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Do Contextual Conditions Moderate the Relationship between Race/Ethnicity and Mammogram Utilization?*

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Objective: The purpose of this research is to explore the extent to which ecological characteristics moderate the relationship between race/ethnicity and mammogram utilization. *Methods*: From a large national U.S. sample of white, black, and Hispanic women aged 41-84 I use multilevel models to examine the relationship between individual race/ethnicity and county-level disadvantage on odds of having a mammogram in the past two years. *Results*: Net of individual- and contextual- controls, black and Hispanic women are significantly more likely than white women to have had a mammogram within the past two years. For all three groups of women, I find that county-level economic disadvantage is inversely associated with odds of having a recent mammogram. I also find that living in counties with moderate percent black populations or large physician supplies is positively associated with utilization. *Conclusions*: The findings do not support the idea that women of color living in disadvantaged communities suffer from differential vulnerability when it comes to obtaining mammograms. Although race/ethnicity does appear to have a greater influence on mammogram utilization in some counties than in others, this variation is not explained by the county-level disadvantage variables included in this analysis.

Keywords: mammograms, county characteristics, race/ethnicity, health care utilization

Do Contextual Conditions Moderate the Relationship between Race/Ethnicity and Mammogram Utilization?

Breast cancer is currently the most common cancer and second leading cause of cancer death among women in the U.S. (CDC, 2007) A number of studies have documented that women of color, particularly black women, are diagnosed at a later stage in the disease and have higher breast cancer mortality rates than white women (Bradley et al., 2002; Campbell et al., 2009; Lannin et al., 2002; Mandelblatt et al., 1991; McCarthy et al., 1998; Schwartz et al., 2003; Swanson et al., 2003; Wells and Horm, 1992). Screening mammograms have proven to be extremely important in breast cancer mortality outcomes (Hendrick and Helvie, 2011). There are inconsistencies in the literature, however, about the existence of racial/ethnic disparities in mammogram utilization. While some studies suggest that black and Hispanic women are significantly less likely than white women to obtain mammograms (Blustein et al., 1995; Burns et al., 1996; Fox and Stein, 1991; Selvin and Brett, 2003; McCarthy et al., 1998; O'Malley et al., 2001; Schneider et al., 2002; Somkin et al., 2004), others have found that the racial gap has narrowed in recent years or that black and Hispanic women are actually more likely than white women to have mammograms (Benjamins et al., 2004; Bigby and Holmes, 2005; Breen et al., 2001; Coughlin et al., 2002; Coughlin et al., 2008).

While researchers have established that various individual characteristics, including socioeconomic status, type of health care plan, and physician visits, may moderate the association between race/ethnicity and mammogram use (Burns et al., 1996; Haas et al., 2002; Merkin et al., 2002; O'Malley et al., 2001), the extent to which community-level characteristics moderate or explain racial differences in mammogram utilization remains unclear. Indeed, in a review of the literature on racial differences in mammogram use, Bigby and Holmes (2005) concluded that there remain significant gaps in knowledge about how domains of inequality interact to affect screening. Examining the relationship between race/ethnicity and community-level disadvantage on mammogram utilization from a social science perspective can help to address these gaps, particularly when using statistical techniques to consider the possibility that the relationship between race and mammogram utilization may vary across geographic contexts. Accordingly, the main research question addressed here is: Do community-level economic disadvantage, minority racial composition, and/or healthcare service supply moderate the association between race/ethnicity and mammogram utilization? The knowledge gained from the present research can be used to focus future research, policy, and service interventions. By understanding which groups of women are most at risk of not obtaining timely

screenings, public health officials can more effectively develop targeted interventions to approach disparities in screening use.

Factors Associated with Racial Differences in Mammogram Utilization

There is substantial research in the public health and epidemiology literatures documenting and attempting to explain racial differences in mammogram utilization. Much of this literature is focused on racial differences in access, with researchers finding that women of color have less access to screening services than white women (O'Malley et al., 2001; Phillips et al., 1998a; Selvin and Brett, 2003; Somkin et al., 2004). However, even in settings where women have unrestricted access to care, including managed care and government sponsored health programs, minority women are more likely to be diagnosed at a later stage in the disease (Hunter et al., 1993; Jacobellis and Cutler, 2002; Li et al., 2003; Royak-Schaler et al., 2003). Accordingly, Somkin et al. (2004) concluded that while access to services is an important predictor of screening, it does little to explain racial variation in use. These results suggest that racial differences in screening may be explained by something other than individual level access to care.

Reflecting a growing awareness in the medical and social science literatures that, net of individual characteristics, physical and social environments are key determinants of health, an increasing number of studies examine the role of various ecological factors in explaining racial differences in mammogram use, including health care service supply (Coughlin et al., 2008; Engelman et al., 2002; Phillips et al., 1998a), community socioeconomic characteristics (Merkin et al., 2002; Rosenburg et al., 2005; Schwartz et al., 2003; Wells and Horm, 1992), and racial composition, (Benjamins et al., 2004; Coughlin et al., 2008; Wells and Horm, 1998). The conclusions from these studies are varied. Coughlin et al. (2008) found that in counties with a least a moderate supply of health clinics and in counties with a large proportion of black female residents, black women are more likely than white women to have had a recent mammogram. Benjamins et al. (2004) found that Hispanic women living in high percent black counties have higher rates of mammogram utilization than Hispanic women in other counties. Results from Merkin et al. (2002) suggest that there is a positive association between neighborhood level educational attainment and earlier stage at breast cancer diagnosis, but that the trend is stronger for white women than for black women. On the other hand, Wells and Horm (1992) found that racial disparities in mammogram utilization in low-SES census tracts do not exist in higher-income and higher-education Census tracts.

Though these studies make valuable contributions to the literature by examining the potential relationships between race/ethnicity, community-level characteristics, and mammogram use, they are limited in several important

