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Research Article

Understanding Reversals of Association between Cancer Screening and Race/Ethnicity

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Abstract

Background: We used a composite variable composed of insurance status, income, and race/ethnicity to investigate access-enhancing programs as a possible reason for "reversals of association" and large percent changes (LPC), between race/ethnicity and cancer screening, when comparing the unadjusted and adjusted ORs.

Methods: Data were from women aged 40–64 years, using the combined 2008 and 2010 Behavioral Risk Factor Surveillance System surveys. Recent mammography was within the past 2 years, and recent Pap testing was within the past 3 years. Initial analyses using all variables singly were followed by analyses that used the composite variable with the remaining covariates.

Results: Analyses with race/ethnicity singly indicated reversals of association for Hispanic women and higher estimated screening for black and Hispanic women than for white women. Analyses with the composite variable found no reversals of association, but there were several LPCs for Hispanic and black women, for lower income, and for uninsured women. White, uninsured, lower income women were among those with the lowest utilization.

Conclusions: Results were consistent with the possibility that access-enhancing programs for lower income, uninsured and often non-white women can lead to overestimates of screening, reversals of association, and LPCs in multivariable analyses. Attention should be given to identifying LPCs to unadjusted ORs. Lower income, uninsured, white women are also a group at risk of extremely low mammography and Pap test utilization.

Impact: Combining variables to create better-targeted population subgroups may help in the interpretation of analyses that produce reversals of association and LPCs for correlates of cancer screening utilization. *Cancer Epidemiol Biomarkers Prev; 21(9); 1450–7. ©2012 AACR.*

Introduction

The development of programs to reduce cancer morbidity and mortality rely heavily on accurate epidemiologic surveillance to identify groups with underutilization of screening (1). Surveillance is typically a combination of univariate/unadjusted and multivariable/adjusted analyses. Policy makers and advocates use these data to identify priority populations for access-enhancing programs. Surveillance tracks these populations over time, monitoring whether new disparities emerge and determining whether or not existing disparities are being mitigated.

Logistic regression has typically been used for conducting these multivariable, adjusted analyses. Some analyses examine which covariates from unadjusted analysis retain statistically significant associations with screening but have no predetermined variable(s)-of-interest. Other analyses investigate a specific variable or category of variables, with the remaining covariates serving as statistical controls, to determine whether a disparity found in unadjusted analysis remains after adjustment. This latter analysis usually has either of 2 outcomes. One is that the variable(s)-of-interest continues to be associated with lower screening (2), supporting the need for advocacy to increase access and utilization via targeted programs and policies and also justifying a continued search for factors causing the disparity. A second outcome is that a disparity at the unadjusted level is eliminated (3), implying that equalizing groups on one or more covariates or finding ways to circumvent those barriers, could remove the disparity. In either case, objectives of public health care advocacy are served.

However, even adjusted analyses can produce unexpected results that are difficult to interpret. The purpose of

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this article is to further investigate one such phenomenon; that is, the existence of "reversals of association" between race/ethnicity and screening utilization at the level of main-effects results (4, 5). A "reversed association" denotes a situation in which a non-white racial/ethnic group has a statistically significant, lower unadjusted OR (UOR) than non-Hispanic Whites but has a multivariable adjusted OR (AOR) greater than 1.00, which achieves statistical significance. In a less extreme form, a nonsignificant UOR for a non-white racial/ethnic group becomes statistically significantly higher after adjustment. Each outcome indicates significantly higher estimated screening for non-white groups, which differs from expectations based on historical patterns of racial/ethnic disparities in health care status and service utilization. To those unfamiliar with adjusted, multivariable analyses, reversals of association can therefore make it appear that non-whites have higher screening utilization than whites. However, reversals of association are outcomes of statistical analyses and not explanations for why the phenomenon occurs.

Reversals of association are often accompanied by large percent changes (LPC) when comparing a group's UOR to their AOR. In a prior article (5), we used a 50% relative change as the criterion for an LPC. For example, a UOR of 0.50 and an AOR of 0.75 would have a percent change of 50% [(0.75 − 0.50)/0.50]. In analyses of Pap testing, Hispanic women had percent changes of 145%, 144%, and 132% in the 2004/2006/2008 BRFSS, respectively. In another article (4), Hispanic women had percent changes of 55% to 84% across the 1996–2006 BRFSS and the 1999–2005 NHIS, using recent mammography as the dependent variable.

