Targeting the Underserved for Breast and Cervical Cancer Screening: The Utility of Ecological Analysis Using the National Health Interview Survey

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ABSTRACT

Objectives. This study tested the utility of ecological variables created from the National Health Interview Survey (NHIS) for strategic targeting of health services for the underserved.

Methods. Ecological variables were created using the 1989–1991 survey years of the NHIS public use data files. Segments, the NHIS secondary sampling units, permit computation of secondary sampling characteristics by percentage Black, percentage Hispanic, percentage below poverty, percentage unemployed, median education, median income, median age, and percentage residing in the United States for 5 years or less. These variables were analyzed with the NHIS Health Promotion and Disease Prevention 1990 supplement reporting mammogram, clinical breast examination, and Pap test use.

Results. Median education of areas was inversely related to never having mammograms. Areas with a high proportion (70%–100%) of Hispanic respondents also were more likely not to have mammograms. Women residing in areas with moderate or high proportions of Hispanic respondents were more likely never to have clinical breast examinations and Pap tests, as were those in areas with low income, poverty, and respondents who had resided in the United States 5 years or less.

Conclusions. The new methodology of constructing ecological variables using the NHIS demonstrates an application that may help identify underserved areas or areas with underutilized services. More studies using this methodology are warranted. (*Am J Public Health*. 1998;88:1484–1489)

Cancer is the leading cause of death in the United States among women 25 to 64 years of age.[1] Effective screening and cancer control are integral to reducing cancer mortality. The effectiveness of programs can perhaps be enhanced if they target those who are at higher risk because they do not participate in cancer screening and control efforts. Individual characteristics (e.g., age, family history) have traditionally been used to determine who should be screened for cancer; it has been suggested that it is equally important to determine where to screen.[2]

An ecological approach that uses groups, rather than individuals, as the unit of study is thought to be an important complement to measures of individual health attributes.[3] Such an approach may help capture the context of communities, cultures, and other groupings. Ecological approaches have been used for assessing breast cancer stage of diagnosis,[4] estimating cancer incidence in small areas,[5] and measuring the association of various indicators of lipid intake with breast cancer mortality.[6] Ecological approaches that directly assess cancer screening and control are less commonly reported. This can perhaps be attributed to the difficulty of obtaining screening information at the ecological level, particularly national data. The National Health Interview Survey (NHIS) now affords this opportunity. We report a new methodology using the NHIS at the ecological level. Specifically, breast and cervical cancer screening and control are assessed using selected NHIS variables.

Methods

The NHIS

The NHIS is a nationally representative survey of about 45 000 households (about 122 000 persons) conducted annually by the National Center for Health Statistics (NCHS).[7] The NHIS collects a wide range of health and health-related topics either from every family member or, in some cases, from randomly selected sample persons or criterion-selected sample persons. The types of information collected range from chronic and acute conditions, doctor visits, hospital stays, and the use of preventive and diagnostic medical services to personal health risk factors such as smoking behavior, diet, alcohol use, exercise, and many other topical areas in addition to a spectrum of sociodemographic indicators.[8]

To protect the confidentiality of survey respondents, the NCHS does not release identifiers for geographic units smaller than the 4 census regions. This constraint presents a problem for those researchers and public health practitioners who want to analyze the data at smaller geographic levels for purposes of efficiently targeting services or to discern environmentally related factors that affect individual behaviors. The method described below has been developed for the dual goals of protecting the confidentiality of NHIS respondents and permitting analyses of NHIS data using ecological variables constructed at the secondary sampling unit level.

Creation of Ecological Variables

The NHIS sample from 1985 to 1994 is a census block–based sample.[9] Within each

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calendar quarter and within each primary sampling unit, the sample is drawn from the same blocks or, in some cases, adjoining blocks throughout the 10-year run of the sample design. The blocks in the sample are called secondary sampling units, and the clusters of housing units selected for interviewing are within these secondary sampling units. While it is not possible to identify blocks or block groups from the NHIS public use files, it is possible to uniquely differentiate among the blocks or block groups in the sample. This characteristic of the NHIS sample allows users to construct estimators of area characteristics from the NHIS public use data files. Because in some cases the NHIS sample expands into adjoining blocks, it is not strictly appropriate to refer to these areas as either blocks or block groups. We have therefore coined the term *very small area* (VSA) to refer to these areas in the analysis presented below. The VSA identifier is constructed from NHIS public use data files by concatenating the RANDOM RECODE OF PSU NUMBER, PROCESSING QUARTER, and SEGMENT NUMBER fields.[10–13]

