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Investigating reversals of association for utilization of recent mammography among Hispanic and Non-Hispanic Black women

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Abstract

Objective—Several papers have found that Hispanic and Non-Hispanic Black women have higher adjusted odds ratios for recent mammography when compared with Non-Hispanic White women, even though their crude percentages were lower than, or about equal to, Non-Hispanic White women's. This paper investigates the existence of "reversals" of association for recent mammography and describes an analysis strategy for identifying variables that might produce them.

Methods—We used every-other-year data for women aged 40–80 from the 1996–2006 Behavioral Risk Factor Surveillance System and the 1999, 2000, 2003, and 2005 National Health Interview Survey. A consistent set of covariates was used across all datasets.

Results—Reversals were found in almost all survey years for Hispanic women. Non-Hispanic Black women often had unadjusted rates comparable to Non-Hispanic Whites, but their adjusted odds ratios were significantly higher in most surveys. A limited number of variables contributed strongly to reversals, and differed somewhat for Hispanic and Black women.

Conclusions—Reversed associations found in adjusted analyses present a challenge for interpretation, but could also denote success of programs to increase screening rates. Users of population-level surveys should be alert for reversals and attempt to find explanations.

Keywords

Mammography; Behavioral science; Women's health; Preventive health services; Race/ethnicity

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Introduction

Studies to identify factors associated with greater versus lesser likelihood of obtaining cancer screening are among the most common in the literature, and make at least two important contributions to the nation's efforts at cancer control. One contribution complements the surveillance of aggregate trends in rates of utilization. Diffusion and adoption take time, and when disparities exist the correlates found in analyses provide information needed to target groups for programs, services, and national priorities such as *Healthy People* [1,2]. A second contribution is tracking the importance of a given correlate over time, especially as a screening test is available over many years. Such monitoring is commonly done for socio-demographic variables such as age, sex, education, race/ethnicity, income, marital status, insurance coverage, and usual source of care. Reports typically start with unadjusted analyses between several independent variables and an indicator of utilization. The next step is multivariable "adjusted" analysis, often using logistic regression. Sometimes there is an a priori variable of interest; other times the investigation is exploratory to find which variables achieve significance. This final set of variables (e.g., age, insurance status, and race/ethnicity) is used to specify groups who need targeted interventions to reduce disparities in utilization.

Multivariable analysis is expected to alter the magnitudes of some unadjusted associations with screening, due to adjustment for correlations among the covariates. Two situations have been common. In one instance, the adjusted odds ratios are consistent with results from the unadjusted analysis. That is, the adjusted odds for underserved, resource-poor groups are still significantly lower than the reference group and indicate lower utilization. The multivariable adjustment suggests that some benefit might occur if those groups had greater access to resources, but the continued disparity also shows the need to find additional factors that contribute to underutilization. The second common situation is when a significant unadjusted odds ratio is still less than 1.00 in the adjusted analysis, but no longer statistically significant, with the 95% confidence interval including 1.00. The usual interpretation in this latter situation is that the additional covariates explain the unadjusted association, so equalizing status on those factors might reduce or eliminate the disparity. In either case, the underserved group is considered a priority audience for intervention and/or social policy.

The contribution of adjusted analysis for policy decisions and intervention planning is especially salient when a factor associated with underutilization also has social relevance. One such factor is race/ethnicity. This paper was stimulated by a series of results in population-level datasets (summarized in Table 1) showing what seemed to be "reversed associations" for Non-White racial/ethnic groups, in analyses of the correlates of mammography. In its most extreme form, a "reversed association" occurred when a Non-White racial/ethnic group had a lower unadjusted screening rate when compared with Non-Hispanic Whites, but had an adjusted odds ratio that was significantly higher. In less extreme form, lower unadjusted odds ratios were non-significant after adjustment, but the adjusted odds ratio still "reversed" from being less than 1.00 to being greater than 1.00. These outcomes were different from the two common situations noted earlier, and suggested that different interpretations could be drawn from the results if unadjusted and adjusted results were compared. The studies included in Table 1 did not set out specifically to investigate the existence or magnitude of reversals of association, and as a result there was no standard methodology or presentation of results. The possibility of reversals is therefore an a posteriori observation that seems deserving of more systematic analysis.

The following abbreviations are used in Table 1 and throughout this paper: NHIS (National Health Interview Survey), BRFSS (Behavioral Risk Factor Surveillance System), HINTS (Health Information National Trends Survey), HRS (Health and Retirement Study), AHEAD

(Asset and Health Dynamics among the Oldest Old), MEPS (Medical Expenditure Panel Survey), AOR (adjusted odds ratio), and 95% CI (95% confidence interval).

Literature has not addressed in detail the possible reasons for higher adjusted odds ratios for Non-Hispanic Blacks and Hispanics. Martin et al. [7], Jones et al. [8], and Rakowski et al. [3] commented on convergence of self-reported screening rates in population-level surveys, suggesting that convergence of unadjusted rates makes it more probable to find reversals in favor of Hispanics and Blacks, because adjusted analyses estimate screening rates if access to resources were equalized. Adams et al.'s [9] analyses included variables for states' National Breast and Cervical Cancer Early Detection Program (NBCCEDP) programs and found that age of program was associated with higher mammography for women under age 65. In addition, the adjusted odds ratios for women with incomes under $10,000 did not differ significantly from higher income groups. Breen et al. [10] cited the availability of screening through the NBCCEDP, reporting requirements under the Health Plan Employer Data and Information Set (HEDIS), and campaigns to raise awareness of breast cancer as potential reasons.

The purpose of this paper was to investigate the existence of reversals for Non-White race/ethnicity groups when comparing unadjusted and adjusted results for recent mammography, using multiple years of the BRFSS and NHIS. The BRFSS and NHIS are routinely used to monitor cancer screening status and correlates of screening. Reversals of association for race/ethnicity have occurred in several studies, across multiple datasets, but without an incommon set of covariates or an a priori plan to investigate their existence. Sociodemographics are routinely used as potential correlates, but studies have differed beyond that. Adams et al. [9] had a limited socio-demographic set. Some papers have included other health behaviors, such as smoking, exercise/activity, seat belt use, Pap testing, dental visit, and alcohol use [3-6]. Contact with the health care system (hospitalizations, physician visits, and emergency room visits) has been included in some reports [6,8]. Ostbye et al. [6] included self-rated health and subjectively estimated life expectancy. The most diverse (though not comprehensive) set of psychosocial variables has been Rakowski et al. [5] with the HINTS, that included cancer worry and perceived risk; attention to, and trust of, information sources; perceived interval for mammography; perceived main causes of cancer deaths; and interference of one's mood with daily activities. Therefore, in order to provide a reference point for additional studies, the research reported here selected a set of socio-demographic variables, likely to be found in major surveys. In addition, a standard procedure was used to investigate variables that contributed to producing reversals.

