



Trends in breast and colorectal cancer screening among U.S. adults by race, healthcare coverage, and SES before, during, and after the great recession

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ARTICLE INFO

Article history:

Received 16 December 2016

Received in revised form 24 February 2017

Accepted 1 April 2017

Available online 5 April 2017

Keywords:

Cancer

Cancer screening

Epidemiology

Socioeconomic factors

Demographics

Health care access

Health care providers

Affordable care act

ABSTRACT

The aim of this study is examine trends in breast and colorectal cancer screening in the U.S. by race, healthcare coverage, and socio-economic status (SES) before the Great Recession (2003–2005), during the recession (2007–2009), and post-recession/Affordable Care Act (ACA) period (2010–2012). Data on a representative sample of U.S. adults was obtained from the Behavioral Risk Factor Surveillance System (BRFSS). Breast and colorectal cancer screening were defined in line with U.S. Preventative Services Task Force guidelines, and survey weighted statistical methods were utilized to analyze trends in cancer screening among 1,858,572 BRFSS participants. Overall, 83% of women received mammograms in the past 2 years, while 95% of adults received colorectal cancer screening in the past 10 years. Compared with the pre-recession period, the odds of colorectal screening within 5 years were slightly higher during the recession (OR: 1.05, 95% CI: 1.03–1.08) but significantly lower in the post-recession/ACA period (OR: 0.73, 95% CI: 0.72–0.75). Odds of mammography screening were lower during (OR: 0.94, 95% CI: 0.91–0.96) and post-recession/ACA period (OR: 0.80, 95% CI: 0.78–0.82). Breast cancer screening rates declined in the recession and post-recession, while colorectal cancer screening rates increased during the recession and decreased post-recession. Low SES adults and those without healthcare coverage were the least likely to receive screening.

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1. Introduction

Over the past two decades, the economy and healthcare policies of the United States (U.S.) have undergone major changes. Following the economic growth experienced between 2004 and early 2007, there was a massive decline between 2007 and 2009, a period termed the Great Recession, leading to significant decreases in employment, income, and insurance coverage during the period (Elsby et al., 2010; Goodman, 2011; Holahan, 2011). From 2007 to 2009, it is estimated that the number of Americans ages 19 to 64 years with employee sponsored health insurance decreased by 5.8 million (Holahan, 2011). This presented a challenge to public health efforts, especially for preventive healthcare including cancer screening. Multiple studies show that lower socioeconomic status (SES), and more importantly lack of health insurance and source of usual health care contribute to lower rates of screening (Breen et al., 2001; Garcia et al., 2012; Rahman et al., 2003; Akinyemiju et al., 2012; Selvin & Brett, 2003; DeVoe et al., 2003; Trivers et al., 2008).

In the years after the recession, unemployment rates declined and the economy improved (Goodman, 2011). Additionally, in 2010 the US government passed the Patient Protection and Affordable Care Act (ACA), a comprehensive health insurance reform package with the goal of expanding health insurance coverage, eliminating coverage barriers for individuals with pre-existing health conditions, expansion of healthcare coverage to low-income adults, and mandating healthcare coverage of essential health benefits including preventive health care (Medicaid.gov, 2017). Following the ACA, mammograms and colorectal cancer screening became cost free for individuals meeting the United States Preventative Services Task Force (USPSTF) guidelines based on age and frequency of tests (HHS.gov, 2017). Under these guidelines adults ages 50–75 are encouraged to receive colonoscopies every 10 years or sigmoidoscopies every 5 years, and women ages 50–74 are recommended to receive mammograms every 2 years (USPSTF, 2016a; USPSTF, 2016b).

These changes in the health insurance landscape, along with positive trends in the US economy, provided conditions for improvements in healthcare insurance, SES, and preventive health care, including cancer screening. Although some studies have examined changes in screening rates before and during the recession, few have compared the recession to the post-recession and ACA period. Given the recent important changes to the healthcare landscape, this remains a critical gap in the

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current literature. In addition, it will be beneficial to identify potential disparities in screening rates in order to provide equity in screening for disadvantaged groups. Therefore, the purpose of this study is to examine the trends in breast and colorectal cancer screening rates and disparities among age-appropriate U.S. adults in the pre-recession, during recession, and post-recession/ACA periods.