ways that I attempt to address in the present research. First, the majority of studies on the relationship between race/ethnicity and mammogram utilization have been restricted to individual states or regions or specific populations of women (i.e. Medicare beneficiaries). This restricts the ability of researchers to generalize results to the population of U.S. women and may partially explain contradictory findings related to the existence of racial differences in mammography. In this study, I utilize nationally representative data on screening use among white, black, and Hispanic women aged 41-84. Second, despite descriptive findings that racial differences in utilization vary across states and regions (Burns et al., 1996; Ramirez et al., 2000), most previous research on racial differences in utilization used statistical models that failed to account for the spatial clustering of individual women within their context of residence. Along these same lines, even within the research that adjusts for spatial clustering, it is assumed that racial variation in mammogram use is homogenous across all geographic contexts; that is that the modifying effect of ecological disadvantage on the relationship between race and mammogram use is consistent across all counties, census tracts, or metropolitan areas. Throughout all analyses here, I utilize multilevel statistical models that account for the clustered sampling design of individual women within their counties of residence. By including random slopes for race/ethnicity, I also consider whether county-level differences are more pronounced for blacks and Hispanics than for whites in certain types of counties (i.e. does the effect of race on mammogram utilization differ across counties?). Third, while social scientists consistently report that low socioeconomic status areas have fewer health care resources (Grumbach et al., 1998; Jiang and Begun, 2002; Prentice, 2006), due to lack of data for certain geographic levels, few studies that examine use of mammogram screening services are able to include direct measures of health care service supply. Instead, researchers tend to use neighborhood economic measures as proxies for screening resource availability. Further, those studies that do include health care service supply typically exclude measures of non-traditional screening sites, such as clinic services for the poor. This is problematic given O'Malley and Mandeblatt's (2003) finding that blacks are more likely to use community health clinics than private doctor's offices for various preventive services, including mammograms. Rather than use area economic disadvantage as a proxy for screening service supply, I utilize actual supply variables, including non-traditional screening services that may better reflect service availability and use in minority communities, while at the same time including indicators of area economic disadvantage. Finally, most studies that examine the extent to which contextual characteristics explain or moderate racial differences in mammogram utilization tend to focus on only one category of neighborhood context. To my knowledge no studies have simultaneously examined the roles of

economic characteristics, screening service supply, and minority racial concentration on mammogram utilization. By examining all of these characteristics simultaneously, I am able to parse out the unique contribution of each and determine whether these conditions independently or concomitantly moderate the relationship between race/ethnicity and mammogram utilization and whether these conditions affect all racial groups equally.

Conceptual Framework

The Behavioral Model of Health Services Utilization (Andersen, 1995; Andersen and Newman, 1973; Phillips et al., 1998) can help us understand why some groups of women are more likely to obtain mammograms than others and why the influence of race/ethnicity on mammogram utilization may vary across ecological conditions, as expressed in Figure 1. The model posits that while certain factors such as age or educational attainment may *predispose* individuals to utilize health care services, various individual- and community-level *enabling or disabling factors* can facilitate or discourage use. Race/ethnicity may act as a predisposing factor of mammogram utilization; women of color may have a lower predisposition to use screening services compared to white women for a variety of reasons. For example, Howard et al. (1998) found that black women are more likely to miss and purposely avoid scheduling mammogram-related doctor's appointments than white women, while Guidry et al. (1997) found that black women are more likely than white women to experience transportation barriers to health care service use. Further, racial minorities tend to have less knowledge about breast cancer seriousness and availability of screening services (Frisby, 2002; Lipkus et al., 1999; Long, 1993; Phillips and Wilbur, 1995; Price et al., 1992), are more skeptical of the medical profession and the value of preventative health activities (Denniston, 1981; LaVeist et al. 2000), and express more fear and anxiety about the procedure and potential findings (Burnett et al., 1995; Cardwell and Collier, 1981; Long, 1993; Stein et al., 1991). Cultural beliefs may also predispose racial minorities toward lower likelihood of screening. For example, Hughes et al. (1996) identified spirituality as a barrier to screening among black women. Similarly, Clarke-Tasker (1993) found that black women are more likely than white women to believe that illness is due to God's will. Schrieber and Homiak (1981) found that modesty and fear of embarrassment are significant barriers to screening among Hispanic women. Based on the findings above and the idea that race/ethnicity is a predisposing factor of health care service utilization, black and Hispanic women should be less likely than white women to have had a recent mammogram (*Hypothesis 1*).

<Figure 1 about here>
Conceptual Model

However, my primary interest is on how these individual race/ethnicity effects may be contingent on contextual-level disadvantage. Membership in socially defined racial/ethnic groups often results in differential exposure to various social determinants of health outcomes, access, and utilization. Based on Andersen's model, the relationship between race/ethnicity and mammogram utilization could be moderated by community-level enabling factors, and it is likely that the relationship between race and mammogram utilization would vary across communities. Findings from the literature discussed earlier lend some support to the idea that neighborhood economic disadvantage and minority racial composition may impact screening use through both intermediate and proximate pathways. Indeed, women of color may experience "differential vulnerability" (McLeod and Kessler 1990) through intersections of individual and contextual disadvantage. Individuals who live in economically disadvantaged communities tend to be isolated from economic resources and institutions that support well-being (Massey and Denton 1993; Massey and Fisher 2000; Wacquant and Wilson 1989) and have limited power to demand health care services (Young and Lyson 2001). When services do exist, the social disorders that are common in disadvantaged neighborhoods, including crime, noise and vandalism may make travelling to obtain screening inconvenient or unsafe. As suggested by Kirby and Kaneda (2005), regularly dealing with the manifestations of neighborhood disorder may also make obtaining routine medical screenings seem relatively unimportant. In addition to diminished investment in health service infrastructure, neighborhood economic disadvantage and social disorder (Ross and Mirowsky, 2001; Sampson et al. 1996) may lead to reduced health related collective efficacy and social cohesion (Browning and Cagney 2003; Jencks and Mayer 1990; Kirby and Kaneda 2005). Limited economic resources may make social and civic institutions, such as churches and volunteer organizations, less viable (Browning and Cagney 2002). A lack of these institutions may restrict the sharing of information about disease seriousness, screening efficacy, and service availability.

In terms of neighborhood racial composition, skepticism towards medical professionals or about the value of screenings among women of color may reduce mammogram utilization through group norms (Benjamins et al., 2004; LaVeist et al., 2000). Previous research has found that racial minorities often experience real or perceived discrimination from providers (Blanchard and Lurie 2004; Casagrande et al. 2007) and racial barriers to service use (Fowler et al. 2006), have less access to culturally competent providers (McGary 1999), and are more likely than whites to feel that they have little or no choice in where they receive their health care (Trevino 1999). Minority women living in areas with higher percentages of their racial groups may be surrounded by peers with more negative

attitudes toward the health care system and/or attitudes that dispel the need for screenings. This may limit the transmission of information about the benefits of screening, where services can be obtained, and the experience of obtaining those services. Social norms and social control that condition attitudes toward health care might be less favorable in neighborhoods with a greater concentration of minorities, and this may be particularly detrimental for women of color living in these neighborhoods. Based on the idea of differential vulnerability then, community economic disadvantage and minority racial concentration should amplify the relationship between race and mammogram utilization; black and Hispanic women living in economically disadvantaged and/or high percent minority areas should be less likely to obtain mammograms than their counterparts in less economically disadvantaged and lower percent minority areas. (*Hypothesis 2*).