Combining several survey years provides a sampling fraction within the block or block group that is large (up to 60% of the block or block group) and capable of producing reasonably stable estimators for a number of ecological variables. We have combined survey years 1989 through 1991 to create ecological variables by VSA for the measures percentage Black, percentage Hispanic, median age, median educational attainment (ages 25 and over), median family income, percent below poverty level, percent unemployed in the past 2 weeks, and percent having resided in the United States 5 years or less. (A table showing the groupings used for each of the ecological variables and distribution of this study's ecological variables across the VSAs is available from the authors upon request.) The ecological variables were created using the "Person File" of the NHIS. This file contains basic information on every person in the sample. The total sample size for the years 1989 through 1991 is 356 592 persons. The ecological variables selected for this study were chosen because we hypothesized that they would have an independent effect on the residents' lifestyles and behaviors and hence on their utilization of health services such as cancer screening. In addition to creating categories for the combined 3 years, we also created the same categories for each of the 3 years individually to investigate the stability of the estimates within the VSAs. We deduced that the estimates are reasonably stable, with education being the most stable and unemployment, poverty, and racial or ethnic composition being the least stable. (A table showing the maximum change among the 3 years for each of the ecological variables is available from the authors upon request.)

One additional advantage of this approach is the often overlooked fact that the composition of small areas is not constant over time; area characteristics change from year to year as residents migrate in and out. This approach is capable of estimating the stability of the areas by yielding annual estimates of the composition of the VSAs according to the created ecological variables. Similar census data, which are only available for 1 year, provide the misleading impression that the composition of small areas is stable over time.

Once the ecological variables have been created for each VSA, they are merged with data from other NHIS data files that use the unique person identifier code, such as the Health Promotion and Disease Prevention special health topic file. For this study, we used the files of females aged 18 to 64 from the 1990 NHIS Health Promotion and Disease Prevention Supplement, which contained questions on personal health practices. Questions on cancer screening included length of time since the last mammogram, clinical breast examination, and Pap test.

Variable Coding Issues

The NHIS Poverty Index, which was used to generate the poverty variable, is based on family size, number of children under 18 years of age, and family income using the 1989 poverty level derived from the August 1990 Current Population Survey.[14] The Hispanic variable was generated using all Hispanic origins, including Puerto Rican, Cuban, Mexican/Mexicano, Mexican American, Chicano, other Latin American, and other Spanish. Mammograms included both those done for breast symptoms or conditions and those done as part of a routine checkup; distinguishing between the two did not elicit differences in results, and collapsing produces the advantages of larger numbers. Because it is the intent here to present a methodology to help identify underserved areas for cancer screening services rather than to investigate compliance with various screening guidelines, the dependent variables were defined as ever/never dichotomous variables. Person-level control variables were coded as follows: poverty (above, below), age (continuous), race (White, Black, other), education (1–8, 9–11, 12, 13–15, 16, 17+ years), family income(<\$5000, \$5000–\$6999, \$7000–\$9999, \$10 000–\$14 999, \$15 000–\$19 999, \$20 000–\$24 999, \$25 000–\$34 999, \$35 000–\$49 999, and \$50 000+), and insurance (insured, not insured).

Data Analysis

The SUDAAN program was used for this analysis.[15] Percentages and standard errors were calculated by incorporating the 1990 NHIS sample weights and design information. SUDAAN logistic regression was used to test the hypothesis of group differences in the regression model. Last mammogram, clinical breast examination, and Pap test were the dependent variables, and each of the ecological variables served as an independent variable. Each of the logistic regression models included statistical controls for the person-level variables of poverty, age, race, education, family income, and insurance status. Individual-level variables were used in addition to area-level characteristics because even though small areas are the analytic units in this study, the constitution of the areas is not homogenous. Thus, to obtain estimates of the effect of the area on screening behaviors, it is prudent to control for individual-level variables. Use of this approach to help partial out the effects of individual-level variables leads to a "purer" estimate of the effect of the area or environment in which the respondents live.

