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Development and Initial Testing of a New Socioeconomic Status Measure Based on Housing Data

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ABSTRACT *Socioeconomic status (SES) has been associated with many health outcomes. Commonly used datasets such as medical records often lack data on SES but do include address information. The authors sought to determine whether an SES measure derived from housing characteristics is associated with other SES measures and outcomes known to be associated with SES. The data come from a telephone survey of parents/guardians of children aged 1–17 years who resided in Olmsted County, Minnesota, and Jackson County, Missouri. Seven variables related to housing and six neighborhood characteristics obtained from local government assessor's offices in Olmsted County, Minnesota, were appended to survey responses. An SES index derived from housing characteristics (hereafter, HOUSES) was constructed using principal components factor analysis. For criterion validity, we assessed Pearson's correlation coefficients between HOUSES and other SES measures, including self-reported parents' educational levels, income, Hollingshead Index, and Nakao–Treas Index. For construct validity, we determined the association between HOUSES and outcomes, risks of low birth weight, overweight, and smoking exposure at home. We applied HOUSES to subjects in another community by formulating HOUSES from housing data of subjects in Jackson County, Missouri, using the same statistical algorithm as HOUSES for subjects in Olmsted County, Minnesota. We found that HOUSES had modest to good correlation with other SES measures. Overall, as hypothesized, HOUSES was inversely associated with outcome measures assessed among subjects from both counties. HOUSES may be a useful surrogate measure of individual SES in epidemiologic research, especially when SES measures for individuals are not available.*

KEYWORDS *Housing, Socioeconomic status, Neighborhood, Health, Epidemiology*

INTRODUCTION

Influences of socioeconomic status (SES) on health have been widely documented in studies in the USA and other countries.[1,2] Yet, despite the importance of SES in health and health disparities, measures of SES can be difficult to obtain and often are

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not included in health studies. Liberatos et al., for example, reported that only 40% of 76 studies concerned with chronic diseases in the *American Journal of Epidemiology* (1982–1985) incorporated some measure of social class.[3] Krieger et al. reported that the 2002 edition of *Health, United States*, an annual publication profiling the health of the nation, lacked socioeconomic data in 85.5% of its 71 tables on "health status and determinants."[4,5] One reason for insufficient use of SES in such studies is the frequent absence of variables commonly used to construct SES indices in medical records, administrative data sets, and other data sources.[3,4]

To overcome the unavailability of measures of SES in the common data sources, SES measures have been developed that are based on socioeconomic indicators derived from the census or other aggregate geographic units. These measures assign a common SES to all individuals or families living in that area. Despite the advantages of ease of measurement and low expense, limitations hamper the routine use of these measures in epidemiologic research, especially in research concerning the etiology of health problems. A study that compared the effects of SES at individual- and census tract- or block-group-level on high blood pressure, height, smoking, and number of full-term pregnancies showed that area-based socioeconomic indicators underestimated the impact of SES on the outcomes.[6] Also, the geographic unit used for area-based SES measures may not be a mere census-defined boundary sharing some similar SES characteristics; rather, the relevant unit for analysis may be a socially defined neighborhood affecting the health of individuals along with individual SES.[7,8] Area-based SES indicators may be appropriate for public health surveillance but may be unsuitable for clinical or social epidemiologic research focused on the health outcomes of individuals. An understanding of complex interactive effects between areas and individuals will require measures for individual SES.

Alternatives have been suggested but incompletely explored. Smith and others have suggested use of household asset-based indices of SES such as housing characteristics. Such indices might lead to more finely tuned appraisals of SES[9] and have been shown to have reasonable association with health outcomes[9–14] and adequate correlations with existing measures of SES.[15,16] Conceptually, housing is a critical site in the daily life of individuals. Housing attributes is a reflection of SES through its association with the distribution of wealth and income, control over life circumstances, and access to human, materialistic, and social resources. Thus, housing reflects physical context of daily living which can potentially contribute to disparate health outcomes in the model for disparate health outcome suggested by Warnecke.[17] Yet, no systematic study of the use of housing data to construct a measure of *individual* SES has been reported. To address these concerns, we developed a housing-asset-based measure of SES (hereafter, HOUSES) and compare it to existing SES measures and health outcomes known to be associated with SES.

