Education, Zip Code-based Annualized Household Income, and Health Outcomes in Patients with Systemic Lupus Erythematosus

MEENAKSHI JOLLY, RACHEL A. MIKOLAITIS, NAJIA SHAKOOR, LOUIS F. FOGG, and JOEL A. BLOCK

ABSTRACT. ***Objective.*** To determine the association of socioeconomic status [SES; education and zip code-based annual household income (Z-AHI)] and ethnicity with health-related quality of life (HRQOL) among patients with systemic lupus erythematosus (SLE).

Methods. Data on 211 subjects from a cross-sectional study (LupusPRO©) using the Medical Outcomes Study Short Form-36 questionnaire to evaluate physical health scores (PCS) and mental health scores were used to obtain education and zip code. The 2000 US Census was used to obtain each zip code's median annual household income.

Results. Education and Z-AHI correlated with PCS (education standardized ß = 0.17, 95% CI 0.47, 3.65, p = 0.01, r^2 = 0.03; Z-AHI standardized ß = 0.15, 95% CI 0.57, 8.30, p = 0.02, r^2 = 0.02) on regression analysis. Z-AHI was linked to PCS, independent of education. Ethnicity was associated with PCS through disease activity and SES.

Conclusion. SES is associated with HRQOL in SLE. Z-AHI and education are equally predictive surrogates of SES; however, Z-AHI, independent of education, was predictive of HRQOL. Z-AHI has less subject bias and is easily obtainable, therefore its use for future HRQOL studies is suggested. (First Release April 1 2010; J Rheumatol 2010;37:1150–7; doi:10.3899/jrheum.090862)

Key Indexing Terms:
HEALTH-RELATED QUALITY OF LIFE SOCIOECONOMIC STATUS
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Systemic lupus erythematosus (SLE) is a multisystem autoimmune disease that affects numerous physical, social, and psychological aspects of a patient's health-related quality of life (HRQOL)[1]. The latter is a multidimensional concept that measures 5 different aspects: physical function (PF), psychological function, social function, perception of health, and overall life satisfaction. While physicians often focus on the importance of clinical and laboratory evaluation to assess disease-related health outcomes, patients tend to emphasize resultant disease-related functional limitations as the most important determinant of their health outcomes[2].

Research has shown an association between HRQOL and socioeconomic status (SES) in patients with SLE[3,4]. HRQOL has also been shown to be lower in certain ethnic groups[5]. Further, SES and ethnicity have each been associated with disease activity[6,7] and damage[6,8], disability[9], and survival[10] among patients with SLE. The direct relation to SLE itself may be confounded by the strong association between SES and ethnicity and access to or quality of medical care and risky health behaviors[11], which may result in either an inability to comply or poor adherence to recommended treatment and followup. Patients with SLE who have lower income are reportedly less likely to see a rheumatologist even though they have medical insurance[12].

All these factors, particularly compliance with care, may affect disease-related morbidity[13] and therefore health outcomes. It remains unclear whether the observation of an association between ethnicity and health outcomes in SLE, such as HRQOL or disease activity and damage, is primarily due to a patient's SES or is related to genotypic or phenotypic disease variations that may exist among various ethnic groups.

Most studies use individual SES surrogates. Indicators of SES are meant to provide information about an individual's access to social and economic resources[14]. Examples include education level, employment, income, household income, and type of health insurance. Although useful, these are all associated with some pitfalls. Further, they do not reflect contextually available household (family), social (friends), or community-based resources (such as support groups, elder care, child care, education centers, medical care, health and recreational centers) available to the individual, especially those that may be pertinent to health.

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As a result there exists a need for a better and more objective measure of SES in research studies. Zip code and tract-based income measures[15] are 2 such measures of an individual's contextual SES, and research is beginning to use these measures more frequently[15-18]. Zip Code Tabulation Areas (ZCTA) were developed by the US Census Bureau and are one way to tabulate summary statistics from Census 2000. These are generalized area representations of US Postal Service zip code service areas, and each is built by aggregating the Census 2000 blocks. Addresses that use a given zip code form a ZCTA, which gets that zip code assigned as its ZCTA code[19]. In most instances, the ZCTA code equals the zip code for an area. Census tracts are small, relatively permanent statistical subdivisions of a county. These are delineated for most metropolitan areas and other densely populated counties by local census statistical area committees following Census Bureau guidelines[20]. These are designed to be homogeneous with respect to population characteristics, economic status, and living conditions[20]. Census tract data are updated every 10 years. Thomas, *et al* found a strong correlation between US Census tract and zip code-based household income[15], while Krieger, *et al* found block-group and tract measures of SES to be better than zip code measures[21].