To determine the statistical significance of trends across the levels of the ecological variables, weighted linear regressions were conducted individually for last mammogram, clinical breast examination, and Pap test. These regressions were done using the inverse of the variances from the logistic regression as the weights.[16]

Results

Table 1 shows the results of the multivariate analysis of each of the ecological variables with use of mammograms, clinical breast examinations, and Pap tests.

Mammogram Use

Mammogram use showed a strong trend ($P < .01$) with the ecological variable median education; each education level under 16 years was statistically significant in both the univariate model and in the adjusted model that controlled for poverty, race (Black and other), age, insurance, income, and individual's education. Odds ratios (ORs) of never having mammograms increased as median education level decreased (OR = 1.69, $P < .0001$ among those with <12 years of education; OR = 1.53, $P = .0001$ with 12 years; OR = 1.28, $P = .006$ with 12–15 years). This effect is further illustrated in Figure 1.

Mammograms were also slightly more likely to have never been used by women in

TABLE 1—Logistic Regression Analyses Comparing Odds of Never Having Had Mammography, Clinical Breast Examination, and Pap Test with Ecological Variables

	Mammography (35–64)		Clinical Breast Examination (35–64)		Pap Test (18–64)	
	Univariate OR (95% CI)	Adjusted OR[a] (95% CI)	Univariate OR (95% CI)	Adjusted OR[a] (95% CI)	Univariate OR (95% CI)	Adjusted OR[a] (95% CI)
% Black (comparison group = 0%)						
1–9	0.92 (0.82, 1.04)	1.04 (0.91, 1.19)	1.24 (0.95, 1.63)	1.09 (0.81, 1.45)	1.18 (0.85, 1.64)	0.98 (0.69, 1.40)
10–39	0.82*(0.73, 0.94)	0.89 (0.77, 1.03)	1.46*(1.12, 1.89)	1.22 (0.93, 1.60)	1.31 (0.99, 1.72)	1.09 (0.80, 1.48)
40–69	0.92 (0.77, 1.11)	0.87 (0.70, 1.09)	1.53*(1.10, 2.13)	1.22 (0.83, 1.80)	1.23 (0.83, 1.84)	1.38 (0.86, 2.19)
70–100	1.14 (0.98, 1.34)	1.04 (0.84, 1.29)	1.00 (0.70, 1.45)	0.76 (0.48, 1.20)	0.99 (0.68, 1.44)	0.94 (0.57, 1.56)
Trend *P*	.420	.819	.906	.531	.880	.717
% Hispanic (comparison group = 0%)						
1–9	1.02 (0.93, 1.13)	1.08 (0.97, 1.21)	1.22 (0.99, 1.52)	1.22 (0.98, 1.51)	1.17 (0.90, 1.51)	1.05 (0.81, 1.35)
10–39	0.94 (0.83, 1.06)	1.05 (0.92, 1.19)	1.54*(1.19, 1.99)	1.37* (1.03, 1.82)	1.71* (1.29, 2.26)	1.37* (1.00, 1.86)
40–69	0.98 (0.80, 1.21)	1.02 (0.82, 1.28)	3.29*(2.34, 4.63)	1.96* (1.31, 2.93)	3.08* (2.14, 4.42)	1.78* (1.18, 2.68)
70–100	1.48*(1.15, 1.91)	1.65*(1.25, 2.17)	3.11* (2.04, 4.76)	1.82* (1.14, 2.91)	3.42* (2.32, 5.05)	2.14* (1.37, 3.35)
Trend *P*	.184	.146	.022	.029	.003	.000
% Poverty (comparison group = 0%)						
1–9	1.15*(1.03, 1.27)	1.05 (0.92, 1.20)	1.59*(1.25, 2.02)	1.37* (1.04, 1.79)	1.50* (1.15, 1.96)	1.40* (1.03, 1.88)
10–39	1.21*(1.10, 1.33)	1.17*(1.03, 1.32)	1.93*(1.56, 2.39)	1.27 (0.98, 1.65)	1.44* (1.13, 1.84)	1.03 (0.77, 1.39)
