Research Article

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# Area-Level Socioeconomic Position and Repeat Mammography Screening Use: Results from the 2005 National Health Interview Survey

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## Abstract

**Background:** Despite a considerable number of studies describing the relationship between area-level socioeconomic conditions and mammography screening, definitive conclusions have yet to be drawn. The aim of this study was to examine the relationship between area-level socioeconomic position (SEP) and repeat mammography screening, using nationwide U.S. census SEP data linked to a nationally representative sample of women who participated in the 2005 National Health Interview Survey (NHIS).

**Methods:** An area-level SEP index using 2000 U.S. census tract data was constructed and categorized into quartiles, including information on unemployment, poverty, housing values, annual family income, education, and occupation. Repeat mammography utilization (dichotomous variable) was defined as having three mammograms over the course of 6 years (24-month interval), which must have included a recent mammogram (in past 2 years). Results were obtained by ordinary multivariable logistic regression for survey data. Women ages 46 to 79 years ($n = 7{,}352$) were included in the analysis.

**Results:** In a model adjusted for sociodemographics, health care factors, and known correlates of mammography screening, women living in more disadvantaged areas had lower odds of engaging in repeat mammography than women living in the most advantaged areas [OR comparing quartile 4 (most disadvantaged) to quartile 1 (most advantaged) = 0.63; 95% confidence interval, 0.50–0.80].

**Conclusion:** The results of this nationwide study support the hypothesis that area-level SEP is independently associated with mammography utilization.

**Impact:** These findings underscore the importance of addressing area-level social inequalities, if uptake of mammography screening guidelines is to be realized across all social strata. *Cancer Epidemiol Biomarkers Prev; 20(11); 2331–44. ©2011 AACR.*

## Introduction

Area-level socioeconomic effects on health have received ample attention in the literature. There are numerous documented associations between area-level socioeconomic position (SEP) and all-cause mortality, chronic and infectious disease outcomes, and health behaviors (1). There is growing interest in how residential environments influence other health outcomes, access to health care, health disparities, and health behaviors, including cancer screening behaviors, such as mammography use. Despite the recent controversies over appropriate age-specific screening intervals, mammography remains the primary means for detecting breast cancer early for women. Considering persistent socioeconomic and racial/ethnic disparities in distant-stage breast cancer diagnoses (2), understanding factors that facilitate adherence to recommended mammography screening guidelines is important in understanding disparities in breast cancer mortality. Although many of the individual-level predictors of mammography use have been well researched, definitive conclusions have yet to be drawn with respect to area-level influences on mammography screening behavior.

Over the past decade, a considerable number of studies have examined area-level characteristics and mammography screening use. In 2009, Pruitt and colleagues published a systematic review of the association of area-level socioeconomic status and cancer screening (3). The majority of studies published showed significant positive associations between area-level socioeconomic disadvantage and poor mammography outcomes. For example, a Canadian study by Kothari and colleagues

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found that a regional-level variable (percentage of high school graduates in provinces' public health agency boundaries) had a significant effect on mammography utilization, independent of individual-level education (4). Schootman and colleagues (5) found that area-level poverty was associated with never having a mammogram and Litaker and colleagues (6) reported that the number of primary care physicians per capita and proportion of female-headed households were independently associated with breast cancer screening. From a prospective study conducted in Connecticut, Dailey and colleagues showed that living in the most disadvantaged neighborhoods was independently associated with nonadherence to recommended mammography screening guidelines in effect at the time of the study (7). Furthermore, studies have shown that mammography screening utilization is influenced by area-level health maintenance organization market share and other system-level factors (8–10). Although the majority of studies have shown a positive relationship between neighborhood disadvantage and poor mammography utilization measures, there were also null reports, depending on the measure used. For example, Rosenberg and colleagues reported that neighborhood-level socioeconomic characteristics were not associated with regular mammography use among the women enrolled in the Black Women's Health Study, after adjustment for household income (11). After reviewing all of the evidence, Pruitt and colleagues concluded that definitive conclusions about the association could not be drawn due to the heterogeneity of methods, statistical modeling, and results across studies (3). Our study aims to further our understanding of the relationship between area-level SEP and mammography screening by studying a large, nationally representative sample of U.S. women who participated in the 2005 National Health Interview Survey (NHIS), linked to nationwide U.S. census data.

## Materials and Methods

### Study population, procedures, and participation

The 2005 NHIS (12) and 2000 U.S. census tract-level data (13) were used to conduct this analysis. NHIS is a cross-sectional survey with a multistage area probability design comprising computer-assisted personal interviews collected annually to track the health status of the country. The survey is a data collection program of the National Center for Health Statistics (NCHS) of the Centers for Disease Control and Prevention. The design began with selection of primary sampling units (single counties, groups of adjacent counties or equivalent jurisdictions, or metropolitan areas), followed by selection of secondary sampling units, with oversampling of black and Hispanic populations. The Research Data Center (RDC) of NCHS linked the 2 data sets, using restricted geographic variables (state, county, and tract). The investigators traveled to the secure premises of the RDC offices in Hyattsville, MD and Atlanta, GA to complete all analyses. This study was approved by the University of Florida and Gettysburg College Institutional Review Boards. Analysis of restricted data through the NCHS Research Data Center is also approved by the NCHS Ethics Review Board.

The 2005 NHIS sample consisted of 31,428 persons ages 18 years and older. Nearly 87% of households selected to participate responded to the survey. Less than 5% of nonresponse was due to failure to locate an eligible respondent at home after repeated calls; the remaining nonresponse was due to respondent refusal or unacceptable partial interviews. For this analysis, we included women between the ages of 46 and 79. During the interview, women were asked how many mammograms they have had in the past 6 years. Thus, for this analysis, we excluded women younger than 46 to allow calculation of the number of mammograms over the full 6-year time period. At the time of the study, national guidelines called for women ages 40 and older to have mammograms every 1 to 2 years (14). The upper bound of this age range was chosen given the controversy and mixed advice surrounding screening women ages 80s and older. Women who reported that their reason for their most recent mammogram was other than part of a routine exam, or had ever been told by a doctor or other health professional that they had breast cancer were excluded. There were 7,352 women who met all criteria.

