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Comparison of individual-level versus area-level socioeconomic measures in assessing health outcomes of children in Olmsted County, Minnesota

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Abstract

Background—Socioeconomic status (SES) is an important determinant of health, but SES measures are frequently unavailable in commonly used datasets. Area-level SES measures are used as proxy measures of individual SES when the individual measures are lacking. Little is known about the agreement between individual-level versus area-level SES measures in mixed urban–rural settings.

Methods—We identified SES agreement by comparing information from telephone self-reported SES levels and SES calculated from area-level SES measures. We assessed the impact of this agreement on reported associations between SES and rates of childhood obesity, low birth weight <2500 g and smoking within the household in a mixed urban–rural setting.

Results—750 households were surveyed with a response rate of 62%: 51% male, 89% Caucasian; mean child age 9.5 years. Individual-level self-reported income was more strongly associated with all three childhood health outcomes compared to area-level SES. We found significant disagreement rates of 22–31%. The weighted Cohen's κ indices ranged from 0.15 to 0.22, suggesting poor agreement between individual-level and area-level measures.

Conclusion—In a mixed urban–rural setting comprised of both rural and urbanised areas, area-level SES proxy measures significantly disagree with individual SES measures, and have different

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patterns of association with health outcomes from individual-level SES measures. Area-level SES may be an unsuitable proxy for SES when individual rather than community characteristics are of primary concern.

INTRODUCTION

Socioeconomic status (SES) is an important determinant of health in adults and children, and this association has been widely documented in both developed and developing countries.^{1–7} Currently, the influences of SES on health through interactions with biological mechanisms have drawn scientific attention.^{8–10}

Despite the importance of SES in relation to human health, SES is difficult to obtain and is frequently absent in the commonly used datasets such as medical records, disease registries and administrative datasets.¹¹ For example, a recent study analysing cost and hospitalisations among children with asthma based their conclusions on socioeconomic data derived from area-level zip codes SES, despite significant confounding because individual socioeconomic data were unavailable.¹² In a population-based case–control study in Olmsted County, Minnesota, we found that SES measures were unavailable for 70% of study subjects.¹³ Absence of socioeconomic data has been a major barrier in advancing our understanding about the role of SES in health.

To overcome the absence of individual-level SES measures, area-level SES measures based on the census data at the census block group, or census tract levels have been widely used as proxies for the former.^{14,15} However, despite this common approach, there have been concerns that area-level SES measures may not be a suitable proxy for individual-level SES because of potential disagreement and contextual effects of neighbourhood environments on health outcomes independent of individual SES. While some studies assessed either agreement between individual-level and area-level SES measures^{15–19} or the relationship between health outcomes and individual-level versus area-level SES,^{20–25} few studies examined both agreement between individual-level and area-level SES measures and their relationship with health outcomes.²⁶ In addition, no previous studies have specifically focused on childhood health outcomes and assessed agreement between individual-level and area-level SES measures using multiple SES measures. Moreover, it is unknown as to whether individual-level versus area-level SES measures are correlated in mixed urban–rural settings with relative ethnic and socioeconomic homogeneity in the USA. In metropolitan areas (urban setting), residents with lower SES tend to live in homogeneous inner city enclaves with lower neighbourhood SES and, thus census-based neighbourhood SES measure could be a proxy measure for individual SES.²⁷ In contrast, the mixed urban–rural settings such as Olmsted County may not have such distinct enclaves but have a greater heterogeneity of individual SES measures within neighbourhoods leading to a greater misclassification of one's socioeconomic position.²⁸ To address the limitations of previous studies, we conducted a cross-sectional study using a population-based sampling frame to determine the degree of agreement between individual-level and area-level SES measures in Olmsted County. Also, we compared the association of individual-level versus area-level SES measures with health outcomes among children.