The existence of racial/ethnic disparities in cancer screening rates can be investigated, and at least some interventions can be planned from, the perspectives of the classic Andersen Model that proposes need, predisposing, and enabling factors at the individual level [11] as well as social ecological models [12]. Disparities in utilization for a particular racial/ethnic group are the result of many contributing factors, the likelihood being that while specific barriers can differ from individual-to-individual, the number and severity of these factors disproportionately affect that group. The Andersen Model has not traditionally addressed in detail the processes by which need/predisposing/enabling factors operate, but it can accommodate a large range, and treats them as resources that are present or absent. In so far as interventions to reduce and eliminate disparities can be seen as efforts at resource delivery, resource support, and resource configuration, the Andersen Model provides a useful means of classification. The social ecological model in turn directs attention specifically to the multi-level sectors or domains from which need/predisposing/enabling factors can be drawn. The Andersen Model also has macro-level constructs, and so is compatible with social ecological approaches. For purposes of this investigation specific to mammography, three covariates used were considered predisposing (age, marital status, region) and four were viewed as being more directly enabling (income, health insurance, education, and usual source of care).

Methods

Data sources

Behavioral risk factor surveillance system—The BRFSS is a collaboration between the Centers for Disease Control and Prevention and each state and affiliated United States territory [13]. The BRFSS is an annual random-digit-dial telephone survey of the adult non-institutionalized population. Each state is responsible for its own survey. Each annual BRFSS is comprised: (1) a core set of questions required to be in each state's survey, (2) a number of optional, topic-specific modules asked by states at their discretion, and (3) items asked by each state to address its own priorities.

Public-use datasets were downloaded from the BRFSS website [14]. Women aged 40–80 were selected from the 1996/1998/2000/2002/2004/2006 BRFSS. Beginning in 2000, the Women's Health module has been included in the BRFSS core only in even-numbered years. The weighting formula for sampled persons is identical across states, so that each state has its own sample, but data can be aggregated to produce national-level estimates. The state-level median response rate has been gradually decreasing, from 63.2% in 1996 to 51.4% in 2006, reflecting the more general trend of lower response to phone-based surveys [15].

National health interview survey—The NHIS, conducted by the US Bureau of the Census, is an annual, in-person household interview of the civilian, non-institutionalized population conducted continuously throughout a calendar year. The NHIS has a complex sampling design based on stratification, clustering of samples, and multistage sampling. After 1995, the NHIS was redesigned to oversample Hispanics and Blacks [16,17]. Response rates have remained relatively high, when compared with surveys that rely on telephone-based recruitment, ranging from 69.6% (1999) to 74.2% (2005). Public-use datasets were downloaded from the NHIS website [18]. Women aged 40–80 were selected from the 1999/2000/2003/2005 NHIS. The 2000 and 2005 surveys included a full Cancer Control Module; the 1999 and 2003 NHIS asked about mammography as a part of the Adult Module. There were no questions about mammography in 2001/2002/2004/2006.

Dependent variables

The dependent variables for recent mammography from both the BRFSS and the NHIS were based on self-report, and coded as: within 2 years versus more than 2 years/Never had/Don't know or Refused to answer any of the questions to determine most recent screening.

Each BRFSS survey asked two closed-ended questions. The first assessed ever having a mammogram. For those who ever had, the second question asked for time since most recent examination using a pre-determined set of categories: less than 12 months, 12 months to less than 2 years, 2 years to less than 3 years, 3–5 years, and more than 5 years [19].

The 2000, 2003, and 2005 NHIS used four questions. The first assessed ever having a mammogram. The next question asked for month and year of the most recent mammogram. If that could not be recalled, another question asked for timing based on number of days/weeks/months/years prior to the interview. If that could not be recalled, a final question asked the same closed-ended categories as those in the BRFSS. In 1999, the question about specific month and year was not used.

Independent variables

Because this was an a priori investigation of reversed associations, and variables that contributed to those reversals, the unadjusted and adjusted analyses used the same set of independent variables across surveys. Our additional intention was to investigate a process for

studying reversals. The covariates listed below were the first ones chosen, and were chosen because they were in-common across all surveys. Each has been associated with recent mammography rates. In addition (except for a slight difference for income, noted below), each independent variable had the same categories, for each BRFSS and NHIS survey.

Race/ethnicity was defined as: Non-Hispanic White (reference group), Non-Hispanic Black, Hispanic, and Non-Hispanic other.

The six covariates in-common across all surveys were: age, income, education, insurance status, marital status, and Census region of the country. Age was coded as: 40–54, 55–64 (reference group), and 65–80. Income was coded in the BRFSS as: DK/refused, less than $20,000, $20,000–$34,999, $35,000–$49,999, and $50,000 or more (reference group). Due to available coding categories, income in the NHIS was grouped as: DK/refused, less than $20,000, $20,000–$34,999, $35,000–$54,999, and $55,000 or more (reference group).

Education was coded as: less than high school, high school graduate/GED, and some college, college graduate (reference group). Insurance status was dichotomized as: non-insured versus insured (reference group).

Marital status was coded as: never married, previously married (widowed/separated/divorced), and married/partnered (reference group). Region of the country used the four primary Census regions: West, Midwest, South, and Northeast (reference group).

Usual source of care was available in the 2002/2004/2006 core BRFSS and so was used in supplementary analyses for those survey years, and coded as: having no regular source of care versus having one or more sources (reference group).

Analysis plan

To account for the probability-based, complex sampling designs of the NHIS and BRFSS (i.e., multiple stages of sampling, stratification, and clustering), and to produce nationally representative estimates, all analyses were conducted using SAS-callable SUDAAN (Release 9.0.1; [20]). Because decisions about the presence of a reversal depend in part on the confidence interval around an odds ratio, it is essential to correct for sample design. Not doing this would result in smaller standard errors and tighter confidence intervals, increasing the possibility of finding an association deemed statistically significant.