2. Methods

2.1. Data Source

Data was obtained in 2016 from the Behavioral Risk Factor Surveillance System (BRFSS) from 2003 to 2012 and included adults ages 50 years and older (CDC, 2016). BRFSS conducts annual telephone surveys in the U.S., which gathers information on demographics, chronic health conditions, risk behaviors pertaining to health, and the utilization of preventative services of U.S. adults aged 18 and older. A disproportionate stratified sample (DSS) design is utilized to collect nationally representative data using land-line and cell-phone telephone numbers chosen randomly, garnering data on 400,000 adults in all 50 states, including three U.S. territories and the District of Columbia (CDC, 2014a).

2.2. Study Variables

Breast and colorectal cancer screening were the primary variables of interest. BRFSS participants were asked how long it had been since their last mammogram, and given the following options: within the past year, 2 years, 3 years, 5 years, 5 or more years ago, don't know/not sure, and refused. They were also asked how long it had been since their last sigmoidoscopy or colonoscopy, and were provided the following options: within the past year, 2 years, 3 years, 5 years, 10 years, 10 or more years ago, don't know/not sure, and refused. In addition, socioeconomic and sociodemographic characteristics, including age, marital status, race/ethnicity, education, employment status, and income were analyzed. Data on health care provider and health care coverage were analyzed, the latter including all forms of coverage, such as health insurance, government plans, and prepaid plans (CDC, 2016). Self-reported data on past diagnosis of comorbid conditions was also included as a study covariate. Three study periods were defined for analysis: pre-recession (2003–2005), during the recession (2007–2009), and after the recession and ACA introduction (2010–2012).

2.3. Statistical Analysis

Descriptive statistics were conducted using chi-square tests for socio-economic, socio-demographic, and healthcare characteristic patterns in each study period. Comorbidity was defined as the average number of chronic health conditions reported by study participants, and differences in mean comorbidity were determined across the study periods using ANOVA. The proportion of women who reported receiving a mammogram within 2 years, and the proportion of adults who received sigmoidoscopies or colonoscopies within 5 years and 10 years, respectively was examined. To determine if statistically significant trends existed in annual screening rates, tests for linear trend using regression models with each screening variable and assessing the linear effect of year was conducted. In addition, to determine whether there were differences among race, SES and healthcare coverage in screening across the study periods, multivariable adjusted logistic regression models were conducted and adjusted for socio-demographic, SES and healthcare access, with sex being excluded from the mammogram model. Collinearity between study covariates were assessed using the Variance Inflation Factor analysis, with results suggesting minimal collinearity in the statistical models. All analyses were conducted in 2016 using survey statistical procedures in SAS (V. 9.4, Cary NC) incorporating individual weights, strata, and cluster variables to account for survey sampling strategy and enhance generalizability to the US population.

3. Results

There were 1,858,572 eligible BRFSS participants, 463,337 in the pre-recession, 791,596 during-, and 603,639 in the post-recession (Table 1). The majority of participants were White (83.1%) and female (62.2%), and there was a higher proportion of adults ages 50–59 (33.9%). Compared to the pre-recession, there was a higher proportion of adults with incomes >\$50,000 in the recession and post-recession (32.9% vs. 37.9% and 38.8%). The proportion of adults who were employed decreased across the periods (31.5% vs 30.8% and 29.4%), and the proportion with a usual health care provider was higher in the post- vs. pre-recession period (91.7% vs. 91.4%). The mean number of comorbidity reported was highest during the recession (1.15, SE: 0.001), but declined post-recession (0.64, SE: 0.001).

Screening rates for mammography and colorectal cancer by study period and stratified by race, SES, and healthcare coverage are presented in Table 2. Overall, mammography rates decreased from the pre-recession to the recession and post-recession periods (84.7%, 84.4%, and 82.4%; p -value < 0.0001). Screening among Whites decreased across the periods (84.7%, 84.2%, and 82.2%; p -value < 0.0001), while screening among Blacks increased in the recession and decreased post-recession (87.1%, 87.4%, and 86.5%; p < 0.0001) with trends similar among Hispanics. Participants with health care coverage had significantly higher screening rates compared with participants without healthcare coverage across all time periods (86.2%, 86.2% and 84.4% vs. 64.8%, 61.7% and 58.5%); the same trend was observed in those with a healthcare provider (p < 0.0001). However, screening rates declined in all groups across study periods. Among low-SES adults (annual income <\$10,000), 76% were screened pre-recession, 75% during- and 74% post-recession, with screening rates significantly higher among adults with incomes \geq \$50,000. Screening rates were lower among participants with <high school education at pre-recession (79%) and post-recession (77%) periods. The highest mammography screening rate post-recession was observed among Blacks (87%), and participants who were employed (84%). Annual trends in mammography screening showed declines between 2003 and 2012 with healthcare coverage contributing to the largest disparity (Fig. 1a–c).