Our purpose was to measure and compare the association of individual and contextual surrogates for SES with HRQOL in patients with SLE. The individual SES surrogate used was education level achieved. For contextual SES, we utilized the participant's residential postal zip code (ZCTA) and the 2000 Census data to arrive at zip code-based Annual Household Income (Z-AHI) to determine median household income. Our specific aims were (1) to determine the strength of association of SES and ethnicity with HRQOL after adjusting for disease activity and damage among patients with SLE; (2) to evaluate the correlation of SES and ethnicity with disease activity and damage; and (3) to compare the relative value of 2 surrogates of SES, individual (education) and contextual surrogate for SES (Z-AHI), in evaluating HRQOL in patients with SLE. The hypotheses tested were that SES is independently associated with HRQOL; that ethnicity will be associated with disease activity and damage, and SES; and that use of both contextual SES and individual measure of SES (education) will provide additional information. Moreover, Z-AHI will perform equally well if not better than education as an SES marker in evaluating HRQOL in SLE. The potential applications of this study include a better understanding of the determinants (inclusive of SES) of health outcomes in patients with SLE, while creating benchmarks for contextual SES status research in SLE. Also, the data may serve to identify health disparities and design of health policy interventions at individual and community levels for SLE.

MATERIALS AND METHODS

Patients. This cross-sectional survey study was approved by the Rush University and Cook County Institutional Review Board. Patients were enrolled after providing informed consent if they met the American College of Rheumatology classification criteria for SLE[22] and were 18 years of age or older; the cohort was originally recruited for a study aimed at determining the reliability and validity of a disease-specific patient-reported outcome measure developed at our institution, LupusPRO©[23], and consisted of a multiethnic group of patients with SLE receiving care at the Section of Rheumatology of Rush University Medical Center, and at Cook County Hospital.

Variables. Patients were asked to complete HRQOL surveys including the Medical Outcomes Study Short Form-36 questionnaire (SF-36; www.rand.org)[24] and the LupusPRO©. A single rheumatologist administered the Systemic Lupus Erythematosus Disease Activity Index (SLEDAI) and the System Lupus International Collaboration Clinics/American College of Rheumatology Damage Index for Systemic Lupus Erythematosus (SLICC/SDI) to assess disease activity and damage at the time of the visit. Both of these measures have been validated and are widely used[25,26]. All data were obtained during routine visits to the rheumatologist. Demographic variables such as age, sex, and ethnicity were recorded.

For the purposes of this study the SF-36 was the only HRQOL survey used in analysis. The SF-36 has been validated and widely used in medical research[24]. The SF-36 measures 8 domains of health, including physical health, role physical (RP), bodily pain (BP), social functioning, general health, mental health, role emotional (RE), and vitality (VT). From these 8 domains, 2 composite scores are calculated, the physical component scale (PCS) and the mental component scale (MCS). Higher scores indicate better HRQOL. Referent US normative values for a similar age group of women were used to compare SF-36 domain scores.

The 2 socioeconomic variables studied were Z-AHI and self-reported highest education achieved. Education and zip code were obtained from each subject's volunteer information form. Z-AHI was obtained from the 2000 US Census fact finder for ZCTA for the zip code area's median annual household income (http://factfinder.census.gov). Since these data are heterogeneous and not normally distributed, median statistics were used. This was categorized as ≤ $35,000/year and > $35,000/year. Reported results for Z-AHI are in US dollars; 1 unit of Z-AHI is $1000. Education data were categorized as follows: less than high school, high school, college or university degree, or graduate degree.

Statistical analysis. SPSS version 12.0 was used for analysis. Missing data imputations were undertaken for the SF-36. Complete PCS and MCS, Z-AHI, and education data were available for 211 subjects. Descriptive analysis was performed on all variables and its distribution assessed. Appropriate transformations were undertaken to ensure normal distribution when indicated. Continuous data variables were compared using appropriate parametric/nonparametric tests stratified by SES and ethnicity for aims 1 and 2. For aim 3, univariate linear regression with PCS as the dependent variable was performed with age, ethnicity, disease activity and damage, and SES as independent variables. Hierarchical regression analyses were performed for PCS and MCS, composite scores of the SF-36. In model 1, age was entered. For model 2, ethnicity was added. Model 3 included additionally disease activity and damage variables. In model 4, education was added, and in model 5, Z-AHI. Standard ß values, a measure of change in the dependent variable when the independent variable is changed by 1 unit, along with r^2 change for each model, were noted. A p value ≤ 0.05 was considered significant on 2-tailed tests.