An LPC can be important in its own right, however, because LPCs do not have to produce reversals of associations. That is, if a racial/ethnic group's crude/unadjusted utilization percentage is very discrepant compared with whites for a specific reference year, a statistically significant reversals of association is not realistically possible even if there is an LPC. However, if racial/ethnic groups' utilization rates converge over a period of years after that reference point, the possibility of a reversal of association increases. A reversed association will therefore appear to have emerged without warning, when in fact, it was developing over a period of years, and could have been detected by checking for LPCs.

Prior articles (4, 5) investigated reversals of associations only with main-effect independent variables used singly and not in combination to create more targeted population subgroups. However, because reversals of associations and LPCs were seen most often for mammography and Pap testing, compared with colorectal and prostate testing, we considered it possible that the existence of access-enhancing social programs, such as the National Breast and Cervical Cancer Early Detection Program (NBCCEDP) and parallel state and local initiatives, might help explain reversals of associations and LPCs. In contrast, there are no nationally comprehensive access-enhancing initiatives for colorectal and prostate testing. However, there is a growing emphasis on colorectal testing since the late 1990s, including a current 5-year initiative through the CDC with 25 states and 4 tribal organizations (6, 7). Programs for mammography and Pap testing typically prioritize reaching uninsured, lower income, and non-white racial/ethnic groups, but they do not change these disadvantaged women's status on key sociodemographic resources (e.g., income, health care insurance). As a result, multivariable analyses may overestimate the predicted screening utilization of non-white women, producing LPCs and reversals of associations. These reversals of associations and LPCs results may therefore indicate the initial steps of success of access-enhancing programs, even when disparities continue to exist, and suggest the possible benefit of focusing on a variable that combines race/ethnicity, insurance status, and income.

This report extends those prior articles (4, 5) by utilizing a composite variable of race/ethnicity, health care insurance, and income to investigate one possible explanation for why reversals of associations and LPCs for race/ethnicity as a single, stand-alone variable have occurred. This composite variable is based on the existence of access-enhancing programs for mammography and Pap testing, and the uninsured, lower income, and often minority group women they are intended to serve. Specifically, if uninsured status, lower income, and non-white race/ethnicity are used to define the composite variable, our hypothesis was that reversals of associations and LPCs would be more likely to occur for the women in those groups than for insured, higher income, and white women.

Materials and Methods

Data sources

Analyses used data for women aged 40–64, from the 2 most recent BRFSS surveys (2008, 2010) that had the necessary questions to create the mammography and Pap testing dependent variables. Sample size (see Tables 1 and 2) was lower for Pap testing because Pap testing is generally reserved for women with an intact uterus. The 2 surveys were combined because the composite variable of race/ethnicity, income, and insurance status (described below) produced a large number of subcategories and we wanted to have optimally large samples in each group. Questions asked in 2008 and 2010 were identical for the variables used here. Analyses of the 2008 and 2010 data separately (not reported here; available upon request) showed highly similar results compared with the combined datasets.

The BRFSS, a collaboration between the Centers for Disease Control and Prevention and each state and affiliated U.S. territory (8), is an annual telephone survey of the U.S. adult noninstitutionalized population, conducted continuously throughout the year, using disproportionate stratified random sampling (8).

Table 1. Crude percentages, UOR and AOR, and predicted percentages for race/ethnicity with recent mammography in the 2008/2010 BRFSS ($N = 248{,}110$)