### Measures

***Repeat mammography outcome.*** On the basis of the number of mammograms the respondent had in the past 6 years, a dichotomous 24-month repeat mammography interval outcome variable was created, consistent with the calculation by Rakowski and colleagues in their analysis of the prevalence and correlates of repeat mammography, using the 2000 NHIS (15). To be coded as adherent to the 24-month screening interval, respondents needed to have reported having 3 or more mammograms in the past 6 years, plus the additional criterion of having the most recent mammogram within the past 2 years. The time since cancer screening test recodes provided by NHIS were used to calculate time since mammogram screening (16).

***Area-level SEP.*** A composite area-level SEP index was created from census tract-level data, following the example of Krieger and colleagues, using a standardized *z* score combining data on percentage of working class, percentage of unemployed, percentage below the U.S. poverty line, percentage without a high school education, median housing values, and median household income; a higher score indicates a higher degree of deprivation (17). Owing to concern over regional SEP differences, the SEP index variable was ranked within states and then quartile values were combined across all states, allowing us to collapse the most advantaged census tracts in one state with the most advantaged census tracts in other states.

***Additional variables.*** Individual-level SEP was measured by education and annual family income. Education was categorized into 4 levels (less than high school,

completed high school, some college, and completed college or more). Annual family income was categorized into 6 levels (<$20,000, $20,000–$44,999, $45,000–$74,999, ≥$75,000, ≥$20,000 without further detail specified, and a category for "do not know/refused"). The number of individuals in each family was measured continuously. Race/ethnicity was coded as Hispanic, non-Hispanic white, and non-Hispanic black. Years in the United States was categorized as born in the United States, foreign-born and having lived less than 10 years in the United States, and foreign-born and having lived 10 years or more in the United States. Marital status was categorized in 3 levels (married/living with partner; widowed, separated, or divorced; never married). Access to health care and use of health services variables included health insurance status (not covered; public insurance only; private insurance only; combination of private and public insurance), having a usual source/place of care (yes; no), provider recommendation of a mammogram in the past year (yes; no, or did not see a doctor in the past 12 months; do not know/refused), and whether the respondent had seen a physician in the past year (yes; no). Known predictors of mammography were also examined, including family history of cancer (yes; no), smoking status (never smoker; former smoker who quit more than 6 years ago; former smoker who quit less than 6 years ago; current smoker), perceived breast cancer risk (low; medium; high; do not know/refused), and activity limitations (yes; no).

### Statistical analyses

Unadjusted associations of area-level SEP and of repeat mammography with the sociodemographic and other potential correlates of mammography use were examined. Unadjusted associations between area-level SEP and the other independent variables were also analyzed. Statistical significance was determined by the $\chi^2$ test for complex survey data ($P < 0.05$). Ordinary multivariable logistic regression for survey data (using PROC SURVEYLOGISTIC in SAS), estimating population average effects, was used to determine adjusted associations; adjusted OR with 95% confidence intervals (95% CI) are reported. A multilevel modeling method, estimating area-specific effects of covariates, was also undertaken [using GLLAMM macro for STATA version 10 (18), programmed by Rabe-Hesketh and Skrondal (19, 20)], which required the specification of unconditional and conditional probability weights, primary sampling units, secondary sampling units, and strata. Though the results were similar regardless of statistical method employed, the multilevel modeling method for complex survey data may have produced biased results due to small clusters and informative sampling weights (19, 21). Thus, although we continue to work on methodological advancements in this area, we are reporting only the ordinary logistic regression, weighted according to the complex sampling design. Interactions by race/ethnicity and area-level SEP were tested. All reported analyses were carried out with SAS software, version 9.2 (22).

## Results

Characteristics of the study population are presented in Table 1. On the basis of the weighted frequencies, more than half of the women were in the age range of 50 to 64 years. The racial/ethnic makeup of the weighted data was 8.6% Hispanic, 76.3% non-Hispanic white, 11.1% non-Hispanic black, and 4.0% non-Hispanic other race. Majority of the women were married or living as married, have attained at least a high school education, and had annual family incomes of $20,000 or more. With respect to area-level SEP, ranked by state and categorized into quartiles, women in the population were distributed as follows: quartile 1 (most advantaged SEP): 28.5%; quartile 2: 27.5%; quartile 3: 25.7%; quartile 4 (most disadvantaged SEP): 18.2%. The majority of women reported that they had health insurance, a usual place of health care, and had seen a physician in the past year. However, just over half of women reported that they had received a recommendation from a doctor to get a mammogram in the past year. More than one-third of women did not receive a mammogram within the calculated 24-month interval. With respect to known correlates of mammography, more than one-third of women reported low perceived risk of breast cancer, and less than 10% reported a high perceived risk of breast cancer. More than half of the women reported a history of cancer (any type) in their immediate family. The majority of women had never smoked, and most women did not report any activity limitations.