RESULTS

The original cohort consisted of 216 patients, of which 211 were included in our analyses. Five patients were excluded because their zip codes were outside Illinois. The cohort consisted of 196 women and 15 men, with a mean age of 42 years (41.9 ± 13.2). The ethnic distribution was 127 African American (60.2%), 42 Caucasian (19.9%), 14 Asian (6.6%), and 28 Hispanic (13.3%). The mean ± SD age of Caucasian

patients was significantly higher than others ($p < 0.0001$): caucasian 47.8 ± 13.0, African Americans 42.8 ± 12.6, Hispanic 34.5 ± 12.0, and Asian 32.5 ± 10.7 years.

Clinical manifestations (%) were as follows: mucocutaneous 72%, serositis 20%, cytopenia 36%, thromboembolism 6%, renal 25%, and arthralgia 78%. Descriptive scores [mean ± SD (median)] for demographics, disease characteristics, and HRQOL for the study cohort are shown in Table 1. The mean ± SD (median) SLEDAI and SDI were 6.3 ± 6.1^{4} and 1.9 ± 1.9^{1}, respectively. Z-AHI increased with the education level ($p = 0.03$). Mean ± SD (median) Z-AHI by education level were as follows: lower than high school, 38.5 ± 12.2 (36.0); high school, 40.0 ± 14.4 (36.0); college, 44.0 ± 18.1 (38.0); and graduate degree, 49.1 ± 14.7 (51.0). Distribution of Z-AHI and education stratified by disease measures (physician global assessment, SLEDAI, and SDI) is shown in Table 2. SES (education and Z-AHI) varied significantly by ethnicity ($p < 0.001$; Tables 3 and 4). All domains of the SF-36 were adversely affected by SLE, especially RP (Table 5) as compared to referent US norms from women of a similar age group.

SES, ethnicity, and HRQOL. Summary scores for the SF-36 domains stratified by SES (Z-AHI and education; Table 2) and ethnicity (Table 4) were significant for the following observations: PCS was significantly higher among patients with better education level ($p < 0.01$). Higher education level was associated specifically with better PF and less BP (Table 2). But lower Z-AHI was associated with greater BP. Hispanic ethnicity was associated with greater BP (Table 4; $p \leq 0.005$). Whites scored worst on VT ($p < 0.05$) and African Americans on the RE domain ($p < 0.05$).

On univariate analysis, age, SES (education and Z-AHI), and disease activity (but not ethnicity or disease damage) were predictors of PCS (Table 6). Each of these variables individually accounted for less than 5% of variation in the PCS score. Hispanic ethnicity showed a trend toward lower PCS scores ($p = 0.17$). On multiple regression analysis, ethnicity (Hispanic) was found to be a significant predictor of PCS, after adjusting for age and disease activity and damage (Table 7, model 3; ß –0.14, 95% CI –8.80, –0.05, $p < 0.04$). Similarly, SES remained a significant predictor of PCS, after adjusting for age, ethnicity (Hispanic), and disease activity and damage (Table 7, model 4). After introduction of SES, ethnicity did not retain its association with PCS (Table 7, model 4).

SES, ethnicity, and disease characteristics. Hispanic ethnicity was associated with a greater disease activity (Table 4; $p < 0.02$). Disease damage was higher among less-educated patients ($p < 0.05$); however, no differences in disease activity based on patients' SES were observed.

Comparison of education and Z-AHI as SES surrogates. Both education and Z-AHI were significant predictors of PCS on univariate analysis and explained similar amounts of variation (r^2) in its value (Table 6). The correlation between median Z-AHI and education was 0.20 ($p = 0.003$). Both SES surrogates were associated with ethnicity ($p < 0.0001$; Table 3). Disease damage was associated with education level, but not Z-AHI (Table 2).

On hierarchical modeling (Table 7, model 4), after adjusting for age, ethnicity, and disease activity and damage, addition of education to the model led to a significant change in the model's overall r^2 value and it remained an independent predictor of PCS (ß 0.15, 95% CI 0.20, 3.43, $p < 0.02$). Addition of Z-AHI to this model led to a significant increase in the r^2 value for the overall model (Table 7, model 5). Z-AHI independently predicted PCS; education did not retain its independent association with PCS with the addition of Z-AHI to this model. In the final model, only 13% of the variance of the PCS scores could be explained by age, ethnicity, disease characteristics, and SES, 4% of which was accountable to the SES (education and Z-AHI).