Finally, health care infrastructure is a community-level enabling factor that may affect a woman's ability to obtain a mammogram (Benjamins et al., 2004) and moderate the relationship between race/ethnicity and mammogram utilization. Economically disadvantaged communities and communities with higher percentages of minorities have been found to be targeted for community health clinics and educational health campaigns (Makuc et al. 1999; Berk et al. 1997). The supply of screening services or physician supply may be a stronger predictor of mammogram use for women of color if the greater supply helps to alleviate challenges associated with transportation or the neighborhood disorders discussed above. If an individual's race/ethnicity is more strongly associated with obtaining a screening in areas with a greater supply of health care services, then we would expect to see positive interactions between individual race/ethnicity and the supply of screening services in the county (Hypothesis 3). Examining the possible additive and interactive effects of race/ethnicity and ecological conditions on mammogram utilization, while simultaneously controlling for several individual- and county-level factors, can help to clarify the mechanisms through which communities shape mammogram utilization for white, black, and Hispanic women.

Methods

Data

The data for this research come from three different sources. First, the dependent variable and all individual level variables come from the Behavioral Risk Factor Surveillance System (BRFSS) for 2006, 2008, and 2010 (Centers for Disease Control). The BRFSS is an ongoing collaborative project of the Centers for Disease Control and U.S. states. This state-based system of telephone surveys collects information on preventive health practices,

access to health care resources, health behaviors, and demographic and socioeconomic factors for all 50 states and Washington, DC. The comparability of surveys across the three years (same question wording and sequence) permits pooling the data to construct a combined sample. I excluded data from 2009, 2007, and years prior to 2006 because the cancer screening module questions were not utilized by all states in those years.

To obtain area-based measures of screening service supply, I utilized the 2008 Area Resource File (ARF). The ARF contains integrated county-level data for all 3,141 counties and county equivalents in the U.S from a variety of primary data sources, including the American Medical Association and the National Center for Health Statistics. The ARF variables in this study overlap with the BRFSS 2006-2010 reporting period. County-level demographic and socioeconomic variables come from the 2005-2009 U.S. Census Bureau American Community Survey (ACS) 5-year estimates. These data represent the average characteristics for the period of January 2005-December 2009 and provide information for all counties in the U.S., rather than just those with populations of 20,000 people or greater (3-year estimates) or 65,000 people or greater (1-year estimates). I linked the individual data from the BRFSS with the county-level data from the ARF and ACS using the Federal Information Processing Standards (FIPS) code. I excluded cases where the FIPS code was suppressed in the BRFSS data. The CDC suppresses county FIPS codes for people residing in counties where fewer than 50 respondents were surveyed (including all counties in Alaska). Out of the 3,141 counties, I was able to include individuals from 2,241 counties. Individuals from excluded counties were not systematically different from individuals included in the sample along any of the variables of interest, except for that excluded individuals were more likely to reside in rural counties. I used BRFSS sampling weights throughout all analyses to adjust for sampling design and non-response bias.

Although context is measured differently across health outcome studies, there is precedent for using the county as the contextual unit of analysis (Benjamins et al., 2004; Coughlin et al., 2008; Monnat and Pickett, 2011; Tian et al., 2010). The county is an appropriate unit of analysis in this study because it is large enough to be meaningful for social policy and health intervention efforts and small enough to reflect local social and economic conditions. Through processes of second order devolution (the flow of funding and responsibility from state to local governments), the county is the unit through which state-level funding is processed and where local governments provide political and economic structure. Finally, the county represents the context within which most social and health services, including health care, are funded and delivered (McLaughlin et al., 2001).

Measures

The dependent variable in this study is *mammogram utilization*. Each female respondent was asked whether she had ever had a mammogram. Women who answered affirmatively were then asked how long it had been since their last mammogram. Consistent with most recent research in this area and USPSTF (2009) recommendations, I include women between the ages of 40 and 84 in the present study and identify the study outcome as having *had a mammogram within the past two years*. The sample includes 356,010 women.

The main independent variable of interest is individual *race/ethnicity*. In the BRFSS, individuals were asked to 1) identify themselves as Hispanic or non-Hispanic, and 2) identify the racial category or categories that best represent them. From these variables, I created three categories: non-Hispanic white (reference group), non-Hispanic black, and Hispanic (any race). Small sample sizes prevented me from including the other racial groups available in the BRFSS (Asians, American Indians, and mixed-race).

I examine whether the relationship between race/ethnicity and mammogram utilization varies across three categories of county-level conditions: 1) economic disadvantage, 2) health care service supply, and 3) minority racial concentration. First, to measure *county economic disadvantage* I include a scaled index that sums the percent of residents without a high school diploma, percent poverty, percent public assistance receipt, unemployment rate, and percent without health insurance (Cronbach's alpha = 0.81). I then converted scale scores into z-scores, such that one unit represents one standard deviation from the mean economic disadvantage score. The scale has a minimum of 16.45 in the least economically disadvantaged county included in the sample and a maximum of 147.07 in the most economic disadvantaged county in the sample.

Second, rather than employing economic disadvantage as a proxy for health care availability, I utilize actual measures of county-level *health care supply*. To measure the supply of infrastructure – facilities that can provide mammograms or referrals for mammogram services – I include a summed measure of number of hospitals with community outreach, health screening services, indigent care services, and mobile health services per 10,000 residents and number of hospitals with services for women and mammogram services per 10,000 female residents aged 35-85 (Cronbach's alpha = .770). Although my study group is women aged 40-84, the Area Resource File includes pre-categorized age group counts. Therefore, I did not have the option to create a per capita measure for the 40-84 age category included in this analysis. As with economic disadvantage, I converted the health care supply scale scores into z scores for the purpose of analysis. The scale has a minimum score of 0 in several counties and a

maximum of 49.96. To measure the county physician supply, I included a summed scale of the number of non-federal active MDs per 10,000 residents and the number of gynecologists per 10,000 female residents aged 35-85 (Cronbach's alpha = .907). The physician scale went from a minimum of 0 in several counties to a maximum of 322.78. Scale scores were converted into z scores.

Finally, I created three categories of *minority racial concentration* for percent black and percent Hispanic: low percent black (below the 75th percentile, 10.2%), moderate percent black (75th-90th percentiles, 10.2% to 30.5%), and high percent black (above the 90th percentile, 30.5%). Similarly, low percent Hispanic indicates a county below the national 75th percentile Hispanic population (7.28%). Moderate percent Hispanic indicates a county between the 75th and 90th percentile (7.28% to 19.49%), and high percent Hispanic indicates a county with a Hispanic percentage above the 90th percentile (19.49%). Collapsing the percent minority variables into categories is preferable to leaving them in their interval-ratio format because the effect of minority racial concentration on mammogram utilization has been found to be significant only at the highest levels (e.g. highest percent black) (Benjamins et al., 2004). I considered several options for cut points, including the 25th percentile and the median. However, a very small percentage of black women (less than 1%) live in a county with a percent black population below the 25th percentile (2.10%). A similarly small percentage of Hispanic women live in a county with a Hispanic population lower than the median percent Hispanic (2.73%). I selected cut points that allowed for a sufficient and logical distribution of black and Hispanic women into each of the three racial composition categories. I assessed correlations between all variables to avoid problems with multicollinearity in the regression analyses (correlation matrix available upon request).