40–100	1.16 (0.97, 1.39)	1.09 (0.87, 1.37)	4.07*(2.99, 5.52)	2.17* (1.48, 3.19)	3.64* (2.61, 5.06)	2.10* (1.40, 3.15)
Trend *P*	.487	.526	.014	.064	.046	.162
Unemployed (comparison group < 10%)						
10–19	1.12 (0.98, 1.27)	1.07 (0.92, 1.23)	1.34*(1.08, 1.65)	1.06 (0.84, 1.35)	1.29* (1.00, 1.65)	1.09 (0.83, 1.43)
20–100	1.22 (0.95, 1.57)	1.16 (0.87, 1.54)	1.19 (0.85, 1.68)	0.81 (0.56, 1.18)	1.01 (0.59, 1.72)	0.75 (0.42, 1.31)
Trend *P*	.274	.195	.864	.240	.779	.257
Median education (comparison group > 15 y)						
<12 y	1.96*(1.68, 2.29)	1.69*(1.38, 2.06)	2.16*(1.44, 3.26)	0.99 (0.66, 1.51)	1.38 (0.93, 2.04)	0.77 (0.51, 1.18)
12 y	1.68*(1.36, 2.06)	1.53*(1.19, 1.97)	1.46 (0.89, 2.38)	0.95 (0.58, 1.55)	0.90 (0.54, 1.51)	0.66 (0.39, 1.14)
12–15 y	1.40*(1.20, 1.63)	1.28*(1.08, 1.53)	1.13 (0.74, 1.73)	0.83 (0.55, 1.24)	0.91 (0.60, 1.38)	0.72 (0.48, 1.09)
Trend *P*	.004	.007	.052	.851	.355	.349
Median income (comparison group ≥ $30 000)						
<$10 000	1.21 (0.98, 1.48)	1.11 (0.87, 1.41)	3.65*(2.62, 5.08)	1.85* (1.22, 2.80)	3.51* (2.45, 5.02)	2.27* (1.45, 3.56)
$10 000–19 999	1.31*(1.19, 1.44)	1.21*(1.05, 1.39)	1.88*(1.52, 2.32)	1.15 (0.88, 1.51)	1.45* (1.14, 1.86)	1.01 (0.73, 1.41)
$20 000–29 999	1.20*(1.08, 1.32)	1.14*(1.01, 1.29)	1.36*(1.09, 1.70)	0.99 (0.77, 1.27)	1.23 (0.95, 1.59)	0.99 (0.74, 1.34)
Trend *P*	.235	.374	.086	.166	.156	.248
Median age (comparison group = 45–59 y)						
18–29 y	0.81*(0.69, 0.95)	1.49*(1.22, 1.82)	1.36 (0.94, 1.96)	0.70 (0.45, 1.07)	1.13 (0.77, 1.68)	0.51* (0.32, 0.80)
30–44 y	0.99 (0.85, 1.16)	1.42*(1.18, 1.71)	0.87 (0.60, 1.27)	0.74 (0.49, 1.11)	0.74 (0.50, 1.09)	0.59* (0.37, 0.93)
60+	1.08 (0.76, 1.55)	0.81 (0.54, 1.22)	0.48 (0.19, 1.17)	0.66 (0.27, 1.64)	0.74 (0.38, 1.43)	0.97 (0.40, 2.31)
Trend *P*	.320	.0744	.109	.787	.344	.096
% Residing in US 5 y or less (comparison group = 0%)						
1–9	0.89*(0.80, 1.00)	0.91 (0.81, 1.02)	1.59* (1.27, 2.00)	1.37* (1.09, 1.73)	1.88* (1.47, 2.40)	1.49* (1.15, 1.92)
10–19	0.99 (0.79, 1.24)	1.03 (0.80, 1.33)	2.32* (1.64, 3.27)	1.64* (1.12, 2.39)	2.57* (1.84, 3.58)	1.77* (1.21, 2.61)
20–100	1.09 (0.78, 1.52)	1.16 (0.85, 1.58)	3.68* (2.20, 6.18)	2.39* (1.48, 3.88)	4.77* (2.80, 8.15)	2.90* (1.81, 4.65)
Trend *P*	.222	.120	.050	.043	.029	.029

Note. OR = odds ratio; CI = confidence interval.
[a]From logistic regression model that controlled for poverty, race (Black and other), age, insurance, income, and individual's education.
**P* < .05.

those areas with median incomes between $10 000 and $29 999 (OR = 1.21, *P* = .01 in $10 000–19 999; OR = 1.14, *P* <.04 in $20 000–29 999) and in those areas with 10% to 39% living in poverty (OR = 1.17, *P* < .02). Women in areas with lower median ages were more likely never to use mammograms (OR = 1.49, *P* = .0001 among those aged 18–29 years; OR = 1.42, *P* = .0003 among those aged 30–44 years) than women in areas with a median age between 45 and 59 years.