		Unadjusted			Adjusted[a]			
Ages 40–64	**Sample size (*n*)**	**Crude%**	**95% CI**	**OR (95% CI)**	**Predicted%**	**95% CI**	**OR (95% CI)**	**% Change**
Non-Hispanic white	198,249	74.8	±0.2	(ref)	72.4	±0.2	(ref)	—
Non-Hispanic black	22,516	76.2	±0.5	1.08 (1.01–1.14)	79.3	±0.5	1.53 (1.43–1.64)	41.7
Hispanic	14,612	70.4	±0.7	***0.80*** *(0.75–0.86)*	81.2	±0.6	***1.77*** *(1.63–1.93)*	**121.3**
Non-Hispanic other	12,733	66.5	±0.9	0.67 (0.62–0.72)	68.3	±0.8	0.80 (0.74–0.87)	19.4
		Unadjusted			**Adjusted[b]**			
Race × insurance × income		**Crude%**	**95% CI**	**OR (95% CI)**	**Predicted%**	**95% CI**	**OR (95% CI)**	
Non-Hispanic white								
Insured								
Low income	39,823	69.3	±0.4	0.55 (0.52–0.57)	68.4	±0.4	0.57 (0.55–0.60)	3.6
High income	118,966	80.5	±0.2	(ref)	78.5	±0.2	(ref)	—
Missing	18,411	79.3	±0.5	0.93 (0.87–0.99)	77.4	±0.5	0.93 (0.87–1.00)	0.0
Uninsured								
Low income	13,395	37.3	±0.7	0.14 (0.14–0.15)	44.9	±0.8	0.20 (0.19–0.22)	42.9
High income	5,006	48.4	±1.2	0.23 (0.21–0.25)	52.6	±1.2	0.28 (0.25–0.31)	21.7
Missing	2,448	42.6	±1.7	0.18 (0.16–0.21)	48.7	±1.8	0.24 (0.21–0.28)	33.3
Non-Hispanic black Insured								
Low income	8,670	76.7	±0.9	0.80 (0.72–0.89)	76.9	±0.9	0.91 (0.81–1.02)	13.8
High income	7,710	84.4	±0.7	1.31 (1.17–1.46)	83.1	±0.8	1.37 (1.22–1.54)	4.6
Missing	1,766	80.4	±1.8	1.00 (0.80–1.25)	79.2	±1.9	1.05 (0.83–1.33)	5.0
Uninsured								
Low income	3,338	53.5	±1.6	**0.28** (0.25–0.32)	63.9	±1.6	**0.46** (0.40–0.53)	**64.3**
High income	521	63.8	±3.7	0.43 (0.31–0.58)	69.7	±3.2	0.61 (0.44–0.84)	41.9
Missing	468	57.8	±4.0	**0.33** (0.24–0.46)	66.0	±3.6	**0.51** (0.36–0.72)	**54.5**
Hispanic Insured								
Low income	4,574	76.3	±1.2	0.78 (0.68–0.89)	80.7	±1.1	1.15 (1.00–1.33)	47.4
High income	4,588	79.2	±1.1	0.92 (0.81–1.05)	79.6	±1.0	1.07 (0.94–1.22)	16.3
Missing	1,128	66.0	±2.8	0.47 (0.37–0.60)	71.5	±2.6	0.67 (0.51–0.88)	42.6
Uninsured								
Low income	3,156	58.8	±1.6	**0.35** (0.30–0.39)	73.7	±1.4	**0.75** (0.65–0.87)	**114.3**
High income	507	50.7	±4.0	**0.25** (0.18–0.34)	64.8	±3.6	**0.48** (0.35–0.67)	**92.0**
Missing	624	52.3	±3.7	**0.27** (0.20–0.36)	71.9	±3.6	**0.68** (0.47–0.99)	**151.9**
Non-Hispanic other Insured								
Low income	3,624	65.1	±1.7	0.45 (0.39–0.52)	66.5	±1.6	0.52 (0.45–0.61)	15.6
High income	5,982	74.6	±1.1	0.71 (0.64–0.80)	73.8	±1.1	0.76 (0.68–0.86)	7.0
Missing	1,094	64.3	±2.9	0.44 (0.34–0.56)	67.1	±2.6	0.54 (0.42–0.69)	22.7
Uninsured								
Low income	1,317	38.9	±2.6	**0.15** (0.12–0.19)	47.9	±2.9	**0.23** (0.18–0.29)	**53.3**
High Income	465	45.2	±5.0	0.20 (0.14–0.30)	52.7	±5.0	0.28 (0.19–0.43)	40.0
Missing	228	35.1	±6.1	0.13 (0.08–0.22)	42.8	±6.7	0.19 (0.11–0.33)	46.2

NOTE: LPCs to the UORs are **in bold**. Reversed associations are in italics.

[a]Multivariable logistic regression independent variables: race/ethnicity, income, insurance status, age, usual source of care, education, marital status, and census region.

[b]Multivariable analysis with composite variable adjusted for: age, usual source of care, education, marital status, and census region.

