latina	1.20	0.93	1.10	0.99	1.15	1.06	1.09	1.06	0.90
European/Middle Eastern	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Poverty level									
Missing data		1.43							1.42
≤ 100%		2.04							2.01
101%–200%		1.18							1.17
201%–300%		1.13							1.13
301%–400%		0.68							0.69
≥ 401%		1.00							1.00
Income (log transformed, per $1,000)			0.82						
Income									
Missing data				2.43[b]					
First quartile				2.28[d]					
Second quartile				1.76[c]					
Third quartile				1.40					
Fourth quartile				1.00					
Maternal education in years					0.98				
Maternal education in categories									
Less than high school						1.66			1.21
High school graduate or GED						1.26			1.01
Some college						1.23			1.14
College graduate or more						1.00			1.00
Household education in years							0.95		
Household education in categories									
Less than high school								1.79	
High school graduate or GED								1.45	
Some college								1.38[d]	
College graduate or more								1.00	

NOTE: All models were adjusted for age (in continuous years) and parity (first birth as reference category, 2–4 births, ≥ 5 births). Confidence intervals and results for income divided by family size and paternal education are not shown for space reasons but are available on request from the authors.

[a]American Indian/Alaskan Natives not included due to small sample size (n = 55)

[b]$p \leq 0.001$

[c]$p \leq 0.01$

[d]$p \leq 0.05$

adjustment. There were significant associations between each measure of educational attainment (except for the continuous measure of maternal education) and lack of breastfeeding intention. However, the results with adjustment for income were less consistent. Only those with missing income or incomes below the federal poverty level were more likely to lack intention to breastfeed. Maternal education remained strongly associated with breastfeeding intention in the model that also included poverty level, but poverty level became non-significant after education was included.

For each health indicator, we found that the models with both poverty level and maternal education (Models I) fit the data significantly better ($p < 0.0005$) than the models with poverty level alone (Models B) based on chi square tests of the likelihood ratios (chi

Table 6. Adjusted associations between race/ethnicity and no intention to breastfeed

	Logistic regression model								
Variable	*A*	*B*	*C*	*D*	*E*	*F*	*G*	*H*	*I*
Race/ethnicity[a]									
African American	1.35	1.31	1.34	1.20	1.30	1.31	1.29	1.25	1.37
Asian/Pacific Islander	0.84	0.86	0.82	0.83	0.84	0.92	0.85	0.93	0.96
Latina	0.50[b]	0.48[b]	0.52[b]	0.50[b]	0.49[b]	0.40[b]	0.48[b]	0.39[b]	0.42[b]
European/Middle Eastern	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Poverty level									
Missing data		1.98[c]							1.45
≤ 100%		2.08[c]							1.40
101%–200%		1.58							1.14
201%–300%		2.71							2.19
301%–400%		2.16							1.88
≥ 401%		1.00							1.00
Income (log transformed, per $1,000)			0.96						
Income									
Missing data				1.66[d]					
First quartile				1.05					
Second quartile				0.98					
Third quartile				1.42					
Fourth quartile				1.00					
Maternal education in years					0.96				
Maternal education in categories									
Less than high school						3.67[b]			3.61[b]
High school graduate or GED						2.75[b]			2.63[b]
Some college						2.50[b]			2.30[b]
College graduate or more						1.00			1.00
Household education in years							0.94[d]		
Household education in categories									
Less than high school								3.29[b]	
High school graduate or GED								2.88[b]	
Some college								2.25[c]	
College graduate or more								1.00	

NOTE: All models were adjusted for age (in continuous years) and parity (first birth as reference category, 2–4 births, ≥ 5 births). Confidence intervals and results for income divided by family size and paternal education are not shown for space reasons but are available on request from the authors.

[a]American Indian/Alaskan Natives not included due to small sample size (n = 55)

square with 3 degrees of freedom = 22.5 for low birthweight, 135.2 for delayed prenatal care, 35.3 for unintended pregnancy, and 145.9 for lack of breastfeeding intention).