Women in VSAs with populations 70% to 100% Hispanic were significantly more likely to report never having had a mammogram (OR = 1.65, *P* < .001) than women in areas with no Hispanics. Percentage of the area's population who were recent residents of the United States was not associated with mammogram use.

Clinical Breast Examination Use

Women in those VSAs with a population of 10% or more Hispanic respondents were significantly more likely to report never having had a clinical breast examination (OR = 1.37, *P* < .03 in areas 10%–39% Hispanic; OR = 1.96, *P* < .002 in areas 40%–69% Hispanic; OR = 1.82, *P* < .02 in areas 70%–100% Hispanic). Figure 2 further illustrates this relationship. In VSAs with respondents who had been US residents for 5 years or less, women in every percentage category were significantly more likely not to have had a clinical breast examination (OR = 1.37, *P* < .007 in those areas where 1%–9% of respondents were recent residents; OR = 1.64, *P* < .02 where the figure was 10%–19%; OR = 2.39, *P* < .001 where the figure was 20%–100%).

Never having had a clinical breast examination was reported significantly more often by women in the lower and upper levels of poverty (OR = 1.37, *P* < .03 for 1%–9% poverty; OR = 2.17, *P* = .0001 for 40%–100% poverty). Women living in the lowest median income areas (<$10 000) were also significantly more likely not to report such examinations (OR = 1.85, *P* < .005).

Pap Test Use

The Pap test results mirror many of the clinical breast examination findings. Women in all areas where 10% or more of respondents were Hispanic were significantly more likely to report never having a Pap test than were women in areas with no Hispanics (OR = 1.37, $P < .05$ for 10%–39% Hispanic; OR = 1.78, $P < .007$ for 40%–69% Hispanic; OR = 2.14, $P < .002$ for 70%–100% Hispanic). Women in all areas with respondents who had resided in the United States for 5 years or less were significantly more likely to report never having had a Pap test (OR = 1.5, $P < .003$ where 1%–9% of respondents had been in the United States 5 years or less; OR = 1.8, $P < .005$ where the figure was 10%–19%; OR = 2.9, $P < .00001$ where the figure was 20%–100%). Figure 3 graphically displays the relationship between recent US residency and Pap test use.

Women in VSAs with lower and higher levels of poverty were significantly more likely to report never having had a Pap test than were women in areas with no poverty (OR = 1.40, $P < .03$ for 1%–9% poverty; OR = 2.10, $P = .0005$ for 40%–100% poverty). Women in areas with a median income less than $10 000 were also significantly more likely to report never having had a Pap test (OR = 2.27, $P = .0005$). Women in areas with median ages of 18 to 29 and 30 to 44 years were significantly more likely to report having had a Pap test (OR = 0.51, $P < .005$; OR = 0.59, $P < .05$) than those in areas with a median age of 45 to 59 years.

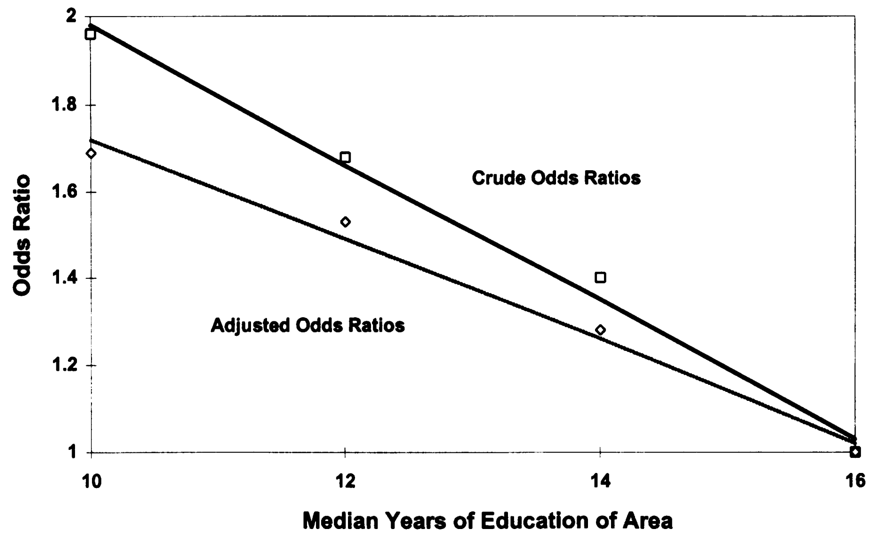

FIGURE 1—Crude and adjusted odds ratios of not having had a mammogram, by median educational level of very small areas: 1990 National Health Interview Survey.