Controls. I include controls for several individual- and county-level characteristics that may impact a woman's access to or likelihood of obtaining a mammogram. At the individual level, I include educational attainment (four-year college graduate, high school graduate, less than high school=ref), employment status (unemployed=ref), household income (less than $20,000, $20,000-49,999 and $50,000 or more=ref), health insurance coverage, experienced a cost barrier to medical treatment in the past year, has a regular doctor, had a routine health checkup in past 2 years, poor/fair self-rated health, smoking status (current smoker, former smoker, never smoked=ref), weight status (obese, overweight, neither=ref), marital status (married=ref), presence of children in the household, a measure of whether the respondent gets the emotional support she needs, and age (40-49=ref, 50-59, 60-84). At the county level, I control for metropolitan (ref) vs. nonmetropolitan county and U.S. Census region

(northeast, Midwest, west, and south=ref). The categories and descriptive statistics for all variables included in the models are displayed in Table 1.

<Table 1 about here>
Descriptive Statistics for all Variables Included in the Analysis

Statistical Analysis

I conceptualized the analysis in a multilevel structure comprising individual women at level 1 nested within counties at level 2 (Raudenbush and Bryk, 2002). I fitted the data using multilevel logistic regression models, adjusting for both individual- and county-level variables as fixed effects and allowing for heterogeneity between counties through the inclusion of random intercepts. Multilevel modeling is now popular in research that examines the relationships between individual health outcomes and contextual covariates because these models control for the complex error structure resulting from the clustering of individuals within geographic contexts, effectively deal with biases related to missing data and measurement error, and parse out how much variation in the dependent variable is attributable to individual vs. contextual differences.

After examining the county-level variation in odds of having a recent mammogram without including any explanatory variables (Null Model), I examine the relationship between individual race/ethnicity and mammogram utilization by including fixed effects for race/ethnicity without adjusting for any individual or county characteristics (Model 2). Next, to consider whether race has a greater influence on mammogram utilization in some counties than in others, I extend Model 2 by allowing the regression slopes for 'black' and 'Hispanic' to vary randomly at the county level (Model 3). I then adjust for individual-level control variables in Model 4 and add county-level variables in Model 5. In the next three models, I add cross-level interaction terms between individual race/ethnicity and county-level economic disadvantage (Model 6), racial composition (Model 7), and service supply (Model 8). Finally, I rerun Model 8 without random slopes for race/ethnicity to demonstrate how compositional effects can be conflated with contextual effects when random slopes are not properly taken into account.

Results

Table 1 describes the demographic, economic, and health behavior characteristics of the sample as well as the characteristics of counties by race/ethnicity. The majority of respondents (78.4%) reported having a mammogram within the past two years. Compared to whites, black women are significantly more likely to report a mammogram within the past two years ($p<.001$), and Hispanic women are less likely to report a recent mammogram, although this difference is not statistically significant. The average county-level economic

disadvantage scale is the lowest for white women and highest for Hispanic women. White women are also more likely to live in counties with a greater supply of health care facilities but a lower supply of physicians. White women are more likely to live in low percent black and low percent Hispanic counties. Black women are most likely to live in moderate percent black and low percent Hispanic counties, and Hispanic women are most likely to live in low percent black and high percent Hispanic counties. While white women aged 40-84 are more evenly distributed across the four US Census regions, over half of black women live in the south, and almost half of Hispanic women live in a Western state. In terms of individual covariates, white women have higher household incomes, are more likely to have a college degree, be employed, have health insurance, have a personal doctor, be married, get the emotional support they need, and not be overweight. They are also older than the black and Hispanic women in the sample. Black and Hispanic women are more likely than white women to have experienced cost barriers to medical service in the past 12 months, to report fair or poor health, and to be overweight or obese, but black women are more likely than white women to have had a routine medical checkup within the past 2 years. Black and Hispanic women are also more likely to have at least one child living in the household.

Table 2 presents the results of multilevel logistic regressions predicting the association between race/ethnicity and odds of having a mammogram within the past 2 years. The significant county-level variance in the null model indicates that probabilities of mammogram utilization among individual women differ across counties. The county-level variance is 0.187, which produces an intraclass correlation coefficient [$(ICC = \sigma^2/(\sigma^2 + 3.29)]$ of 0.054 (Snijders and Bosker, 1999). Although an ICC of 0.054 indicates that most of the residual variability in mammogram utilization is located at the individual level (94.6%), the magnitude and significance of the ICC ($p<.001$) are consistent with that found in previous multilevel health research (Browning and Cagney, 2002), and suggest that there is considerable heterogeneity in mammogram use both within and between counties. Results from the fixed effects model for race/ethnicity (Model 2) indicate that compared to white women, black women are significantly more likely (OR = 1.05), and Hispanic women are significantly less likely to report having a mammogram within the past 2 years (OR = 0.91).

<Table 2 about here>
Multilevel Logistic Regression Models Predicting Association between Race/Ethnicity and Recent Mammogram, US Women aged 40-84

Model 3 in Table 2 examines whether the relationship between individual race/ethnicity and mammogram utilization differs from one county to another. The significant slope variances for both ‘black’ and ‘Hispanic’

indicate that the relationship between race and mammogram utilization does indeed vary across counties; while blacks and Hispanics are less likely than whites to have had a recent mammogram in some counties, they are more likely than whites to have had a recent mammogram in others. The introduction of random slopes also reduced the magnitude of the overall coefficient for 'Hispanic', rendering it statistically insignificant. Conversely, the magnitude of the coefficient for 'black' increased, such that, after accounting for the possibility that black-white differences in mammogram utilization may vary across counties, black women have about 13% greater odds of reporting a recent mammogram compared to white women (OR = 1.13). The introduction of individual-level controls in Model 4 further increased the magnitude of the fixed effects for 'black' and 'Hispanic.' After adjusting for various individual demographic, economic, family, and health lifestyle characteristics, both black and Hispanic women have significantly greater odds of reporting a mammogram within the past 2 years compared to white women.