Documenting "reversal" of association—The same procedure was used in each BRFSS and NHIS survey. Using a single-variable logistic regression, we first obtained the unadjusted odds ratio and 95% CI for race/ethnicity with recent mammography. Multivariable logistic regression was then used for an omnibus analysis with race/ethnicity and the other six variables, to derive the adjusted odds ratios and 95% CIs. The adjusted results were also used to create predicted estimates of mammography for each racial/ethnic group.

A comparison was made between the direction and magnitude of the unadjusted and adjusted odds ratios. We were looking for two types of reversals: (1) an unadjusted odds ratio for a Non-White racial/ethnic group that was significantly lower than for the Non-Hispanic White women, but became significantly higher after multivariable analysis and (2) an unadjusted odds ratio that was not significantly different, but an adjusted odds ratio that was significantly higher. We expected this second situation to be more likely if self-reported rates were relatively close in a particular survey. We also calculated percentage change between the unadjusted and adjusted odds ratios: [(adjusted OR – unadjusted OR)/unadjusted OR] × 100.

Investigating variables producing the reversal—After the omnibus adjusted regression, three sequences of analyses were done to identify the covariates most responsible for producing changes in the unadjusted odds ratio. If a reversal does occur, there will have likely been a sizeable change to the unadjusted odds ratio, and even a 10% change is often used as a criterion for identifying potential confounders. This strategy has been referred to as "change in point estimate" [21].

We conducted one analysis sequence each for Non-Hispanic Black, Hispanic, and Non-Hispanic other women. In the first sequence, that focused on Non-Hispanic Black women, each of the other six independent variables was entered individually with race/ethnicity, and the one producing the greatest change to their unadjusted odds ratio was identified. That variable was then paired with race/ethnicity and the process was repeated with the remaining five variables. The one producing the greatest change to the two-variable adjusted odds ratio for Non-Hispanic Black women was chosen, creating a triad of covariates, and the process repeated through the remaining variables (the last step therefore replicated the omnibus adjusted analysis).

This process was repeated twice more, focusing next on the Hispanic and then on the Non-Hispanic other women. The entire sample was therefore used in each sequence, because odds ratio changes of a different Non-White racial/ethnic group were the target in each sequence. The result was an order of entry based on the relative change in the odds ratio that each variable produced from the prior step of analysis, for each racial/ethnic group.

Results

Mammography rates

Tables 2 and 3 present results for the six BRFSS and four NHIS surveys, respectively. Sample sizes are shown next to the survey year. The left-most column shows the unadjusted recent mammography percentages and 95% CIs for each racial/ethnic group, and the next column shows the corresponding unadjusted odds ratios and CIs. The next column shows the predicted recent mammography rates and 95% CIs based on the omnibus adjusted analysis, and the right-most column shows the final adjusted odds ratios and CIs. Taken as a whole, there were 30 contrasts with Non-Hispanic White women, based on the three Non-White racial/ethnic groups in each of the ten surveys.

Reversals of association

None of the 20 contrasts involving Hispanic and Non-Hispanic Black women had adjusted odds ratios that were significantly lower than Non-Hispanic Whites, and in 17 of the 20 contrasts, the adjusted odds ratios were significantly higher. All three non-significant contrasts were in the NHIS. There were no reversals of associations for the Non-Hispanic other group of women.

BRFSS: 1996–2006—Table 2 shows that the unadjusted odds ratios for Non-Hispanic Black women were slightly above and below 1.00 in all six surveys, with all 95% CIs including 1.00. In the adjusted models, all six odds ratios exceeded 1.00, with 95% CIs that did not include 1.00. Relative changes between the unadjusted and adjusted odds ratios were: 39% ('96), 40% ('98), 45% ('00), 42% ('02), 43% ('04), and 49% ('06).

Each of the six BRFSS surveys showed unadjusted odds ratios for Hispanic women that were less than 1.00, with five 95% CIs not including 1.00. The adjusted odds ratios in all six surveys were greater than 1.00, with 95% CIs not including 1.00. Relative changes in the odds ratios were: 55% ('96), 70% ('98), 79% ('00), 80% ('02), 83% ('04), and 82% ('06).

NHIS: 1999–2005—Table 3 shows that the unadjusted odds for Non-Hispanic Black women were below 1.00 in all years, with 95% CIs not including 1.00 in 2000 and 2005. However, the adjusted odds ratios exceeded 1.00 in all surveys years, with 95% CIs that did not include 1.00 in 1999, 2003, and 2005. Relative odds ratio changes were comparable with the BRFSS: 42% (‘99), 49% (‘00), 52% (‘03), and 48% (‘05).

Each of the 4 years had unadjusted odds ratios for Hispanic women less than 1.00, with 95% CIs not including 1.00. The adjusted odds ratios were greater than 1.00, with 95% CIs not including 1.00, in 1999 and 2003. The odds ratio exceeded 1.00 in 2005, but the CI included 1.00. Despite non-significance in 2000 and 2005, the relative odds ratio changes were still large and comparable to the BRFSS: 72% (‘99), 60% (‘00), 84% (‘03), and 71% (‘05).

Variables contributing to reversals

Tables 4 (BRFSS) and 5 (NHIS) show the orders in which covariates contributed to producing odds ratio changes for Non-Hispanic Black and Hispanic women. Analyses for Non-Hispanic other women were not conducted because there were no reversals. The odds ratios heading each column are the unadjusted odds for the racial/ethnic group, as also shown in Tables 2 and 3. The last entry in each column is the fully adjusted odds ratio, also shown in Tables 2 and 3. The intermediate steps present the adjusted odds ratios and 95% CIs for the racial/ethnic group at each step of analysis, as well as the percentage change of the odds ratio from the prior step.

BRFSS 1996–2006—For Non-Hispanic Blacks, income alone was sufficient to produce a significant adjusted odds ratio for Black women in all years except 1998, and changed the odds ratio by at least 12% in all years. Age was prominent in more recent years, entering second in 2002, 2004, and 2006. Region was the last variable in all six surveys.