METHODS

This study was reviewed and approved by the Mayo Clinic Institutional Review Board. The details of the study methods have been reported previously.²⁹

Study setting and population

The study subjects were a random sample of caregivers of children ages 1–17 years in Olmsted County. Details have been described previously.²⁹ Olmsted County is located 90 miles southeast of Minneapolis. According to the 2000 census, the population of Olmsted County, was 124 277; 90.3% white compared to 89.4% in Minnesota and 75.1% in the USA. With the exception of a higher proportion of the working population employed in the healthcare industry, characteristics of Olmsted County populations were similar to those of the US white population. Olmsted County is relatively less segregated geographically and demographically compared to larger metropolitan areas. The dissimilarity index measuring the degree of uniformity of demographic factors of the community calculated by race for white versus other minority groups in the Rochester metropolitan statistical area (MSA) was 36.8 in 2000, ranking 265 of 331 metropolitan areas; lower ranking suggests more racial/socioeconomic homogeneity.³⁰

Study design

The study employed a cross-sectional design with telephone interviews. We determined agreement between individual-level versus area-level SES derived from census block-group level and associations of individual-level and area-level SES with health outcomes.

Data collection

Individual-level SES and parent-reported health outcomes for their children were collected by administering telephone interviews to caregivers. We adopted the 2002 National Health Interview Survey questionnaire for the telephone Interview.³¹ The individual-level SES was measured by parents' highest education level and annual family income. Health outcomes for children to be assessed were low birth weight (<2500 g of birth weight), overweight (95% of body mass index for age and gender of children) and tobacco smoking status of household members. Area-level SES measures were collected from the 2000 census data. We collected the percentage of people with a bachelor degree or higher education and median family income at a census block-group level.

Data analysis

We categorised individual education levels into four categories (high-school graduate or below; some college without degree; associate/college degree; graduate or professional degree) and individual income in five categories (<\$49 999; \$50 000–\$74 999; \$75 000–\$99 999; \$100 000–\$149 999; >\$150 000). Area-level SES measures were categorised into four quartile groups according to the percentage of people with bachelor degree or higher educational level in the block group and to the percentage of people with a median family income equal to \$62 255 or higher in census block group. We considered first and second strata (below median) as low SES groups and third and fourth strata (above median) as high SES on area-level data. We cross-tabulated individual-level and area-level SES measures to descriptively show the misclassification of individual-level SES measures (tables 1 and 2). In order to determine concordance between individual-level and area-level SES measures, we calculated weighted Cohen's κ indexes using the categories of individual-level and area-level SES measures as described above (table 3). To compare the associations of individual-level versus area-level SES measures with health outcomes captured by binary variables, low birth weight, overweight and household smoking exposure data were fitted to logistic regression models to calculate ORs and 95% CIs. All tests of statistical significance used a two-sided α error of 0.05. All analysis was conducted using Stata V.11.2 Stata Corp, Texas, USA.

RESULTS

Characteristics of subjects

The survey response rate was 62% (750/1209) in Olmsted County. After eliminating respondents with missing data, the final study cohort consisted of 746 respondents. More than 75% of the adult respondents were women, and 89% of the subjects were white (median age, 41 years). The sociodemographic characteristics of the study subjects' children were previously reported.²⁹ Overall, except for gender, the sociodemographic characteristics of the study subjects were similar to Olmsted County population as a whole.

Descriptive summary of agreement of individual-level SES measure

The number and percentages of cases in agreement and disagreement between individual-level and aggregate-level measures are seen in tables 1 and 2. Of 196 caregivers who had not completed a bachelor degree, 50 (26%) were classified as a high SES group-based area-level data. Of 550 caregivers who had completed a college degree or above, 103 (19%) were classified as being a low SES group based on area-level data. Similarly, of the 148 caregivers in the highest-income group (>\$150 000), 46 (31%) were classified as a low SES group based on area-level data. Of the 108 caregivers in the lowest income group (<\$49 999), 29 (27%) were classified as a high SES group at a census block-group level.

Concordance between individual-level versus area-level SES measures

The weighted Cohen's κ coefficients indicating the concordance between individual-level and area-level education and income measures are shown in table 3. All κ index values ranged from 0.14 to 0.20, which were below 0.40, suggesting poor agreement.³²

Comparisons of associations of individual-level versus area-level SES measures with health outcomes

As indicated in table 4, while individual-level income was strongly associated with risk of low birth weight, area-level income measure was not. Also, area-level SES was not associated with a risk of being overweight, except in the highest SES group. Both individual-level and area-level incomes were associated with household smoking exposure, although area-level income showed weaker associations than individual-level measures. Similarly, both individual-level and area-level educational measures were associated with risk of household smoking exposure, although area-level educational measures had a weaker association with risk of household smoking exposure than individual-level measures. However, neither individual-level nor area-level educational measures were associated with the risk of being either overweight or having low birth weight (table 4).