Table 2 shows the unadjusted relationships between repeat mammography use and sociodemographics, access to health care variables, and known correlates of mammography screening behavior. Women in the age groups of 46 to 50 and 65 to 79 had lower odds of receiving repeat mammograms than the reference age group of 50 to 64. Hispanic women, non-Hispanic black women, and women of all other race groups (non-Hispanic) were less likely than non-Hispanic white women to have had repeat mammograms. Women who were widowed, separated, or divorced or never married had lower odds of repeat mammograms than women who were married or living as married. Individual-level SEP was also associated with having received repeat mammograms; women with lower education and income levels were less likely to have had repeat mammograms. With respect to area-level SEP, significantly less women living in more disadvantaged areas (quartiles 2–4) received repeat mammograms than women living in the most advantaged areas (quartile 1). Women who were foreign-born (both women who had lived in the United States less than 10 years and those who had lived in the United States more than 10 years) had lower odds of having repeat mammograms than women born in the United States. Having no health insurance, no usual place of care, having not seen a physician in the past year, and not receiving a recommendation from a doctor to get a mammogram were all health care access factors associated with not receiving repeat mammograms. Low perceived risk of breast cancer was also associated with

**Table 1.** Characteristics of women ages 46 to 79; 2005 NHIS ($n = 7,352$)

| Domain | Variables | Unweighted frequency | Weighted frequency | Weighted % | 95% CI |
|---|---|---|---|---|---|
| Primary independent variable | Area-level SEP[a] | | | | |
| | Quartile 1 (most advantaged) | 1,829 | 12,839,533 | 28.5 | 26.8–30.2 |
| | Quartile 2 | 1,927 | 12,398,630 | 27.5 | 25.8–29.3 |
| | Quartile 3 | 1,876 | 11,597,336 | 25.7 | 24.0–27.5 |
| | Quartile 4 (most disadvantaged) | 1,641 | 8,211,557 | 18.2 | 16.7–19.7 |
| Sociodemographics | Age, y | | | | |
| | <50 | 1,259 | 8,646,498 | 19.0 | 17.9–20.1 |
| | 50–64 | 3,773 | 23,973,087 | 52.6 | 51.3–54.0 |
| | 65–79 | 2,320 | 12,934,567 | 28.4 | 27.2–29.6 |
| | Race/ethnicity | | | | |
| | Hispanic | 912 | 3,910,819 | 8.6 | 7.8–9.4 |
| | Non-Hispanic white | 5,136 | 34,778,780 | 76.3 | 75.1–77.6 |
| | Non-Hispanic black | 1,060 | 5,052,008 | 11.1 | 10.2–12.0 |
| | Non-Hispanic other | 244 | 1,812,545 | 4.0 | 3.3–4.7 |
| | Marital status | | | | |
| | Married/living as married | 3,426 | 28,190,784 | 62.2 | 60.9–63.5 |
| | Widowed/separated/ divorced | 3,290 | 14,677,866 | 32.4 | 31.1–33.6 |
| | Never married | 585 | 2,469,058 | 5.4 | 4.9–6.0 |
| | Education | | | | |
| | Less than high school | 1,395 | 7,455,582 | 16.5 | 15.4–17.7 |
| | Completed high school | 2,352 | 15,176,189 | 33.7 | 32.3–35.0 |
| | Some college | 1,896 | 11,830,525 | 26.3 | 25.1–27.4 |
| | Completed college | 1,625 | 10,605,400 | 23.5 | 22.2–24.8 |
| | Annual family income | | | | |
| | <$20,000 | 1,904 | 8,337,167 | 18.3 | 17.3–19.3 |
| | $20,000–$44,999 | 1,731 | 10,060,343 | 22.1 | 21.0–23.2 |
| | $45,000–$74,999 | 1,066 | 7,266,145 | 16.0 | 15.0–16.9 |
| | ≥$75,000 | 1,113 | 9,367,002 | 20.6 | 19.3–21.9 |
| | ≥$20,000 (no additional details provided) | 992 | 7,325,731 | 16.1 | 14.9–17.2 |
| | Do not know/refused | 546 | 3,197,764 | 7.0 | 6.2–7.8 |
| | Years in the U.S. | | | | |
| | Born in the U.S. | 6,287 | 39,653,460 | 87.3 | 86.4–88.2 |
| | Foreign born; lived in U.S. less than 10 years | 101 | 671,099 | 1.5 | 1.1–1.8 |
| | Foreign born; lived in U.S. 10 years or more | 939 | 5,099,116 | 11.2 | 10.3–12.1 |
| Access to health care | Insurance coverage | | | | |
| | Not covered | 762 | 4,315,211 | 9.5 | 8.7–10.3 |
| | Public insurance only | 1,534 | 7,805,313 | 17.2 | 16.1–18.2 |
| | Private insurance only | 3,666 | 25,236,411 | 55.5 | 54.1–57.0 |
| | Combination of private and public insurance | 1,367 | 8,081,291 | 17.8 | 16.8–18.8 |
| | Usual place of care | | | | |
| | No | 483 | 2,721,130 | 6.0 | 5.3–6.7 |
| | Yes | 6,816 | 42,524,756 | 94.0 | 93.3–94.7 |
| | Saw a physician in past year | | | | |
| | No | 1,134 | 6,716,398 | 14.9 | 14.0–15.9 |
| | Yes | 6,131 | 38330292 | 85.1 | 84.1–86.0 |