For Hispanic women, insurance and education were the first- and second-entering variables in each year, and each produced double-digit percentage changes to the odds ratios. Insurance produced changes in the odds ratios that exceeded 25% in all years. Age and income consistently occupied the third and fourth spots, while marital status and region were the last to enter the models, and sometimes attenuated the odds ratio slightly (indicated by a negative percentage change).

NHIS 1999–2005—For Non-Hispanic Black women, income was again the most important variable, producing at least a 15% change in the odd ratios in each survey, although more variables were needed to produce a reversal in the NHIS than in the BRFSS. Only income produced a double-digit percentage change. Region was again the last to enter the model.

For Hispanic women, orders of entry results were nearly identical to the BRFSS. Insurance and education continued to be the most influential variables, with insurance producing at least a 26% change in each year, and education at least 18%. Age and income were the third and fourth variables, with region and marital status entering the models last.

Usual source of care in the BRFSS

The analyses above were repeated for the 2002/2004/2006 BRFSS, adding usual source of care as a covariate. Results differed for Non-Hispanic Black and Non-Hispanic other women versus Hispanic women (tables available on request). For Hispanic women source of care became the first-entering variable in 2002, and the second variable (after insurance) in 2004 and 2006. Changes to the unadjusted odds ratios were 32.2% (‘02), 10.5% (‘04), and 15.4% (‘06). Compared to the fully adjusted odds ratios in Table 2, adding source of care increased the adjusted odds ratios for Hispanic women to: 2002 AOR = 1.42 (CI = 1.20–1.68), 2004 AOR

= 1.57 (CI = 1.36–1.82), and 2006 AOR = 1.70 (CI = 1.48–1.96). The associated percentage odds ratio changes were: 106% (‘02), 104% (‘04), and 102% (‘06).

In contrast, source of care was the last or next-to-last variable to enter the models for Black women in all analyses, and percentage changes to the preceding odds ratios were correspondingly minimal when entering the model: 0.20% (‘02), −0.99% (‘04), and 0.06% (‘06). Source of care also had no substantial effect for Non-Hispanic other women, with percentage changes to the odds ratio being: 3.25% (‘02), 1.46% (‘04), and 1.15% (‘06).

Discussion

Review of results

The purpose of this study was to be an initial step investigating reversed associations between race/ethnicity and recent mammography status, using multiple BRFSS and NHIS survey databases, and an in-common set of covariates. The findings supported several prior observations, and demonstrated two relatively uncommon situations. The reversals of association for Hispanic women in each of the six BRFSS surveys and in 2 years of the NHIS (1999, 2003), were situations where the unadjusted odds ratios were less than 1.00 and significantly lower than for Non-Hispanic Whites, whereas the adjusted odds were greater than 1.00 and achieved statistical significance. The results for Non-Hispanic Black women in all six BRFSS surveys and 2 years of the NHIS (1999, 2003) were situations where the unadjusted odds were between 0.91 and 1.05 and not significantly different from White women, while the adjusted odds were significantly higher. The results here make it important for users of these datasets to be alert for reversals when they analyze past, and especially future, BRFSS and NHIS surveys.

It is not possible to specify exactly the role that characteristics of the two surveys might have played in the results. The NHIS response rates have been and still are higher than the annual state median BRFSS rates, and the NHIS uses a more detailed assessment to determine recent mammography. The NHIS also uses in-person data collection. The BRFSS has state-by-state coverage, and does not rely on primary sampling units (PSUs) as in the NHIS. On the other hand, BRFSS implementation is complex because each state oversees conduct of its own survey. Regardless of the differences, however, the BRFSS and the NHIS each had evidence of reversals between race/ethnicity and recent mammography.

The percentage odds ratio changes from unadjusted to adjusted analyses were substantial for Black women, but were even larger for Hispanic women. The Non-Hispanic other group did not show reversals or even large relative changes in their odds ratios. What is unknown is the specific composition of these three broad racial/ethnic groups. Perhaps the Non-Hispanic other group had a more diverse racial/ethnic composition. The absence of reversals does not mean reversals are totally absent for all groups comprising the Non-Hispanic other racial/ethnic group. Similarly, these results do not mean that there would be reversals for all specific groups within the broadly defined Hispanic and Non-Hispanic Black populations. Group-specific analyses are necessary in order to further investigate the existence of reversals. Papers should include both unadjusted and adjusted odds ratios (along with 95% CIs), so that estimates of percentage change can be calculated.

The predicted recent mammography rates in Tables 2 and 3 demonstrate the influence of the multivariable adjustments. The predicted rates (which are “best estimates” in the presence of statistical control) increased for Hispanic and Black women relative to their unadjusted rates, while the predicted estimates for Whites decreased and became as much as 5–7% lower than for Hispanics and Blacks. Even in the two NHIS surveys, where Hispanic women did not show a statistically significant reversal (2000, 2005), their predicted estimates increased 9–11%,

which were the same magnitude as occurred for 1999 and 2003, where significant reversals did occur. Increases in predicted estimates for Black women were generally 4–5%, but reached about 6.5% in the 2003 and 2005 NHIS. Nonetheless, the predicted rates for Non-Hispanic Black and Hispanic women were still no higher than the low 80%'s, and were much lower for the Non-Hispanic other women. Investigators should consider including predicted estimates of screening. Crude rates are routinely provided, but the adjusted odds ratios create a different context and can be a practical piece of information to use in judging the impact of multivariable adjustment.

Conceptual considerations

Of the six in-common covariates used here, the ones most consistently entering the model first or second to contribute to reversals were in the enabling factors category of the Andersen Model (i.e., income, insurance, education). This finding is consistent with the fact that utilization of mammography requires practical, tangible resources. The fact that usual source of care performed differently for Hispanic and Non-Hispanic Black women is a caution that enabling factors will not always be the most important.

As noted earlier, however, we investigated reversals using a purposely limited set of socio-demographic variables commonly used in analyses of screening. Our primary objective was to provide a starting point to investigate the existence of racial/ethnic reversals of association. For these analyses of recent mammography, we found strong evidence of reversals with even the six covariates that were initially selected. We are therefore not proposing a specific group of variables that are "the" ones we believe would always contribute the most to producing reversals. As noted, adding source of care to the analyses with the three BRFSS surveys showed that other variables can affect results, and may not operate similarly for all racial/ethnic groups. Variables such as personal and family history of cancer are others that might be influential in adjusted analyses. We also did not include psychosocial variables such as perceived risk, self-efficacy, family/peer support, perceived benefits/barriers, factual knowledge about cancer, social capital or acculturation. The BRFSS and NHIS do not routinely ask such questions from year to year.

