Published OnlineFirst March 10, 2011; DOI: 10.1158/1055-9965.EPI-10-1226

Research Article

Cancer Epidemiology, Biomarkers & Prevention

Reversals of Association for Pap, Colorectal, and Prostate Cancer Testing among Hispanic and Non-Hispanic Black Women and Men

William Rakowski[1,2], Melissa A. Clark[1,2,3], Michelle L. Rogers[1,2,3], and Sherry H. Weitzen[1]

Abstract

Background: Several studies have found that Hispanics and non-Hispanic blacks have statistically significantly higher adjusted OR for cancer screening tests compared to non-Hispanic whites, even though their crude percentages were lower than, or about equal to, those for the non-Hispanic whites. Most documentation is for mammography. This article investigates the prevalence of such unadjusted-to-adjusted "reversed associations" (RA) for Pap, colorectal, and prostate testing. We also investigate large percent changes (LPC) to the unadjusted ORs.

Methods: Data were from the 2004/2006/2008 Behavioral Risk Factor Surveillance System (BRFSS) and the 2000/2003/2005/2008 National Health Interview Survey (NHIS). Analyses used a consistent set of covariates.

Results: RAs were more common for non-Hispanic blacks than Hispanics, but Hispanics had a greater number of LPCs. RAs and LPCs occurred more often for Pap testing than colorectal and prostate testing. However, results from the BRFSS and NHIS were often not consistent.

Conclusions: Attention should be given to the National Breast and Cervical Cancer Early Detection Program, as well as public programs addressing other cancers, as possible contributors to RAs and LPCs. Hispanics may show more RAs in analyses of future data. Discrepancies between the BRFSS and the NHIS also must be recognized and explained.

Impact: This research highlights the need for vigilance regarding the results of analyses to identify race/ethnicity as a correlate of cancer screening. Results also direct attention to aspects of the results of multivariable analysis other than ORs and confidence intervals. *Cancer Epidemiol Biomarkers Prev; 20(5); 876–89.* *©2011 AACR.*

Introduction

Public health initiatives to reduce the morbidity and mortality burden of cancer rely heavily on accurate epidemiologic surveillance to identify groups with underutilization of effective screening techniques (1). Surveillance of underserved groups is typically a combination of univariate (unadjusted) and multivariable (adjusted) analyses. Univariate analyses examine independent variables separately against screening status, and are followed by multivariable, adjusted analyses. Advocacy draws on these data to specify priority populations for access-enhancing programs to screening and timely treatment. Continued surveillance tracks these groups over time, and monitors whether new underserved groups emerge. Other research identifies barriers to, and facilitators of utilization (2, 3).

Logistic regression has been the usual method for conducting adjusted analyses to identify correlates of utilization, because screening status is often a dichotomous or ordinal variable (e.g., adherent versus nonadherent; adherent versus screened but nonadherent versus never screened). The most general use of multivariable analysis is simply to find which covariates retain statistically significant associations with screening status, but with no a priori focus on a particular variable. Primary interest is in the "story told" by the significant and nonsignificant covariates, and how the significant covariates inform advocacy and more targeted follow-up research.

A second, more focused, purpose of multivariable analysis is examining the importance of a specific variable (e.g., having a primary care provider), or a category of variables (e.g., access to health care). The remaining covariates serve as statistical controls or confounders to investigate whether the disparity continues even after

Authors' Affiliations: [1]Department of Community Health, [2]Center for Gerontology and Health Care Research, and [3]Center for Population Health and Clinical Epidemiology, Brown University, Providence, Rhode Island

Corresponding Author: William Rakowski, Department of Community Health, Box G-S121, 2nd Floor, Brown University, Providence, RI 02912. Phone: 401-863-3263; Fax: 401-863-3713. E-mail: William_Rakowski@brown.edu

doi: 10.1158/1055-9965.EPI-10-1226

Published OnlineFirst March 10, 2011; DOI: 10.1158/1055-9965.EPI-10-1226

adjustment. This second purpose has typically had either of 2 outcomes. One is that the variable(s) of interest can continue to be associated with lower screening. This result supports the need for advocacy via targeted programs and policies by providing evidence for the continued existence of the disparity, and encourages a continued search for the factors causing it. Alternately, a disparity at the univariate level may be eliminated. In this instance, the implication is that equalizing groups on one or more of these covariates, or finding ways to circumvent those barriers, could act to remove the disparity. Again, objectives of public health advocacy are served.

Nonetheless, the issue of *interpretability* of multivariable analysis is crucial. Multivariable analysis is neither a panacea nor infallible. Anomalies or unanticipated aspects of a database can produce unexpected, even confusing results. The purpose of this article is to further investigate one such potentially confusing phenomenon; that is, the existence of "reversals of association" (RA) and the often accompanying large percent changes (LPC) to the unadjusted ORs for nonwhite racial/ethnic groups in studies of the correlates of cancer screening utilization. An earlier article about mammography (4) found a large number of RAs and LPCs in multiple years of the Behavioral Risk Factor Surveillance System (BRFSS) and the National Health Interview Survey (NHIS). In its most extreme form, a "reversed association" occurred when a non-white racial/ethnic group had a statistically significant, *lower univariate OR* than non-Hispanic whites, but had a *multivariable* adjusted OR (AOR) greater than 1.00 which achieved statistical significance. In less extreme form, a nonstatistically significant univariate OR for a non-white racial/ethnic group became statistically significantly higher after adjustment. Both outcomes indicate *higher* estimated mammography screening for non-white groups after adjustment, which differs from what would be expected based on longstanding racial/ethnic disparities in health behaviors and health status. These 2 outcomes were often accompanied by LPCs when comparing the unadjusted ORs to the adjusted ORs (AOR). For example, Hispanic women had percent changes to the unadjusted ORs for mammography ranging from 55% to 84% (4). Another feature accompanying RAs was that the predicted estimates of mammography for non-white groups were higher than the predicted estimates for non-Hispanic white women, reflecting the fact that the AOR for a non-white group was greater than 1.00. Predicted mammography rates have not usually been reported in studies of cancer screening correlates, but can be calculated based on the AORs.

The focus of this article is on cervical, colorectal, and prostate cancer testing. Our "facts" about the existence of disparities are a product of epidemiologic surveillance. Public health policies, resource allocation, and access-enhancing programs are based on that information. The presence of RAs can complicate this process because RAs are outcomes of analyses, not explanations for why the phenomenon occurs. It is important to know whether RAs and LPCs for race/ethnicity exist more broadly than for mammography. Some reports have found indications of reversed associations for Pap and colorectal testing (5–10). However, covariates used in multivariable analyses differ across studies and unadjusted ORs were often not reported, thereby limiting the ability to determine the extent of possible RAs and LPCs. The existence of LPCs can be important. If a racial/ethnic group's utilization is very discrepant compared to non-Hispanic whites, a statistically significant reversal is not always realistically possible; the disparity is too large, despite an LPC to the OR. However, if utilization rates rise and racial/ethnic groups' rates converge in coming years, especially for colorectal and prostate testing, the possibility of a reversal also increases. This anomalous situation will seem to have emerged unexpectedly for epidemiologic surveillance, when in fact it was in-process for some time, and could have been anticipated by looking for LPCs.

Classification of reversals of association and large percent changes

This article uses the following definitions in the Results and Discussion sections for RAs and LPCs. The definitions below assume that the AOR for a given racial/ethnic group is being compared to their unadjusted OR, with non-Hispanic whites (whites) as the reference group.

Reversed associations

We distinguish 2 types of RAs. Type 1 RAs and type 2 RAs each have an *AOR* for a racial/ethnic group that indicates a statistically significant, *higher* estimated screening rate compared to whites. Type 1 and type 2 RAs differ based on their *unadjusted* ORs. A type 1 RA has an unadjusted OR that is statistically significantly lower than whites. The type 2 RA has an unadjusted OR that is not significantly different from whites.

Neither RA outcome is better than the other; each simply reflects a particular outcome of analysis. Type 1 and 2 RAs may or may not also be accompanied by an LPC (as defined below) from the unadjusted OR to the AOR.

Large percent changes

To our knowledge there is no criterion for what constitutes a "large percent change" to the unadjusted OR when compared to the AOR. An individual variable is often considered a "confounder," and included in multivariable analyses, if it changes the unadjusted OR of a variable of interest (e.g., race/ethnicity) by 10% or more. This strategy has been referred to as the change-in-estimate criterion (11). We will therefore consider a multivariable, fully-adjusted change of 50% or more to the unadjusted OR to be an LPC.

Published OnlineFirst March 10, 2011; DOI: 10.1158/1055-9965.EPI-10-1226

Methods

Data sources

Our analyses used the 3 most recent BRFSS and NHIS surveys with the necessary questions to create the dependent and independent variables of interest. The 2004, 2006, and 2008 BRFSS were used, as were the 2000 (for Pap test only), 2003, 2005, and 2008 NHIS. Sample sizes differed for the Pap, colorectal, and prostate analyses due to gender-specificity of the tests, age guidelines, and the BRFSS and NHIS sample sizes in those years. Tables 1, 3, and 5 include the analytic sample sizes.

Behavioral Risk Factor Surveillance System

The BRFSS is a collaboration between the Centers for Disease Control and Prevention (CDC) and each state and affiliated United States territory (12). It is an annual telephone survey of the adult noninstitutionalized population, conducted continuously throughout the year, using disproportionate stratified random sampling (12). States are responsible for conducting their surveys, directly or by contract. Only landline phones were used until 2008, when a pilot project with 18 states also collected data from cell phones (13).

Public use data sets were downloaded (14). Beginning in 2000, the Women's Health module (for mammography and Pap testing) became a BRFSS core module only in even-numbered years. Colorectal and prostate testing are also assessed in the cores of even-numbered BRFSS years. The weighting formula for sampled persons is identical across states, so 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 53.3% in 2008, (15, 16) reflecting the general trend of lower response to phone surveys (1).