Dependent variables

The BRFSS uses predetermined categories to assess most recent mammogram and Pap test. All data are self-report.

Mammography. The analysis sample was women aged 40–64. Routine screening mammography generally begins at 40, and Medicare coverage begins at age 65. Access-enhancing programs would therefore be most

Table 2. Crude percentages, UOR and AOR, and predicted percentages for race/ethnicity with recent Pap testing in the 2008/2010 BRFSS ($N = 177{,}850$)

		Unadjusted			Adjusted[a]			
Ages 40–64	**Sample size (*n*)**	**Crude%**	**95% CI**	**OR (95% CI)**	**Predicted%**	**95% CI**	**OR (95% CI)**	**% Change**
Non-Hispanic white	142,712	85.7	±0.2	(ref)	83.8	±0.2	(ref)	—
Non-Hispanic black	14,614	85.8	±0.5	1.01 (0.92–1.11)	88.5	±0.5	1.56 (1.40–1.73)	**54.5**
Hispanic	11,006	81.7	±0.7	***0.75*** *(0.68–0.82)*	89.7	±0.5	***1.80*** *(1.60–2.03)*	**140.0**
Non-Hispanic other	9,518	76.9	±0.9	0.56 (0.50–0.62)	77.7	±0.8	0.64 (0.57–0.71)	14.3%
		Unadjusted			**Adjusted[b]**			
Race × insurance × income		**Crude%**	**95% CI**	**OR (95% CI)**	**Predicted%**	**95% CI**	**OR (95% CI)**	
Non-Hispanic white Insured								
Low income	25,714	79.0	±0.4	0.37 (0.35–0.40)	80.5	±0.4	0.48 (0.45–0.51)	29.7
High income	89,094	91.0	±0.2	(ref)	89.2	±0.2	(ref)	—
Missing	12,910	85.9	±0.5	0.6 (0.55–0.66)	85.8	±0.5	0.72 (0.66–0.79)	20.0
Uninsured								
Low income	9,432	54.2	±0.9	**0.12** (0.11–0.13)	65.3	±0.9	**0.21** (0.19–0.23)	**75.0**
High income	3,707	66.4	±1.4	0.20 (0.17–0.22)	70.1	±1.3	0.26 (0.23–0.30)	30.0
Missing	1,707	57.5	±2.1	**0.13** (0.11–0.16)	67.3	±1.9	**0.23** (0.19–0.28)	**76.9**
Non-Hispanic black Insured								
Low income	5,388	85.7	±0.9	0.59 (0.51–0.69)	87.0	±0.9	0.80 (0.68–0.94)	35.6
High income	5,100	92.7	±0.7	1.25 (1.03–1.53)	90.8	±0.8	1.20 (0.99–1.46)	–4.0
Missing	1,133	84.6	±2.0	0.54 (0.40–0.73)	85.1	±1.9	0.68 (0.49–0.93)	25.9
Uninsured								
Low income	2,262	71.2	±1.8	**0.25** (0.21–0.29)	82.3	±1.3	**0.54** (0.45–0.65)	**116.0**
High income	369	74.9	±3.9	**0.30** (0.20–0.45)	79.7	±3.6	**0.46** (0.29–0.72)	**53.3**
Missing	330	71.1	±4.2	**0.24** (0.16–0.36)	81.3	±3.0	**0.51** (0.34–0.77)	**112.5**
Hispanic Insured								
Low income	3,251	84.0	±1.3	**0.52** (0.43–0.62)	87.5	±1.0	**0.84** (0.69–1.03)	**61.5**
High income	3,479	89.4	±0.9	0.84 (0.69–1.02)	88.1	±1.0	0.89 (0.73–1.09)	6.0
Missing	813	69.2	±3.1	**0.22** (0.17–0.30)	77.7	±2.7	**0.40** (0.29–0.55)	**81.8**
Uninsured								
Low income	2,542	75.9	±1.5	**0.31** (0.26–0.37)	87.0	±1.0	**0.80** (0.66–0.96)	**158.1**
High income	398	74.8	±4.1	**0.29** (0.19–0.45)	84.7	±2.7	**0.66** (0.43–1.01)	**127.6**
Missing	497	67.8	±3.8	**0.21** (0.15–0.29)	86.4	±2.5	**0.75** (0.49–1.16)	**257.1**
Non-Hispanic other Insured								
Low income	2,471	74.4	±1.8	0.29 (0.24–0.35)	76.8	±1.7	0.38 (0.31–0.47)	31.0
High income	4,720	84.7	±1.0	0.55 (0.47, 0.64)	82.4	±1.1	0.55 (0.47–0.64)	0.0
Missing	807	66.8	±3.4	0.20 (0.15–0.27)	70.7	±2.9	0.27 (0.20–0.36)	35.0
Uninsured								
Low income	977	56.5	±3.2	**0.13** (0.10–0.17)	68.6	±2.8	**0.24** (0.18–0.32)	**84.6**
High Income	353	60.9	±5.5	0.15 (0.10–0.24)	65.8	±5.5	0.21 (0.13–0.36)	40.0
Missing	171	48.1	±7.4	**0.09** (0.05–0.16)	57.9	±8.4	**0.15** (0.07–0.31)	**66.7**