*(Continued on the following page)*

**Table 1.** Characteristics of women ages 46 to 79; 2005 NHIS ($n = 7,352$) (Cont'd)

| Domain | Variables | Unweighted frequency | Weighted frequency | Weighted % | 95% CI |
|---|---|---|---|---|---|
| | Mammogram recommended in past year | | | | |
| | No, or did not see a doctor in past 12 months | 2,583 | 15,607,789 | 34.3 | 32.9–35.7 |
| | Yes | 3,842 | 24,391,537 | 53.5 | 52.0–55.1 |
| | Do not know/refused | 927 | 5,554,826 | 12.2 | 11.2–13.2 |
| | Received mammogram within 24-month interval | | | | |
| | No | 2,751 | 16,335,410 | 39.8 | 38.3–41.2 |
| | Yes | 3,859 | 24,736,445 | 60.2 | 58.8–61.7 |
| Additional correlates of mammography use | Perceived breast cancer risk | | | | |
| | Low | 2,519 | 15,760,220 | 34.6 | 33.2–36.0 |
| | Medium | 3,127 | 19,518,760 | 42.8 | 41.5–44.2 |
| | High | 674 | 4,267,443 | 9.4 | 8.6–10.1 |
| | Do not know/refused | 1,032 | 6,007,729 | 13.2 | 12.2–14.2 |
| | Family history of cancer | | | | |
| | No | 3,097 | 18,650,785 | 43.8 | 42.5–45.1 |
| | Yes | 3,759 | 23,927,867 | 56.2 | 54.9–57.5 |
| | Smoking status | | | | |
| | Current smoker | 1,207 | 7,198,238 | 16.0 | 15.0–16.9 |
| | Former smoker who quit less than 6 years ago | 323 | 1,923,465 | 4.3 | 3.8–4.8 |
| | Former smoker who quit more than 6 years ago | 1,474 | 9,180,222 | 20.4 | 19.3–21.5 |
| | Never smoker | 4,258 | 26,758,391 | 59.4 | 58.1–60.7 |
| | Activity limitations | | | | |
| | No | 5,537 | 35,417,748 | 77.7 | 76.6–78.9 |
| | Yes | 1,815 | 10,136,404 | 22.3 | 21.1–23.4 |

NOTE: Data sources NCHS (2005) and U.S. Census (2000).

[a]A composite area-level SEP index was created using U.S. Census data (13), following the example of Krieger and colleagues (17), using a standardized *z* score combining data on percentage of working class, percentage of unemployed, percentage below the U.S. poverty line, percentage without a high school education, median housing values, and median household income; a higher score indicates a higher degree of deprivation.

lower odds of repeat mammograms, compared with moderate perceived risk. Furthermore, women who reported a family history of cancer were more likely to have had repeat mammograms than women who did not report a family history of cancer, and women who reported an activity limitation had lower odds of having repeat mammograms than women with no activity limitations.

Table 3 shows the unadjusted relationships between area-level SEP and sociodemographics, access to health care variables, and known correlates of mammography screening behavior. There were significant differences in area-level SEP by all sociodemographic variables examined. Of particular note, as area-level disadvantage increased by quartile, the percentage of non-Hispanic blacks and Hispanics represented in those areas also increased. The percentage of married (or living as married) women decreased as the area-level SEP disadvantage by quartile increased. For education, as area-level SEP disadvantage increased by quartile, higher percentages of lower education levels were observed. Similarly, with respect to income, as area-level SEP disadvantage increased by quartile, a higher percentage of the women reported less than $20,000 in annual family income. The most disadvantaged area-level SEP quartile (4) had higher percentages of foreign-born women who had lived in the United States more than 10 years and a lower percentage of U.S.-born women than other area-level SEP quartiles did.

Percentages of uninsured were highest in the most disadvantaged area-level SEP quartiles, as were the percentages of women without a usual place of health care,

**Table 2.** Unadjusted associations between repeat mammography use and sociodemographics, access to health care variables, and known correlates of mammography screening behavior; 2005 NHIS ($n = 7,352$)

| Domain | Variables | Repeat mammography use | | OR | 95% CI |
|---|---|---|---|---|---|
| | | Yes (weighted %) | No (weighted %) | | |
| Primary independent variable | Area-level SEP[a] | | | | |
| | Quartile 1 (most advantaged) | 33.6 | 21.4 | 1.00 | Referent |
| | Quartile 2 | 28.1 | 26.4 | 0.68 | 0.57–0.80 |
| | Quartile 3 | 23.7 | 28.2 | 0.54 | 0.45–0.63 |
| | Quartile 4 (most disadvantaged) | 14.7 | 23.9 | 0.39 | 0.33–0.47 |
| Sociodemographics | Age, y | | | | |
| | <50 | 17.4 | 22.1 | 0.70 | 0.61–0.82 |
| | 50–64 | 55.5 | 49.5 | 1.00 | Referent |
| | 65–79 | 27.1 | 28.4 | 0.85 | 0.75–0.97 |
| | Race/ethnicity | | | | |
| | Hispanic | 6.7 | 11.0 | 0.55 | 0.45–0.67 |
| | Non-Hispanic white | 80.5 | 72.2 | 1.00 | Referent |
| | Non-Hispanic black | 9.8 | 12.2 | 0.72 | 0.60–0.87 |
| | Non-Hispanic other race | 3.0 | 4.7 | 0.57 | 0.41–0.79 |
| | Marital status | | | | |
| | Married/living as married | 66.7 | 56.9 | 1.00 | Referent |
| | Widowed/separated/ divorced | 28.7 | 36.5 | 0.67 | 0.60–0.75 |
| | Never married | 4.6 | 6.6 | 0.60 | 0.48–0.74 |
| | Education | | | | |
| | Less than high school | 11.7 | 22.8 | 0.31 | 0.26–0.37 |
| | Completed high school | 32.1 | 35.7 | 0.54 | 0.47–0.63 |
| | Some college | 27.9 | 24.4 | 0.69 | 0.59–0.81 |
| | Completed college | 28.3 | 17.0 | 1.00 | Referent |
| | Annual family income | | | | |
| | <$20,000 | 13.3 | 26.0 | 0.30 | 0.25–0.36 |
| | $20,000–$44,999 | 22.4 | 23.4 | 0.56 | 0.46–0.68 |
| | $45,000–$74,999 | 18.4 | 14.1 | 0.76 | 0.62–0.94 |
| | ≥$75,000 | 25.8 | 15.1 | 1.00 | Referent |
| | ≥$20,000 (no additional details provided) | 15.0 | 13.9 | 0.64 | 0.50–0.80 |
| | Do not know/refused | 5.1 | 7.4 | 0.41 | 0.32–0.52 |
| | Years in the U.S. | | | | |
| | Born in the U.S. | 89.6 | 85.3 | 1.00 | Referent |
| | Foreign born; lived in U.S. less than 10 years | 0.9 | 2.3 | 0.35 | 0.19–0.65 |
| | Foreign born; lived in U.S. 10 years or more | 9.6 | 12.4 | 0.74 | 0.62–0.88 |
| Access to health care | Insurance coverage | | | | |
| | Not covered | 4.7 | 16.6 | 0.21 | 0.17–0.26 |
| | Public insurance only | 13.5 | 22.0 | 0.45 | 0.39–0.54 |
| | Private insurance only | 62.5 | 46.6 | 1.00 | Referent |