National Health Interview Survey

The NHIS is conducted by the U.S. Bureau of the Census. It is an annual in-person household interview of the civilian, noninstitutionalized population conducted continuously throughout a calendar year. The NHIS has a complex sampling design based on stratification, clustering of samples, and multistage sampling (17, 18). Response rates to the Adult module have remained relatively high, compared to surveys that rely on telephone-based recruitment, ranging from 69.6% (1999) to 74.2% (2008) (19, 20).

Public use data sets were downloaded (21). Because each of the questions required for determining screening were not asked each year, we used the 2000, 2005, and 2008 NHIS for the Pap test analyses and the 2003, 2005, and 2008 data for the colorectal and prostate analyses.

Dependent variables

The BRFSS uses predetermined categories to assess a respondent's most recent examination, while the NHIS allows specific month/year recall with defaults to predetermined categories if the person cannot recall exactly. All data are self-report.

Pap testing

The analysis sample comprised women aged 40 to 69, without a hysterectomy. Three years is the longest interval specified for women younger than 70 years, by groups that recommend guidelines (22, 23). Age 40 was chosen so that the focus of all three screening tests for this article would be on middle-aged and older adults. Age 69 was the upper bound because screening guidelines for older women can have substantial leeway based on sexual history and prior Pap test results, and neither the BRFSS nor the NHIS have the necessary questions to make that determination. The dependent variable is coded as Pap testing: "1" within 3 years, versus "0" more than 3 years/never/don't know/refused.

Prostate testing

The analysis sample was men aged 50 and older. The benefit/cost tradeoffs of routine prostate testing continue to be reviewed (24–26), even though there is a substantial morbidity and mortality burden from prostate cancer. This uncertainty therefore provided an opportunity to investigate RAs and LPCs in a context of no mandate for routine testing. A 2-year time frame seemed more reasonable than a 1-year interval, allowing some leeway for provider-patient discussion. The BRFSS asked about both prostate-specific antigen (PSA) testing and digital rectal examination (DRE). The NHIS asked only about PSA testing. The dependent variable for the BRFSS is coded as "1" PSA test and/or DRE within 2 years, versus "0" neither PSA test nor DRE within 2 years/never/don't know/refused. The dependent variable for the NHIS is coded as "1" PSA test within 2 years, versus "0" no PSA within 2 years/never/don't know/refused.

Colorectal testing

The analysis sample was men and women aged 50 and older. Both surveys asked about fecal occult blood testing (FOBT). In 2004 and 2006, the BRFSS asked about sigmoidoscopy and colonoscopy together, so that the 5-year (sigmoidoscopy) versus the 10-year (colonoscopy) interval could not be differentiated. The 2004 and 2006 BRFSS are coded as "1" FOBT within past year and/or sigmoidoscopy/colonoscopy within 10 years, versus "0" FOBT not within past year and sigmoidoscopy/colonoscopy not within 10 years/never/don't know/refused.

All 3 NHIS surveys and the 2008 BRFSS asked about sigmoidoscopy and colonoscopy separately. The dependent variable for all NHIS surveys and the 2008 BRFSS is coded as "1" FOBT within past year and/or sigmoidoscopy within 5 years or colonoscopy within 10 years, versus "0" FOBT not within past year and sigmoidoscopy not within 5 years and colonoscopy not within 10 years/never/don't know/refused.

Published OnlineFirst March 10, 2011; DOI: 10.1158/1055-9965.EPI-10-1226

Table 1. Three-year Pap testing in the BRFSS and NHIS (women aged 40–69, no hysterectomy): univariate and multivariate design-adjusted ORs and 95% CIs for race/ethnicity, and percent change to the unadjusted ORs[a,b]

	2004 BRFSS (*N* = 64,937)				2006 BRFSS (*N* = 80,313)				2008 BRFSS (*N* = 98,881)			
	Crude %	Univariate OR (95% CI)	Predicted %	Adjusted OR (95% CI)	Crude %	Univariate OR (95% CI)	Predicted %	Adjusted OR (95% CI)	Crude %	Univariate OR (95% CI)	Predicted %	Adjusted OR (95% CI)
Non-Hispanic white	87.1 ± 0.3	(Ref)	85.3 ± 0.3	(Ref)	86.5 ± 0.3	(Ref)	84.6 ± 0.3	(Ref)	85.5 ± 0.2	(Ref)	83.8 ± 0.2	(Ref)
Non-Hispanic black	87.4 ± 0.9	1.03 (0.87–1.21)	89.9 ± 0.8	1.61$^{RA2,\ LPC}$ (1.32–1.97)	88.5 ± 0.7	1.20 (1.04–1.40)	91.4 ± 0.6	2.10^{LPC} (1.77–2.49)	86.0 ± 0.8	1.04 (0.92–1.18)	88.2 ± 0.7	1.52^{RA2} (1.31–1.77)
Hispanic	82.8 ± 1.4	0.71 (0.59–0.86)	90.5 ± 0.9	1.74$^{RA1,\ LPC}$ (1.37–2.22)	83.9 ± 1.1	0.81 (0.69–0.97)	91.0 ± 0.7	1.98$^{RA1,\ LPC}$ (1.61–2.44)	81.4 ± 1.0	0.74 (0.65–0.85)	89.4 ± 0.7	1.72$^{RA1,\ LPC}$ (1.44–2.06)
All other	80.0 ± 1.7	0.59 (0.48–0.73)	79.5 ± 1.6	0.63 (0.50–0.80)	78.8 ± 1.6	0.58 (0.48–0.71)	78.5 ± 1.6	0.62 (0.50–0.77)	77.2 ± 1.3	0.57 (0.50–0.66)	78.5 ± 1.1	0.67 (0.58–0.79)

% Change in OR (univariate to multivariate)	
Non-Hispanic black	56.3%
Hispanic	145.1%
All Other	6.8%

% Change in OR (univariate to multivariate)	
Non-Hispanic black	75.0%
Hispanic	144.0%
All Other	6.9%

% Change in OR (univariate to multivariate)	
Non-Hispanic black	46.2%
Hispanic	132.4%
All Other	17.5%

	2000 NHIS (*N* = 5,562)				2005 NHIS (*N* = 5,869)				2008 NHIS (*N* = 4,113)			
	Crude %	Univariate OR (95% CI)	Predicted %	Adjusted OR (95% CI)	Crude %	Univariate OR (95% CI)	Predicted %	Adjusted OR (95% CI)	Crude %	Univariate OR (95% CI)	Predicted %	Adjusted OR (95% CI)
Non-Hispanic white	85.2 ± 0.6	(Ref)	83.6 ± 0.7	(Ref)	82.0 ± 0.7	(Ref)	80.5 ± 0.8	(Ref)	83.6 ± 0.8	(Ref)	82.3 ± 0.9	(Ref)
Non-Hispanic black	82.8 ± 1.3	0.83 (0.68–1.02)	87.3 ± 1.1	1.41$^{RA2,\ LPC}$ (1.08–1.83)	78.4 ± 1.7	0.80 (0.64–0.997)	83.9 ± 1.5	1.30^{LPC} (1.00–1.69)	84.5 ± 1.7	1.06 (0.80–1.41)	87.3 ± 1.5	1.56^{RA2} (1.12–2.18)
Hispanic	76.8 ± 2.0	0.58 (0.46–0.73)	84.8 ± 1.5	1.11^{LPC} (0.83–1.48)	74.8 ± 1.9	0.65 (0.53–0.81)	82.1 ± 1.5	1.12^{LPC} (0.87–1.45)	77.4 ± 2.1	0.67 (0.52–0.87)	83.8 ± 1.8	1.13^{LPC} (0.81–1.58)
All other	58.8 ± 3.8	0.25 (0.18–0.34)	60.8 ± 3.8	0.25 (0.17–0.37)	62.8 ± 3.7	0.37 (0.27–0.52)	63.5 ± 3.5	0.37 (0.26–0.53)	73.1 ± 3.1	0.53 (0.38–0.74)	69.6 ± 3.4	0.43 (0.29–0.64)

% Change in OR (univariate to multivariate)	
Non-Hispanic black	69.9%
Hispanic	91.4%
All Other	0.0%

% Change in OR (univariate to multivariate)	
Non-Hispanic black	62.5%
Hispanic	72.3%
All Other	0.0%

% Change in OR (univariate to multivariate)	
Non-Hispanic black	47.2%
Hispanic	68.7%
All Other	−18.9%

[a]Superscripts to adjusted ORs indicate presence of reversed associations (RA1, RA2) and/or large percent changes (LPC) to the unadjusted ORs.

RA1: Unadjusted OR statistically significantly lower than whites; adjusted OR statistically significant, higher estimated screening rate compared to whites.

RA2: Unadjusted OR not significantly different from whites; adjusted OR statistically significant, higher estimated screening rate compared to whites.

LPC: The multivariable, fully-adjusted change from the unadjusted OR is 50% or more.

[b]Analysis sample sizes are shown in the box with each survey year. Analyses incorporated adjustments for sampling.

Published OnlineFirst March 10, 2011; DOI: 10.1158/1055-9965.EPI-10-1226

Independent variables

The univariate and multivariable analyses used the same independent variables in each survey, with gender added for the colorectal analyses. Except for income and age as noted below, each independent variable had the same categories for each screening domain, across each BRFSS and NHIS survey.

Race/ethnicity was defined as: non-Hispanic white (white: reference group), non-Hispanic black (black), Hispanic, and non-Hispanic Other (NHO). The common set of 7 covariates for each screening domain were: age, income, education, insurance status, marital status, usual source of care, and Census region of the country. *Age* was coded into 5-year age groups within the age range for each domain of testing. *Income* was coded in the 2004 and 2006 BRFSS as DK/refused; less than $20,000; $20,000 to $34,999; $35,000 to $49,999; and $50,000 or more (reference group). Due to available coding categories, income in the 2004 and 2006 NHIS was grouped as DK/refused, less than $20,000; $20,000 to $34,999; $35,000 to $54,999; and $55,000 or more (reference group). Because of changes in income categories, the 2008 BRFSS and NHIS income codes were DK/refused, less than $35,000; $35,000 to $49,999; $50,000 to $74,999; and $75,000 or more (reference group). *Education* was coded as less than high school, high school graduate/GED, some college, college graduate (reference group). *Insurance status* was dichotomized as noninsured versus insured (reference group). *Usual source of care* was coded as having no regular source of care versus having one or more sources (reference group). *Marital status* was coded as never married, previously married (widowed/separated/divorced), and married/partnered (reference group). *Region* was from the 4 primary Census regions, west, midwest, south, northeast (reference group).