NOTE: LPCs to the UORs are **in bold**. Reversed associations are in italics.
[a]Multivariable logistic regression independent variables: race/ethnicity, income, insurance status, age, usual source of care, education, marital status, and census region.
[b]Multivariable analysis with composite variable adjusted for: age, usual source of care, education, marital status, and census region.

effective for producing reversals of associations and LPCs in the 40–64 age range.

Mammography was assessed with 2 questions. One asked ever having a mammogram. Women who ever-had were asked time since most recent examination: less than 12 months; 12 months to less than 2 years, 2 years to less than 3 years, 3 to 5 years, and more than 5 years. The dependent variable was less than 2 years, versus 2 years or more/never/don't know/refused. Refusals and "don't know' responses were coded with past-due status because in real-world, clinical, or referral situations, these women would not be considered on-schedule and there would be need to resolve their status.

Pap testing. The analysis sample was women aged 40–64, without a hysterectomy. Medicare coverage begins at 65. Although routine Pap testing starts at an earlier age than mammography, using 40 as the lower age boundary retained a focus on middle-aged women for both screening domains.

Pap testing was assessed with 2 questions. One asked ever having a Pap test. Women who ever-had were asked time since most recent examination: less than 12 months, 12 months to less than 2 years, 2 years to less than 3 years, 3 to 5 years, and more than 5 years. Three years is the longest interval specified by groups that recommend guidelines (9, 10). The dependent variable was less than 3 years versus 3 years or more/never/don't know/refused. Again, refusals and "don't know' responses were coded with past-due status because in real-world, clinical, or referral situations, these women would not be considered on-schedule and there would be a need to resolve their status.

Independent variables

Analyses used the same independent variables for mammography and Pap testing, coded with the same categories. Covariates were race/ethnicity, insurance status, income, age, education, marital status, usual source of care, and census region. Race/ethnicity, income, and insurance status were the focus of reversals of associations and LPCs and the basis for the composite variable (described below). Age, marital status, and census region were viewed as standard demographic covariates. Education and usual source of care are standard demographic covariates but are also resources for interaction with the health care system, so are important to have as statistical controls for the composite variable.

Race/ethnicity was defined as: non-Hispanic white (white: reference), non-Hispanic black (black), Hispanic, and non-Hispanic other. *Insurance status* was dichotomized as: uninsured versus insured (reference), because access-enhancing programs commonly use this dichotomy as an eligibility criterion. *Income* was coded as missing (DK/refused); less than $35,000; and greater than $35,000 (reference). Federal poverty levels are adjusted for household size and states often have eligibility as high as 250% of the federal poverty level. Women with incomes above $35,000 could therefore be screening-eligible. However, the next BRFSS income category topped-off at $50,000, which is why we used $35,000 as the cutpoint. *Education* was coded as: no college versus any college (reference). *Age* was coded into 5-year groups (age 40–44: reference). *Usual source of care* was coded as: no regular source of care versus one or more sources (reference). *Marital status* was coded as: never married, previously married, and married/partnered (reference). *Region* included the 4 primary census regions: West, Midwest, South, Northeast (reference).

Analysis plan

To account for the probability-based, complex BRFSS sampling design and to produce nationally representative estimates, all analyses used SAS-callable SUDAAN (11).