MCS did not show any association with the variables being tested (data not shown) in the above model. On univariate analysis no associations between ethnicity, SES, and MCS were noted. Depression was the strongest predictor for MCS (ß –0.23, 95% CI –6.47, –1.74, $p = 0.001$).

Table 1. Characteristics of the SLE study cohort. Z-AHI is measured in US dollars (unit = 1000).

Characteristic	Mean ± SD (median)
Age, yrs	41.99 ± 13.28 (43.00)
Disease duration, yrs	9.31 ± 7.92 (7.00)
Z-AHI	42.41 ± 15.85 (38.00)
Physician global assessment	1.12 ± 0.79 (1.00)
SLEDAI	6.39 ± 6.13 (4.00)
SDI	1.90 ± 1.98 (1.00)
Physical component scale	34.91 ± 10.70 (34.43)
Mental component scale	51.94 ± 8.52 (52.32)

SLE: systemic lupus erythematosus; Z-AHI: zip code-based annual household income; SLEDAI: SLE Disease Activity Index; SDI: American College of Rheumatology Damage Index.

DISCUSSION

Most health disparity research in the United States focuses on cross-sectional, individual SES, and not on the cumulative or dynamic nature of SES. There are advantages and disadvantages with the SES surrogates used commonly in medical research. Education level, one of the most widely used individual-level SES surrogates[6,8,9,27], is of limited use because of its potential disjunct with (1) employment status, especially in hard economic times; (2) an employment level consistent with the level of education achieved; (3) on-the-job training and other career investments made by individuals with similar levels of formal schooling; and (4) confounding/modification of its effect on health by its association with health behaviors[14]. Further, education, a marker of early life circumstances[28], is unlikely to change

Table 2. Disease characteristics and health-related quality of life stratified by socioeconomic status. Numbers are mean ± SD, median.

Characteristic	Z-AHI (US dollars: unit = 1000)		Education			
	≤ $35,000/yr	> $35,000/yr	< High School	High School	College/Univ Degree	Graduate Degree
Physician global assessment	1.09 ± 0.83, 1.00	1.11 ± 0.75, 1.00	0.91 ± 0.77, 1.00	1.17 ± 0.84, 1.00	1.14 ± 0.75, 1.00	1.04 ± 0.75, 1.00
SLEDAI	6.50 ± 6.09, 5.00	6.33 ± 6.26, 4.00	7.88 ± 7.92, 6.00	7.17 ± 6.89, 5.00	5.75 ± 4.53, 4.00	4.00 ± 4.03, 2.00
SDI	1.86 ± 1.99, 1.00	1.98 ± 1.96, 1.00	2.76 ± 2.61, 2.00	1.90 ± 1.82, 1.00	1.61 ± 1.83, 1.00	1.72 ± 1.60, 1.00*
Physical function	51.23 ± 27.19, 50.00	55.79 ± 29.61, 55.00	46.47 ± 25.24, 47.50	48.67 ± 27.24, 50.00	59.18 ± 28.49, 55.00	61.00 ± 32.08, 70.00*
Role physical	34.09 ± 39.31, 25.00	38.61 ± 41.16, 25.00	38.97 ± 45.31, 0.00	29.11 ± 35.90, 0.00	40.07 ± 41.19, 25.00	44.00 ± 41.63, 50.00
Bodily pain	48.81 ± 25.14, 41.00	56.86 ± 27.00, 52.00*	54.71 ± 25.59, 51.00	47.13 ± 26.72, 41.00	53.88 ± 26.00, 51.00	63.84 ± 23.63, 62.00*
General health	39.85 ± 20.50, 37.00	43.21 ± 19.48, 42.00	38.00 ± 19.88, 35.00	38.71 ± 19.68, 37.00	43.68 ± 19.48, 42.00	48.36 ± 21.63, 52.00
Vitality	47.09 ± 20.70, 50.00	45.54 ± 22.62, 45.00	51.47 ± 21.12, 50.00	45.19 ± 21.48, 45.00	45.00 ± 22.90, 45.00	47.00 ± 18.71, 50.00
Social function	59.20 ± 25.55, 50.00	59.90 ± 27.06, 62.50	59.93 ± 26.61, 62.50	57.28 ± 25.76, 62.50	59.76 ± 25.79, 62.50	65.50 ± 28.93, 75.00
Role emotional	53.33 ± 45.42, 66.67	59.74 ± 44.05, 66.67	55.88 ± 44.74, 66.67	53.16 ± 45.45, 66.67	57.99 ± 45.14, 66.67	62.67 ± 43.38, 100.00
Mental health	67.13 ± 19.89, 68.00	68.24 ± 20.02, 72.00	63.88 ± 24.43, 70.00	69.27 ± 18.22, 72.00	66.41 ± 19.76, 68.00	71.36 ± 18.71, 80.00
Physical component scale	33.80 ± 10.41, 33.20	36.08 ± 10.81, 35.90	34.30 ± 10.34, 33.68	32.17 ± 10.44, 31.02	36.84 ± 10.70, 37.85	38.63 ± 9.71, 40.97**
Mental component scale	52.02 ± 8.12, 51.75	51.92 ± 8.79, 53.69	51.95 ± 9.02, 52.50	53.11 ± 8.41, 52.73	50.88 ± 7.82, 51.32	51.59 ± 9.41, 53.70