Analysis plan

To account for the probability-based, complex NHIS and BRFSS sampling designs (multiple stages of sampling, stratification, and clustering), and to produce nationally representative estimates, all analyses used SAS-callable SUDAAN (27).

Documenting "reversal" of association

The procedure used by Rakowski and colleagues for mammography (4) was used in each survey, for each dependent variable. First, single-variable logistic regressions were computed to obtain the univariate, unadjusted Ors, and 95% CIs for race/ethnicity with Pap, prostate, and colorectal testing. Multivariable logistic regression was then used for an omnibus analysis with race/ethnicity and all covariates, to derive the fully-adjusted ORs and 95% CIs. A comparison between the univariate and multivariable ORs and 95% CIs determined whether an RA and/or an LPC occurred for one or more racial/ethnic groups. Percent change between the unadjusted and adjusted ORs was calculated as [(adjusted OR − unadjusted OR)/unadjusted OR] × 100. The omnibus multivariable results also provided predicted prevalence estimates of Pap, prostate, and colorectal testing for each racial/ethnic group.

Investigating variables producing a reversal

The omnibus multivariable regression for a dependent variable (Pap, colorectal, or prostate) was followed by 3 sequences of variable-by-variable analyses. Each sequence of analyses identified the order in which independent variables produced changes to the OR for a particular racial/ethnic group. All non-white groups were included in each sequence of analyses, but the focus was on the ORs for blacks, Hispanics, and NHOs, respectively. There were multiple steps within each sequence of analyses. In the first analysis sequence, directed at ORs for Blacks, each of the other independent variables was entered individually with race/ethnicity, and the variable producing the greatest change to the unadjusted OR for blacks was selected. That variable was then paired with race/ethnicity and the process was repeated with the remaining independent variables. The next variable producing the greatest percent change for blacks was chosen, creating a triad of covariates, and the process was repeated in turn with the remaining variables (the last step therefore replicated the omnibus multivariable analysis).

This sequence of analyses was repeated twice more, focusing next on OR changes for Hispanics and then for NHOs. The result, for each racial/ethnic group, was a listing of the changes to the OR that each independent variable produced at the step of analysis that it was selected.

Results

Results are discussed for Hispanics and blacks compared to whites, and focus on the presence of RAs and LPCs, variable-by-variable changes to the ORs, and differences between unadjusted and predicted screening rates. There was no evidence of RAs or LPCs for NHOs. However, NHOs had statistically significant lower utilization compared to whites in all 18 analyses (3 test domains × 6 surveys per test), a finding that must be recognized in its own right.

Pap testing

Table 1 presents the unadjusted and fully-adjusted results for race/ethnicity. Superscripts denote when a result is an RA and/or an LPC. Table 2 shows the variable-by-variable results for each survey. The top rows in Table 2, for blacks and Hispanics, match their unadjusted ORs in Table 1. The bottom rows match their fully-adjusted ORs in Table 1.

Behavioral Risk Factor Surveillance System. The unadjusted screening rates in 2004 and 2008 for black women did not differ significantly from white women. However, the adjusted analyses indicated significantly higher screening than whites, so that both were type 2

Published OnlineFirst March 10, 2011; DOI: 10.1158/1055-9965.EPI-10-1226

Table 2. Covariates contributing to changes from univariate to multivariable adjusted odds ratios, for 3-year Pap testing, for Hispanic and non-Hispanic black women in the BRFSS and NHIS (limited to women age 40–69)[a,b]

2004 BRFSS			2006 BRFSS			2008 BRFSS		
Covariate	**OR (95% CI)**	**% Change**	**Covariate**	**OR (95% CI)**	**% Change**	**Covariate**	**OR (95% CI)**	**% Change**
Non-Hispanic black	1.03 (0.87–1.21)	–	Non-Hispanic black	1.20 (1.04–1.40)	–	Non-Hispanic black	1.04 (0.92–1.18)	–
Income	1.50 (1.26–1.79)	45.6	Income	1.70 (1.46–1.98)	41.7	Income	1.42 (1.25–1.62)	36.5
Insurance	1.57 (1.30–1.89)	4.7	Marital status	1.83 (1.58–2.13)	7.6	Marital status	1.51 (1.32–1.73)	6.3
Marital status	1.64 (1.35–1.98)	4.5	Insurance	1.98 (1.69–2.32)	8.2	Education	1.59 (1.38–1.82)	5.3
Education	1.69 (1.39–2.04)	3.0	Education	2.11 (1.80–2.48)	6.6	Insurance	1.65 (1.43–1.90)	3.8
Region	1.68 (1.38–2.04)	−0.6	Region	2.15 (1.82–2.53)	1.9	Usual source of care	1.63 (1.41–1.89)	−1.2
Usual source of care	1.67 (1.36–2.04)	−0.6	Usual source of care	2.18 (1.84–2.58)	1.4	Age	1.58 (1.36–1.83)	−3.1
Age	1.61 (1.32–1.97)	−3.6	Age	2.10 (1.77–2.49)	−3.7	Region	1.52 (1.31–1.77)	−3.8
Hispanic	0.71 (0.59–0.86)	–	Hispanic	0.81 (0.69–0.97)	–	Hispanic	0.74 (0.65–0.85)	–
Income	1.16 (0.95–1.41)	63.4	Insurance	1.26 (1.04–1.51)	55.6	Education	1.13 (0.97–1.32)	52.7
Usual source of care	1.53 (1.23–1.90)	31.9	Education	1.66 (1.43–1.94)	31.7	Usual source of care	1.47 (1.24–1.73)	30.1
Education	1.78 (1.41–2.25)	16.3	Usual source of care	1.97 (1.59–2.42)	18.7	Income	1.68 (1.41–1.99)	14.3
Insurance	1.88 (1.47–2.39)	5.6	Income	2.14 (1.74–2.64)	8.6	Insurance	1.80 (1.50–2.15)	7.1
Region	1.90 (1.49–2.42)	1.1	Marital status	2.12 (1.72–2.61)	−0.9	Region	1.86 (1.55–2.22)	3.3
Marital status	1.88 (1.48–2.40)	−1.1	Region	2.08 (1.69–2.56)	−1.9	Marital status	1.83 (1.53–2.18)	−1.6
Age	1.74 (1.37–2.22)	−7.4	Age	1.98 (1.61–2.44)	−4.8	Age	1.72 (1.44–2.06)	−6.0

2000 NHIS			2005 NHIS			2008 NHIS		
Covariate	**OR (95% CI)**	**% Change**	**Covariate**	**OR (95% CI)**	**% Change**	**Covariate**	**OR (95% CI)**	**% Change**
Non-Hispanic black	0.83 (0.68–1.02)	–	Non-Hispanic black	0.80 (0.64–0.997)	–	Non-Hispanic black	1.06 (0.80–1.41)	–
Income	1.13 (0.90–1.42)	36.1	Income	1.08 (0.85–1.38)	35.0	Income	1.47 (1.10–1.97)	38.7
Marital status	1.23 (0.98–1.56)	8.8	Education	1.16 (0.91–1.48)	7.4	Insurance	1.56 (1.16–2.10)	6.1
Education	1.38 (1.08–1.75)	12.2	Marital status	1.26 (0.98–1.62)	8.6	Marital status	1.61 (1.18–2.20)	3.2
Insurance	1.45 (1.13–1.84)	5.1	Region	1.34 (1.05–1.72)	6.3	Education	1.69 (1.22–2.34)	5.0
Region	1.50 (1.17–1.93)	3.4	Insurance	1.38 (1.07–1.78)	3.0	Region	1.67 (1.21–2.33)	−1.2
Usual source of care	1.50 (1.15–1.94)	0.0	Usual source of care	1.40 (1.08–1.81)	1.4	Age	1.63 (1.17–2.27)	−2.4
Age	1.41 (1.08–1.83)	−6.0	Age	1.30 (1.00–1.69)	−7.1	Usual source of care	1.56 (1.12–2.18)	−4.3
Hispanic	0.58 (0.46–0.73)	–	Hispanic	0.65 (0.53–0.81)	–	Hispanic	0.67 (0.52–0.87)	–
Education	0.82 (0.63–1.06)	41.4	Education	0.93 (0.74–1.17)	43.1	Insurance	0.94 (0.70–1.25)	40.3
Insurance	1.01 (0.77–1.33)	23.2	Insurance	1.15 (0.90–1.46)	23.7	Education	1.14 (0.83–1.57)	21.3
Usual source of care	1.08 (0.81–1.43)	6.9	Marital status	1.18 (0.92–1.50)	2.6	Income	1.20 (0.87–1.65)	5.3
Income	1.11 (0.84–1.48)	2.8	Usual source of care	1.20 (0.93–1.54)	1.7	Usual source of care	1.23 (0.88–1.72)	2.5
Region	1.13 (0.85–1.51)	1.8	Income	1.21 (0.95–1.54)	0.8	Marital status	1.23 (0.88–1.72)	0.0
Marital status	1.14 (0.85–1.52)	0.9	Region	1.19 (0.93–1.52)	−1.7	Age	1.18 (0.84–1.66)	−4.1
Age	1.11 (0.83–1.48)	−2.6	Age	1.12 (0.87–1.45)	−5.9	Region	1.13 (0.81–1.58)	−4.2

[a]The "OR" columns show the progression of the OR from the prior step, for the specific racial/ethnic group, as the next covariate was added to the model.

[b]The "% Change" columns show the change to the OR from the prior step of analysis, for the specific racial/ethnic group, as the next covariate was added to the model.