Given that the original six covariates yielded such consistent results for Hispanic and Non-Hispanic Black women, there appears to be a basis on which both to expand the covariates being used, and to analyze individual surveys that have such information. The Andersen Model has been expanded to better incorporate psychosocial variables, particularly in relation to studying racial/ethnic disparities in long-term care [22], which should also be a benefit for studies of cancer screening. Also in that regard, the covariates used here were not representative of multiple levels of analysis, as would be derived from a social ecological model. Region of the country was the closest macro-level variable. The potential to link datasets is growing steadily. Future studies can take advantage of links that allow using information from sources such as the Area Resources File, to include macro-level covariates for multi-level analyses.

Challenges presented by reversals

Reversals of associations can present a challenge for using adjusted analyses for intervention planning. Unadjusted data represent the association between two variables as it is in daily life, with all accompanying biases/confounds. When an adjusted reversal occurs for a socio-demographic variable such as race/ethnicity, the interpretation of that group having higher screening based on an all-else-equal, statistically based logic, directly contradicts the observed crude rate. The orders of entry in Tables 4 and 5 indicate that such a finding should not be seen as a quirk or random artifact of the dataset, but instead that it should be seen as a diagnostic clue that the dataset needs more extensive examination.

It is important for authors to provide not only the adjusted odds ratios for each covariate with the screening dependent variable, but also the unadjusted odds ratios. Doing so will allow assessing the percentage change from unadjusted to adjusted analyses, and the unadjusted data will provide a reference point for helping to interpret the adjusted analyses, in conjunction with information about predicted percentages. Ultimately, it is the unadjusted percentages of screening that matter in the day-to-day contexts of people's lives. Statistical adjustments do not reduce real-life disparities in utilization or produce declines in mortality and morbidity rates. Nothing in the results of the adjusted analyses here should be taken to argue against the at-risk status for lower recent mammography, especially among the Hispanic women.

It is important to consider the potential role of the CDC- and state-sponsored NBCCEDP, that has been operating for many years and exists in all 50 states [23,24]. Some papers have suggested that the program has been successful enough to contribute to the adjusted reversals in their studies. In effect, because the NBCCEDP circumvents some resource barriers, screening for at least some Non-White racial/ethnic groups would improve even though their socio-demographic resources would not have changed appreciably. The multivariate algorithms would therefore "over-correct" when estimating the adjusted odds ratios. The prominent roles of income and insurance contributing to changes in the unadjusted odds ratios support the possibility such an inference, given the NBCCEDP's eligibility criteria for receiving services. Our results into the mid-2000's may also represent the continuation of a result, though non-significant for Hispanics and Non-Hispanic Blacks, observed by Breen and colleagues with pooled data from the 1996–2000 BRFSS merged with NBCCEDP data [25].

The possible influence of social programs is another reason why it is important to understand the variables producing a reversal. If a successful program ends, but disparities on the resource/access variables that produce the disparities have not been redressed, the situation will be expected to return to its prior state and disparities will be evident in odds ratios even after multivariate adjustment. This argument is routinely used in the human service sector, especially in the context of shrinking budgets that threaten funding levels.

There are other challenges presented by reversals. The presence of reversals raises the question of the level or depth at which relationships between covariates have to be examined prior to conducting adjusted analyses. The situation underlying reversals appears to be more complex than two-variable confounding. Results here reinforce the importance of carefully examining each covariate that is used in a multivariable analysis. Another challenge is considering what reversals might imply in regard to which covariates should be included in a final adjusted model. Variables producing a reversal are as valid a part of the dataset as the unadjusted association that is reversed by the adjusted analysis. One option may be conducting stratum-specific analyses to identify correlates of screening within each category of a variable that produces a reversal.

Limitations and considerations

There are some considerations about these results. Self-report data are used in both the BRFSS and the NHIS, so absolute rates of mammography are likely to be higher than actually exist [26]. The response rates for both surveys have room for improvement. Response rate considerations raise the related issues of whether there may be systematic biases in three key areas: (1) the identification and contact of potential participants, (2) characteristics of persons who then agree to participate, and (3) self-reports of recency of utilization.

There may be differential race/ethnic response rates to the invitation to respond to a survey generally, or a health-related survey specifically. Prevalence estimates for recent mammography may be higher due to a "volunteer bias" of women more likely to have been screened, and the seeming convergence of mammography rates may be influenced even more

if there is a differential participation bias by Non-White women who are in higher SES strata and therefore more likely to have a recent mammogram. If there is also a general tendency to report mammograms more recently than actually occurred [26], analyses will be affected by having the traditionally underserved racial/ethnic women reporting higher rates than actually exist. Combined with any benefits of the NBCCEDP, reported mammography rates may appear to have converged more than is actually is the case. On the one hand, it could be informative to do analyses using insurance claims or other presumably official records. On the other hand, claims-based records can include a bias towards persons with characteristics associated with better coverage.

In addition, the results here are based on state- and national-level data. The results do not necessarily represent what would be found in regional, within-state, or purposively drawn local samples. It would be informative to conduct BRFSS-based analyses in states with relatively larger populations of Non-White racial/ethnic groups. Also, our results are specific to recent mammography. There is a need to investigate the existence of reversals and the variables producing them, for repeat mammography and for other screening domains (e.g., cervical, colorectal, and prostate). Analyses for these screening domains are underway and will be reported in subsequent papers. In conclusion, the presence of reversals is neither “good” nor “bad”—it is a feature of the relationship among variables in a dataset. The challenge is to understand why they occur and how to use the results in the context of intervention planning.