* $p < 0.05$, ** $p < 0.01$. Z-AHI: zip code-based annual household income; SLEDAI: Systemic Lupus Erythematosus Disease Activity Index; SDI: American College of Rheumatology Damage Index.

throughout adult life once education is achieved, as compared to income or occupational social class. The latter may be a better discriminator of socioeconomic differentials in mortality than education in adults[28]. Use of "occupation" as an SES surrogate is problematic among teenaged mothers and others with little labor market experience. Moreover, late career occupation is subject to reverse causation problems if poor health leads to declines in occupational status[14]. This problem has been noted in chronic diseases such as SLE, which may cause patients to experience disease-related temporary periods of unemployment or work disability and thus have wide fluctuations in income/occupation[9,29]. Self-reported income data may be inaccurate and/or incomplete, as respondents may be "sensitive" and/or uncomfortable with sharing this information[30].

While education and individual income reveal individually-based dimensions of SES, household income is more indicative of a standard of living and of advantages household members experience through sharing goods and services[14]. The problems with use of household income are (1) subjects may not feel comfortable revealing the income of someone else within their household; (2) household members may not have equal access to household income[14], especially women[31]; and (3) information regarding other tangible or intangible assets of the individual/household is lacking, thus "household income" may not adequately reflect the standard of living of retired individuals, and it disregards the cumulative effects of a lifetime of deprivation or privilege. Health insurance and poverty level have also been used as SES variables in previous research of SLE mortality[6].

While individual SES is a known correlate of health outcomes, an individual's contextual SES is also known to be associated with that person's health outcomes, and may be not only easier to obtain but also helpful to identify[32] and design interventions[17] to reduce health disparities. Also, contextual SES may be more resistant to the temporary fluctuations in occupational status of subjects. Zip codes and the US Census have seldom been used in studies[33-37]. Most studies have been conducted in urban areas using zip codes in conjunction with socioeconomic and demographic variables from the US census[33,35,37]. Zip code measures usually cover a larger area and have more within-unit variation, but are easily obtained[21]. Geocoding based on census tracts is expensive and requires addresses, which may not be accessible in medical research in order to ensure patient confidentiality. Zip code-based median income measures may be more stable because they are computed from larger popula-

Table 3. Socioeconomic status stratified by ethnicity. Z-AHI is measured in US dollars (unit = 1000).

SES	Category	Ethnicity (%)
Z-AHI	≤ $35,000/yr	AA 77.3*
		C 3.6
		A 5.5
		H 13.6
	> $35,000/yr	AA 41.6
		C 37.6
		A 7.9
		H 12.9
Education	< High school	AA 73.5*
		C 5.9
		A 2.9
		H 17.6
	High school	AA 65.8
		C 13.9
		A 3.8
		H 16.5
	College/univ degree	AA 56.2
		C 26
		A 5.5
		H 12.3
	Graduate degree	AA 36
		C 40
		A 24
		H 0

* $p < 0.0001$. Z-AHI: zip code-based annual household income; SES: socioeconomic status; AA: African American; C: Caucasian; A: Asian; H: Hispanic.

tions as compared to the census tracts. Zip codes and US Census data have been used in a study of lupus nephritis[38]. That study used a composite area-based measure of SES that, based on the characteristics of zip codes, assigned an SES score to each person. The study identified 7 measures to be included in the composite measure of SES by a components analysis of socioeconomic indicators from the 2000 US Census. These indicators were (1) log of median household income; (2) proportion with income below 200% of the federal poverty level; (3) log of median house value; (4) log of median monthly rent; (5) mean education level; (6) proportion of people age 25 or older with a college degree; and (7) proportion of employed persons with a professional occupation[38]. The other study supporting the use of Z-AHI in SLE is by Trupin, *et al*[36].