DISCUSSION

Our study findings suggest a significant disagreement between individual-level and area-level SES measures. The poor agreement between individual-level and area-level SES measures was found equally in both lower and higher SES groups. Overall, area-level SES measures had different patterns of association with health outcomes from individual-level SES measures.

In our study setting there is a relatively heterogeneous distribution of people in terms of race, employment opportunities, etc within geographic boundaries. Thus, area-level measures of SES may not be suitable proxy measures for *individual* SES, which can be quite heterogeneous within these boundaries. The weighted Cohen's κ indices, indeed, suggest a poor agreement between area-level versus individual-level SES measures, ranging from 0.14 to 0.20 for education and 0.16 to 0.19 for income. As a result, significant proportions of

individuals were misclassified (10–35% in education and 27–31% in income) as shown in tables 1 and 2. One also may attribute poor agreement of individual SES in our study to the unit of measure at aggregate levels. The census block-group level used in our study is the smallest geographic unit for which income and other SES data are published. SES or other attributes in the community including census block-level SES data is not publicly available. Typically, a block group contains between 600 and 3000 people with an optimum size of 1500 people³³ as compared with census tracts, which typically have between 1500 and 8000 people, with an average size of about 4000 people.³⁴ The census tract is the next higher aggregate level, and is commonly used for a measure of neighbourhood environment.³⁵ Thus, given the census block group as the smallest unit of census SES data that is publicly available, census block group is likely to minimise within-group heterogeneity. In rural parts of Olmsted County, however, block groups can be over 80 square miles in area, introducing wide heterogeneity in what are conventionally considered ‘neighbourhoods’, resulting in a significant misclassification bias.

We postulate that poor agreement between area-level versus individual-level SES measures may result in different patterns of associations of individual-level and area-level SES measures with health outcomes. Indeed, while individual-level income was strongly associated with risk of low birth weight, area-level income measures were not. Compared to individual-level SES measures, area-level measures showed weaker associations with health outcomes. Geronimus *et al.*,²⁰ reported a weaker association between aggregate measures and health outcomes and suggested a careful application of aggregate measures as a proxy measure for individual SES.³⁶ Similarly, a study comparing the effects of SES at individual-tract and census-tract or block-group levels on high blood pressure, height, smoking and number of full-term pregnancies showed that area-based socioeconomic indicators greatly underestimated the impact of SES on the outcomes.¹⁴ Also, the geographic unit used for area-level SES measures may not be a mere census-defined boundary sharing similar SES characteristics, but rather the unit may be a socially defined neighbourhood affecting the health of individuals along with individual SES.^{37,38} Thus, even if area-level SES measures were associated with risks of being low birth weight, overweight or smoking exposure in household, the associations could be attributed to an influence of neighbourhood environment, which could be difficult to disentangle from that of individual-level SES measures. For instance, O’Campo *et al.* reported that the census tract-level variables modified the associations between the individual-level factors and the risk of low birth weight.^{38–40} Similarly, Black and Macinko⁴¹ demonstrated that both individual and neighbourhood factors were independently associated with reduced obesity. Thus, neighbourhood or area-level factors themselves can be an important contextual factor influencing health outcomes and should be considered in health studies independent of socioeconomic measures.

Previous studies have reported a substantial lack of agreement between individual-level and area-level information.^{15–18,20,25,26} Similarly, Marra *et al.*¹⁷ found poor agreement between individual-level and aggregate-level measures of income and education, and the weighted Cohen’s κ index ranged from 0.13 to 0.27. A recent study showed that individual-level and area-level SES measures have an average concordance rate 64–69%.^{17,15–19,25,26} Also, few studies assessed the agreement between individual-level and area-level SES measures in the context of health outcomes among children. Thus, our study is the first study based on a population-based sampling frame that examined the agreement between individual-level and area-level SES measures and their relationships with childhood health outcomes in a mixed urban–rural setting.

Our study results have implications for research and public health. If the purpose of a study was to assess the role of SES in etiological pathways at an individual level, that is,

generalising the findings to individuals, using area-level SES as a mere surrogate measure for individual SES may not be suitable without considering the study setting.