RAs. In 2006, black women had a significantly higher unadjusted rate of Pap testing than white women, but there was still an LPC of 75%. All 3 AORs for black women indicated significantly higher Pap testing compared to whites. The PCs to their unadjusted ORs ranged from 46% to 75%.

Hispanic women had type 1 RAs and LPCs in all 3 years. Their unadjusted ORs indicated significantly lower Pap testing than white women, but their AORs indicated significantly higher estimated rates. The PCs for Hispanic women's ORs to AORs ranged from 132% to 145%, the largest in any analyses.

Predicted Pap testing rates for Hispanics after adjustment were an absolute 6.1% to 8.0% higher than their unadjusted rates across survey years, compared with being 2.2% to 2.9% higher for black women.

National Health Interview Survey. The unadjusted ORs for black women generally indicated nonsignificant differences compared to white women in all 3 years, though trending lower in 2005. However, their AORs

Published OnlineFirst March 10, 2011; DOI: 10.1158/1055-9965.EPI-10-1226

were significantly higher than whites in all 3 years, with PCs ranging from 47% to 69%. As a result, there was a type 2 RA and LPC in 2000, an LPC in 2005, and a type 2 RA in 2008. However, noted below, age affected the analysis for black women in 2005.

The unadjusted ORs for Hispanic women indicated significantly lower testing than whites in all 3 years, but differences were not significant after adjustment. Percent changes ranged from 68% to 91%. All 3 surveys therefore had LPCs but no RAs.

Predicted Pap testing rates for Hispanics were an absolute 6.4% to 8.0% higher than the unadjusted rates, compared to being 2.8% to 5.5% higher for black women.

Variable-by-Variable Results. Income was consistently the first variable selected for black women in each of the 6 analyses, producing OR changes from 35% to 46%. Education, income, insurance, and usual source of care were most important for Hispanic women, although the order varied across surveys. The smallest first-variable PC for Hispanics was 40% and the largest was 63%. Even the second-ranked variable for Hispanics produced changes from 21% to 32%.

However, results in Table 2 also show the potential for attenuation of the OR. The −7% change for black women in the 2005 NHIS resulted in the *elimination* of a potential reversal. In addition, age attenuated the OR for Hispanic women in all 3 BRFSS surveys, by about −5% to −7, and by −4% to −7% for black women. Usual source of care, region, and marital status also had attenuating effects in some analyses.

Prostate testing

Tables 3 and 4 for prostate testing are structured identically to Tables 1 and 2.

Behavioral Risk Factor Surveillance System. Black men had a type 1 RA in 2004 and a type 2 RA in 2008. There was no RA in 2006; however, attenuation occurred as noted below. Percent changes to black men's unadjusted ORs ranged from 33% to 44%, so there were no LPCs, showing that RAs can occur without LPCs.

There were no RAs for Hispanic men. The AORs for Hispanic men were nonsignificant compared to white men in all 3 years. However, percent changes to their unadjusted ORs ranged from about 61% to 86%, so all 3 years yielded LPCs.

Hispanics' predicted screening rates after adjustment were an absolute 10.6% to 13.3% higher than their unadjusted rates, and were 5.3% to 6.7% higher for blacks. However, Hispanic men's unadjusted utilization rates were an absolute 16% to 17% lower than white men's, creating an extremely large disparity to reverse.

National Health Interview Survey. There were no RAs and only one LPC for black men in the NHIS; however, the reason for absence of an RA in 2003 was an attenuation—the same as occurred for black men in the 2006 BRFSS. For Hispanic men, there were no RAs, but there were LPCs in all 3 years, similar to the results in the BRFSS. As in the BRFSS, Hispanic men showed larger magnitude PCs than black men, ranging from 60% to 82%, compared to 36% to 52% for black men.

Hispanic's predicted screening rates after adjustment were an absolute 10.3% to 13.2% higher than their unadjusted rates, and were 6.1% to 8.4% higher for blacks. However, Hispanic men's unadjusted utilization rates were an absolute 16% to 17% lower than white men, again presenting a challenge for showing RAs.

Variable-by-variable results. Education produced the largest changes to the unadjusted ORs for Hispanic men in all 6 analyses. Education and income were the first variables selected for black men. The second variable selected was not consistent for black and Hispanic men.

There were 2 instances where reversed associations in the variable-by-variable process were "lost" at the omnibus level of analysis (Table 4). These instances were for black men in the 2006 BRFSS (due to region and usual source of care, eliminating a type 1 RA) and in the 2003 NHIS (due to region, eliminating a type 2 RA).

Colorectal testing

Tables 5 and 6 are structured identically to those for Pap and prostate testing.

Behavioral Risk Factor Surveillance System. Blacks had type 1 RAs in 2004, 2006, and 2008. Their unadjusted ORs in all 3 years indicated statistically significantly lower testing than whites, but their AORs estimated statistically significantly higher testing. However, changes to the unadjusted ORs were between 34% to 36% across surveys, so there were no LPCs.

Hispanics' unadjusted *and* adjusted ORs were significantly lower than whites in all 3 years, so there were no RAs. However, the PCs to the unadjusted ORs ranged from 56% to 69%, so all 3 analyses yielded LPCs.

For Hispanics, predicted screening rates were about 10% to 11% higher than their unadjusted rates, and were about 5% to 5.7% higher for blacks. However, Hispanic's unadjusted utilization rates were an absolute 15% to 18% lower than whites, and 11% to 14% lower than blacks.

National Health Interview Survey. In direct contrast to the results for the BRFSS there were no RAs for blacks in any of the 3 NHIS surveys, although in all 3 years the AORs indicated no significant difference from whites. There were also no LPCs for blacks; changes to their unadjusted OR ranged from 30% to 36.8%.

As in the BRFSS, Hispanics had ORs and AORs indicating significantly lower testing in all 3 years. There were LPCs in 2003 and 2005 but not in 2008; 2003 just met the 50% criterion and 2008 was just below.

Predicted screening rates were about 8% to 9% higher than the unadjusted rates for Hispanics, and were 5% to 6% higher for blacks. Hispanics' unadjusted utilization differed from whites, ranging from an

Published OnlineFirst March 10, 2011; DOI: 10.1158/1055-9965.EPI-10-1226

Table 3. Two-year prostate testing in the BRFSS and NHIS (men age 50 and over): univariate and multivariate design-adjusted ORs and 95% confidence intervals for race/ethnicity, and percent change to the unadjusted ORs[a,b]

	2004 BRFSS (*N* = 55,638)				2006 BRFSS (*N* = 73,884)				2008 BRFSS (N = 93,514)			
	Crude %	Univariate OR (95% CI)	Predicted %	Adjusted OR (95% CI)	Crude %	Univariate OR (95% CI)	Predicted %	Adjusted OR (95% CI)	Crude %	Univariate OR (95% CI)	Predicted %	Adjusted OR (95% CI)
Non-Hispanic white	53.4 ± 0.4	(Ref)	51.4 ± 0.4	(Ref)	54.3 ± 0.4	(Ref)	52.6 ± 0.4	(ref)	53.1 ± 0.3	(Ref)	51.2 ± 0.3	(Ref)
Non-Hispanic black	48.9 ± 1.7	0.84 (0.73–0.96)	55.6 ± 1.7	1.21^{RA1} (1.04–1.41)	50.1 ± 1.5	0.85 (0.75–0.95)	55.4 ± 1.5	1.13 (0.99–1.30)	52.3 ± 1.3	0.97 (0.87–1.07)	57.8 ± 1.3	1.35^{RA2} (1.20–1.53)
Hispanic	36.0 ± 2.4	0.49 (0.40–0.60)	49.3 ± 2.6	0.91^{LPC} (0.72–1.14)	37.5 ± 2.2	0.51 (0.42–0.61)	48.1 ± 2.4	0.82^{LPC} (0.67–1.01)	37.3 ± 1.6	0.53 (0.46–0.60)	49.7 ± 1.7	0.94^{LPC} (0.80–1.09)
All other	42.6 ± 2.5	0.65 (0.53–0.79)	46.1 ± 2.6	0.79 (0.64–0.97)	39.7 ± 2.0	0.55 (0.47–0.66)	41.6 ± 2.1	0.61 (0.51–0.74)	39.2 ± 1.6	0.57 (0.50–0.65)	40.8 ± 1.6	0.63 (0.54–0.73)
	% Change in OR (univariate to multivariate)				% Change in OR (univariate to multivariate)				% Change in OR (univariate to multivariate)			
	Non-Hispanic black	44.0%			Non-Hispanic black	32.9%			Non-Hispanic black	39.2%		
	Hispanic	85.7%			Hispanic	60.8%			Hispanic	77.4%		
	All Other	21.5%			All Other	10.9%			All Other	10.5%		
	2003 NHIS (*N* = 5,122)				**2005 NHIS (*N* = 5,711)**				**2008 NHIS (*N* = 4,073)**			
	Crude %	Univariate OR (95% CI)	Predicted %	Adjusted OR (95% CI)	Crude %	Univariate OR (95% CI)	Predicted %	Adjusted OR (95% CI)	Crude %	Univariate OR (95% CI)	Predicted %	Adjusted OR (95% CI)
Non-Hispanic white	54.0 ± 0.9	(Ref)	52.8 ± 0.9	(Ref)	50.3 ± 0.9	(Ref)	48.7 ± 0.9	(Ref)	54.8 ± 1.2	(Ref)	53.0 ± 1.1	(Ref)
Non-Hispanic black	48.8 ± 2.5	0.81 (0.66–1.003)	57.2 ± 2.5	1.23^{LPC} (0.96–1.57)	43.1 ± 2.7	0.75 (0.60–0.94)	49.2 ± 2.5	1.02 (0.81–1.29)	48.2 ± 2.7	0.77 (0.61–0.96)	54.9 ± 2.5	1.10 (0.85–1.41)
Hispanic	37.1 ± 2.7	0.50 (0.40–0.64)	50.0 ± 3.0	0.88^{LPC} (0.66–1.17)	33.6 ± 2.4	0.50 (0.40–0.62)	43.9 ± 2.7	0.80^{LPC} (0.62–1.04)	38.7 ± 3.0	0.52 (0.40–0.68)	51.9 ± 3.0	0.95^{LPC} (0.70–1.29)
All Other	38.5 ± 4.4	0.53 (0.37–0.78)	39.8 ± 4.3	0.55 (0.37–0.83)	32.3 ± 4.3	0.47 (0.32–0.70)	35.3 ± 4.6	0.54 (0.34–0.84)	37.6 ± 3.6	0.50 (0.36–0.68)	37.8 ± 3.3	0.49 (0.35–0.68)
	% Change in OR (univariate to multivariate)				% Change in OR (univariate to multivariate)				% Change in OR (univariate to multivariate)			
	Non-Hispanic black	51.9%			Non-Hispanic black	36.0%			Non-Hispanic black	42.9%		
	Hispanic	76.0%			Hispanic	60.0%			Hispanic	82.7%		
	All Other	3.8%			All Other	14.9%			All Other	−2.0%		

[a]Superscripts to adjusted ORs indicate presence of reversed associations (RA1, RA2) and/or large percent changes (LPC) to the unadjusted ORs.