We have tried to separate the effects of SES, ethnicity, and disease activity and damage on the HRQOL of patients with SLE. Moreover, we attempted to highlight the importance of the use of contextual SES surrogates (Z-AHI) in addition to the standard individual-based SES surrogate (education). We found an association of SES and ethnicity, using either of the 2 SES surrogates; being white was associated with a better SES. Greater disease activity was observed among Hispanics and greater disease damage was observed among less-educated patients with SLE. This observation may be partly due to association of education status with health behaviors and access to and quality of care. These findings are consistent with others[6-8].

Better HRQOL (PCS, PF, and BP) was observed among better-educated patients with SLE. Similarly, participants with greater Z-AHI performed better on HRQOL (BP). These observations are plausible, because higher education level is also associated with positive health behaviors and compliance. Higher Z-AHI and better education status may be associated with easier access to care, better quality of care, and better community health resources[11], all of which are factors that may affect overall disease damage and HRQOL.

Ethnicity itself was not found to be associated with HRQOL (PCS) on univariate analysis. Ethnicity (Hispanic) was in fact an independent predictor of PCS, after adjusting for the differential age, a finding supported by others[7,8,27,39,40]. Because an association between disease activity and ethnicity was observed in our cohort, it is possible

Table 4. Z-AHI, disease characteristics, and health-related quality of life stratified by ethnicity. Z-AHI is measured in US dollars (unit = 1000).

Characteristic	African American	Caucasian	Asian	Hispanic
Z-AHI	37.37 ± 12.53, 35.00*	57.35 ± 15.69, 57.00	47.14 ± 15.37, 46.50	39.46 ± 15.53, 37.00
Physician global assessment	1.07 ± 0.79, 1.00	1.10 ± 0.79, 1.00	1.29 ± 0.82, 1.00	1.19 ± 0.74, 1.00
SLEDAI	6.67 ± 6.57, 4.00**	4.86 ± 4.68, 4.00	5.14 ± 4.48, 4.00	8.00 ± 6.24, 7.50**
SDI	1.88 ± 2.11, 1.00	1.71 ± 1.67, 1.00	2.29 ± 2.09, 1.50	2.12 ± 1.63, 2.00
Physical function	52.12 ± 28.61, 50.00	57.38 ± 28.41, 55.00	60.71 ± 30.37, 67.50	49.64 ± 26.55, 50.00
Role physical	37.79 ± 40.68, 25.00	26.78 ± 36.37, 0.00	55.35 ± 40.64, 50.00	33.92 ± 40.94, 0.00
Bodily pain	50.09 ± 25.91, 42.00*	58.19 ± 26.84, 56.50	72.42 ± 23.06, 74.00	46.14 ± 23.84, 41.50
General health	40.71 ± 19.91, 40.00	46.07 ± 20.19, 44.50	41.28 ± 17.28, 39.50	38.00 ± 21.48, 34.50
Vitality	47.08 ± 20.98, 50.00**	40.23 ± 22.84, 40.00	60 ± 15.44, 57.50	45.35 ± 22.56, 47.50
Social function	61.02 ± 26.23, 62.50	57.14 ± 27.62, 62.50	56.25 ± 25.82, 56.25	58.03 ± 25.04, 62.50
Role emotional	50.65 ± 45.20, 33.33**	57.14 ± 45.55, 83.33	85.71 ± 28.38, 100.00	66.66 ± 42.55, 100.00
Mental health	67.93 ± 18.41, 68.00	65.71 ± 20.96, 70.00	76.00 ± 17.47, 78.00	65.14 ± 25.27, 72.00
Physical component scale	34.68 ± 10.91, 33.58	36.07 ± 10.48, 35.35	38.34 ± 9.46, 36.37	32.34 ± 9.96, 32.60
Mental component scale	51.37 ± 7.60, 51.32†	50.82 ± 10.07, 52.35	57.76 ± 4.46, 57.24	53.46 ± 9.77, 55.27