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Table 1

Summary of studies showing unadjusted crude rates and adjusted odds ratios (OR), and 95% confidence intervals (CI) for mammography: Blacks and Hispanics versus Non-Hispanic Whites

Study	Data sources and dependent variables[a]	Whites: unadjusted screening rate (%)	Blacks: unadjusted screening rate (%)	Hispanics: unadjusted screening rate (%)	Blacks: adjusted OR, 95% CI (relative to Whites)	Hispanics: adjusted OR, 95% CI (relative to Whites)
Rakowski et al. [3]	2000 NHIS					
	12 months (repeat)	50.5	46.0	38.3	1.29 (1.00–1.66)	1.31 (0.91–1.87)
	24 months (repeat)	65.6	61.8	51.9	1.33 (1.01–1.76)	1.21 (0.85–1.71)
Rakowski et al. [4]	2002 BRFSS					
	12 months (recent)	67.2	68.3	62.7	1.37 (1.18–1.58)	1.19 (0.95–1.50)
	24 months (recent)	81.0	82.3	77.7	1.38 (1.13–1.69)	1.31 (0.98–1.75)
Rakowski et al. [5]	2003 HINTS					
	24 months (recent)	82.8	82.8	74.6	2.60 (1.32–5.12)	1.16 (0.62–2.19)
	24 months (repeat)	74.3	67.7	65.5	1.58 (0.88–2.82)	1.37 (0.76–2.46)
Ostbye et al. [6]	1996 & 2000 HRS					
	24 months (recent: 1996 HRS)	72	73	N/A	1.37 (1.20–1.57)[b]	N/A
	24 months (recent: 2000 HRS)	77	78			
	1995 & 2000 AHEAD					
	24 months (recent: 1995 AHEAD)	54	57		1.57 (1.40–1.78)[b]	
	24 months (recent: 2000 AHEAD)	62	58			
Martin et al. [7]	1992 NHIS					
	12 months (recent)	29.9	23.0	28.6	1.0 (0.7–1.5)	1.4 (1.0–2.0)
Jones et al. [8]	1996 MEPS					
	12 months (recent)	51.9	49.8	50.8	1.20 (0.95–1.51)	1.39 (1.08–1.78)
	24 months (recent)	68.5	68.2	66.9	1.31 (1.04–1.66)	1.43 (1.07–1.91)
Adams et al. [9]	1996–2000 BRFSS					
	12 months (recent), age 40–64	N/A	N/A	N/A	1.34 (1.26–1.43)	1.39 (1.28–1.51)
	12 months (recent), age 65+				1.23 (1.12–1.35)	1.22 (1.06–1.41)

N/A data were not presented in published article

[a]Column entries indicate number of months used to define mammography interval. “Recent” refers to obtaining a mammogram within the specified time interval; “repeat” refers to obtaining two or more on-schedule mammograms, each in the specified time interval

[b]1996 and 2000 HRS data were pooled; 1995 and 2000 AHEAD data were pooled

Table 2

Crude percentages, unadjusted and multivariate-adjusted odds ratios[a], and predicted percentages[b] for race/ethnicity with recent mammography[c] in the 1996, 1998, 2000, 2002, 2004, and 2006 BRFSS surveys[d]

	1996 (*N* = 40,155)				1998 (*N* = 49,657)				2000 (*N* = 62,383)			
	Crude %	Unadjusted	Predicted %	Adjusted	Crude %	Unadjusted	Predicted %	Adjusted	Crude %	Unadjusted	Predicted %	Adjusted
Non-Hispanic White	71.2 ± 0.4	(ref)	69.9 ± 0.4	(ref)	73.5 ± 0.3	(ref)	72.1 ± 0.4	(ref)	77.4 ± 0.3	(ref)	75.9 ± 0.3	(ref)
Non-Hispanic Black	71.3 ± 1.1	1.01 (0.90–1.13)	76.2 ± 1.1	1.40 (1.23–1.59)	72.2 ± 1.1	0.94 (0.84–1.05)	76.9 ± 1.0	1.32 (1.16–1.49)	77.5 ± 0.9	1.00 (0.90–1.12)	81.6 ± 0.9	1.45 (1.28–1.64)
Hispanic	65.7 ± 1.8	0.78 (0.86–0.91)	73.5 ± 1.6	1.21 (1.01–1.44)	66.2 ± 1.7	0.71 (0.61–0.82)	75.5 ± 1.4	1.21 (1.02–1.43)	75.4 ± 1.4	0.90 (0.77–1.04)	83.1 ± 1.0	1.61 (1.37–1.89)
Non-Hispanic other	64.3 ± 2.9	0.73 (0.57–0.93)	64.9 ± 2.8	0.78 (0.60–1.02)	70.9 ± 2.5	0.88 (0.69–1.11)	70.9 ± 2.5	0.94 (0.73–1.21)	70.3 ± 2.3	0.69 (0.55–0.86)	71.3 ±2.3	0.78 (0.61–0.99)

	2002 (*N* = 89,359)				2004 (*N* = 117,966)				2006 (*N* = 148,241)			
	Crude %	Unadjusted	Predicted %	Adjusted	Crude %	Unadjusted	Predicted %	Adjusted	Crude %	Unadjusted	Predicted %	Adjusted
Non-Hispanic White	77.3 ± 0.3	(ref)	75.6 ± 0.3	(ref)	75.5 ± 0.3	(ref)	73.6 ± 0.3	(ref)	77.3 ± 0.2	(ref)	75.5 ± 0.2	(ref)
Non-Hispanic Black	77.7 ± 0.9	1.03 (0.92–1.14)	81.5 ± 0.8	1.46 (1.30–1.65)	75.4 ± 0.8	1.00 (0.91–1.09)	79.4 ± 0.8	1.42 (1.28–1.57)	78.2 ± 0.8	1.05 (0.96–1.15)	82.4 ± 0.7	1.57 (1.42–1.75)
Hispanic	70.2 ± 1.6	0.69 (0.60–0.81)	79.1 ± 1.3	1.25 (1.06–1.47)	70.2 ± 1.3	0.77 (0.68–0.87)	79.3 ± 1.0	1.41 (1.23–1.62)	74.1 ± 1.1	0.84 (0.75–0.95)	82.1 ± 0.9	1.53 (1.34–1.75)
Non-Hispanic other	70.3 ± 1.8	0.70 (0.58–0.83)	71.4 ± 1.8	0.80 (0.66–0.96)	66.9 ± 1.6	0.66 (0.57–0.76)	68.1 ± 1.5	0.75 (0.65–0.87)	71.7 ± 1.3	0.74 (0.65–0.84)	72.9 ± 1.2	0.86 (0.75–0.99)

[a] Adjusted for age, education, household income, health insurance, marital status, and Census region

[b] Predicted percentages calculated from regression weights in the adjusted models