RA1: Unadjusted OR statistically significantly lower than whites; adjusted OR statistically significant, higher estimated screening rate compared to whites.

RA2: Unadjusted OR not significantly different from whites; adjusted OR statistically significant, higher estimated screening rate compared to whites.

LPC: The multivariable, fully-adjusted change from the unadjusted OR is 50% or more.

[b]Analysis sample sizes are shown in the box with each survey year. Analyses incorporated adjustments for sampling.

Published OnlineFirst March 10, 2011; DOI: 10.1158/1055-9965.EPI-10-1226

Table 4. Covariates contributing to changes from univariate to multivariable adjusted ORs for 2-year prostate testing, for Hispanic and non-Hispanic black men in the BRFSS and NHIS (men age 50 and over)[a,b]

2004 BRFSS			2006 BRFSS			2008 BRFSS		
Covariate	**OR (95% CI)**	**% Change**	**Covariate**	**OR (95% CI)**	**% Change**	**Covariate**	**OR (95% CI)**	**% Change**
Non-Hispanic black	0.84 (0.73–0.96)	–	Non-Hispanic black	0.85 (0.75–0.95)	–	Non-Hispanic black	0.97 (0.87–1.07)	–
Income	0.98 (0.86–1.13)	16.7	Education	0.99 (0.87–1.12)	16.5	Income	1.12 (1.003–1.24)	15.5
Age	1.09 (0.94–1.25)	11.2	Marital status	1.06 (0.93–1.20)	7.1	Insurance	1.18 (1.05–1.31)	5.4
Education	1.17 (1.01–1.35)	7.3	Insurance	1.10 (0.97–1.25)	3.8	Age	1.28 (1.14–1.44)	8.5
Marital status	1.21 (1.05–1.40)	3.4	Age	1.13 (0.99–1.29)	2.7	Education	1.33 (1.18–1.50)	3.9
Insurance	1.24 (1.07–1.44)	2.5	Income	1.16 (1.02–1.33)	2.7	Marital status	1.38 (1.23–1.56)	3.8
Usual source of care	1.23 (1.06–1.43)	−0.8	Region	1.15 (1.01–1.32)	−0.9	Usual source of care	1.38 (1.23–1.56)	0.0
Region	1.21 (1.04–1.41)	−1.6	Usual source of care	1.13 (0.99–1.30)	−1.7	Region	1.35 (1.20–1.53)	−2.2
Hispanic	0.49 (0.40–0.60)	–	Hispanic	0.51 (0.42–0.61)	–	Hispanic	0.53 (0.46–0.60)	–
Education	0.63 (0.51–0.78)	28.6	Education	0.63 (0.53–0.77)	23.5	Education	0.68 (0.59–0.79)	28.3
Usual source of care	0.73 (0.59–0.91)	15.9	Usual source of care	0.72 (0.59–0.88)	14.3	Usual source of care	0.79 (0.68–0.91)	16.2
Age	0.80 (0.63–1.00)	9.6	Insurance	0.75 (0.61–0.92)	4.2	Age	0.84 (0.73–0.98)	6.3
Income	0.87 (0.69–1.09)	8.7	Age	0.78 (0.63–0.96)	4.0	Income	0.92 (0.79–1.07)	9.5
Region	0.90 (0.72–1.13)	3.4	Income	0.82 (0.66–1.01)	5.1	Region	0.94 (0.80–1.09)	2.2
Insurance	0.91 (0.73–1.15)	1.1	Region	0.84 (0.69–1.03)	2.4	Insurance	0.95 (0.82–1.11)	1.1
Marital status	0.91 (0.72–1.14)	0.0	Marital status	0.82 (0.67–1.01)	−2.4	Marital status	0.94 (0.80–1.09)	−1.1

2003 NHIS			2005 NHIS			2008 NHIS		
Covariate	**OR (95% CI)**	**% Change**	**Covariate**	**OR (95% CI)**	**% Change**	**Covariate**	**OR (95% CI)**	**% Change**
Non-Hispanic black	0.81 (0.66–1.00)	–	Non-Hispanic black	0.75 (0.60–0.94)	–	Non-Hispanic black	0.77 (0.61–0.96)	–
Education	0.99 (0.80–1.23)	22.2	Income	0.84 (0.67–1.05)	12.0	Education	0.90 (0.71–1.14)	16.9
Age	1.10 (0.87–1.38)	11.1	Age	0.97 (0.76–1.23)	15.5	Age	1.04 (0.83–1.31)	15.6
Marital status	1.20 (0.95–1.51)	9.1	Marital status	1.01 (0.80–1.28)	4.1	Marital status	1.12 (0.88–1.41)	7.7
Income	1.28 (1.01–1.62)	6.7	Education	1.06 (0.84–1.33)	5.0	Income	1.15 (0.91–1.46)	2.7
Insurance	1.29 (1.02–1.64)	0.8	Insurance	1.08 (0.86–1.36)	1.9	Insurance	1.17 (0.92–1.49)	1.7
Usual source of care	1.29 (1.01–1.63)	0.0	Usual source of care	1.07 (0.85–1.35)	−0.9	Usual source of care	1.15 (0.90–1.47)	−1.7
Region	1.23 (0.96–1.57)	−4.7	Region	1.02 (0.81–1.29)	−4.7	Region	1.10 (0.86–1.41)	−4.3
Hispanic	0.50 (0.40–0.64)	–	Hispanic	0.50 (0.40–0.62)	–	Hispanic	0.52 (0.40–0.68)	–
Education	0.66 (0.52–0.85)	32.0	Education	0.59 (0.47–0.73)	18.0	Education	0.66 (0.50–0.86)	26.9
Usual source of care	0.75 (0.58–0.97)	13.6	Age	0.68 (0.54–0.87)	15.3	Age	0.80 (0.60–1.06)	21.2
Age	0.82 (0.63–1.08)	9.3	Usual source of care	0.75 (0.58–0.96)	10.3	Insurance	0.88 (0.66–1.18)	10.0
Insurance	0.86 (0.65–1.14)	4.9	Income	0.78 (0.61–1.00)	4.0	Region	0.93 (0.68–1.27)	5.7
Income	0.89 (0.67–1.17)	3.5	Insurance	0.80 (0.62–1.03)	2.6	Income	0.95 (0.71–1.29)	2.2
Region	0.90 (0.68–1.20)	1.1	Region	0.79 (0.61–1.02)	−1.3	Usual source of care	0.97 (0.71–1.32)	2.1
Marital status	0.88 (0.66–1.17)	−2.2	Marital status	0.80 (0.62–1.04)	1.3	Marital status	0.95 (0.70–1.29)	−2.1

[a]The "OR" columns show the progression of the OR from the prior step, for the specific racial/ethnic group, as the next covariate was added to the model.

[b]The "% Change" columns show the change to the OR from the prior step of analysis, for the specific racial/ethnic group, as the next covariate was added to the model.

absolute 17% to 20% lower, again making reversals unlikely to occur.

Variable-by-Variable Results. Insurance and education produced the largest OR changes for Hispanics in 5 analyses, although there was no percent-change for the first-selected variable greater than 23%. Insurance, education, marital status, income, and age produced the largest OR changes for blacks in the BRFSS and NHIS. However, the order of selection varied and there was no PC for any one variable for blacks that was greater than 13%.