The first step of analysis documented reversals of associations and percent changes for race/ethnicity as a stand-alone variable for mammography and Pap testing. Two unadjusted analyses were done only with race/ethnicity status, followed by 2 models with race/ethnicity and the covariates noted above. The next step used the composite variable.

Composite variable. We created a 24-category, 3-way variable that combined race/ethnicity, insurance status, and income. Insured, white women, with incomes of $35,000 or more were the reference group. We first used only the composite variable to examine its univariate association with screening. We then ran multivariable models to identify reversals of associations and LPCs that included the composite variable along with age, education, usual source of care, marital status, and region as the additional covariates. Output provides UORs and AORs and their associated 95% confidence intervals (CI) and estimated screening utilization for each category of an independent variable. We did not view this variable as a formal interaction term to be tested for significance because our interest was in reversals of association and LPC results for specific categories. However, the composite variable provides results identical to the traditional approach of an interaction term that includes each of the 3 variables separately as main effects, all 3 of their 2-way interactions, and their 3-way interaction.

Documenting reversals of association and percent changes. A comparison between the UORs, AORs, and 95% CIs determined whether a reversal of association occurred, both for race/ethnicity as a single variable and for the subgroups of the composite variable. We also calculated the percent change to the UOR for race/ethnicity alone and for the composite variable's subgroups. Percent change was calculated as: $[(\text{AOR} - \text{UOR})/\text{UOR}] \times 100\%$. As in a prior article (5), 50% was the criterion for an LPC.

Results

Mammography

Table 1 presents results for mammography. The top section shows UOR and AOR results, as well as the percent changes and predicted screening rates for race/ethnicity as a stand-alone independent variable. The bottom section shows this same information for the composite variable's subgroups. Table 2 is set up identically to Table 1.

The crude mammography percentage for black women was slightly higher than for white women (OR, 1.08), and their AOR (1.53) also indicated significantly higher estimated screening, with a percent change to the UOR of 41.7%. Hispanic women showed a reversal of association; their crude rate was significantly lower than White women's (70.4%, OR, 0.80) but their AOR (1.77) was significantly higher, with a percent change of 121%. The non-Hispanic other group showed minimal difference between the UORs and AORs, similar to previous findings (4).

The analysis with the composite variable showed that the crude rate for white, insured, higher income women (reference group) was several percentage points higher than the crude rate for all White women (80.5% vs. 74.8%). There were no reversals of associations for the subgroups. However, lower income, insured Hispanic women had an AOR of 1.15 versus the reference group, with the lower bound of the 95% CI at 1.00. Also, black, insured, higher income women had a significantly higher UOR (1.31) and AOR (1.37) than the white, insured, higher income women reference group.

Relevant for this study's research question, for all 4 racial/ethnic groups, the percent changes to the UORs were larger for uninsured than for insured women in the corresponding income category (e.g., Hispanic/uninsured/lower income = 114.3%; Hispanic/insured/lower income = 47.4%). In addition, among *uninsured* women in each racial/ethnic group, lower income women had larger percent changes than did higher income women. The crude mammography rate for Hispanic, uninsured, *lower income* women (58.8%) was higher than the rate for Hispanic, uninsured, *higher income* women (50.7%). This discrepancy persisted in the adjusted analyses, although the estimated utilization for both groups was still significantly lower than for the white, insured, higher income reference group. For both insured and uninsured women, Hispanics had larger percent change than the other 3 racial/ethnic groups.

One other finding deserves attention; that is, the UOR (0.14), AOR (0.20), and percent change (42.9%) for uninsured, lower income, white women were even lower than the corresponding UORs, AORs, and percent changes for black and Hispanic women. In addition, their crude mammography rate was an absolute 43.2% lower than the reference group (37.3% vs. 80.5%).

Pap testing

Table 2 shows results for Pap testing, which paralleled those for mammography. Crude Pap testing rates were nonsignificant for blacks compared with whites, but the AOR (1.56) for black women indicated a significantly higher estimated percentage, with a percent change of 54.5%. As with mammography, Hispanics showed a reversal of association, with a significantly lower crude rate (81.7%; UOR = 0.75) but a significantly higher estimated screening rate (89.7%; AOR = 1.80) and a percent change of 140%. The non-Hispanic other women again showed minimal difference between the UORs and AORs (4).