Coefficients for models that include county-level variables are displayed in Table 3. Model 5 introduces the county-level independent variables of interest, as well as controls for metropolitan county and region. We can see that accounting for county-level economic disadvantage, racial composition, and service supply slightly increases the black-white difference in odds of reporting a recent mammogram from .387 to .389 and increases the Hispanic-white difference in odds of reporting a recent mammogram from .385 to .401. Results further suggest that, with the exception of 'high percent Hispanic', each of the county-level independent variables are significantly associated with mammogram utilization. Residing in a county with greater economic disadvantage or a greater supply of health facilities is inversely associated with odds of having a recent mammogram, while residing in a county with a greater supply of physicians is associated with increased odds of having a recent mammogram. In terms of racial composition, residents of counties with moderate or high percent black populations are more likely to have had a recent mammogram than residents of counties with a low percent black population. Conversely, residents of counties with a moderate Hispanic population are less likely to have had a recent mammogram than residents of counties with a low Hispanic population.

<Table 3 about here>

Table 3. Multilevel Logistic Regression Models of the Effects of County-Level Factors on Mammogram Utilization among US Women aged 40-84

Models 6-8 in Table 3 introduce cross-level interactions between race/ethnicity and county-level conditions. We see that while the interactions themselves are not significant, adjusting for the interaction between race and county economic disadvantage (Model 6) renders the contextual effect of high percent black statistically

insignificant. The inclusion of the racial minority concentration interactions in Model 7 further eliminates the statistical significance of health facility supply. The only significant cross-level interaction however, is for blacks residing in high percent Hispanic counties. Black women residing in these types of counties are expected to have lower odds of having a recent mammogram than black women in low percent Hispanic counties. The addition of interactions for health facility and physician supply in Model 8 result in almost no change to the magnitude or significance of any of the variables of interest. After adjusting for individual-and county-level factors and for between-county variation in the relationship between race/ethnicity and mammogram utilization, we see that compared to white women, black women have about 50% greater odds (OR =1.50) and Hispanic women have about 40% greater odds (OR = 1.40) of having a recent mammogram. Regardless of race, living in an economically disadvantaged county or a county with a moderate Hispanic population is associated with reduced odds of having a recent mammogram, while living in a county with a moderate black population or a greater supply of physicians is associated with increased odds. Residing in a county with a large percentage of Hispanics is associated with reduced odds of a recent mammogram only for black women. The remaining unexplained county-level variation and significant slope variances for 'black' and 'Hispanic' suggest that there are county-level factors not included in these models that may explain racial differences in mammogram utilization. Coefficients for the control variables from Model 8 are displayed in Appendix A.

The final model in Table 3 illustrates the importance of considering random slopes for individual race/ethnicity. When I treat the effect of race/ethnicity on mammogram utilization across counties as fixed only, it appears that there are several cross-level interactions between individual race and county-level factors. However, this fixed-slopes model conflates individual-level variation with contextual-variation. Including the random slopes gives the correct estimate of standard errors in the presence of heteroscedasticity. Confounding across levels is masked by not explicitly modeling the variance at both the individual and county level. The random intercept-random slope framework considers place differences after allowing for within-county composition and avoids conflating individual-level variation in mammogram utilization with variation at the county level.

Discussion

This article assesses whether the relationship between race/ethnicity and mammogram utilization is moderated by ecological conditions. The central research question was: Do county-level economic disadvantage, minority racial concentration, and medical service supply differentially impact odds of having a recent mammogram

for white, black, and Hispanic women? Consistent with other research that uses nationally representative data (Benjamins et al., 2004; Coughlin et al., 2002; Coughlin et al., 2008) I found that compared with white women, black and Hispanic women are more likely to have had a mammogram in the past two years. Furthermore, these associations increase when both the composition of individuals within counties and the contextual conditions of counties themselves are considered. Though the effect of counties on mammogram utilization is modest (the majority of the variation in mammogram utilization can be explained by individual-level differences), county-level economic disadvantage, minority racial concentration, and physician supply are all significant predictors of mammogram utilization.

Consistent with the health service utilization model and with findings from Schwartz et al. (2003) and Wells and Horm (1998) residing in an economically disadvantaged area is inversely associated with having a recent mammogram. However, none of the black or Hispanic advantage in mammogram utilization vis a vis whites is explained by county-level economic disadvantage. Contrary to the "differential vulnerability" argument, black and Hispanic women do not experience any additional reduction in mammogram use by living in an economically disadvantaged county than do white women. However, because black and Hispanic women are more likely to live in disadvantaged counties than are white women, they are negatively affected by contextual economic disadvantage at a greater rate than white women. A limitation of this study is that I am unable to directly test the mechanisms through which county economic disadvantage is related to obtaining mammograms. Associations between screening use and ecological economic disadvantage may be related to poor social, physical, and service environments that impede or discourage women from seeking, locating, and traveling to health care services. Information on the availability of public transportation or on the distance from a respondent's home to a screening facility would be useful for testing mechanisms of community disadvantage (Kirby and Kaneda, 2005). Similarly, variables that measure social disorder, social networks, and the ways in which information is exchanged between residents within counties would be useful for exploring pathways of ecological social support and cohesion on variation in mammogram utilization.

The differential vulnerability hypothesis is largely unsupported by my findings related to county racial minority concentration as well. Contrary to the expectation that black and Hispanic women living in counties with a greater concentration of their racial/ethnic group would be less likely to obtain mammograms, the only significant interaction I found was for black women living in counties with a Hispanic population above the 90^{th} percentile.

There is some evidence in the literature to suggest that blacks living in communities with large Hispanic populations are especially vulnerable to economic changes resulting from the increasing Hispanic population (Shulman, 2003; Shihadeh and Barranco, 2010). Black women living in these communities may also be isolated from mainstream economic opportunities and health promoting social norms which may limit the transmission of information about screening benefits and where to obtain services. Unfortunately, the data do not allow me to control for these possibilities. It may also be that counties with a greater concentration of Hispanics have fewer of the types of health services black women are more likely to use. Previous research suggests that black women are more likely to use community health services and low income clinics (O'Malley and Mandelblatt, 2003), and that women who receive services at these types of clinics are more likely to be up to date on their screenings (Regan et al., 1999). While the measures of health care supply used here are the best available from county-level data , community health clinics and non-profit organizations that are separate from hospitals are likely not captured by the hospital supply variables included in this analysis.