[c] Recent mammography is defined as within the past 2 years

[d] 95% confidence intervals are indicated by ± signs under crude and predicted percentages, and by numbers in parentheses under unadjusted and adjusted odds ratios

Table 3

Crude percentages, unadjusted and multivariate-adjusted odds ratios[a], and predicted percentages[b] for race/ethnicity with recent mammography[c] in the 1999, 2000, 2003, and 2005 NHIS surveys[d]

	1999 (*N* = 9,649)				2000 (*N* = 10,069)			
	Crude %	**Unadjusted**	**Predicted %**	**Adjusted**	**Crude %**	**Unadjusted**	**Predicted %**	**Adjusted**
Non-Hispanic White	72.4 ± 0.6	(ref)	70.9 ± 0.6	(ref)	72.3 ± 0.7	(ref)	70.5 ± 0.7	(ref)
Non-Hispanic Black	70.5 ± 1.5	0.91 (0.78–1.07)	75.5 ± 1.3	1.29 (1.10–1.52)	66.3 ± 1.7	0.76 (0.65–0.88)	72.7 ± 1.6	1.12 (0.94–1.34)
Hispanic	65.4 ± 1.7	0.72 (0.62–0.84)	74.8 ± 1.4	1.24 (1.05–1.46)	60.2 ± 1.7	0.58 (0.50–0.68)	69.8 ± 1.6	0.96 (0.81–1.15)
Non-Hispanic other	57.5 ± 3.3	0.52 (0.39–0.68)	59.7 ± 3.3	0.58 (0.43–0.79)	49.3 ± 4.2	0.37 (0.27–0.52)	52.6 ± 4.0	0.43 (0.30–0.61)

	2003 (*N* = 9,797)				2005 (*N* = 10,130)			
	Crude %	**Unadjusted**	**Predicted %**	**Adjusted**	**Crude %**	**Unadjusted**	**Predicted %**	**Adjusted**
Non-Hispanic White	70.6 ± 0.7	(ref)	69.0 ± 0.7	(ref)	67.6 ± 0.7	(ref)	65.9 ± 0.7	(ref)
Non-Hispanic Black	69.0 ± 1.6	0.92 (0.79–1.08)	75.2 ± 1.4	1.40 (1.17–1.67)	63.5 ± 1.6	0.83 (0.72–0.97)	70.1 ± 1.5	1.23 (1.05–1.44)
Hispanic	63.8 ± 1.7	0.73 (0.62–0.86)	74.5 ± 1.6	1.34 (1.10–1.64)	56.9 ± 2.0	0.63 (0.54–0.75)	67.5 ± 1.8	1.08 (0.90–1.30)
Non-Hispanic other	60.2 ± 3.4	0.63 (0.47–0.84)	62.2 ± 3.3	0.72 (0.53–0.97)	54.1 ± 3.3	0.57 (0.43–0.74)	54.7 ± 3.2	0.60 (0.46–0.79)

[a] Adjusted for age, education, household income, health insurance, marital status, and Census region

[b] Predicted percentages calculated from regression weights in the adjusted models

[c] Recent mammography is defined as within the past 2 years

[d] 95% confidence intervals are indicated by ± signs under crude and predicted percentages, and by numbers in parentheses under unadjusted and adjusted odds ratios

Table 4

Covariates contributing to changes from unadjusted to multivariable-adjusted odds ratios for Hispanic and African-American Women in the 1996, 1998, 2000, 2002, 2004, and 2006 BRFSS surveys

1996 (*N* = 40,155)			1998 (*N* = 49,657)			2000 (*N* = 62,383)		
Covariate	**Odds ratio**[a]	**% Change**[b]	**Covariate**	**Odds ratio**	**% Change**	**Covariate**	**Odds ratio**	**% Change**
Non-Hispanic Black	1.01	–		0.94	–		1.00	–
Income	1.14 (1.01,1.28)	12.60	Insurance	1.05 (0.94,1.18)	12.61	Income	1.16 (1.03,1.29)	15.15
Insurance	1.23 (1.09,1.39)	8.28	Education	1.15 (1.02,1.29)	9.01	Insurance	1.26 (1.12,1.42)	9.35
Age	1.29 (1.14,1.46)	4.64	Marital status	1.22 (1.08,1.38)	6.09	Age	1.33 (1.17,1.50)	4.99
Marital status	1.34 (1.18,1.52)	4.20	Age	1.28 (1.13,1.45)	4.92	Education	1.38 (1.22,1.56)	3.77
Education	1.40 (1.24,1.59)	4.78	Income	1.32 (1.17,1.50)	3.52	Marital status	1.43 (1.27,1.62)	4.14
Region	1.40 (1.23,1.59)	−0.07	Region	1.32 (1.16,1.49)	−0.60	Region	1.45 (1.28,1.64)	1.06
Hispanic	0.78	–		0.71	–		0.90	–
Insurance	0.98 (0.83,1.16)	25.58	Insurance	0.90 (0.76,1.07)	27.76	Insurance	1.21 (1.02,1.29)	33.48
Education	1.09 (0.92,1.30)	11.87	Education	1.04 (0.88,1.23)	15.41	Education	1.44 (1.23,1.69)	20.23
Age	1.16 (0.98,1.38)	6.22	Age	1.13 (0.96,1.34)	8.93	Age	1.54 (1.31,1.81)	7.23
Income	1.24 (1.04,1.48)	6.98	Income	1.21 (1.02,1.43)	6.79	Income	1.65 (1.40,1.94)	6.87
Marital status	1.24 (1.04,1.48)	−0.16	Region	1.21 (1.02,1.43)	0.00	Marital status	1.64 (1.39,1.92)	−0.79
Region	1.21 (1.01,1.44)	−2.58	Marital status	1.21 (1.02,1.43)	0.00	Region	1.61 (1.37,1.89)	−1.71