Discussion

Summary of results

This research investigated RAs and LPCs between the unadjusted and adjusted ORs for non-white racial/ethnic groups, focusing on Pap, colorectal, and prostate testing. Pap testing showed the largest number of RAs and LPCs, with an RA and/or LPC in each of the 6 surveys. Across the 3 domains of testing, Hispanics had larger PCs than blacks and NHOs in each survey year. Importantly, the Pap testing attenuation results for age draw attention to

Published OnlineFirst March 10, 2011; DOI: 10.1158/1055-9965.EPI-10-1226

Table 5. Colorectal cancer screening in the BRFSS and NHIS (men and women age 50 and over): univariate and multivariate design-adjusted ORs and 95% confidence intervals for race/ethnicity, and percent change to the unadjusted ORs[a,b]

	2004 BRFSS (*N* = 146,794)				2006 BRFSS (*N* = 195,318)				2008 BRFSS (*N* = 251,623)			
	Crude %	Univariate OR (95% CI)	Predicted %	Adjusted OR (95% CI)	Crude %	Univariate OR (95% CI)	Predicted %	Adjusted OR (95% CI)	Crude %	Univariate OR (95% CI)	Predicted %	Adjusted OR (95% CI)
Non-Hispanic white	57.8 ± 0.3	(Ref)	56.2 ± 0.3	(Ref)	61.9 ± 0.2	(Ref)	60.3 ± 0.2	(Ref)	64.3 ± 0.2	(Ref)	62.5 ± 0.2	(Ref)
Non-Hispanic black	53.4 ± 1.0	0.84 (0.77–0.90)	59.1 ± 1.0	1.14[RA1] (1.04–1.25)	57.2 ± 0.9	0.82 (0.77–0.89)	62.4 ± 0.8	1.10[RA1] (1.01–1.19)	60.2 ± 0.8	0.84 (0.79–0.89)	65.1 ± 0.7	1.13[RA1] (1.05–1.22)
Hispanic	42.1 ± 1.5	0.53 (0.47–0.60)	52.5 ± 1.5	0.85[LPC] (0.74–0.97)	44.7 ± 1.4	0.50 (0.45–0.56)	54.8 ± 1.3	0.78[LPC] (0.69–0.87)	45.6 ± 1.1	0.46 (0.43–0.51)	57.3 ± 1.0	0.78[LPC] (0.71–0.86)
All Other	47.4 ± 1.7	0.66 (0.58–0.75)	50.5 ± 1.5	0.78 (0.68–0.89)	54.2 ± 1.4	0.73 (0.65–0.82)	55.8 ± 1.3	0.81 (0.72–0.91)	53.0 ± 1.1	0.63 (0.57–0.68)	55.5 ± 1.0	0.72 (0.66–0.79)
	% Change in OR (univariate to multivariate)				% Change in OR (univariate to multivariate)				% Change in OR (univariate to multivariate)			
	Non-Hispanic black	35.7%			Non-Hispanic black	34.1%			Non-Hispanic black	34.5%		
	Hispanic	60.4%			Hispanic	56.0%			Hispanic	69.6%		
	All Other	18.2%			All Other	11.0%			All Other	14.3%		

	2003 NHIS (*N* = 21,115)				2005 NHIS (*N* = 13,480)				2008 NHIS (*N* = 9,722)			
	Crude %	Univariate OR (95% CI)	Predicted %	Adjusted OR (95% CI)	Crude %	Univariate OR (95% CI)	Predicted %	Adjusted OR (95% CI)	Crude %	Univariate OR (95% CI)	Predicted %	Adjusted OR (95% CI)
Non-Hispanic white	45.5 ± 0.7	(Ref)	44.5 ± 0.7	(Ref)	49.6 ± 0.7	(Ref)	48.3 ± 0.7	(Ref)	56.8 ± 0.8	(Ref)	55.4 ± 0.8	(Ref)
Non-Hispanic black	36.2 ± 1.5	0.68 (0.59–0.78)	42.8 ± 1.6	0.93 (0.80–1.07)	39.3 ± 1.4	0.66 (0.58–0.75)	45.2 ± 1.5	0.87 (0.76–1.01)	48.9 ± 1.8	0.73 (0.63–0.84)	54.2 ± 1.7	0.95 (0.80–1.12)
Hispanic	28.5 ± 1.6	0.48 (0.40–0.56)	37.3 ± 1.9	0.72[LPC] (0.60–0.87)	30.0 ± 1.7	0.44 (0.37–0.52)	39.6 ± 2.0	0.68[LPC] (0.56–0.82)	36.2 ± 1.7	0.43 (0.37–0.51)	45.5 ± 2.0	0.64 (0.53–0.78)
All Other	24.1 ± 2.7	0.38 (0.28–0.51)	25.6 ± 2.8	0.41 (0.30–0.56)	32.1 ± 3.3	0.48 (0.35–0.65)	34.3 ± 3.3	0.53 (0.39–0.73)	46.5 ± 2.8	0.66 (0.53–0.83)	46.4 ± 2.8	0.67 (0.53–0.86)
	% Change in OR (univariate to multivariate)				% Change in OR (univariate to multivariate)				% Change in OR (univariate to multivariate)			
	Non-Hispanic black	36.8%			Non-Hispanic black	31.8%			Non-Hispanic black	30.1%		
	Hispanic	50.0%			Hispanic	54.5%			Hispanic	48.8%		
	All Other	7.9%			All Other	10.4%			All Other	1.5%		

[a]Superscripts to adjusted ORs indicate presence of reversed associations (RA1, RA2) and/or large percent changes (LPC) to the unadjusted ORs.
RA1: Unadjusted OR statistically significantly lower than whites; adjusted OR statistically significant, higher estimated screening rate compared to whites.
RA2: Unadjusted OR not significantly different from whites; adjusted OR statistically significant, higher estimated screening rate compared to whites.
LPC: The multivariable, fully-adjusted change from the unadjusted OR is 50% or more.
[b]Analysis sample sizes are shown in the box with each survey year. Analyses incorporated adjustments for sampling.

Published OnlineFirst March 10, 2011; DOI: 10.1158/1055-9965.EPI-10-1226

Table 6. Covariates contributing to changes from univariate to multivariable adjusted ORs for colorectal cancer screening, for Hispanic and non-Hispanic black men and women in the BRFSS and NHIS (limited to adults age 50 and over)[a,b]

2004 BRFSS			2006 BRFSS			2008 BRFSS		
Covariate	**OR (95% CI)**	**% Change**	**Covariate**	**OR (95% CI)**	**% Change**	**Covariate**	**OR (95% CI)**	**% Change**
Non-Hispanic black	0.84 (0.77–0.90)	–	Non-Hispanic black	0.82 (0.77–0.89)	–	Non-Hispanic black	0.84 (0.79–0.89)	–
Insurance	0.92 (0.84–0.997)	9.5	Education	0.91 (0.84–0.97)	11.0	Income	0.92 (0.87–0.99)	9.5
Education	0.98 (0.90–1.07)	6.5	Insurance	0.98 (0.91–1.05)	7.7	Age	1.04 (0.97–1.11)	13.0
Age	1.05 (0.96–1.14)	7.1	Marital status	1.02 (0.95–1.10)	4.1	Marital status	1.08 (1.01–1.16)	3.8
Marital status	1.12 (1.03–1.22)	6.7	Age	1.09 (1.01–1.18)	6.9	Education	1.13 (1.06–1.21)	4.6
Income	1.15 (1.05–1.25)	2.7	Income	1.12 (1.03–1.21)	2.8	Insurance	1.16 (1.08–1.25)	2.7
Usual source of care	1.15 (1.05–1.25)	0.0	Gender	1.12 (1.03–1.21)	0.0	Gender	1.16 (1.08–1.25)	0.0
Gender	1.15 (1.05–1.25)	0.0	Region	1.12 (1.03–1.21)	0.0	Usual source of care	1.16 (1.08–1.25)	0.0
Region	1.14 (1.04–1.25)	−0.9	Usual source of care	1.10 (1.01–1.19)	−1.8	Region	1.13 (1.05–1.22)	−2.6
Hispanic	0.53 (0.47–0.60)	–	Hispanic	0.50 (0.45–0.56)	–	Hispanic	0.46 (0.43–0.51)	–
Education	0.62 (0.55–0.70)	17.0	Education	0.59 (0.53–0.66)	18.0	Education	0.56 (0.52–0.62)	21.7
Age	0.72 (0.63–0.82)	16.1	Insurance	0.67 (0.60–0.75)	13.6	Insurance	0.65 (0.60–0.71)	16.1
Usual source of care	0.80 (0.70–0.91)	11.1	Age	0.72 (0.64–0.80)	7.5	Age	0.70 (0.64–0.77)	7.7
Income	0.84 (0.73–0.96)	5.0	Usual source of care	0.75 (0.67–0.84)	4.2	Income	0.74 (0.68–0.81)	5.7
Insurance	0.86 (0.75–0.99)	2.4	Income	0.78 (0.70–0.88)	4.0	Usual source of care	0.78 (0.71–0.85)	5.4
Region	0.87 (0.76–0.99)	1.2	Region	0.79 (0.70–0.88)	1.3	Region	0.79 (0.72–0.86)	1.3
Gender	0.87 (0.76–0.99)	0.0	Gender	0.79 (0.70–0.88)	0.0	Gender	0.79 (0.72–0.86)	0.0
Marital status	0.85 (0.74–0.97)	−2.3	Marital status	0.78 (0.69–0.87)	−1.3	Marital status	0.78 (0.71–0.86)	−1.3

2003 NHIS			2005 NHIS			2008 NHIS		
Covariate	**OR (95% CI)**	**% Change**	**Covariate**	**OR (95% CI)**	**% Change**	**Covariate**	**OR (95% CI)**	**% Change**
Non-Hispanic black	0.68 (0.59–0.78)	–	Non-Hispanic black	0.66 (0.58–0.75)	–	Non-Hispanic black	0.73 (0.63–0.84)	–
Education	0.77 (0.67–0.89)	13.2	Income	0.72 (0.63–0.82)	9.1	Education	0.80 (0.69–0.93)	9.6
Age	0.83 (0.71–0.96)	7.8	Age	0.79 (0.69–0.91)	9.7	Age	0.87 (0.74–1.01)	8.7
Marital status	0.88 (0.75–1.02)	6.0	Marital status	0.82 (0.71–0.94)	3.8	Marital status	0.94 (0.80–1.10)	8.0
Income	0.90 (0.78–1.05)	2.3	Education	0.87 (0.76–1.01)	6.1	Income	0.97 (0.83–1.13)	3.2
Region	0.92 (0.80–1.07)	2.2	Insurance	0.88 (0.76–1.02)	1.1	Insurance	0.97 (0.83–1.14)	0.0
Insurance	0.94 (0.81–1.09)	2.2	Gender	0.88 (0.76–1.02)	0.0	Gender	0.97 (0.83–1.14)	0.0
Gender	0.94 (0.81–1.09)	0.0	Region	0.88 (0.76–1.01)	0.0	Usual source of care	0.95 (0.80–1.12)	−2.1
Usual source of care	0.93 (0.80–1.07)	−1.1	Usual source of care	0.87 (0.76–1.01)	−1.1	Region	0.95 (0.80–1.12)	0.0
Hispanic	0.48 (0.40–0.56)	–	Hispanic	0.44 (0.37–0.52)	–	Hispanic	0.43 (0.37–0.51)	–
Education	0.59 (0.50–0.71)	22.9	Insurance	0.51 (0.43–0.61)	15.9	Education	0.52 (0.44–0.61)	20.9
Insurance	0.66 (0.55–0.79)	11.9	Education	0.59 (0.50–0.70)	15.7	Insurance	0.59 (0.50–0.71)	13.5
Age	0.70 (0.58–0.83)	6.1	Age	0.63 (0.53–0.76)	6.8	Age	0.62 (0.51–0.74)	5.1
Usual source of care	0.71 (0.59–0.85)	1.4	Income	0.66 (0.55–0.79)	4.8	Usual source of care	0.63 (0.52–0.76)	1.6
Income	0.72 (0.60–0.87)	1.4	Usual source of care	0.67 (0.55–0.80)	1.5	Income	0.64 (0.53–0.77)	1.6
Marital status	0.73 (0.61–0.87)	1.4	Region	0.67 (0.56–0.81)	0.0	Region	0.65 (0.54–0.78)	1.6
Gender	0.73 (0.61–0.87)	0.0	Marital status	0.68 (0.56–0.82)	1.5	Gender	0.65 (0.54–0.78)	0.0
Region	0.72 (0.60–0.87)	−1.4	Gender	0.68 (0.56–0.82)	0.0	Marital status	0.64 (0.53–0.78)	−1.5

[a]The "OR" columns show the progression of the OR from the prior step, for the specific racial/ethnic group, as the next covariate was added to the model.