Also related to racial composition, while Benjamins et al. (2004) found that percent black in county of residence is positively associated with screening use, and Wells and Horm (1998) found that percent Hispanic is inversely associated with use, I found only that residence in a *moderate* percent black county is positively associated with utilization while residence in a *moderate* percent Hispanic county is inversely associated with utilization. These differences in findings related to moderate vs. high minority populations may reflect variations in the cut-points selected for minority racial concentration. For example, Benjamins et al. (2004) elected to use the 75^{th} percentile to operationalize 'high black' and 'high Hispanic' counties, while I used a 90^{th} percentile cut-off. Percent black may be acting as a proxy for unmeasured services or campaigns that encourage or facilitate mammogram use among all women. Communities with higher percentages of blacks tend to be targeted for community health clinics and educational campaigns (Makuc et al., 1999; Berk et al., 1997) which I am unable to measure in these analyses. In addition, enhanced social networks and social supports in areas with a moderate black population may enhance the transmission of information about the necessity and availability of mammograms. It is possible that there is a percent black 'tipping point', such that health promoting services and social norms are more prevalent in counties with moderate black populations but not in counties with the very highest concentration of blacks. The divergence in these findings from previous research that has found significant cross-level interactions for individual race and racial concentration on mammogram utilization may also be explained by my inclusion of random slopes for

race/ethnicity. Failure to examine whether the county environment as a whole modifies the association between race and mammogram utilization risks producing regression models with biased standard errors that do not account for potential confounding across levels. My results suggest that while there is significant county-to-county variation in the relationship between race and mammogram use, that variation is not explained by the racial composition of the county.

It also does not appear to be the case that the infrastructure of health services is more strongly associated with screening among black and Hispanic women compared to white women. However, the finding that the physician supply in the county is positively associated with having a recent mammogram but that the actual health facility supply has no significant effect appears to be related to the introduction of the minority racial concentration interaction. When including race*racial composition interactions, the significant negative association between health facility supply and mammogram utilization disappeared. The descriptive statistics show that both black and Hispanic women in this subset of women (aged 40-84) live in counties with a higher average physician supply but a lower average health care facility supply than white women. Once this racial heterogeneity is controlled, we see that women living in counties with a greater supply of active MDs and OBGYNs are more likely to be screened regardless of the number of actual hospitals in the area and regardless of individual race/ethnicity. Therefore, the supply of physicians appears to be a community-level enabling factor (Andersen, 1995; Phillips et al., 1998) for mammogram utilization.

Study Limitations

Despite the strengths and new contributions of this study, there are additional limitations that must be considered in interpreting the results. First, the BRFSS suppression of county FIPS codes for counties with fewer than 50 respondents prevented me from including all U.S. counties in the analysis. However, maximum likelihood estimates employed in my multilevel models and my use of stratification weights reduces the bias associated with excluding these counties. Second, as with any cross-sectional data, the present time measures of mammogram use likely capture lifetime exposure to residential context, socioeconomic status, and health attitudes. Only longitudinal data with information on individuals and communities over time can shed light on the cumulative impact of residential context on screening utilization. Third, findings from previous research indicate that cancer screening rates may vary by type of health insurance coverage, with greater use of mammography among individuals in non-

managed care HMO plans (Baker et al., 2004). The health insurance variable available in the BRFSS data does not distinguish between different types of coverage. One explanation for why women are more likely to be screened in moderate percent black counties and counties with a greater physician supply may be that these counties have a greater saturation of non-managed care HMO plans. Fourth, the data do not allow me to capture inconsistencies between county of residence and county of service use. As suggested by Goodman et al. (2003), medical service provider coverage areas do not necessarily correspond to strict county boundaries. Women may travel to adjacent resource rich counties to obtain their screenings. Thus the economic conditions and screening service supply of adjacent counties may influence screening use. Future research could use spatial mapping and spatial data analysis techniques to examine differences in screening practices across adjacent counties as well as within counties. Future data collection efforts should also focus on smaller geographic levels (e.g. census tracts) that are more representative of actual community or neighborhood conditions.

Despite these limitations, this study makes several important contributions to the literatures on race, place, and health. First, the results build on existing evidence that physical and social environments are key determinants of health care utilization. Second, I extend research in this area by examining the relationship between individual race/ethnicity and mammogram utilization, while also examining whether the effect of race on mammogram utilization varies across spatial contexts. The strength of my data is that it is a nationally representative large sample of women with considerable detail about socioeconomic status, family structure, and health behavior at the individual level clustered within a large sample of counties across the United States. This large sample allowed me to conduct complex analyses related to additive and interactive effects of county-level conditions on racial variation in mammogram utilization.

Conclusion

In this article, I have examined the individual vs. contextual relationships between race/ethnicity and mammogram utilization and explored interactions between race/ethnicity and county economic factors, minority racial concentration, and health care supply on odds of having a recent screening. Findings reflect that the majority of the variation in mammogram utilization is explained by differences between individuals. However, a significant proportion of individual-level variation in mammogram use is attributable to differences at the county level. Net of controls for individual and contextual characteristics, black and Hispanic women are more likely than white women to have had a recent mammogram. The findings raise doubts about the applicability of a differential vulnerability

hypothesis for women of color living in disadvantaged communities. Overall, race/ethnicity does appear to have a greater influence on mammogram utilization in some counties than in others; the association between being black (vs. white) or Hispanic (vs. white) and obtaining a mammogram within the past two years is positive is some counties and negative in others. However, this variation is not explained by the county disadvantage variables examined here. This suggests a need for studies at additional units of analysis (e.g. Census tracts, block groups, etc.) that include alternative contextual conditions that may explain or moderate the relationship between race and mammogram use. Such conditions may include community collective efficacy, transportation services, the presence of non-profit organizations providing health services, HMO saturation, and the existence of screening educational campaigns.

Overall, my finding that women residing in counties with greater economic disadvantage and counties with moderate Hispanic populations are less likely to obtain mammograms, regardless of their individual race/ethnicity, suggests the need for targeted interventions, educational campaigns, and community based low-income screening clinics in these communities. Researchers and practitioners may also wish to examine when and how black and Hispanic women surpassed white women in mammogram utilization, given the plethora of previous findings that black and Hispanic women are less likely to be screened (Blustein et al., 1995; Burns et al., 1996; Fox and Stein, 1991; Selvin and Brett, 2003; McCarthy et al., 1998; O'Malley et al., 2001; Schneider et al., 2002; Somkin et al., 2004). Further, if black and Hispanic women are now more likely than white women to obtain mammograms, as is suggested by the present study as well as by findings from Benjamins et al (2004), Coughlin et al. (2002), and Coughlin et al. (2008), future studies should examine why black women continue to be diagnosed at a later stage in the disease and continue to have higher breast cancer mortality rates than white women.