2002 (*N* = 89,359)			2004 (*N* = 117,966)			2006 (*N* = 148,241)		
Covariate	**Odds ratio**	**% Change**	**Covariate**	**Odds ratio**	**% Change**	**Covariate**	**Odds ratio**	**% Change**
Non-Hispanic Black	1.03	–		1.00	–		1.05	–
Income	1.19 (1.07,1.32)	15.79	Income	1.16 (1.06,1.28)	16.98	Income	1.24 (1.13,1.36)	17.97
Age	1.31 (1.17,1.46)	9.93	Age	1.30 (1.18,1.43)	11.15	Age	1.39 (1.26,1.53)	11.60
Insurance	1.37 (1.22,1.53)	4.52	Insurance	1.35 (1.23,1.49)	4.16	Marital status	1.46 (1.32,1.61)	5.13
Marital status	1.43 (1.27,1.61)	4.47	Marital status	1.39 (1.26,1.54)	2.74	Insurance	1.52 (1.38,1.69)	4.60
Education	1.48 (1.31,1.66)	3.44	Education	1.42 (1.28,1.57)	2.09	Education	1.56 (1.41,1.73)	2.69
Region	1.46 (1.30,1.65)	−0.88	Region	1.42 (1.28,1.57)	0.07	Region	1.57 (1.42,1.75)	0.58
Hispanic	0.69	–		0.77	–		0.84	–
Insurance	0.89 (0.76,1.06)	28.86	Insurance	1.03 (0.90,1.17)	34.46	Insurance	1.16 (1.10,1.32)	37.69
Education	1.06 (0.90,1.25)	18.48	Education	1.17 (1.02,1.34)	13.69	Education	1.33 (1.16,1.41)	14.94

2002 (*N* = 89,359)			2004 (*N* = 117,966)			2006 (*N* = 148,241)		
Covariate	**Odds ratio**	**% Change**	**Covariate**	**Odds ratio**	**% Change**	**Covariate**	**Odds ratio**	**% Change**
Age	1.14 (0.96,1.34)	7.47	Age	1.28 (1.12,1.47)	9.22	Age	1.44 (1.26,1.65)	8.11
Income	1.21 (1.02,1.43)	6.24	Income	1.40 (1.22,1.60)	9.07	Income	1.55 (1.35,1.78)	7.78
Region	1.25 (1.06,1.47)	3.64	Region	1.42 (1.24,1.63)	1.72	Region	1.55 (1.36,1.77)	0.06
Marital status	1.25 (1.06,1.47)	−0.56	Marital status	1.41 (1.23,1.62)	−0.78	Marital status	1.53 (1.34,1.75)	−1.35

[a]The race/ethnicity odds ratio heading a column is unadjusted. Subsequent race/ethnicity odds ratios are adjusted for covariates up to that step

[b]Covariates are listed in the order of which they produced change to the odds ratio in the prior step. Percentage change is from the prior step. All odds ratios are for race/ethnicity

Table 5

Covariates contributing to changes from unadjusted to multivariable-adjusted odds ratios for Hispanic and African-American Women in the 1999, 2000, 2003, and 2005 NHIS surveys

1999 (*N* = 9,649)			2000 (*N* = 10,069)		
Covariate	**Odds ratio**[a]	**% Change**[b]	**Covariate**	**Odds ratio**	**% Change**
Non-Hispanic Black	0.91	–		0.76	–
Income	1.05 (0.90,1.24)	15.7	Income	0.89 (0.76,1.05)	17.6
Insurance	1.13 (0.96,1.32)	6.8	Insurance	0.96 (0.82,1.13)	8.2
Marital status	1.17 (0.99,1.38)	4.0	Marital status	1.01 (0.86,1.20)	5.4
Education	1.21 (1.03,1.43)	3.8	Education	1.07 (0.90,1.26)	5.2
Age	1.28 (1.08,1.50)	5.1	Age	1.11 (0.93,1.33)	4.3
Region	1.29 (1.10,1.52)	1.1	Region	1.12 (0.94,1.34)	1.0
Hispanic	0.72	–		0.58	–
Insurance	0.92 (0.79,1.07)	27.9	Insurance	0.73 (0.62,0.87)	26.3
Education	1.14 (0.98,1.33)	23.9	Education	0.89 (0.75,1.06)	21.3
Age	1.18 (1.01,1.38)	3.3	Age	0.91 (0.77,1.09)	2.6
Income	1.21 (1.04,1.41)	2.7	Income	0.95 (0.80,1.13)	3.7
Region	1.22 (1.04,1.44)	1.1	Region	0.96 (0.80,1.14)	1.0
Marital status	1.24 (1.05,1.46)	1.1	Marital status	0.96 (0.81,1.15)	0.5

2003 (*N* = 9,797)			2005 (*N* = 10,130)		
Covariate	**Odds ratio**	**% Change**	**Covariate**	**Odds ratio**	**% Change**
Non-Hispanic Black	0.92	–		0.83	–
Income	1.07 (0.91,1.23)	15.7	Income	1.00 (0.86,1.16)	19.7
Insurance	1.17 (0.99,1.38)	9.1	Age	1.06 (0.91,1.24)	6.3
Education	1.24 (1.05,1.47)	6.5	Education	1.13 (0.97,1.32)	6.4
Age	1.32 (1.11,1.57)	6.1	Marital status	1.21 (1.03,1.41)	6.7
Marital status	1.40 (1.17,1.67)	6.0	Insurance	1.24 (1.06,1.44)	2.5
Region	1.40 (1.17,1.67)	0.0	Region	1.23 (1.05,1.44)	−0.2
Hispanic	0.73	–		0.63	–
Insurance	0.99 (0.83,1.18)	35.1	Insurance	0.83 (0.80,1.07)	30.7
Education	1.17 (0.96,1.42)	18.1	Education	1.01 (0.85,1.20)	21.9

2003 (*N* = 9,797)			2005 (*N* = 10,130)		
Covariate	**Odds ratio**	**% Change**	**Covariate**	**Odds ratio**	**% Change**
Age	1.23 (1.01,1.50)	5.5	Age	1.04 (0.87,1.24)	3.1
Income	1.30 (1.06,1.59)	5.4	Income	1.07 (0.88,1.26)	3.0
Region	1.35 (1.11,1.65)	3.9	Marital status	1.07 (0.90,1.29)	0.4
Marital status	1.34 (1.10,1.64)	−0.3	Region	1.08 (0.90,1.30)	0.4

[a]The race/ethnicity odds ratio heading a column is unadjusted. Subsequent race/ethnicity odds ratios are adjusted for covariates up to that step

[b]Covariates are listed in the order of which they produced change to the odds ratio in the prior step. Percentage change is from the prior step. All odds ratios are for race/ethnicity