*(Continued on the following page)*

**Table 2.** Unadjusted associations between repeat mammography use and sociodemographics, access to health care variables, and known correlates of mammography screening behavior; 2005 NHIS ($n$ = 7,352) (Cont'd)

| Domain | Variables | Repeat mammography use | | OR | 95% CI |
|---|---|---|---|---|---|
| | | Yes (weighted %) | No (weighted %) | | |
| | Combination of private and public insurance | 19.3 | 14.9 | 0.96 | 0.83–1.12 |
| | Usual place of care | | | | |
| | No | 2.4 | 11.5 | 0.19 | 0.15–0.24 |
| | Yes | 97.6 | 88.5 | 1.00 | Referent |
| | Saw a physician in past year | | | | |
| | No | 6.2 | 27.5 | 0.17 | 0.14–0.21 |
| | Yes | 93.8 | 72.5 | 1.00 | Referent |
| | Mammogram recommended in past year | | | | |
| | No, or did not see a doctor in past 12 months | 24.3 | 56.6 | 0.19 | 0.17–0.21 |
| | Yes | 75.1 | 33.3 | 1.00 | Referent |
| | Do not know/refused | 0.6 | 10.1 | 0.03 | 0.01–0.04 |
| Additional correlates of mammography use | Perceived breast cancer risk | | | | |
| | Low | 35.6 | 40.2 | 0.83 | 0.73–0.95 |
| | Medium | 47.1 | 44.2 | 1.00 | Referent |
| | High | 11.8 | 7.7 | 1.43 | 1.16–1.76 |
| | Do not know/refused | 5.5 | 7.8 | 0.66 | 0.52–0.83 |
| | Family history of cancer | | | | |
| | No | 40.0 | 48.0 | 0.73 | 0.65–0.81 |
| | Yes | 60.0 | 52.0 | 1.00 | Referent |
| | Smoking status | | | | |
| | Current smoker | 12.1 | 21.8 | 0.52 | 0.45–0.61 |
| | Former smoker who quit less than 6 years ago | 4.1 | 4.4 | 0.88 | 0.66–1.17 |
| | Former smoker who quit more than 6 years ago | 23.7 | 17.1 | 1.31 | 1.12–1.52 |
| | Never smoker | 60.0 | 56.6 | 1.00 | Referent |
| | Activity limitations | | | | |
| | No | 80.2 | 74.4 | 1.00 | Referent |
| | Yes | 19.8 | 25.6 | 0.72 | 0.63–0.81 |

NOTE: Data sources NCHS (2005) and U.S. Census (2000).

[a]A composite area-level SEP index was created using U.S. Census data (13), following the example of Krieger and colleagues (17), using a standardized $z$ score combining data on percentage of working class, percentage of unemployed, percentage below the U.S. poverty line, percentage without a high school education, median housing values, and median household income; a higher score indicates a higher degree of deprivation.

percentages of women who had not seen a physician in the past year, and women who had not received a recommendation for a mammogram. There was a significant difference in reported family history of cancer by area-level SEP. However, a clear pattern was not apparent. The quartiles representing the most disadvantaged areas had higher percentages of current smokers; yet the most disadvantaged areas (quartile 4) also had the highest

**Table 3.** Unadjusted associations between area-level SEP and sociodemographics, access to health care variables, and known correlates of mammography screening behavior; 2005 NHIS ($n = 7,352$)

| Domain | Variables | Area-level SEP[a] | | | | $\chi^2$ *P* value |
|---|---|---|---|---|---|---|
| | | Quartile 1 (weighted %) | Quartile 2 (weighted %) | Quartile 3 (weighted %) | Quartile 4 (weighted %) | |
| Sociodemographics | Age, y | | | | | |
| | <50 | 19.7 | 18.8 | 17.8 | 19.5 | 0.003 |
| | 50–64 | 54.8 | 54.1 | 50.8 | 49.3 | |
| | 65–79 | 25.5 | 27.1 | 31.3 | 31.2 | |
| | Race/ethnicity | | | | | |
| | Hispanic | 3.7 | 6.2 | 8.3 | 20.6 | <0.001 |
| | Non-Hispanic white | 86.5 | 83.3 | 76.7 | 48.4 | |
| | Non-Hispanic black | 4.9 | 7.2 | 11.5 | 26.7 | |
| | Non-Hispanic other | 4.9 | 3.2 | 3.6 | 4.3 | |
| | Marital status | | | | | |
| | Married/living as married | 68.1 | 65.0 | 60.0 | 50.8 | <0.001 |
| | Widowed/separated/divorced | 27.3 | 31.0 | 34.7 | 40.0 | |
| | Never married | 4.6 | 4.0 | 5.3 | 9.2 | |
| | Education | | | | | |
| | Less than high school | 6.0 | 13.2 | 19.1 | 35.5 | <0.001 |
| | Completed high school | 26.5 | 37.3 | 37.4 | 34.6 | |
| | Some college | 28.5 | 26.2 | 28.0 | 19.7 | |
| | Completed college | 39.0 | 23.3 | 15.5 | 10.2 | |
| | Annual family income | | | | | |
| | <$20,000 | 7.0 | 14.6 | 21.5 | 37.5 | <0.001 |
| | $20,000–$44,999 | 17.3 | 22.5 | 24.7 | 24.9 | |
| | $45,000–$74,999 | 17.2 | 15.7 | 17.1 | 12.3 | |
| | ≥$75,000 | 34.8 | 21.8 | 12.7 | 6.9 | |
| | ≥$20,000 (no additional details provided) | 17.8 | 17.3 | 16.2 | 12.1 | |
| | Do not know/refused | 5.9 | 8.1 | 7.8 | 6.3 | |
| | Years in the U.S. | | | | | |
| | Born in the U.S. | 88.8 | 90.1 | 88.3 | 78.9 | <0.001 |
| | Foreign born; lived in U.S. less than 10 years | 1.5 | 1.1 | 1.6 | 1.9 | |
| | Foreign born; lived in U.S. 10 years or more | 9.7 | 8.8 | 10.1 | 19.2 | |
| Access to health are | Insurance coverage | | | | | |
| | Not covered | 5.7 | 8.1 | 10.5 | 16.3 | <0.001 |
| | Public insurance only | 8.5 | 14.0 | 20.4 | 31.1 | |
| | Private insurance only | 67.5 | 58.9 | 50.2 | 38.7 | |
| | Combination of private and public insurance | 18.3 | 19.0 | 18.9 | 14.0 | |
| | Usual place of care | | | | | |
| | No | 4.1 | 5.7 | 7.5 | 7.6 | <0.001 |
| | Yes | 95.9 | 94.3 | 92.5 | 92.4 | |