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Figure 1. Conceptual Model of Contextual Conditions as Moderators in the Relationship between Race/Ethnicity and Mammogram Use

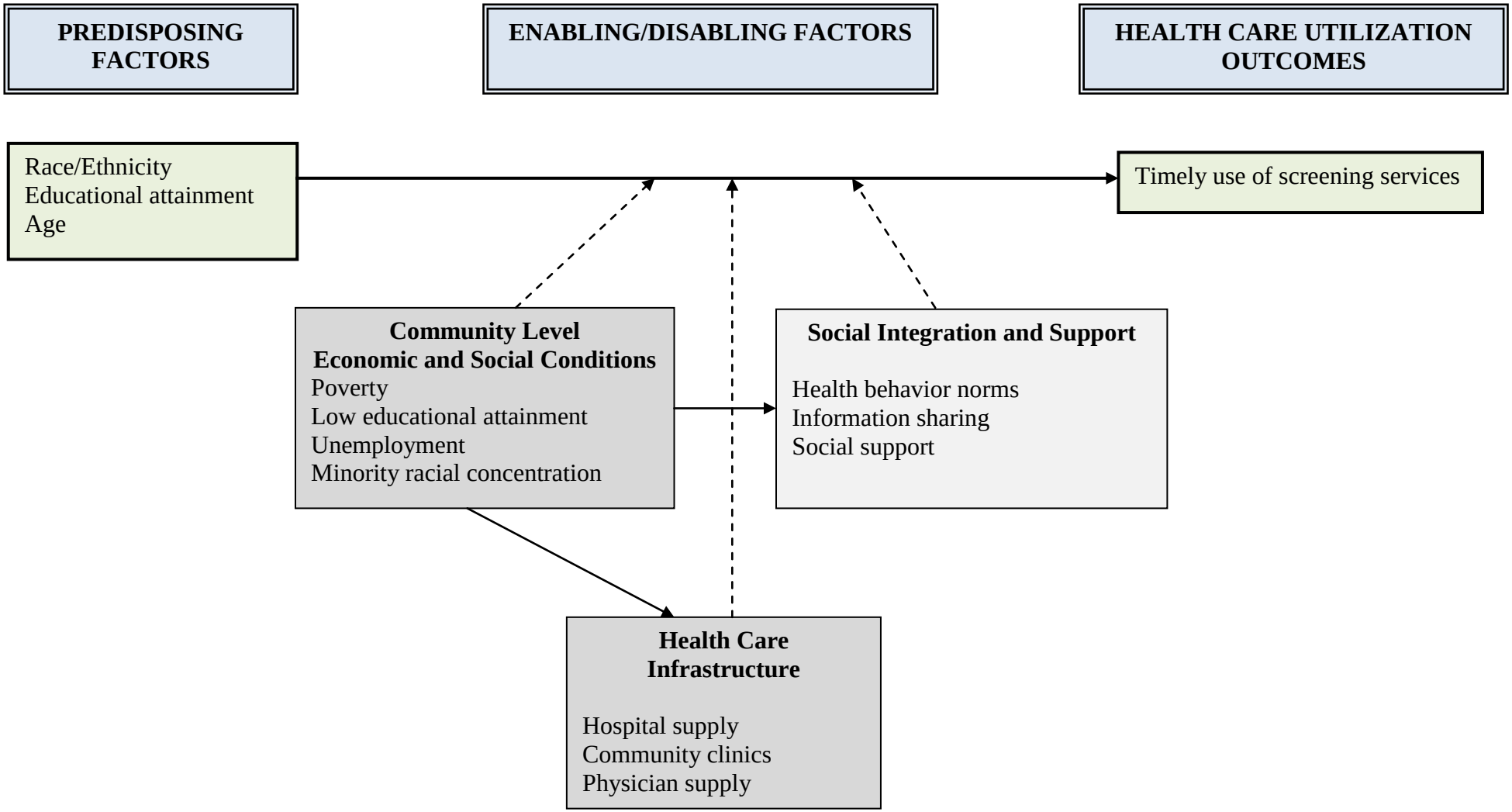

Table 1. Descriptive Statistics of Contextual and Individual Level Characteristics by Race/Ethnicity, US Women aged 40-84, 2006, 2008, 2010

	Full Sample N=356,010	White N=307,086	Black N=31,677	Hispanic N=17,247
Had mammogram in past 2 years	78.4	78.3	79.8	77.8
Contextual Independent Variables				
Economic disadvantage scale	49.5 (15.3)	47.3 (13.2)	55.5 (16.3)	61.2 (28.2)
Physician supply	31.8 (20.9)	30.7 (19.8)	38.9 (26.0)	32.4 (26.2)
Health care service supply	.95 (.86)	.99 (.99)	.84 (.83)	.70 (.85)
Minority Racial Concentration				
Low percent black	60.0	64.6	18.5	68.1
Moderate percent black	31.3	29.6	47.7	27.0
High percent black	8.7	5.8	33.9	4.9
Low percent Hispanic	48.9	53.9	46.0	10.7
Moderate percent Hispanic	24.6	25.6	25.0	16.2
High percent Hispanic	26.5	20.5	29.0	73.2
County Level Controls				
Lives in nonmetropolitan county	15.7	17.7	9.9	6.1
Region				
Northeast	19.7	20.5	18.4	14.5
Midwest	22.0	24.2	19.5	6.8
South	36.0	34.3	53.6	30.4
West	22.3	21.0	8.5	48.3
Individual Level Controls				
Household Income				
Less than $20,000	17.6	13.4	32.6	35.5
$20,000-49,000	34.8	34.0	38.6	37.7
$50,000 or more	47.6	52.6	28.9	26.8
Educational attainment				
Less than high school	8.6	5.4	12.6	30.7
High school graduate	56.7	57.3	60.0	48.1
4-year college graduate	34.7	37.3	27.4	21.3
Employed for wage or self-employed	52.4	52.8	51.3	50.4
Has any type of health care coverage	90.7	93.2	85.1	76.1
Time in past year when could not see doctor due to cost	12.8	10.4	19.5	25.4
Has a personal doctor/health care provider	91.4	92.9	90.1	80.9
Had a medical checkup in past 2 years	88.3	87.8	93.3	86.7
Self-rated health (fair/poor)	19.3	16.1	28.8	35.3
Smoker Status				
Never smoked	56.2	54.1	59.6	69.7
Former smoker	27.9	29.8	21.6	18.8
Current smoker	16.0	16.1	18.8	11.5
Weight				
Not overweight or obese	38.5	42.2	20.5	28.9
Overweight	32.4	31.9	33.5	35.3
Obese	29.1	26.0	46.0	35.9
Married	62.3	65.9	37.8	60.3
At least one child in household	28.5	26.0	33.7	43.4
Gets Emotional Support Needed (Always/Usually)	81.8	84.8	69.8	70.7
Age				

40-49	31.3	29.7	33.8	42.1
50-59	31.1	30.9	32.6	31.7
60-84	37.6	39.5	33.6	26.2

Note: Weighted values; Percentages reported for categorical variables; Means (standard deviations) presented for interval ratio variables. White-black differences for all variables significant at p<.001 level. White-Hispanic differences for all variables significance at p<.001 level, except had mammogram in past two years (ns).