Analysis with the composite variable showed that the crude rate for the white, insured, higher income reference group was several percentage points higher than the crude rate for all white women (91.0% vs. 85.7%). There were no reversals of associations for the composite variable's subgroups, although black, insured, higher income women had a significantly higher UOR (1.25) than the reference group, which remained higher but not significantly after adjustment (1.20).

Similar to mammography, and consistent with the study's hypothesis, the percent changes to the UORs for all 4 racial/ethnic groups were larger for uninsured women than for insured women in the corresponding income groups. In addition, for uninsured groups in each racial/ethnic group, lower income women had larger percent changes than higher income women.

As with mammography, uninsured, lower income Whites had an extremely low UOR (0.12) and AOR (0.21) for Pap testing. Their crude screening rate was an absolute 36.8% less than the white, insured, higher income reference group (54.2% vs. 91.0%). Their UOR and AOR were lower than the UORs and AORs for black and Hispanic women, which themselves were significantly lower than the reference group. The crude Pap testing rate for Hispanic, uninsured, lower income women was slightly higher than the rate for Hispanic, uninsured, higher income women (76.4% vs. 75.9%). This discrepancy persisted in the estimated rates after the adjusted analyses.

More so than for mammography, the "Missing" income group of women sometimes had large percent changes. Uninsured black and Hispanic women with missing income showed 2 of the largest percent changes (112%, 257%). However, uninsured, lower income, Hispanic women had a 158% change to the UOR; uninsured, higher income, Hispanic women had a 127% change; and uninsured, lower income, black women had a 116% change.

Discussion

At the level of results for race/ethnicity as a stand-alone independent variable (the top section of Tables 1 and 2), reversals of association were found for Hispanic women for mammography and Pap testing, along with LPCs to the UORs, supporting previous findings (4, 5). Black women did not have reversals of associations because their self-reported screening rates at the UOR level were as high, or higher, than white women's. However, black women's AORs were significantly higher, and for Pap testing, the percent change met the criterion for an LPC. This article had the objective of "deconstructing" those results. It is challenging to attempt to explain results for a single main-effects variable, to find possible reasons for a reversal of association and/or an LPC. Composite variables (that parallel interaction terms) reduce sample sizes in the subgroups due to the many groups that are created. In addition, the reference group is different due to the combination of variables, as the referent is typically defined to highlight the highest or lowest screening rate. As noted above, the reference group for the analyses with the composite variable had higher screening rates than white women overall in the analyses with race/ethnicity as a single variable.

An empirical rationale for the occurrence of reversals of associations and LPCs, based on the existence of access-enhancing programs, has been proposed in earlier articles (4, 5) and is supported by the results here. Programs such as the NBCCEDP and companion state- and locally funded initiatives typically target under/uninsured and lower income women. Non-whites are disproportionately lower income and under/uninsured. These programs increase screening utilization but do not change participants' status on access-related variables (e.g., health care insurance, income, having a usual source of care). Therefore, stating the statistical "confounder" rationale of multivariable analysis in colloquial terms, the algorithms in multivariable analyses "see" higher screening rates for lower income, uninsured, and non-white women than would be expected on the basis of their sociodemographic indicators and therefore "over-correct" when estimating screening rates, resulting in statistically significant AORs for non-whites. That overestimation is evidenced as reversals of associations, LPCs, or both.

Three aspects of the results were consistent with the hypothesis that access-enhancing programs could help explain reversals of associations for race/ethnicity as a stand-alone, single independent variable. One is that larger percent changes to the UORs were found for uninsured women than for insured women, for both mammography and Pap testing. A second is that larger percent changes were found for Hispanic and black women than for white women. A third is that within the uninsured subgroups, percent changes were larger for lower income women than higher income women. The composite variable allowed doing analyses at a level of specificity not beyond what stand-alone independent variables can provide.

The question of how these results with the composite variable can help explain reversals of associations and statistically significant, higher estimated screening rates is important. On the one hand, there was only one borderline reversal of association for the composite variable (Table 2, Hispanic, insured, lower income, for mammography), and there were only a few instances where significantly lower UORs for blacks and Hispanics became nonsignificant AORs. Importantly, however, the most consistent outcome of the multivariable analyses with the composite variable was that of LPCs to the UORs for uninsured Hispanic and black women, for mammography and for Pap testing. Main-effect results for individual independent variables can be viewed as an outcome of results with a multiply-defined composite variable being collapsed "upwards." The results in this article suggest that main-effect analyses for race/ethnicity can "hide the action" occurring in the subgroups defined by the composite variable. Moving "upward" analytically, to a 2-way combination and then to the main-effects, successively expands the composition of the reference group. The percent changes to the UORs could therefore, from an analytic perspective, be passed along the 2-way and single-variable levels and help explain the reversals of associations and LPCs for Hispanic women and the statistically significant AORs for black and Hispanic women.