*(Continued on the following page)*

**Table 3.** Unadjusted associations between area-level SEP and sociodemographics, access to health care variables, and known correlates of mammography screening behavior; 2005 NHIS ($n = 7,352$) (Cont'd)

| Domain | Variables | Area-level SEP[a] | | | | $\chi^2$ *P* value |
|---|---|---|---|---|---|---|
| | | Quartile 1 (weighted %) | Quartile 2 (weighted %) | Quartile 3 (weighted %) | Quartile 4 (weighted %) | |
| | Saw a physician in past year | | | | | |
| | No | 12.4 | 14.2 | 16.8 | 17.1 | 0.001 |
| | Yes | 87.6 | 85.8 | 83.2 | 82.9 | |
| | Mammogram recommended in past year | | | | | |
| | No, or did not see a doctor in past 12 months | 32.9 | 32.4 | 35.4 | 39.2 | 0.008 |
| | Yes | 56.3 | 54.9 | 51.6 | 48.6 | |
| | Do not know/refused | 10.9 | 12.7 | 13.0 | 12.2 | |
| Additional correlates of mammography use | Perceived breast cancer risk | | | | | |
| | Low | 34.3 | 35.1 | 35.4 | 33.0 | 0.14 |
| | Medium | 44.6 | 42.8 | 41.1 | 43.7 | |
| | High | 10.0 | 9.1 | 8.7 | 9.0 | |
| | Do not know/refused | 11.2 | 13.0 | 14.8 | 14.3 | |
| | Family history of cancer | | | | | |
| | No | 42.4 | 43.1 | 42.4 | 49.3 | 0.004 |
| | Yes | 57.6 | 56.9 | 57.6 | 50.7 | |
| | Smoking status | | | | | |
| | Current smoker | 12.5 | 15.9 | 17.7 | 19.5 | <0.001 |
| | Former smoker who quit less than 6 years ago | 4.1 | 4.2 | 4.9 | 3.8 | |
| | Former smoker who quit more than 6 years ago | 22.5 | 21.6 | 20.7 | 14.4 | |
| | Never smoker | 60.8 | 58.3 | 56.8 | 62.3 | |
| | Activity limitations | | | | | |
| | No | 84.1 | 78.4 | 76.3 | 68.8 | <0.001 |
| | Yes | 15.9 | 21.6 | 23.7 | 31.2 | |

NOTE: Data sources NCHS (2005) and U.S. Census (2000).

[a]A composite area-level SEP index was created using U.S. Census data (13), following the example of Krieger and colleagues (17), using a standardized *z* score combining data on percentage of working class, percentage of unemployed, percentage below the U.S. poverty line, percentage without a high school education, median housing values, and median household income; a higher score indicates a higher degree of deprivation.

percentage of women who had never smoked. As area-level disadvantage increased by quartile, the percentages of women with activity limitations also increased.

The multivariable regression model of the adjusted relationship between area-level SEP and repeat mammography use is presented in Table 4. After adjustment for sociodemographics access to health care variables and additional known correlates of mammography use, the association between area-level SEP and repeat mammography was attenuated, but the relationship remained statistically significant. Women living in more disadvantaged areas (quartiles 2–4) had significantly lower odds of having repeat mammograms than women living in the most advantaged areas (quartile 1), after adjustment for all covariates (quartile 4 vs. quartile 1: OR = 0.63; 95% CI, 0.50–0.80; quartile 3 vs. quartile 1: OR = 0.69; 95% CI, 0.56–0.85; quartile 2 vs. quartile 1: OR = 0.77; 95% CI,