Table 2. Multilevel Logistic Regression Models Predicting Association between Race/Ethnicity and Recent Mammogram, US Women aged 40-84

	Model 1 Null Model	Model 2 Fixed Effect	Model 3 Random Effects	Model 4 + Level 1 Controls
Intercept	1.155 (.012)***	1.156 (.012)***	1.156 (.012)***	-1.686 (.035)***
Individual Race (ref=white)	---	---	---	---
Black	---	.045 (.015)**	.121 (.032)***	.387 (.034)***
Hispanic	---	-.092 (.016)***	.003 (.043)	.385 (.048)***
Variance - County Level	.187 (.009)***	.186 (.009)***	.178 (.009)***	.122 (.008)***
Variance - Black	---	---	.468 (.046)***	.451 (.046)***
Variance - Hispanic	---	---	.892 (.080)***	1.076 (.094)***
Generalized Chi-Square/DF	.99	.99	.98	.97
Intraclass Correlation	.054	.054	.051	.036
Percent of County Variance Explained	-----	.500	5.56	33.3

Note: Log odds and (standard errors); weighted values. ***p< 0.001; **p<0.01; *p<0.05; two-tailed tests
Model 4 controls for age, education, employment status, household income, cost barrier to medical care in past year, health insurance coverage, has a regular doctor, had a checkup in past two years, self-rated health, smoking status, weight, marital status, presence of children in household, and gets emotional support needed.

Table 3. Multilevel Logistic Regression Models of the Effects of County-Level Factors on Mammogram Utilization among US Women aged 40-84

	Model 5	Model 6	Model 7	Model 8	w/o Random Slopes
Intercept	-1.657 (.042)***	-1.657 (.042)***	-1.657 (.042)***	-1.657 (.042)***	-1.609 (.042)***
Individual Race (ref=white)	---	---	---	---	---
Black	.389 (.034)***	.379 (.036)***	.417 (.068)***	.406 (.070)***	.301 (.042)***
Hispanic	.401 (.048)***	.393 (.049)***	.314 (.083)***	.336 (.088)***	.281 (.050)***
Contextual Independent Variables					
Economic disadvantage	-.060 (.016)***	-.063 (.016)***	-.062 (.016)***	-.063 (.016)***	-.077 (.016)***
*Black	---	.031 (.037)	.041 (.044)	.033 (.050)	.088 (.028)**
*Hispanic	---	.035 (.047)	-.006 (.056)	.020 (.060)	.056 (.023)*
Minority Racial Concentration	---	---	---	---	---
Moderate percent black	.057 (.029)*	.057 (.029)*	.056 (.029)*	.057 (.029)*	.065 (.029)*
*Black	---	---	-.029 (.079)	-.022 (.080)	.016 (.042)
*Hispanic	---	---	.014 (.111)	-.015 (.115)	-.128 (.041)**
High percent black	.086 (.043)*	.083 (.043)	.067 (.044)	.066 (.044)	.066 (.044)
*Black	---	---	.027 (.108)	.044 (.111)	.102 (.058)
*Hispanic	---	---	.290 (.195)	.250 (.202)	.355 (.092)***
Moderate percent Hispanic	-.083 (.027)**	-.083 (.027)**	-.084 (.028)**	-.083 (.028)**	-.084 (.028)**
*Black	---	---	.017 (.082)	.021 (.083)	.093 (.042)*
*Hispanic	---	---	.064 (.114)	.046 (.115)	.104 (.061)
High percent Hispanic	.002 (.042)	.001 (.042)	.006 (.042)	.009 (.042)	-.008 (.043)
*Black	---	---	-.329 (.111)**	-.322 (.115)**	-.189 (.048)***
*Hispanic	---	---	.164 (.138)	.117 (.141)	.116 (.061)
Health facility service supply	-.052 (.026)*	-.052 (.026)*	-.052 (.026)	-.044 (.027)	-.032 (.027)
*Black	---	---	---	-.047 (.115)	-.071 (.080)
*Hispanic	---	---	---	-.235 (.125)	-.308 (.079)***
Physician supply	.042 (.010)***	.042 (.010)***	.042 (.010)***	.043 (.010)***	.041 (.011)***
*Black	---	---	---	-.020 (.028)	-.033 (.013)*
*Hispanic	---	---	---	.005 (.047)	.037 (.017)*
Variance - County Level	.110 (.007)***	.110 (.007)***	.109 (.007)***	.109 (.007)***	.121 (.007)***
Variance - Black	.447 (.046)***	.446 (.046)***	.435 (.045)***	.437 (.046)***	---

Variance - Hispanic	1.070 (.093)***	1.069 (.093)***	1.065 (.093)***	1.057 (.093)***	---
Generalized Chi-Square/DF	.97	.97	.97	.97	.98
Intraclass Correlation	.032	.032	.032	.032	.035
Percent of County Var. Explained	40.7	40.7	40.7	40.7	35.2

Note: Log odds and (standard errors); weighted values. ***p< 0.001; **p<0.01; *p<0.05; two-tailed tests

All model include controls for metro vs. non-metro county, region, age, education, employment status, household income, cost barrier to medical care in past year, health insurance coverage, has a regular doctor, had a checkup in past two years, self-rated health, smoking status, weight, marital status, presence of children in household, and gets emotional support needed.

Appendix A. Multilevel Coefficients for all Control Variables from Full Random Effects Model (Model 8)

Individual Controls	Log Odds (SE)
Household income (ref = $50.000+)	---
$20,000-49,999	-.227 (.012)***
< $20,000	-.407 (.017)***
Education (ref=less than high school)	---
High school graduate	.037 (.017)*
4-year college degree	.174 (.020)***
Employed	.044 (.011)***
Cost barrier to medical care (1=yes)	-.214 (.014)***
Any health care coverage (1=yes)	.560 (.016)***
Personal doctor (1=yes)	.734 (.015)***
Checkup within past 2 years (1=yes)	1.810 (.013)***
Self rated health is fair/poor	-.182 (.012)***
Smoking status (ref=never smoked)	---
Current smoker	-.504 (.013)***
Former smoker	.012 (.011)
Weight (ref=normal weight)	---
Overweight	.064 (.011)***
Obese	-.060 (.012)***
Married	.175 (.011)***
At least one child in household (1=yes)	-.207 (.012)***
Always/Usually gets emotional support needed	.194 (.012)***
Age (ref=40-49)	
50-59	.366 (.013)***
60-84	.267 (.014)***
County Controls	
Nonmetropolitan county (1=yes)	-.030 (.026)
Region (ref=south)	
Northeast	.095 (.035)**
Midwest	.000 (.029)
West	-.017 (.037)

Note: Weighted values. ***p< 0.001; **p<0.01; *p<0.05; two-tailed tests