Discussion

Geographic variability of site-specific cancer incidence, prevalence, and mortality has long been studied. Disease variation mapping has been used to help determine health resource utilization and can help function as baseline data for health program planning and evaluation. We contend that the identification of screening variation at the ecological level can serve the same function. Furthermore, geographically based targeting of cancer screening and control programs need no longer be limited to extrapolations only from incidence and mortality data.

This investigation's results suggest that several estimators of specific area characteristics are associated with cancer screening and control service accessibility and utilization. One application of these findings is purposeful targeting—for example, providing particular attention to educational strata when offering mammography programs. Similarly, the lack of mammogram use in areas with a high proportion of Hispanics suggests the need to target screening and control activities in those areas. Although some ecological variable results, such as those for poverty and income, presented somewhat less consistent patterns of statistical significance, there is no evidence to suggest that areas with low income or with any poverty would not benefit from targeted cancer screening and control. Each of the above variables—education, Hispanic ethnicity, income, and poverty—has shown similar results for mammogram, clinical breast examination, and Pap test use (i.e., inverse relationships) when studied at the individual level.[17–20] Two of the ecological variables investigated, those estimating area unemployment and proportion of Blacks, were not significantly associated with any of the dependent variables when poverty, income, an individual's education, and other variables were controlled for in the regression model. From these results, it appears that those variables with somewhat less stability across the 3 years studied (e.g., poverty and unemployment) were less likely to be correlated with cancer screening than the more stable ones (e.g., education). This suggests that variables that are relatively less stable over time may not be as well suited for VSA analysis.

In some respects, the results on median age were what might be anticipated. For instance, areas with younger median age reported less mammogram use than those with older median age. On the other hand, the significant difference in Pap test use between the younger age groups (18–29 and 30–44 years) and those aged 45 to 59 years suggests a discrepancy that screening programs might help alleviate. Since the median age for cervical cancer is 47 years,[21] areas with median ages between 45 and 59 should not have fewer Pap tests than those areas with younger women. The findings here seem to lend credence to the belief that women of this age group may be less likely to have Pap tests when they seek less or different care than they did during their reproductive years. When women's reproductive needs and care change, such as might be the case for women about 45 to 59 years of age, it may be crucial to target cervical cancer screening programs to these woman.

It is perhaps of interest that the ecological profiles that showed associations with never having clinical breast examinations or Pap tests differed somewhat from those area characteristics associated with never having mammograms, although the age ranges of those included in the groups differ. Nonetheless, it suggests the importance of considering not only access but also the multitude of other factors (e.g., self-selection for complying with recommendations such as having a mammogram) that affect the delivery of cancer screening and control services to women. Considering the multitude of factors is integral because while ecological profiles may identify reported use of services, they do not, in themselves, identify why services may not be available, accessible, or utilized. And while this study limited its report to those ever screened, future ecological research should investigate regular cancer screening.