[b]The "% Change" columns show the change to the OR from the prior step of analysis, for the specific racial/ethnic group, as the next covariate was added to the model.

the possibility that an omnibus multivariable analysis "hides" other dynamics among the covariates.

Results of RAs and LPCs for prostate testing were less consistent than the results for Pap testing, which might be expected given the absence of definitive testing guidelines. However, there was also the complication with the results for black men. Region of the country and usual source of care eliminated RAs for black men in both the 2006 BRFSS and the 2003 NHIS. Hispanic men did not show RAs in the prostate analyses, although all 6 analyses yielded LPCs larger than those for black men. Hispanic men's prostate examination rates were notably lower

Published OnlineFirst March 10, 2011; DOI: 10.1158/1055-9965.EPI-10-1226

than white men's rates, thereby reducing the likelihood of type 1 RAs.

Results for colorectal testing showed that blacks had type 1 RAs in all 3 years of the BRFSS, although the associated PCs did not qualify as LPCs. In contrast, however, blacks showed no RAs in the NHIS, and also had no LPCs. Crude percentages of testing for Hispanics were statistically significantly lower than whites in all 6 surveys. However, Hispanics had PCs larger than blacks that qualified as LPCs in 5 of 6 surveys.

Across all 3 screening tests, there was a notably consistent outcome. That is, Hispanics showed RAs and/or LPCs in 17 of 18 analyses, spanning gender-specific and nonspecific tests. This included all 6 years for prostate testing, which has no definitive guidelines. The large majority of outcomes were LPCs not associated with RAs. This may signal that Hispanics are coming closer to showing RAs. blacks showed RAs and/or LPCs in 12 of 18 analyses. However, as noted above, blacks also "lost" 2 potential RAs to attenuation. Researchers should therefore not be surprised in coming years if multivariable analyses of cancer screening increasingly yield RA and LPC results for blacks and Hispanics.

Possible role of social policies and programs

On a societal level, cancer screening occurs based on processes of diffusion (as a technology), adoption (by individuals and professionals), and access-enhancing programs for groups with low utilization (public policy). Mammography and Pap testing are further along in this multifaceted process than colorectal testing, with prostate testing far behind. One possibility worth exploring as a contributor to RAs and LPCs is the national availability of public programs to enhance access to these 2 screening domains. The National Breast and Cervical Cancer Early Detection Program operates in all 50 states, albeit with finite funding and within-state variability of convenient access, in addition to the existence of widespread local initiatives. There have been no parallel, national-level programs for colorectal and prostate testing, and RA/LPC results were less uniform for those latter 2 domains.

In effect, the NBCCEDP, other access-enhancing programs, and even Medicare coverage for certain screening tests circumvent some access barriers (e.g., low income and lack of insurance), but do not improve socioeconomic resources for non-white groups. The multivariate algorithms of regression models would therefore "overcorrect" when calculating their AORs and estimated screening rates, thereby producing RAs as well as LPCs. Therefore, RAs and LPCs could possibly indicate a "success story" for programs intended to increase access. There has been progress toward wider availability of colorectal screening programs. The CDC (28) reported that 23 states had active colorectal screening programs, and there was a recently completed CDC-funded, 5-site demonstration project (29–31). All 50 states, Washington DC, and several tribal groups also have a CDC-supported, comprehensive cancer control program, that includes colorectal screening (32, 33). Wider program availability in the future could contribute to convergence of colorectal screening rates and increase likelihood of RAs and LPCs.

Implications for multivariable analysis

The results here may inform how multivariable analyses of the correlates of cancer screening utilization are reviewed and interpreted. Specifically, there seem to be 4 elements to consider. The first is comparing the unadjusted and fully-adjusted ORs and 95% CIs for a variable of interest (e.g., race/ethnicity). This comparison detects the presence or absence of an RA, and is the basis for calculating percent change to the unadjusted ORs. Whenever possible, papers on the correlates of screening should include the unadjusted ORs, to allow this comparison and calculation.

A second consideration is a comparison of the *crude* screening rates for each racial/ethnic group versus the screening rates that are *predicted* by the multivariable analyses. Predicted percentages have usually not been highlighted in cancer screening literature, but they are part-and-parcel of the "message" produced by a multivariable analysis. In this study, the predicted percentages for Hispanics were between 6% and 13% higher than their crude percentages; predicted percentages for blacks were generally 3% to 6% higher. Predicted screening rates less than 10 percentage points higher than the crude rates can still be associated with type 1 RAs and LPCs, such as in the 3 BRFSS results for Hispanic women's Pap testing (Table 1), and for black's colorectal testing in the BRFSS (Table 5).

A third focus of attention is the *variable-by-variable* change to the OR. Our procedure was not a standard, forward stepwise regression. Instead, the analytical process determined the variable-by-variable changes in the OR in separate analyses focused in turn on blacks, Hispanics, and the NHOs. This procedure therefore allowed looking "behind the curtain" of what otherwise occurs in omnibus multivariable analyses. In this regard, age had an attenuating effect in all of the Pat test analyses (Table 2). Attenuation did not affect the bottom-line presence of RAs for Hispanic women's Pap testing, but it did lower the magnitudes of association and the overall percent of change to the ORs. Attenuation did affect the bottom-line RA results for black men's prostate testing in the 2006 BRFSS and the 2003 NHIS. Age cannot be omitted as a covariate in analyses of cancer screening, but our results suggest that it can complicate results as readily as it can be a correlate of utilization.

A final consideration, important for the possibility of finding RAs, is *comparing the unadjusted, crude percentages* of utilization across the respective racial/ethnic groups. Even with multivariable adjustment, some crude-rate disparities were large enough not to be reversed by the relatively small set of covariates we used. Tables 1, 3, and 5 show that black's self-reported utilization rates were closer to those of whites than were

Published OnlineFirst March 10, 2011; DOI: 10.1158/1055-9965.EPI-10-1226

the rates for Hispanics. black men had type 1 RAs for colorectal testing in all 3 BRFSS surveys, where rates were relatively closer. Hispanic women showed type 1 RAs for Pap testing, when their self-reported rates were much closer to whites (i.e., 9% or less of a difference). The practical reality is that RAs for Hispanics are less likely when crude percentages are 15% to 20% lower than whites, as they were for colorectal and prostate testing. However, LPCs to unadjusted ORs are still possible, and Tables 1, 3, and 5 in fact show that in all except one analysis, Hispanics had larger changes to their unadjusted ORs than did blacks. In the prior article by Rakowski and colleagues (4) mammography rates were also relatively closer for Hispanics compared to white women, being less than 10% in the instances where type 1 RAs were found. Therefore, if non-white (especially Hispanic's) colorectal and prostate testing rates converge with those for whites, the likelihood of finding RAs may increase.

Limitations

The research reported here has limitations and constraints. All data are based on self-report, and self-reported screening rates are higher than found when medical records or claims data are examined (34). "Telescoping" of test recency could be a consideration if non-white racial/ethnic groups telescoped to a greater degree than whites. It was also not possible to distinguish tests obtained for screening versus those obtained due to a possible problem or for diagnosis.

It was not possible to account for any biases that may accompany racial/ethnic group differentials in recruitment contact rates and subsequent rates of agreement-to-participate. Individuals' survey weights are routinely adjusted to account for nonparticipation along certain key demographic variables. However, differential recruitment will still be a consideration if those who participate are more likely to report recent screening, because the participants will be disproportionately up-weighted when producing estimates of their group's screening.

We deliberately used a consistent, relatively small set of covariates across all analyses. On one hand, the fact that RAs and LPCs were found highlights the salience of the RA/LPC phenomenon. On the other hand, the absence of RAs and LPCs in some analyses does not mean they would never appear; other covariates, such as cancer worry, factual knowledge about the benefits of testing, perceived social norms, or county-level variables might produce RAs and LPCs. That said, the fact that some covariates attenuated the ORs strongly indicates that "more" variables added to a model is not necessarily a guarantee of the analyses being "better" or more informative.

We also followed the typical practice of using only main effects for the independent variables. It is possible that RAs, and even LPCs not associated with RAs, suggest complicated screening-relevant life circumstances for subgroups of the sample that would be evident if captured as interaction terms. Investigating interactions is one of the next-steps for cancer screening research, although knowing which variables are best candidates for interaction analysis is not clear. It may be useful to start such investigations with the variables that produce the greatest changes to the ORs when a reversal occurs, as well as variables (such as age) that act to attenuate the ORs.