METHODS

Study Population

The study population included parents of children aged 1–17 years living in Olmsted County, Minnesota, or Jackson County, Missouri. Olmsted County was chosen as the HOUSES development site given its proximity to the study principals and our familiarity with the Olmsted County population. Jackson County, Missouri, was chosen to assess the explanatory robustness (external validity) of HOUSES

developed from Olmsted County, Minnesota. Jackson County, Missouri, is a socioeconomically more diverse community than Olmsted County, Minnesota. Due to the necessity of linking survey data with property data via address, the survey sampling frame for the two sites utilized a list-appended random digit dial (RDD) sample purchased from Survey Sampling, Inc. (SSI; http://www.surveysampling.com/en) whereby postal addresses were appended to the RDD telephone numbers if they were found in listed directories. SSI provided selection probabilities for each listing, along with the household listing information (name, phone number, address, and expected age characteristics).

Data Collection

Telephone interviews were conducted by the Center for Social Science and Behavioral Research (CSBR), University of Northern Iowa, from August 2006 to October 2006. The institutional review boards at both the University of Northern Iowa and Mayo Clinic approved the consent and study procedures. A total of 750 and 781 parents or guardians completed the survey in Olmsted County and Jackson County, respectively. The overall response rate for the survey was 61% in Olmsted County and 55% in Jackson County.

Using the address information available in the sampling frame list, survey data, real property data, census data from the Rochester-Olmsted County Planning Department, and the Office of the Assessor, Jackson County, Missouri were matched. Seven different real property data and six different neighborhood characteristics that were available at both study sites were included. The real property data included in the study are: (1) homestead code: a proxy measure for owner occupancy in a housing unit (owner vs. non-owner); (2) lot size of housing unit: assessor's data for lot size of the parcel where the building is situated; (3) size of housing unit: actual square footage that includes all buildings, decks, patios, etc.; (4) residential status: whether a housing unit is in a residential zoning; (5) number of bathrooms; (6) number of bedrooms; and (7) estimated building value: assessor's estimated building value. The neighborhood characteristics were collected at a census-tract level, and these include: (1) percent of households with female householders; (2) percent of households that are non-family householders; (3) percent of households speaking English as a second language; (4) percent of population born in foreign countries; (5) percent of population with less than high school education; and (6) percent of families with family income below poverty level.

In Olmsted County, a total of 746 survey respondents (99.4%) were matched with real property and Census data using address information. In Jackson County, 704 of survey respondents (90.1%) were matched with real property and Census data.

Measures

Dependent Variables. We included three dependent variables that have been reported to be associated with SES.[2,18–26] These include risk of low birth weight (<2,500 g of birth weight), overweight (≥95% of BMI for age and gender) of children, and tobacco smoking status of household members (yes vs. no). We used the 2002 National Health Interview Survey (NHIS) questions to obtain these dependent variables ("What was child's birth weight?" "How much does child weight now?" "How tall is child now?" and "Does anyone in the household use cigarettes, cigars, or pipe tobacco?").[27]

Independent Variables. The main independent variables were socioeconomic measures which include single measures of SES (e.g., educational levels of parents or annual

family income), two widely used composite measures of SES (e.g., Hollingshead and Nakao–Treas indices), and HOUSES derived from real property data. Educational levels of parents/guardians were measured by using a response to the question "What is the highest grade or year of school that has been completed by a parent or primary caregiver in your household?" Annual family income was measured by using a response to stepwise questions regarding income category. The first question was "Would you say it was more than $25,000 a year or less than $25,000 a year?" Subsequent questions were repeated for increments of income in a stepwise manner. Both questions were adopted from a standard questionnaire for telephone surveys.

The Hollingshead Four-Factor Index uses education, occupation, sex, and marital status to determine a family's composite SES.[28] Each family's composite score was computed by multiplying the Occupation scale value by a weight of 5 and the Education scale value by 3 and summing the products.[28,29] Hollingshead Education scores range from 1 (less than seventh grade) to 7 (graduate professional training), and Hollingshead Occupation codes ranged from 1 (farm laborers/menial service workers) to 9 (higher executives and major professionals). Hollingshead Index raw scores range from 8 to 66, with higher scores reflecting higher SES. According to these indices, subjects were placed in one of four social classes (i.e., quartiles). In contrasts to the Hollingshead Index, the Nakao–Treas Index is derived from both educational attainment and income of job incumbents corresponding to the 1980 census.[30] Ratings range from 0 to 100 (lower ratings reflect more prestigious occupations) and are cross-referenced to 1980 census occupational codes. Therefore, we also used the Nakao–Treas Socioeconomic Index of Occupations as a standard for SES in addition to Hollingshead Index.