* $p < 0.005$, ** $p < 0.05$. † $p < 0.01$. Z-AHI: zip code-based annual household income; SLEDAI: Systemic Lupus Erythematosus Disease Activity Index; SDI: American College of Rheumatology Damage Index.

that the association of ethnicity with PCS could be due to this association alone. After adjusting the model for disease activity and damage, ethnicity (Hispanic) was still found to be associated with PCS. On specific domains, we found ethnic minorities to have greater BP, while African Americans and whites had the worst RE and vitality scores, respectively. The next plausible explanation for the reported association between ethnicity and PCS is through SES. We had observed better SES among whites. Ethnicity did not retain its independent predictor status for PCS when SES variables were entered into the model. These observations suggest that ethnicity lowered the HRQOL in SLE through 2 distinct mechanisms: disease activity and SES.

SES (education or Z-AHI separately) remained an independent predictor of PCS in SLE, after accounting for differences in the patient's age, ethnicity, and disease activity and damage. When Z-AHI was sequentially added to the PCS model that included age, ethnicity, disease activity and damage, and education, then education did not retain its significance as an independent predictor, while Z-AHI did. This observation suggests that education is an important SES surrogate, but that Z-AHI provides more distinct and additive SES information than education alone. This is in accord with our hypothesis that Z-AHI will perform better than if not similar to education, as an SES surrogate. To our knowledge this is the first study in SLE reporting a link between neighborhood SES and HRQOL, independent of individual SES.

Poor Z-AHI and/or lower education levels were associated with a worse HRQOL (PCS), although there was no association of SES with disease activity. Trupin, *et al* reported lower SES to be associated with greater disease activity[36]. This difference in the findings may be ascribed to varied study cohort and methodology. Their study cohort, although much larger than ours, was mainly composed of Caucasians,

Table 5. SF-36 scores [mean ± SD (median)].

SF-36 Domain	SLE	US Norms
Physical function	53.36 ± 28.41 (50.00)	88.06 ± 17.70 (95.00)*
Role physical	36.15 ± 40.33 (25.00)	83.65 ± 32.21 (100.00)*
Bodily pain	53.24 ± 26.24 (51.00)	74.85 ± 22.74 (74.00)*
General health	41.25 ± 20.11 (42.00)	74.25 ± 19.44 (77.00)*
Vitality	46.51 ± 21.59 (50.00)	59.43 ± 19.72 (60.00)*
Social function	59.99 ± 26.06 (62.50)	83.07 ± 23.27 (93.75)*
Role emotional	56.69 ± 45.04 (66.66)	80.08 ± 33.88 (100.00)*
Mental health	67.60 ± 19.84 (72.00)	73.32 ± 17.79 (76.00)**

* $p < 0.0001$, ** $p < 0.001$. SF-36: Medical Outcomes Study Short Form-36 Questionnaire; SLE: systemic lupus erythematosus.

Table 6. Univariate model for physical component scale.

Variable	ß	95% CI	R^2	p
Age	–0.19	–0.26, –0.04	0.03	0.005
Hispanic ethnicity	–0.09	–7.18, 1.31	0.009	0.17
Z-AHI*	0.15	0.57, 8.30	0.02	0.02
Education	0.17	0.47, 3.65	0.03	0.01
SLEDAI	–0.15	–0.50, –0.03	0.02	0.02
SDI	–0.03	–0.94, 0.53	0.001	0.59

* US dollars (unit = 1000). Z-AHI: zip code-based annual household income; SLEDAI: Systemic Lupus Erythematosus Disease Activity Index; SDI: American College of Rheumatology Damage Index.

Table 7. Hierarchical regression modeling for health-related quality of life.