The NHO group did not show RAs or even LPCs. The lack of reversals does not mean that RAs and LPCs would be totally absent for all of the racial/ethnic subgroups in that broad NHO category, but larger samples for those separate groups are necessary to conduct the type of analyses done for black and Hispanic women. Along the same lines, it is also possible that RAs and LPCs would not be found for some groups within the broad "Hispanic" and "black" umbrellas.

Using 2008 as a same-year comparison, it appears that the BRFSS and NHIS cannot be relied upon to give similar results. For Pap testing, Latinas had a type 1 RA in the BRFSS, but their NHIS analyses yielded only an LPC. Blacks had a type 1 RA in the 2008 BRFSS for colorectal testing, but had no RA in the NHIS. Blacks had a type 2 RA for prostate testing in the 2008 BRFSS, and no reversal in the NHIS. The fact that results for race/ethnicity may not be consistent between 2 prominent surveys must be recognized. It is beyond the scope of this article to explore reasons, but attention should be directed to aggregate response rates, racial/ethnic response rates, correlations among covariates, and the response formats used to assess testing status, since the NHIS allows specific month/year reporting. Finally, the BRFSS and NHIS data are cross-sectional. The results therefore give associations, not prospectively-based predictions.

Conclusion

Reversed associations are an intriguing but potentially confusing outcome of multivariable analyses. Clearly, racial/ethnic groups with RAs in multivariable analyses do not actually have higher rates of screening than whites. Analyses that yield RAs can therefore challenge the role that multivariable analyses typically play in advocacy and the identification of priority populations for programs and interventions to enhance access. Reversed associations do not defeat that process, but imply that analytic strategies need to be more complex to identify the variables that produce the reversals. The objective is not simply to make RAs "go away" because they can be confusing anomalies, but instead to understand how the variables that eliminate main-effect reversals for race/ethnicity may, in turn, help to better target resources for programs and policies. If, for example, interaction terms of race/ethnicity with income and education eliminated main-effect RAs, the identification of specific race/ethnic combinations with income/education that had especially high predicted screening rates after multivariable adjustment could target resources to

Published OnlineFirst March 10, 2011; DOI: 10.1158/1055-9965.EPI-10-1226

those groups. Although multivariable analyses are typically used to be descriptive to identify groups at-risk of lower screening utilization, analyses done to identify variables (and interactions of variables) that eliminate RAs might be helpful in a "diagnostic" sense, to target groups most likely to benefit from access-enhancing policies and programs.

Disclosure of Potential Conflicts of Interest

No potential conflicts of interest were disclosed.

Grant Support

Support for preparation of the manuscript was provided by NIH grant number R21-CA127828 from the National Cancer Institute. The content of this article is solely the responsibility of the authors and does not necessarily represent the official views of the National Cancer Institute or the NIH.

The costs of publication of this article were defrayed in part by the payment of page charges. This article must therefore be hereby marked *advertisement* in accordance with 18 U.S.C. Section 1734 solely to indicate this fact.

Received November 23, 2010; revised February 3, 2011; accepted February 23, 2011; published OnlineFirst March 10, 2011.

References

1. Mokdad AH, Stroup DF, Giles WH. Public health surveillance for behavioral risk factors in a changing environment. Recommendations from the Behavioral Risk Factor Surveillance Team. MMWR Recomm Rep 2003;52:1–12.
2. Hiatt RA, Klabunde C, Breen N, Swan J, Ballard-Barbash R. Cancer screening practices from National Health Interview Surveys: past, present, and future. J Natl Cancer Inst 2002;94:1837–46.
3. Rakowski W, Breslau ES. Perspectives on behavioral and social science research on cancer screening. Cancer 2004;101 Suppl:1118–30.
4. Rakowski W, Clark MA, Rogers ML, Weitzen S. Investigating reversals of association for utilization of recent mammography among Hispanic and non-Hispanic black women. Cancer Causes Control 2009:20;1483–95.
5. Breen N, Wagener DK, Brown ML, Davis WW, Ballard-Barbash R. Progress in cancer screening over a decade: results of cancer screening from the 1987, 1992, and 1998 National Health Interview Surveys. J Natl Cancer Inst 2001;93:1704–13.
6. Ostbye T, Greenberg GN, Taylor DH Jr, Lee AM. Screening mammography and Pap tests among older American women 1996–2000: results from the Health and Retirement Study (HRS) and Asset and Health Dynamics among the oldest old (AHEAD). Ann Fam Med 2003;1:209–17.
7. Carlos RC, Fendrick AM, Patterson SK, Bernstein SJ. Associations in breast and colon cancer screening behavior in women. Acad Radio 2005;12:451–8.
8. Subramanian S, Amonkar MM, Hunt TL. Use of colonoscopy for colorectal cancer screening: evidence from the 2000 National Health Interview Survey. Cancer Epidemiol Biomarkers Prev 2005;14:409–16.
9. Adams EK, Florence CS, Thorpe KE, Becker ER, Joski PJ. Preventive care: female cancer screening, 1996–2000. Am J Prev Med 2003;25:301–7.
10. De Alba I, Ngo-Metzger Q, Sweningson JM, Hubbell FA. Pap smear use in California: are we closing the racial/ethnic gap? Prev Med 2005;40:747–55.
11. Rothman KJ, Greenland S. Modern Epidemiology. 2nd ed. Philadelphia, PA: Lippincott Williams & Wilkins; 1998. p. 256.
12. Behavioral Risk Factor Surveillance System Operational and User's Guide, Version 3.0. Available from: ftp://ftp.cdc.gov/pub/Data/Brfss/userguide.pdf.
13. Behavioral Risk Factor Surveillance System Cell Phone Pilot Operational Protocol [last retrieved on 2011 Jan 25]. Available from: http://www.ndhealth.gov/brfss/publications/2008%20BRFSS%20Cell%20Phone%20Pilot%20Opeartional%20Protocol-Final.pdf.
14. Behavioral Risk Factor Surveillance System Survey Data. Available from: http://www.cdc.gov/brfss/technical_infodata/surveydata.htm.
15. 2008 BRFSS Summary Data Quality Report [last retrieved on 2011 Jan 25]. Available from: ftp://ftp.cdc.gov/pub/Data/Brfss/2006Summary-DataQualityReport.pdf.
16. 1998 BRFSS Summary Quality Control Report [last retrieved on 2011 Jan 25]. Available from:ftp://ftp.cdc.gov/pub/Data/Brfss/98quality.pdf.
17. Centers for Disease Control and Prevention. National Health Interview Survey: Research for the 1995–2004 redesign. Vital Health Statistics 1999;2:1–119.
18. Centers for Disease Control and Prevention. Design and estimation for the National Health Interview Survey, 1995–2004. Vital Health Statistics 2000;2:1–31.
19. NHIS Survey Description [last retrieved on 2011 Jan 25]. Available from: ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/1999/srvydesc.pdf.
20. NHIS Survey Description [last retrieved on 2011 Jan 25]. Available from: ftp://ftp.cdc.gov/pub/Health_Statistics/NCHS/Dataset_Documentation/NHIS/2008/srvydesc.pdf.
21. Questionnaires, datasets, and related documentation. Available from: http://www.cdc.gov/nchs/about/major/nhis/quest_data_related_1997_forward.htm.
22. Smith RA, Cokkinides V, Brooks D, Saslow D, Brawley OW. Cancer screening in the United States, 2010: a review of current American Cancer Society guidelines and issues in cancer screening. CA Cancer J Clin 2010;60:99–119.
23. Screening for cervical cancer. Available from: http://www.uspreventiveservicestaskforce.org/uspstf/uspscerv.htm.
24. Wolf AM, Wender RC, Etzioni RB, Thompson IM, D'Amico AV, Volk RJ, et al. American Cancer Society guideline for the early detection of prostate cancer: update 2010. CA Cancer J Clin 2010;60:70–98.
25. Stark JR, Mucci L, Rothman KJ, Adami HO. Screening for prostate cancer remains controversial. BMJ 2009;339:b3601.
26. Screening for prostate cancer. Available from: http://www.uspreventiveservicestaskforce.org/uspstf/uspsprca.htm.
27. Research Triangle Institute. SUDAAN: Software for the statistical analyses of correlated data (Release 10.0). In., 10.0 ed. Research Triangle Park, NC: RTI International; 2008.
28. Summary of Colorectal Cancer Activities in the U.S. States, Select Tribal Organizations and Territories. Available from: http://www.cdc.gov/cancer/Colorectal/pdf/colorectal_cancer_activities.pdf.
29. Seeff LC, DeGroff A, Tangka F, Wanliss E, Major A, Nadel M, et al. Development of a federally funded demonstration colorectal cancer screening program. Prev Chronic Dis 2008;5:A64.
30. DeGroff A, Boehm J, Goode Green S, Holden D, Seeff LC. Facilitators and challenges to start-up of the colorectal cancer screening demonstration program. Prev Chronic Dis 2008;5:A39.
31. DeGroff A, Holden D, Goode Green S, Boehm J, Seeff LC, Tangka F. Start-up of the colorectal cancer screening demonstration program. Prev Chronic Dis 2008;5:A38.
32. Major A, Stewart SL. Celebrating 10 years of the National Comprehensive Cancer Control Program, 1998 to 2008. Prev Chronic Dis 2009;6:A133.
33. Townsend JS, Richardson LC, Steele CB, White DE. Evidence-based interventions and screening recommendations for colorectal cancer in comprehensive cancer control plans: a content analysis. Prev Chronic Dis 2009;6:A127.
34. Rauscher GH, Johnson TP, Cho YI, Walk JA. Accuracy of self-reported cancer-screening histories: a meta-analysis. Cancer Epidemiol Biomarkers Prev 2008;17:748–57.

Cancer Epidemiology, Biomarkers & Prevention

AACR American Association for Cancer Research

Reversals of Association for Pap, Colorectal, and Prostate Cancer Testing among Hispanic and Non-Hispanic Black Women and Men

William Rakowski, Melissa A. Clark, Michelle L. Rogers, et al.

Cancer Epidemiol Biomarkers Prev 2011;20:876-889. Published OnlineFirst March 10, 2011.