CONCLUSIONS

The findings of this study, which used data on a large and ethnically diverse population-based sample of postpartum women, demonstrate empirically that conclusions regarding the role of socioeconomic factors in racial/ethnic health disparities could vary depending on the socioeconomic measure selected. Specifically, a researcher might conclude that there were—or were not—significant independent racial/ethnic disparities—at least in the outcomes studied—among childbearing women after "controlling" for socioeconomic factors, depending on whether education or income was used to represent socioeconomic status, how income or education was specified, i.e., continuously or categorically, and how categories were defined. The specific socioeconomic measure selected could potentially influence both the magnitude and the statistical significance of observed racial/ethnic health dispari-

ties. The observations presented here also show that conclusions about the role of socioeconomic factors could vary not only across health indicators but also across the racial/ethnic groups being considered.

These results are not unique to the dataset used in this study: we found similar results using unpublished data from a smaller (N = 3,483), but more recent (1999), statewide-representative mail and telephone survey of the maternal population in California (Maternal and Infant Health Assessment). The findings of both investigations are consistent with those of Gazmararian et al.'s study of 10,055 "white" women in four other states[13] and Parker et al.'s study of 6,494 "black" and "white" women using national data.[14] While the ethnic diversity of our sample was greater than that in each of the studies just described, and while we believe that our measurement of income was probably more precise than that in relevant prior studies of maternal and child health outcomes, the concepts involved are not new. This article's chief contribution is to express and illustrate the key concepts in a concrete way; our findings are intended to be convincing to the general community of health researchers and hence to influence routine research practice, which has lagged behind the technical literature in the social sciences and social epidemiology.

In the present study, correlations between measures of income and measures of education were not strong. Furthermore, the correlations between education and income measures were weaker for African Americans, Asian/Pacific Islanders, and especially for Latinas, compared to those observed for European/Middle Easterners and American Indians/Alaskan Natives. These findings in themselves provide evidence that measures of education cannot be treated, as they unfortunately often are in the health literature, as proxies for income among childbearing women overall; they also show that doing so would likely result in greater SES misclassification of women of color (except American Indians/Alaskan Natives) than of European/Middle Eastern women. This empiric evidence supports established social science theory in which education and income are regarded as related and overlapping but conceptually distinct dimensions of the broad notion of "SES," which is inherently multidimensional.[15,16,20,21] The practical consequences of these findings are that, regardless of the health indicator being examined, researchers studying diverse populations or racial/ethnic disparities in maternal and infant health cannot claim to have controlled for income when they measure education only, and vice versa. Furthermore, on theoretical grounds, they cannot claim to have controlled for "SES," a broader, multidimensional concept that cannot be represented by any single socioeconomic factor such as education or income alone.

Because researchers are often faced with decisions about how to specify a measure of income or education, we examined how the choice of specification can influence conclusions regarding racial/ethnic disparities and/or the role of socioeconomic factors in those disparities. We found that, overall and within all racial/ethnic groups, correlations among the different measures of income were strong, whether income was measured, for example, continuously without regard to family size, continuously and adjusted by family size, or categorically in 100% increments of the official poverty line. Maternal education in years from birth certificates was strongly correlated with maternal education in levels obtained from face-to-face interview responses elicited by trained interviewers; this should be reassuring to researchers who must rely on education as reported in birth certificate data. Moderate correlations between maternal and paternal education suggest that paternal education should be considered when investigating associations with health indicators among childbearing women, in addition to or in combination with maternal education. Not surprisingly given the manner in which it was computed, household education was strongly correlated with both maternal and paternal education.