In mixed urban–rural settings, census areas or neighbourhoods can be relatively homogeneous in terms of the distribution of race, ethnicity, employment, etc across census areas or neighbourhoods, but have varying SES of individuals within neighbourhoods or small residential areas. In such instances, SES measured on the entire census area may considerably misrepresent the SES of individuals in a study. A clear example of such misrepresentation could occur within a large and relatively sparsely settled census area in which residents of differing SES are widely scattered.^{27,28} Area-level proxies have been used as control variables in studies analysing the influence of different risk factors on specific health outcomes. Recognising the importance of area-level SES measures, we make a few suggestions. First, area-level proxies need to be carefully utilised in health research depending on study settings. Second, given the potentially different, yet important, constructs for individual-level versus area-level SES, multilevel approaches taking into account both individual-level and area-level SES measures should be considered when formulating public health strategies or policy. Third, for those studies using area-level SES measures in health research (eg, secondary dataset), we suggest stratified analysis for the main results by study settings if dataset permits: (1) large MSA, (2) small MSA, (3) small urban non-MSA (urban–rural mixed area) and (4) the remaining rural areas to assess whether the results are consistent across different study settings.

Our study has a few limitations. Individual income, education and health outcomes were self-reported measures. Also, the survey respondents were primarily female caregivers, incurring the possibility of a non-differential misclassification bias with regard to the study results. Since our study was based on a telephone survey that interviewed ‘adult who is most knowledgeable about the health of the children in the home’, the majority of respondents were female caregivers who is unlikely to affect the relationship of individual SES with area-level SES and health outcomes. Another possible limitation is a discrepancy in the timing of measurement as area-level SES measure were derived from the 2000 US census, whereas an individual-level SES telephone survey was conducted in 2006. Although the response rate was only 62%, this is considered as an adequate rate for a telephone-administered survey of more than 5 min.⁴² In addition, the characteristics of non-respondent caregivers were likely to be randomly distributed.²⁹

Despite limitations, our study has some strengths. Our study was a cross-sectional study using a population-based sampling frame, representative of families with children in the community. Olmsted County is an excellent setting in which to conduct some epidemiological studies because medical care is virtually self-contained within the community under the auspices of the Rochester Epidemiology Project.⁴³ Lastly, we collected multiple measures of SES and health outcomes for analysis.

In conclusion, given the poor agreement between individual-level and area-level SES measures, different patterns of their associations with health outcomes and the potential influence of neighbourhood environment on health, area-level SES measurement may not be a suitable proxy measure of individual SES. Our results call for development of individual-level SES measures overcoming the absence of SES measures in commonly used datasets.

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What is already known on this subject

- Aggregate-level measures derived from census data have been frequently used as a proxy measure of individual SES when individual measures are lacking. Little is known about the agreement between aggregate-level and individual-level measures and potential difference in agreement between metropolitan and non-metropolitan areas.

What this study adds

- The agreement between individual-level versus area-level SES measures is poor in a mixed urban–rural area. Area-level SES measures can potentially result in different patterns of associations with health outcomes in children from their individual-level SES measures.

Table 1

Agreement between individual-level versus area-level education measures

Area-level Percentage of bachelor degree or higher education *	Individual-level education			
	High school graduate or below (n=50)	Some college, no degree (n=146)	Associate/college degree (n=293)	Graduate or professional degree (n=257)
1 Lowest SES	32 (64.0%)	56 (38.4%)	70 (23.9%)	33 (12.8%)
2 Low SES	13 (26.0%)	45 (30.8%)	73 (24.9%)	57 (22.2%)
3 High SES	2 (4.0%)	26 (17.8%)	82 (28.0%)	82 (31.9%)
4 Highest SES	3 (6.0%)	19 (13.0%)	68 (23.2%)	85 (33.1%)

* Percentage of bachelor degree or higher education in census block group.

SES, socioeconomic status.