**Table 4.** Multivariable logistic regression results of the adjusted relationship between area-level SEP and repeat mammography use; 2005 NHIS ($n = 6,376$)[a]

| | | OR | 95% CI |
|---|---|---|---|
| Primary independent variable of interest | Area-level socioeconomic position[b] | | |
| | Quartile 1 (most advantaged) | 1.00 | Referent |
| | Quartile 2 | 0.77 | 0.63–0.94 |
| | Quartile 3 | 0.69 | 0.56–0.85 |
| | Quartile 4 (most disadvantaged) | 0.63 | 0.50–0.80 |
| Sociodemographics | Age, y | | |
| | <50 | 0.71 | 0.58–0.86 |
| | 50–64 | 1.00 | Referent |
| | 65–79 | 0.79 | 0.61–1.02 |
| | Race/ethnicity | | |
| | Hispanic | 1.16 | 0.86–1.57 |
| | Non-Hispanic white | 1.00 | Referent |
| | Non-Hispanic black | 1.42 | 1.13–1.79 |
| | Non-Hispanic other race | 0.68 | 0.43–1.07 |
| | Marital status | | |
| | Married/living as married | 1.00 | Referent |
| | Widowed/separated/divorced | 0.77 | 0.66–0.90 |
| | Never married | 0.71 | 0.55–0.93 |
| | Education | | |
| | Less than high school | 0.55 | 0.42–0.74 |
| | Completed high school | 0.69 | 0.56–0.85 |
| | Some college | 0.80 | 0.65–0.99 |
| | Completed college | 1.00 | Referent |
| | Annual family income | | |
| | <$20,000 | 0.58 | 0.43–0.79 |
| | $20,000–$44,999 | 0.90 | 0.68–1.18 |
| | $45,000–$74,999 | 0.92 | 0.71–1.20 |
| | ≥$75,000 | 1.00 | Referent |
| | ≥$20,000 (no additional details provided) | 0.82 | 0.62–1.07 |
| | Do not know/refused | 0.82 | 0.58–1.16 |
| | Years in the U.S. | | |
| | Born in the U.S. | 1.00 | Referent |
| | Foreign born; lived in U.S. less than 10 years | 0.75 | 0.36–1.56 |
| | Foreign born; lived in U.S. 10 years or more | 1.17 | 0.90–1.52 |
| Access to health care | Insurance coverage | | |
| | Not covered | 0.51 | 0.38–0.68 |
| | Public insurance only | 0.89 | 0.67–1.18 |
| | Private insurance only | 1.00 | Referent |
| | Combination of private and public insurance | 1.21 | 0.90–1.61 |
| | Usual place of care | | |
| | No | 0.58 | 0.43–0.78 |
| | Yes | 1.00 | Referent |
| | Saw a physician in past year | | |
| | No | 0.29 | 0.24–0.36 |
| | Yes | 1.00 | Referent |
| | Mammogram recommended in past year | | |
| | No, or did not see a doctor in past 12 months | 0.23 | 0.20–0.26 |
| | Yes | 1.00 | Referent |
| | Do not know/refused | 0.03 | 0.01–0.05 |
| | Perceived breast cancer risk | | |

*(Continued on the following page)*

**Table 4.** Multivariable logistic regression results of the adjusted relationship between area-level SEP and repeat mammography use; 2005 NHIS ($n = 6,376$)[a] (Cont'd)

| | | OR | 95% CI |
|---|---|---|---|
| Additional correlates of mammography use | | | |
| | Low | 0.82 | 0.70–0.96 |
| | Medium | 1.00 | Referent |
| | High | 1.34 | 1.06–1.71 |
| | Do not know/refused | 0.79 | 0.59–1.06 |
| | Family history of cancer | | |
| | No | 0.83 | 0.72–0.96 |
| | Yes | 1.00 | Referent |
| | Smoking status | | |
| | Current smoker | 0.63 | 0.52–0.76 |
| | Former smoker who quit less than 6 years ago | 0.92 | 0.65–1.30 |
| | Former smoker who quit more than 6 years ago | 1.18 | 0.98–1.42 |
| | Never smoker | 1.00 | Referent |
| | Activity limitations | | |
| | No | 1.00 | Referent |
| | Yes | 0.71 | 0.60–0.84 |

NOTE: Data sources NCHS (2005) and U.S. Census (2000).

[a]The model is also adjusted for family size, measured continuously (data not shown).

[b]A composite area-level SEP index was created using U.S. Census data (13), following the example of Krieger and colleagues (17), using a standardized *z* score combining data on percentage of working class, percentage of unemployed, percentage below the U.S. poverty line, percentage without a high school education, median housing values, and median household income; a higher score indicates a higher degree of deprivation.

0.63–0.94). The racial/ethnic differences in repeat mammography use observed in the unadjusted results changed appreciably in the fully adjusted model. Once the variables in the final model were controlled for, Hispanic women were not significantly different from white women with respect to repeat mammography use (OR = 1.16; 95% CI, 0.86–1.57). Furthermore, non-Hispanic black women were significantly more likely to receive repeat mammograms compared with white women when all of the aforementioned variables were accounted for in the model (OR = 1.42; 95% CI, 1.13–1.79). Women in the "non-Hispanic other race" category were less likely than white women to receive repeat mammograms, but the association was no longer statistically significant after adjustment. Interaction between area-level SEP and race/ethnicity was tested and was not statistically significant. The estimate of the association between years participants had lived in the United States and repeat mammography was attenuated and no longer statistically significant in the adjusted model. Variables that were attenuated after adjustment, but remained statistically significantly associated with repeat mammography in the final model included: marital status, education, income, insurance coverage, usual place of health care, having seen a physician in the past year, family history of cancer, and smoking status. Age receiving a recommendation for a mammogram in the past year, perceived breast cancer risk, and activity limitations were not changed substantially by adjustment and remained significant predictors of repeat mammography use. Younger women (<50 years), women with less than a college degree, and women with annual family incomes of less than $20,000 were less likely to have repeat mammograms than their respective reference groups. With respect to access to health care, women who did not have health insurance, did not have a usual place of care, had not seen a physician in the past year, or had not received a recommendation for a mammogram were less likely to receive repeat mammograms than their respective reference groups. Likewise, women who had low perceived risk of breast cancer, smoked, or had an activity limitation were less likely to receive repeat mammograms compared with their respective reference groups. Women with high perceived breast cancer risk had higher odds of repeat mammograms, compared with women who reported medium perceived breast cancer risk.