By themselves, these observations might suggest that, regardless of the health indicator, findings of studies of racial/ethnic (or other) disparities in the population of childbearing women may not be appreciably affected by whether maternal or household education is chosen. However, both unadjusted and multivariate results suggest that, in general, both the choice of socioeconomic dimension (income or education) and the detailed specification of an income and/or education measure can affect conclusions regarding racial/ethnic disparities in the selected health indicators. For example, the choice of dimension produced different conclusions about the disparities between African American women and European/Middle Eastern women in unintended pregnancy: the greater risk of an unintended pregnancy for African American women was no longer observed after adjustment for any specification of income; however, no specification of education accounted for the differences between the two groups. Changes in the specification of income produced different conclusions about the statistical significance of certain racial/ethnic disparities in low birthweight and delayed prenatal care. Similarly, changes in the specification of education produced different conclusions about the statistical significance of the disparities between Latinas and European/

Middle Eastern women in the independent likelihood of experiencing delayed prenatal care. Although including measures of both income and education did not, in most cases, appreciably alter the odds ratios for race/ethnicity that were observed with either SES measure alone in the model, the superior fit of the models including both measures further indicates the importance of including both for more adequate specification of SES.

Not only did the measurement of SES in our examples affect conclusions about racial/ethnic effects; in addition, except for delayed prenatal care, our examples demonstrate that both the dimension and specification of education and income could potentially alter conclusions about the presence of significant socioeconomic effects after adjustment for age, parity, and race/ethnicity. For consistency, we chose to use the most privileged social group as our reference category for all analyses, which introduces imprecision when there are small sample sizes. We caution readers to consider collapsing categories in their own analyses of similar data.

Thus, on both theoretical and empirical grounds, and based on our findings and other relevant research,[13,14] we conclude that researchers studying racial/ethnic (or socioeconomic) disparities in low birthweight, delayed prenatal care, unintended pregnancy, and breastfeeding intention should consider both income and education (along with other SES dimensions that could be appropriate on theoretical grounds) as well as different ways of specifying these dimensions, unless a priori considerations or prior knowledge justify using only a certain dimension and/or specification (e.g., using income measured in categories because previous research found nonlinear effects on a particular health indicator). Consistent with Gazmararian's[13] and Parker's[14] findings, the present study indicates that, apart from the conclusion that education is not an acceptable proxy for income, one cannot make a "one-size-fits-all" prescription about which SES measure(s) to use in studies of racial/ethnic (or socioeconomic) disparities in health.

At the same time, we believe that there is a sound basis for making generalizable recommendations about a systematic process that should routinely be followed in decisions about SES measurement (see Figure 2). In general, researchers should explore and acknowledge explicitly how their conclusions might be altered by using different measures, considering both SES dimensions and specifications. To guide this process, researchers need to have a conceptual understanding of what different SES dimensions may reflect and what different specifications may mean. (For example, when education is measured in years, the described relationship is by definition linear, whereas education measured in categories based on earned credentials implies a nonlinear relationship.) If a data source does not permit selection of SES dimension(s) and/or specification(s) that are appropriate conceptually, researchers should explicitly acknowledge this limitation and the uncertainty it necessarily introduces regarding their conclusions. Researchers also should be aware and acknowledge that conclusions may vary not only according to the SES measure(s) selected but also according to the racial/ethnic group or health outcome being considered.

Figure 2. Recommendations for measuring socioeconomic status/position (SES) in studies of racial/ethnic disparities and diverse populations

Recommendations for studies of maternal and infant health:

- Education is not an acceptable proxy for income for ethnically diverse populations of childbearing women.
- Consider both education and income (and other conceptually appropriate dimensions of SES), if possible, along with a range of ways of measuring them, as recommended below.

General recommendations likely to have broad applicability in studies of health across the life course (including studies of both racial/ethnic and socioeconomic disparities):

- Choose SES measures based on considerations of the potential causal pathways through which socioeconomic factors may affect a specific outcome in a given population.
- Test multiple dimensions of SES that could be relevant (e.g., income, wealth, education, occupation) and multiple ways of specifying them (e.g., income as a continuous variable, income quartiles, income as a percentage of the poverty level).
- Recognize the difficulty of measuring SES adequately and interpret the findings accordingly. Unmeasured socioeconomic differences can bias racial/ethnic (or other) effects.
- Acknowledge the limitations of the socioeconomic measures used (e.g., potentially relevant dimensions, specifications, stages in the life course), and levels of analysis (individual/household or area-level) not covered.