Table 2

Agreement between individual-level versus area-level income measures

Area-level Percentage of median family income or higher*	Individual-level income				
	Income <\$49999 (n=108)	Income \$50000–\$74999 (n=146)	Income \$75000–\$99999 (n=162)	Income \$100000–\$149999 (n=170)	Income >\$150000 (n=148)
1 Lowest SES	49 (45.4%)	55 (37.7%)	41 (25.3%)	19 (11.2%)	21 (14.2%)
2 Low SES	30 (27.8%)	41 (28.0%)	43 (26.5%)	44 (25.9%)	25 (16.9%)
3 High SES	21 (19.4%)	35 (24.0%)	49 (30.3%)	64 (37.6%)	48 (32.4%)
4 Highest SES	8 (7.4%)	15 (10.3%)	29 (17.9%)	43 (25.3%)	54 (36.5%)

*. Percentage of median family income (\$62255) or higher in census block-group.
SES, Socioeconomic status.

Table 3Concordance between area-level and individual-level SES by weighted Cohen's κ coefficient

Area-level measures	<u>Individual-level education (four SES groups)</u>		<u>Individual-level income (five SES groups)</u>	
	κ (95% CI)	p Value	κ (95% CI)	p Value
Quartiles of percentage of median household income	0.16 (0.12 to 0.20)*	<0.001	0.19 (0.17 to 0.23) [‡]	<0.001
Quartiles of percentage of bachelor degree or higher	0.20 (0.16 to 0.25) [‡]	<0.001	0.14 (0.1 to 0.16) [§]	<0.001

* Weighted κ index between individual-level education (four categories) and area-level household income (four categories).

[‡] Weighted κ index between individual-level (four categories) and area-level education (four categories).

[‡] Weighted κ index between individual-level income (five categories) and area-level household income (four categories).

[§] Weighted κ index between individual-level (five categories) and area-level income (four categories).

SES, Socioeconomic status.

Logistic regression models for the association between individual-level and area-level measures of SES and the risk of being overweight, having low birth weight or smoking exposure status at home among children from Olmsted County, Minnesota

Table 4

Socioeconomic measures	Overweight			Low birth weight			Smoking exposure at home		
	OR	95% CI	p Value	OR	95% CI	p Value	OR	95% CI	p Value
Individual-level income									
<\$50000 (referent)									
\$50000-\$74999	0.68	0.33 to 1.38	0.281	0.29	0.11 to 0.79	0.016	0.44	0.24 to 0.82	0.009
\$75000-\$99999	0.40	0.19 to 0.87	0.021	0.45	0.19 to 1.07	0.070	0.28	0.15 to 0.53	<0.001
\$100000-\$149999	0.28	0.13 to 0.63	0.002	0.17	0.05 to 0.53	0.002	0.25	0.13 to 0.48	<0.001
\$150000 and above	0.37	0.17 to 0.81	0.013	0.40	0.16 to 1.0	0.049	0.15	0.07 to 0.34	<0.001
Individual-level education									
HS grad or below (referent)									
Some college, no degree	1.42	0.50 to 4.07	0.513	0.53	0.12 to 2.30	0.900	0.35	0.18 to 0.67	0.002
Associate/college degree	0.62	0.22 to 1.76	0.371	0.63	0.17 to 2.30	0.480	0.08	0.04 to 0.17	<0.001
Graduate/professional degree	0.85	0.30 to 2.38	0.754	1.40	0.4 to 4.89	0.600	0.03	0.01 to 0.07	<0.001
Quartiles of median household income in 1999*									
1 Lowest SES (referent)									
2 Low SES	0.69	0.36 to 1.33	0.270	1.21	0.51 to 2.87	0.670	0.71	0.41 to 1.24	0.235
3 High SES	0.79	0.43 to 1.45	0.450	1.00	0.42 to 2.38	0.993	0.48	0.27 to 0.85	0.012
4 Highest SES	0.28	0.12 to 0.67	0.005	0.96	0.37 to 2.49	0.931	0.48	0.25 to 0.92	0.027
Quartiles of percent of bachelor degree or higher*									
1 Lowest SES (referent)									
2 Low SES	0.66	0.34 to 1.27	0.214	0.84	0.34 to 2.07	0.701	0.65	0.37 to 1.11	0.117
3 High SES	0.63	0.33 to 1.21	0.164	0.90	0.37 to 2.18	0.822	0.39	0.21 to 0.72	0.006
4 Highest SES	0.60	0.31 to 1.19	0.144	1.21	0.52 to 2.82	0.661	0.43	0.23 to 0.80	0.008

* Area-level.

HS, High school; SES, Socioeconomic status.