In formulating HOUSES—the focus of the present investigation—we conceptualized that a composite index that is derived from size, type, ownership status, and value of housing unit, combined with neighborhood (census tract level) socioeconomic characteristics, reflects one's SES (see Table 2). A housing unit was defined as a house, an apartment, a mobile home, a group of rooms or a single room occupied, or intended for occupancy, as separate living quarters in which the occupants live separately from any other people in the building and which has direct access from outside the building or through a common hall.[31] We designed this study to develop HOUSES based on housing data in Olmsted County, Minnesota, the primary study setting, and subsequently applied the developed HOUSES Index using the same statistical algorithm as HOUSES for subjects in Olmsted County, Minnesota, to subjects in Jackson County, Missouri, to assess the external validity of HOUSES.

Statistical Analysis

As a first step to formulate HOUSES, we applied principal components factor analysis using pairwise deletions and Varimax rotation. To construct the measurement model, we selected factors with Eigenvalues greater than 1.0. We used factor loadings ≥ 0.40 as lower bounds for meaningful loadings.[32] We formulated a standardized-HOUSES Index score by summing all variables of each factor after transforming variables to z-scores. Alternatively, we formulated a HOUSES Index score by summing weighted variables using factor loadings on each factor and compared the results with z-score-based results.

For criterion validity of HOUSES, we assessed the Pearson's correlation coefficients between HOUSES and other measures of SES. For construct validity, the data were fit to logistic regression models to determine the association of HOUSES with risks of low birth weight, overweight, and smoking exposure status at home. Composite SES measures were categorized into groups using quartile of the distribution. We calculated unadjusted odds ratio and p values.

RESULTS

The sociodemographic characteristics of the study subjects are summarized in Table 1. Overall, the Olmsted County, Minnesota, residents who participated in our study had higher levels of SES than those who lived in Jackson County, Missouri, and appeared to be socioeconomically and ethnically less diverse than those in Jackson County, Missouri.

The factor analysis results based on data from Olmsted County identified four distinctive factors with Eigenvalues greater than 1.0. Table 2 shows items with significant factor loadings on each factor. FACTOR 1 included number of bedrooms, number of bathrooms, square footage of the housing unit, and estimated building value of the housing unit. This factor accounted for the largest proportion of total variance compared with other factors and appeared to reflect an underlying construct, i.e., size or value of individual housing unit. FACTOR 2 and FACTOR 3 reflected different neighborhood characteristics, poverty versus foreign origin. Items with significant loadings in FACTOR 4 consisted of single-family residence and home ownership. We attempted to formulate HOUSES using various combinations of these four factors and all potential indices derived from different combinations of these four factors and different methods of formulating the index (z-score based vs. factor loading-

TABLE 1 Sociodemographic characteristics of the study subjects

Variables	Children	Olmsted, MN ($n=746$)	Jackson, MO ($n=704$)
Gender (%)	Male	50.67	49.29
Age (%)			
	Under 5 years	25.60	25.57
	5 to 9 years	22.12	24.29
	10 to 14 years	24.93	25.71
	15 to less than 18 years	27.35	24.43
Ethnicity (%)			
	Hispanic or Latino	2.28	5.56
	Not Hispanic or Latino	97.72	94.44
	White alone	88.74	75.89
	Black or African American alone	1.07	12.55
	American Indian or Alaska Native	0.13	0.29
	Asian alone	4.16	1.28
	Native Hawaiian or Pacific Islander	0.13	0.29
	Some other race alone	0.54	0.57
	Two or more races	2.95	3.57
Parents' education			
	Less than high school education	0.53	2.70
	High school graduate	6.17	14.77
	Some college, no degree	19.57	24.57
	Associate/college degree	39.28	32.67
	Graduate or professional degree	34.45	25.28
Family annual income			
	Less than $24,999	1.77	7.76
	$25,000 to $49,999	12.94	21.31
	$50,000 to $74,999	19.89	23.44
	$75,000 to $99,999	22.07	20.70
	Over $100,000	43.32	26.79

TABLE 2 Factor loadings of each variable after rotated factor using Varimax rotation among children from Olmsted County, Minnesota