Dependent Variable	Model	Independent Variable	ß	95% CI	p	Model p	Model R^2	R^2 Change	R^2 Change p
Physical component scale	1	Age	–0.19	–0.26, –0.04	0.005	0.005	0.03	0.03	0.005
	2	Age	–0.23	–0.30, –0.07	0.001	0.002	0.06	0.02	0.02
		Hispanic	–0.15	–9.29, –0.56	0.02				
	3	Age	–0.25	–0.31, –0.09	0.001	0.001	0.09	0.03	0.03
		Hispanic	–0.14	–8.80, –0.15	0.04				
		SLEDAI	–0.17	–0.54, –0.70	0.01				
		SDI	0.009	–0.68, 0.78	0.89				
	4	Age	–0.24	–0.31, –0.09	0.001	0.001	0.11	0.02	0.02
		Hispanic	–0.12	–8.28, 0.33	0.07				
		SLEDAI	–0.15	–0.50, –0.03	0.02				
		SDI	0.03	–0.57, 0.89	0.66				
		Education	0.15	0.20, 3.43	0.02				
	5	Age	–0.26	–0.31, – 0.10	0.001	0.001	0.13	0.02	0.03
		Hispanic	–0.12	–8.14, 0.39	0.07				
		SLEDAI	–0.14	–0.49, –0.01	0.03				
		SDI	0.02	–0.61, 0.84	0.74				
		Education	0.12	–0.09, 3.15	0.06				
		Z-AHI*	0.14	0.39, 8.01	0.03				

* US dollars (unit = 1000). SLEDAI: Systemic Lupus Erythematosus Disease Activity Index; SDI: American College of Rheumatology Damage Index; Z-AHI: zip code-based annual household income.

with better mean HRQOL scores on PF than ours. Also, their recruitment, data collection, and disease activity assessments were significantly different from ours, and may account for the difference observed. We did not find an association between SES and MCS. This could be due to a smaller number of patients of Caucasian, Hispanic, and Asian ethnicity, or a factual finding, considering that the magnitude of the observed effect of SES on PCS was also relatively small. We previously reported that disease activity and damage together account for 14% of PCS and 2% of MCS[41]. In our current study, the variance in the PCS and MCS scores explained by disease activity and damage were 2.4% and 0.01%, respectively. Also, the association between SES and MCS may be mediated through variables (such as coping, mood, illness beliefs, stress) that were not included in this study.

Associations of SES and ethnicity with SLE and its outcomes have been previously reported[6,8,27,39,40,42]. The applicability of socioeconomic and demographic variables in better understanding and improving modifiable societal factors is important[7]. It is widely recognized that improved treatment and prevention strategies that address SES may improve outcomes in patients with SLE[13].

The limitations of our study relate to the use of a preexisting database, which did not allow more SES variables to be evaluated, such as patient-reported income, number of people in the household, number of people contributing to the family income, or current occupation. The generalizability of our study is limited, as the patient population was from city hospital systems and thus was more representative of urban dwellers than suburban or rural residents. Also, we had a greater representation of African Americans than Caucasians in our study, which reflects the ethnic mix of patients seen at our hospital. Lastly, by using the 2000 US Census, a portion of the population may not be represented, such as those without permanent residence or those who choose not to complete the US Census form. Use of the latest census data would have been ideal; however, we chose to use the 2000 Census data because it is in the public domain.

Our study provides support for the use of Z-AHI in future studies. Further, use of Z-AHI may facilitate sociological and health outcomes research using previously collected information from databanks. Because of its objectivity and ease of use, Z-AHI does not burden participants. This will minimize subject discomfort and incomplete, missing, and/or inaccurate data, as well as survey burden. The use of Z-AHI in research studies therefore has the potential to facilitate health disparity and health policy research in a cost-effective way. This would help identify and implement changes to the current healthcare methods and available health resources for the benefit of those with poor SES.

Our goal is to find methods to improve the HRQOL of patients with SLE. Our study indicates that apart from phenotypic and genotypic studies of ethnic variations in disease characteristics (activity and damage), we need to focus also on methods to help patients with low SES. This low status is known to contribute independently to high levels of depressive symptoms[36]. Some of the methods to help these patients are through greater understanding of SES, health behaviors, access to and quality of care, and other community health resources focusing on disease activity and damage and HRQOL of patients with SLE. Although ethnicity cannot be changed, SES, health beliefs, health behaviors, healthcare access, and quality of care are modifiable through community interventions and health policy change. Thus, more research is indicated to clearly establish the relative contributions and interplay of ethnicity, SES, and available community resources with disease activity and damage and health outcomes in SLE.

SES was associated with HRQOL in SLE. Z-AHI and education are both effective surrogates of SES and each appears to reveal unique information on SES. Both are equally predictive of HRQOL among patients with SLE. Since Z-AHI data can be obtained with minimal burden, it may provide a convenient surrogate to assess SES in health research. Additional studies identifying modifiable mechanisms[32] by which SES affects HRQOL may lead to targeted interventions[17] to improve health outcomes and healthcare access, and to reduce health disparities among those with poor SES by providing evidence needed to amend healthcare policy.

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