While this work focused on the association of mammogram, clinical breast exami-

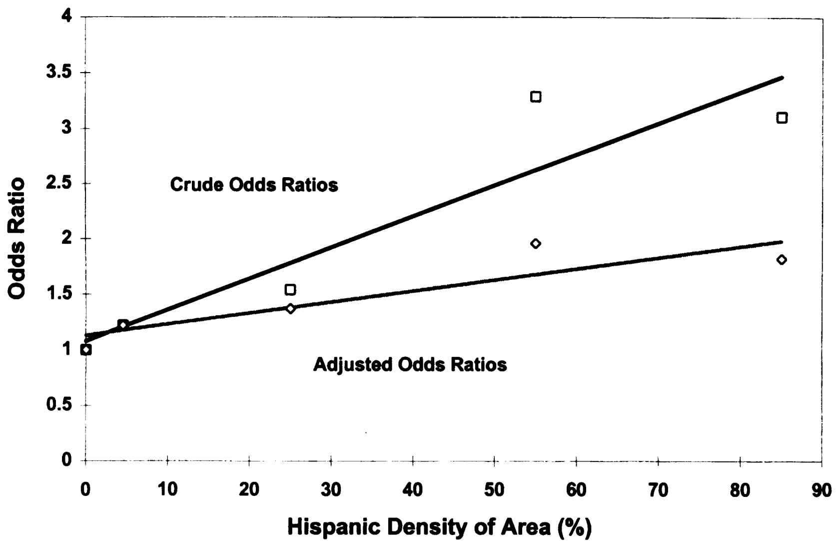

FIGURE 2—Crude and adjusted odds ratios of not having had a clinical breast exam, by proportion Hispanic (Hispanic density) of very small area: 1990 National Health Interview Survey.

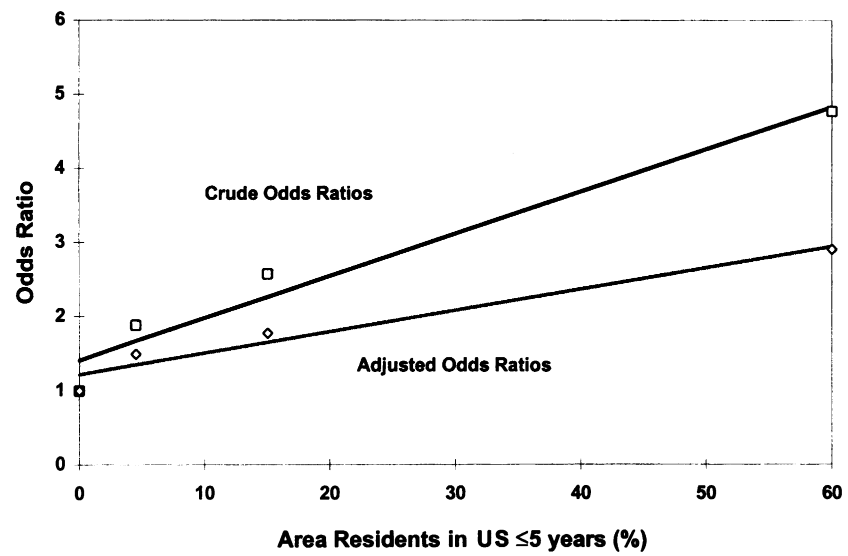

FIGURE 3—Odds ratios of not having had a Pap test, by very small area's percentage of residents in the United States for 5 years or less: 1990 National Health Interview Survey.

nation, and Pap test use with a handful of ecological variables, there are several other variables included on the NHIS that might be used for ecological analyses. For example, excess health problems or excess risk factors might be identified for areas using ecological variables such as type of employment, type of housing unit, marital status, or other variables on the NHIS core that could be considered as contextual. A principal advantage of this ecological method is that it enables researchers and practitioners to control the ecological analysis. The standard approach of using decennial census data requires that NCHS staff geocode NHIS tapes with selected census variables (e.g., income, age, household size, etc.). After geocoding preparation, the NCHS is unable to release the tapes for confidentiality reasons. While the ecological method described here cannot uniquely identify VSAs, the results of analyses using NHIS ecological variables can be applied to other small areas such as blocks or block groups with similar characteristics to identify target areas for screening programs or services.

Although it was noted earlier in this section that the ecological findings reported here parallel research conducted at the individual level, this is not to suggest that ecological analyses are a surrogate for analyses at the individual level. Rather, it seems that cancer screening and control planners would benefit from both. And while identifying underserved areas is one possible application of this methodology, it is not always an end in itself. A key research issue is not that screening reports are lower in neighborhoods or VSAs where these populations reside (and that these neighborhoods should therefore be targeted), but the question of what is it about these VSAs that may present barriers to cancer screening access above and beyond individual behavior. It may be that analysis of behavior by VSA facilitates the generation of new ecological hypotheses to help explain continued screening differences among populations. Traditional mass screening programs have sometimes been criticized for their inability to find cases in a cost-effective manner. Data about ecological variability may be a useful tool for improving the efficiency of such programs. □

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