	Factor 1	Factor 2	Factor 3	Factor 4
Square footage of housing unit	**0.87**	0.09	0.06	0.18
Building value	**0.85**	0.05	0.12	0.33
Number of bathrooms	**0.88**	-0.28	-0.09	-0.04
Number of bedrooms	**0.66**	-0.11	-0.03	-0.10
Ownership of housing unit	0.04	0.1	0.07	**0.89**
Residential area	0.12	0.18	0.12	**0.86**
Lot size of housing unit in acre	0.04	-0.02	-0.30	0.34
Percent of people speaking English as a second language[a]	0.04	0.19	**0.90**	0.04
Percent of foreign-born people[a]	0.04	0.27	**0.90**	0.10
Percent of households headed by female[a]	-0.10	**0.68**	0.24	0.05
Percent of households without family[a]	-0.07	**0.68**	0.30	0.12
Percent of people with less than high-school education[a]	-0.09	**0.85**	-0.01	0.05
Percent of people with income below 1999 poverty level[a]	0.01	**0.85**	0.20	0.09
Percentage of total variance accounted for on each factor	0.27	0.23	0.12	0.09

Bolded values indicate items with factor loadings ≥0.40
[a]Neighborhood characteristics at a census tract level

weighted approach). Results were not significantly different from the parsimonious model based on FACTOR 1 alone (data not shown). Thus, we formulated HOUSES based on FACTOR 1 and focused the rest of analysis on this index. The median of the z-score-based HOUSES was –4.95 (interquartile range, –8.44 to 1.59 and interdecile range, –11.86 to 9.85). The greater the HOUSES, the higher was the SES. We grouped subjects into four groups based on the quartile of HOUSES. The higher the group (i.e., quartile), the higher was SES.

To examine criterion validity, we assessed the correlation between HOUSES and other SES measures. The results are summarized in Table 3. Briefly, the results showed a moderate to good correlation between HOUSES and other measure of SES and that

TABLE 3 The results on the correlation between HOUSES and other measures of SES for children from Olmsted County, Minnesota, and Jackson County, Missouri

	Olmsted County, Minnesota (Pearson's correlation coefficients*)					Jackson County, Missouri (Pearson's correlation coefficients*)				
	Educ	Inc	HOUSES	HS	NT	Educ	Inc	HOUSES	HS	NT
Educ	1.0	-	-	-	-	1.0	-	-	-	-
Inc	0.42	1.0	-	-	-	0.41	1.0	-	-	-
HOUSES	0.30	0.54	1.0	-	-	0.44	0.59	1.0	-	-
HS	0.72	0.45	0.29	1.0	-	0.70	0.42	0.42	1.0	-
NT	0.56	0.41	0.30	0.76	1.0	0.57	0.46	0.39	0.77	1.0

Educ Educational levels of parents or guardians, *Inc* family income, *HOUSES* the HOUSES Index, *HS* Hollingshead Index, *NT* Nakao–Treas Index
*p Values for all correlation coefficient were $p<0.001$

these associations were consistently higher for Jackson County, Missouri. To assess construct validity, we determined the association of HOUSES with risks of low birth weight, overweight, and smoking exposure at home, and the results are summarized in Tables 4 and 5. Overall, HOUSES was inversely associated with risks of low birth weight, overweight, and smoking exposure at home in Jackson County, Missouri. Results were similar in Olmsted County, Minnesota, with the exception of a statistically insignificant association between HOUSES and the risk of low birth weight.

DISCUSSION

Our study results indicate that HOUSES derived from housing characteristics of Olmsted County, Minnesota, is a useful index in measuring SES in epidemiologic

TABLE 4 Logistic regression models of associations between measures of SES and risks of overweight, low birth weight, and smoking exposure at home among children in Olmsted County, Minnesota