We explored only two socioeconomic dimensions in this study, education and income, although these measures are the ones most commonly used in the US health literature. We also measured these dimensions only at the individual or household level and at a single point in the life cycle (i.e., around the time of pregnancy and childbirth). We did not have information to consider other potentially important aspects of education and income, such as private vs public education or different sources of income, nor were we able to examine whether the measures we used had comparable meaning across racial/ethnic groups. For the sake of simplicity, we used quartiles of income rather than relying on more sophisticated methods to determine income categories. We did not examine occupational status, accumulated economic assets, or measures of socioeconomic context (e.g., residential economic segregation or the concentration of poverty in a community). Thus, given the limited measurement of SES in this study, we believe that racial/ethnic disparities observed in findings from our multivariate models reflect some degree of residual confounding by SES. That is to say, adjusting for our measures of income and education alone did not make each racial/ethnic group socioeconomically comparable[22]; thus the racial/ethnic disparities reported here—and in other studies with limited measurement of SES—should not be over-interpreted.

The lack of statistically significant associations between socioeconomic measures and the health indicators observed in our multivariate results should also not be over-interpreted. The race/ethnicity categories undoubtedly reflected unmeasured SES differences not captured by the limited SES measures we examined. In addition, the timing and number of births (reflected in the age and parity variables in our models) are probably on the pathway between socioeconomic factors and the health indicators we examined, operating as mediating variables rather than true confounders. Thus, including race/ethnicity, age, and parity in the models probably resulted in conservative estimates of socioeconomic effects in the findings described here. Furthermore, for simplicity, we did not include in our models other factors such as immigration status that could confound observed associations between race/ethnicity and the outcomes and/or alter the degree to which a given SES measure captured differences in a given outcome. For all of these reasons, the results presented here should be viewed as illustrative examples of general principles about SES measurement, rather than as definitive findings on the magnitude of racial/ethnic or socioeconomic disparities in the selected outcomes.

We believe that the observations and recommendations reported here have general implications for studies using other socioeconomic measures and examining other health outcomes. In the light of theoretical considerations[15,16,20,21] and other empirical evidence,[9-14] these findings and recommendations generally place the burden of proof on an investigator to demonstrate that, with the health indicator and population being studied, conclusions are *not* sensitive to the choice of socioeconomic measures. Although demonstrated empirically here for a limited number of maternal and infant health indicators, we believe that this burden of proof applies more broadly across health outcomes and socioeconomic measures, over the life course. It applies to investigators claiming to have observed significant racial/ethnic disparities independent of SES and/or to have observed that SES either is or is not an important influence on a given outcome. The findings of the present study strongly support the theoretically based prescription that researchers cannot claim to have "controlled for" SES based on use of a single socioeconomic measure. Indeed, even with multiple socioeconomic measures, one must always consider residual confounding due to imperfect or incomplete measurement of socioeconomic factors. Without specific evidence that a given conclusion is stable across diverse socioeconomic measures and population subgroups, investigators should explicitly acknowledge that their conclusions could change with the use of different measures and/or groups.

Taking these implications seriously could have major effects on the health literature in general and on the literature on racial/ethnic disparities in particular. These observations have no bearing on the validity of simply describing racial/ethnic disparities without making causal inferences. However, causal inferences are all too frequently made implicitly, based on observing crude racial/ethnic disparities or based on analyses of data adjusted using poorly measured socioeconomic factors. The relevance of the findings of the present study is in the interpretation of the underlying phenomena reflected—or not reflected—by observed racial/ethnic disparities, and specifically about the role of socioeconomic factors. Concluding that a racial/ethnic disparity is "independent" of socioeconomic factors would require the ability to measure exhaustively and completely all of the socioeconomic factors likely to be relevant to plausible causal pathways. Lacking such exhaustive information, researchers must be extremely cautious about interpreting racial/ethnic differences and particularly about the role of socioeconomic factors in these differences.

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