## Discussion

Results from this analysis support previous findings that area-level SEP is associated with mammography screening behavior. Although it has long been recognized that uptake of mammography screening

recommendations is dependent on many factors, there is increasing evidence that where one lives independently influences screening. Although many studies have examined these relationships in particular regional areas, our study examines the relationship between area-level SEP and repeat mammography, using a large, nationally representative U.S. survey. Similar to our previous findings in Connecticut (7), the results from this study clearly showed that women living in more disadvantaged areas at all quartiles (compared with the most advantaged areas; quartile 1) were less likely to have had repeat mammograms, even after adjusting for individual-level SEP and access to health care. By combining area-level SEP data nationwide, comparing the most socioeconomically advantaged census tracts in the United States with more disadvantaged areas in the United States, we observed strong relationships between area-level SEP and repeat mammograms, independent of the major known predictors of mammography use. Thus, observing this relationship on a national scale and confirming previous reports of area-level SEP patterns in mammography use provides substantial evidence that area-level social inequalities in repeat mammography are occurring in the United States.

One of the primary motivations for examining area-level SEP differences in mammography utilization has been to better understand the processes that have led to socioeconomic and racial/ethnic disparities in later stage of diagnosis of breast cancer and, subsequently, breast cancer mortality. The results of this study show that once area-level SEP and other individual-level predictors of mammography have been controlled for, Hispanics and non-Hispanic blacks are not less likely than white women to receive repeat mammograms. In fact, our results showed that non-Hispanic black women were more likely than white women to receive repeat mammograms in the fully adjusted model. Furthermore, individual-level measures of SEP were attenuated in the adjusted model. Accordingly, interventions addressing multilevel factors that influence access to mammography could prove central to developing appropriate responses to socioeconomic and racial/ethnic disparities in breast cancer outcomes. Access to health insurance, having a usual health care provider, seeing a physician in the past year, and receiving a recommendation for a mammogram all remain examples of critical individual-level or system-level factors to address. However, addressing barriers associated with area-level SEP may also be important to address to realistically reduce racial/ethnic and socioeconomic disparities in mammography utilization.

In the epidemiologic literature, it has become common for researchers to assert that multilevel or hierarchical models are necessary to account for the nested structure of the data and nonindependence of observations. Additional complications arise when applying multilevel statistical modeling to complex survey data; for example, effect estimates may be biased when the sampling bias is strong and the number of sampled individuals per area is small (19, 21). To explore modeling differences by method, a secondary aim of this article was to compare results obtained from ordinary logistic regression using survey procedures in SAS, weighted for the complex sample design, and a multilevel logistic regression using methods by Rabe-Hesketh and Skrondal programmed in GLLAMM (ref. 19; results not shown), accounting for the complex sample design and the multilevel structure of the data. Interestingly, the estimates for the adjusted OR describing the relationship between area-level SEP and repeat mammography were similar regardless of method used. Because there are potential complications and limitations with both of these methods, methodological advancements in the area of multilevel modeling with complex survey data are needed (21, 23). A limitation of ordinary logistic regression with survey data is its inability to capture an unmeasured neighborhood effect; that is, were we interested in an overall effect of neighborhood, we would need to employ generalized linear mixed models. However, as shown in previous work (19, 21), extensions of generalized linear mixed models for complex survey data are prone to bias when the neighborhood sample sizes are small and the sampling is informative. We are currently developing more suitable extensions, based on ideas analogous to those in (24). Nevertheless, for inference concerning effects of measured neighborhood characteristics, such as area-level SEP, the use of ordinary logistic regression with survey data is completely adequate. First, the software adjusts for within-neighborhood correlations automatically using survey standard errors, and second, there is no essential need to present inferences conditional on neighborhood itself (i.e., our "population averaged" inferences are adequate for our purposes).

This study shares some of the same strengths and limitations of other studies that have examined the role of area SEP and health. One limitation of this study is the inability to capture the possible effect of residential instability in the study population. Although it is unlikely that there are drastic changes in upward or downward mobility in terms of socioeconomic conditions one lives in over the course of 6 years for most individuals, the effect of residential instability on mammography outcomes may be an important independent covariate to assess. Another limitation often encountered is the use of census tract boundaries as a proxy for neighborhood; a definition that is not likely socially or culturally meaningful for residents. However, according to the U.S. census, census tracts were "designed to be relatively homogenous units with respect to population characteristics, economic status and living conditions" (25); thus, they may be adequate proxies for area-level socioeconomic conditions. Although the use of administratively available data has its limitations, there are some major advantages. In addition to the data being readily accessible online, the data are systematically

collected for the entire U.S. population. The use of census data at the tract-level has been shown to yield the most consistent results of census-derived area-based socioeconomic measures (17) and important for describing and understanding health disparities, independent of individual-level measures of SEP (26). Although it is not possible to interpret absolute values of the SEP index categories calculated for this study, we ranked SEP quartiles within each state and then combined the quartiles across states to remove some of the regional cost of living differences in the United States. Our intention was to create meaningful area-level categories interpretable at a national level. We acknowledge there may be regional area-level contexts that are masked in this approach related to absolute differences between states, but we considered the relative within state differences vital to capture.

Our results suggest that intervening on community, policy, or structural levels may be an appropriate way to increase early detection of breast cancer in the most socioeconomically vulnerable populations. However, given that women living in the most advantaged areas were more likely to engage in repeat mammography compared with all other quartiles, not just the most disadvantaged areas, our results also suggest that a more comprehensive public health strategy across all communities may be warranted. To date, interventions to reduce structural barriers to mammography screening across have been proven effective and have been recommended by The Community Guide evidence-based task force (27). For future studies, it may be important to evaluate whether these types of interventions have the potential to reduce area-level SEP disparities in mammography use on a larger scale.

## Disclosure of Potential Conflicts of Interest

The findings and conclusions in this paper are those of the authors and do not necessarily represent the views of the Research Data Center, the National Center for Health Statistics, or the Centers for Disease Control and Prevention.

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