	Subjects in Olmsted County, Minnesota					
Health outcomes or risk factors	Risk of overweight[a]		Risk of low birth weight[b]		Risk of smoking exposure[c]	
Socioeconomic measures	OR[d]	*p* Value	OR[c]	*p* Value	OR[c]	*p* Value
HOUSES Index						
Group1 (referent, lowest SES)						
Group2	0.61	0.128	0.97	0.940	0.87	0.640
Group3	0.37	0.007	0.64	0.340	0.56	0.066
Group4 (highest SES)	0.39	0.008	0.63	0.330	0.39	0.007
Income						
Less than $50,000 (referent)						
$50,000–$74,999	0.68	0.281	0.29	0.016	0.29	0.009
$75,000–$99,999	0.40	0.021	0.45	0.070	0.45	<0.001
$100,000–$149,999	0.28	0.002	0.17	0.002	0.17	<0.001
$150,000 and above	0.37	0.013	0.40	0.049	0.40	<0.001
Education						
HS grad or below (referent)						
Some college, no degree	1.42	0.513	0.53	0.900	0.53	0.002
Associate/college degree	0.62	0.371	0.63	0.480	0.63	<0.001
Graduate/professional degree	0.85	0.754	1.40	0.600	1.40	<0.001
Hollingshead Index						
8–48 (referent, lowest SES)						
49–56	0.80	0.492	0.91	0.830	0.91	<0.001
57–63	1.03	0.922	0.31	0.048	0.31	<0.001
Greater than 63 (highest SES)	0.68	0.349	2.17	0.063	2.17	<0.001
Nakao–Treas Index						
0–51.86 (referent, lowest SES)						
51.87–72.23	0.93	0.828	0.37	0.035	0.37	<0.001
72.24–83.65	0.51	0.092	0.37	0.063	0.37	<0.001
Greater than 83.65 (highest SES)	1.06	0.852	1.08	0.832	1.08	<0.001

[a]Overweight ≥95% of BMI for age and gender
[b]Low birth weight <2500 g weight at birth
[c]Household members use cigarette, cigars, or pipe tobacco at home
[d]Unadjusted odds ratios

TABLE 5 Logistic regression models for associations between measures of SES and risks of overweight, low birth weight, and smoking exposure at home among children in Jackson County, Missouri

	Subjects in Jackson County, Missouri					
Health outcomes or risk factors	Risk of overweight[a]		Risk of low birth weight[b]		Risk of smoking exposure[c]	
Socioeconomic measures	OR[d]	*p* Value	OR[d]	*p* Value	OR[d]	*p* Value
HOUSES Index						
Group1 (referent, lowest SES)						
Group2	0.66	0.212	0.16	0.003	0.61	0.029
Group3	0.92	0.784	0.26	0.005	0.38	<0.001
Group4 (highest SES)	0.42	0.018	0.49	0.07	0.24	<0.001
Income						
Less than $50,000 (referent)						
$50,000–$74,999	0.86	0.648	0.34	0.07	0.53	0.007
$75,000–$99,999	0.80	0.526	0.61	0.33	0.44	0.001
$100,000–$149,999	0.58	0.154	0.74	0.54	0.38	<0.001
$150,000 and above	0.49	0.170	1.29	0.65	0.35	0.004
Education						
HS grad or below (referent)						
Some college, no degree	0.86	0.667	0.83	0.65	0.80	0.340
Associate/college degree	0.83	0.583	0.39	0.04	0.24	<0.001
Graduate/professional degree	0.63	0.224	0.52	0.17	0.13	<0.001
Hollingshead Index						
8–48 (referent, lowest SES)						
49–56	1.25	0.491	0.68	0.35	0.81	0.340
57–63	0.68	0.252	0.48	0.07	0.31	<0.001
Greater than 63 (highest SES)	0.73	0.382	0.30	0.02	0.18	<0.001
Nakao–Treas Index						
0–51.86 (referent, lowest SES)						
51.87–72.23	0.68	0.252	0.780	0.47	0.46	<0.001
72.24–83.65	0.78	0.431	0.530	0.16	0.42	<0.001
Greater than 83.65 (highest SES)	0.52	0.056	0.500	0.12	0.19	<0.001

[a]Overweight ≥95% of BMI for age and gender
[b]Low birth weight <2500 g weight at birth
[c]Household members use cigarette, cigars, or pipe tobacco at home
[d]Unadjusted odds ratios

research. Given the advantages of this index and its external validity (generalizability), use of HOUSES in studying and addressing the disparities of health among people with different SES needs to be considered, especially when the conventional SES measures are not available in a dataset.