Despite the focus of this article on a possible explanation for race/ethnicity reversals of associations and LPCs, it is as important to recognize the low AORs for most of the groups that comprised the composite variable. Even if reversals of associations and LPCs do reflect a positive effect of access-enhancing programs, crude utilization rates are by no means comparable across groups. Tables 1 and 2 show that 41 of the 46 comparisons of crude screening rates and UORs, across both mammography and Pap testing, were statistically significantly lower than for white, insured, higher income reference group. Even after adjustment, 36 of the 46 were still significantly lower.

White, uninsured, lower income women had especially low screening utilization. Their crude and estimated rates were even lower than those for the corresponding groups of non-white women. This was unexpected, but consistent for both mammography and Pap testing. Non-Hispanic whites are typically considered to be the more-advantaged group in the population. However, the results here place these women at a comparably underserved status.

The non-Hispanic other group had no reversals of associations in any analyses, as also seen in other analyses (4, 5). Uninsured women in this group did have some LPCs in the analyses with the composite variable but had crude screening rates so much lower than the reference group that even after adjustment, their AORs remained significantly lower. It was not possible to differentiate these women into specific groups (e.g., Asian-American) because the resulting composite variable would have had cells with too few women for reliable analysis. However, reversals of associations and LPCs are not the issue for this group of women; increasing screening utilization is the fundamental priority.

Future research should recognize that reversals of associations and LPCs are not "bad" to find but instead may reflect changing sociodemographic contexts, and variables associated with reversals of associations and LPCs can offer hints about the sources of the change. Evidence to date is from national-level surveys, but state and regional data could yield information of local relevance, as reversals of associations and LPCs may not occur equally nation-wide. Comparison of state/regional results may be linkable to trends in access-enhancing programs, in the sense of "natural experiments." Future research should also monitor LPCs and reversals of associations for colorectal screening, which is steadily receiving increased national-level attention (6, 7). Research can also examine other composite variables for mammography and Pap testing, and study reversals of associations and LPCs for other health-related behaviors, especially those that have shown changes (e.g., smoking, physical activity, and obesity-related behaviors).

This research has limitations and constraints. The BRFSS are cross-sectional and provide no information about availability of access-enhancing programs for mammography and Pap testing in the respondent's locality. Therefore, although results were consistent with the potential influence of access-enhancing programs, it would be helpful to have data that allowed "drilling down" to the local level about the presence of such resources for screening. Even with local data, however, cross-sectional analyses can only show associations, not direct influence.

"Higher income" was a relative term. As noted above, federal poverty levels are adjusted for household size, and states often have eligibility higher than the federal poverty level. Women with incomes above $35,000 could therefore be screening-eligible, which could contribute to instances where "higher income" women also had LPCs. However, lower income women consistently had larger percent changes, as would be expected from access-enhancing programs.

Missing income was sometimes a "wildcard" category in the analyses, particularly for uninsured women. It was important to include women with missing income in the analyses because prevalence was between 10.0% and 11.0% in all 4 analyses and might have introduced biases if omitted. The fact that uninsured Hispanic women with missing income showed the largest percent changes for mammography and Pap testing may be a reason to investigate differential income reporting across racial/ethnic groups.

There is also the issue of under-insurance; having coverage that still places responsibility on a woman to pay out-of-pocket for health care (e.g., high deductible, high co-payments). The BRFSS does not have questions that could allow determining under-insurance for breast and cervical testing.

Finally, the results in this article are specific to recent mammography and Pap testing. Repeat on-schedule testing is another topic that requires investigation. Even with these limitations and considerations, the results for the composite variable provide a line of further inquiry to help explain reversals of associations and LPCs between race/ethnicity and breast and cervical testing.

Disclosure of Potential Conflicts of Interest

No potential conflicts of interest were disclosed.

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