In this study, we were able to develop an alternative index measuring individuals' SES to the conventional measures of SES. A factor that consists of the number of bedrooms, number of bathrooms, square footage of housing unit, and estimated value of housing unit was extracted. These individual variables may represent size or value of housing unit and reflect an underlying construct, i.e., SES of individuals because the number of bedrooms and the value of housing unit have been reported to be correlated with family income.[15,16]

HOUSES had moderate–to–good correlation with other measures of SES (r= 0.39–0.59 among subjects of Jackson County, Missouri and r=0.29–0.54 among subjects of Olmsted County, Minnesota). As anticipated, HOUSES was more closely correlated with income levels than the other SES measures. Thus, HOUSES may reflect more materialistic resource of SES. These findings are consistent with the literature and are not surprising considering that each SES measure has its own unique property. The correlations among education, income, and occupation in this study were relatively modest (r=0.33 for education and income, r=0.40 for occupation and income, and r=0.61 for occupation and education).[3] Thus, given the modest correlations among the conventional measures of SES in the literature, the correlation of HOUSES with other SES measures found herein is reasonable and in expected ranges from the literature. To date, there is no study that has developed an index derived from housing characteristics and assessed its correlation with other SES measure. Thus, we are unable to compare our study results with others.

Importantly, HOUSES showed a dose–response relationship with risks of smoking exposure at home and childhood overweight, which were not observed in parents' education levels and other composite SES measures. However, the association between HOUSES and the risk of low birth weight in Olmsted County was not statistically significant (potentially due to a low incidence of low birth weight). Another potential explanation for the absence of a significant association between low birth weight and HOUSES may be the prevalence of recent immigrants among the low-income population in Olmsted County. A study of Somali immigrants showed that, even though Somali women are of low income, the incidence of low birth weight among Somali women was lower than the average for the USA (2.9–7.2% vs. 9.5–12.5%).[33] In support of the notion that HOUSES reflects a similar underlying construct to that identified by other measures of SES, HOUSES was as strongly associated with smoking exposure status at home as other measures of SES, regardless of the study sites. In predicting the risk of low birth weight among children in Jackson County, Missouri, and the risk of overweight among children from both study sites, HOUSES appeared to perform well compared with other measures of SES. HOUSES was the only SES index significantly associated with the risk of low birth weight among children in Jackson County, Missouri. Previous studies also have reported the association between housing characteristics and health outcomes.[9–14,22] Overall, there was a significant heterogeneity in the results with regard to the study sites, SES measures, and health outcomes which was expected given inconsistent correlations among SES measures in the literature, potentially differential effect of SES on health outcomes, and differences among communities in prevalence of health outcomes of interest, social stratification, ethnicity, and access to health care.

Another important aspect of HOUSES was external validity. We formulated HOUSES based on housing data of Olmsted County, Minnesota, and applied HOUSES (using the same statistical algorithm) to Jackson County, Missouri, using local housing data of Jackson County. We found robust results showing the similar criterion and construct validities to those observed in Olmsted County, Minnesota. Therefore, HOUSES is potentially useful in epidemiologic research and health policy to address the disparities of health, and this index deserves further investigation in the future.

HOUSES has unique advantages over other SES measures. First, the index is an individual level measure, not a proxy measure drawn from aggregated measures. Second, housing data are public information that are maintained and updated

(through electronic records in many places) because they are the basis of real property assessment and taxation. Third, considering that the median duration of residence in the USA (1996 report) was only 4.7 and 1.9 years for people aged 25–34 years,[34] HOUSES can capture changes in individual SES over time. Indeed, housing consumption often reflects longitudinal change in SES; for example, changes in homeownership or a move up or down in housing amenities are commonly associated with altered social position.[12]

The current study has strengths including the fact that it was population-based, conducted at two study settings with different socioeconomic characteristics of study populations and utilized multiple methods of assessing the merits of the HOUSES measure (criterion and construct validity). Our study results, however, should be viewed in the context of its limitations. There were missing values within real property data, but these were at random and did not significantly affect the results (i.e., the pattern) of factor analyses. Our study is based upon self-reported health outcomes instead of ascertained outcomes by objective measurement. Although self-reported outcomes may not be entirely accurate, self-reported outcomes including weight and height are still commonly used in epidemiologic research (e.g., NHIS)[27] and often use of such measures is the only way to conduct large-scale epidemiologic studies. Not all the real property data presented in this paper will be consistently available in other study settings with different property tax laws, administration, and assessment competency. However, our study findings provide a conceptual and methodological basis for development of individualized HOUSES Indices suitable to many study settings.

In conclusion, HOUSES has the potential to be used as a surrogate measure of SES in epidemiologic research, which may overcome the absence of measures of SES in commonly used datasets and provide supplementary information when conventional measures of SES are used. The refinement of this index, however, requires further research for its improvement and application.

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