Overall, colorectal cancer screening rates within 10 years increased from the pre-recession to the recession but decreased in the post-recession period (93.2%, 95.6%, and 95.2% respectively, p -value < 0.0001) (Table 2). The same pattern was observed among Whites, Blacks, and Hispanics. Screening among participants with health care coverage was 93.6% pre-recession, 96.0% during-, and 95.6% post-recession; the same trend was observed in participants with a healthcare provider. Among low SES adults (income <\$10,000), 90% received screening pre-recession, 94% during-, and 93% post-recession. Colorectal screening rates within 5 years increased in the recession but also decreased in the post-recession period (84.0%, 84.6% and 79.3% respectively, p -value < 0.0001), showing similar trends by race, health care access, and SES variables. Annual trends in colorectal cancer screening within 5 years show an increase between 2003 and 2008, but decreases are observed between 2008 and 2012 (Fig. 1d–f) with similar results seen in colorectal screening within 10 years (Fig. 1g–i) and both showing health care coverage as the greatest disparity.

Results of the multivariable adjusted logistic regression models are displayed in Table 3. The odds of receiving a mammogram decreased by 6% during the recession (OR: 0.94; 95% CI, 0.91–0.96) and 20% during the post-recession (OR: 0.80; 95% CI, 0.78–0.82), compared with pre-recession. In contrast, the odds of receiving colorectal screening within 5 years increased by 5% in the recession (OR: 1.05; 95% CI, 1.03–1.08), but decreased by 27% post-recession (OR: 0.73; 95% CI, 0.72–0.75), while the odds of receiving colorectal cancer screening within 10 years increased by 58% during the recession (OR: 1.58; 95% CI, 1.51–1.65) and 45% during the post-recession (OR: 1.45; 95% CI, 1.40–1.51).

Table 1
Baseline characteristics of study population by study periods, BRFSS 2003–2012^a.

Sample characteristics	Study periods				p value ^b
	Total	Pre-recession	Recession	Post-recession	
	(2003–2012)	(2003–2005)	(2007–2009)	(2010–2012)	
	N = 1,858,572	N = 463,337	N = 791,596	N = 603,639	
Age					
50–59	651,630 (33.90)	38.47	34.84	32.35	<0.0001
60–69	576,260 (31.67)	29.06	31.05	32.63	
≥ 70	630,682 (34.43)	32.47	34.11	35.02	
Sex					
Male	700,671 (37.77)	37.78	37.33	(38.17)	<0.0001
Female	1,157,901 (62.23)	62.22	62.67	(61.83)	
Race					
White	1,531,646 (83.11)	83.91	83.54	82.61	<0.001
Black	130,505 (7.29)	6.74	7.06	7.59	
Hispanic	91,169 (5.01)	4.92	4.92	5.11	
Multiracial	27,699 (1.52)	1.58	1.47	1.56	
Other race	55,377 (3.06)	2.86	3.01	3.13	
Education					
<High school	209,085 (10.62)	12.95	10.98	9.92	<0.001
High school grad	593,286 (31.84)	32.51	32.09	31.51	
Some college	476,441 (25.98)	24.92	25.85	26.25	
≥College	573,953 (31.57)	29.63	31.08	32.32	
Income level					
<\$10,000	96,324 (5.86)	7.11	5.69	5.80	<0.001
\$10,000–<\$20,000	259,291 (16.22)	17.88	15.93	16.23	
\$20,000–<\$50,000	636,638 (39.97)	42.15	40.51	39.16	
≥50,000	574,965 (37.94)	32.87	37.86	38.80	
Employment					
Employed	564,938 (30.15)	31.51	30.76	29.40	<0.001
Self-employed	151,734 (8.10)	8.34	8.19	7.98	
Unemployed	65,079 (3.79)	2.84	3.39	4.30	
Student/homemaker/retired	924,817 (49.89)	49.98	49.96	49.81	
Unable to work	145,031 (8.07)	7.33	7.71	8.51	
Marital Status					
Married	994,350 (53.53)	53.67	54.05	53.03	<0.001
Divorced/Widowed/Separated	722,620 (38.84)	39.71	38.73	38.80	
Never married	115,668 (6.54)	5.64	6.22	6.97	
Unmarried couple	19,416 (1.10)	0.98	1.00	1.20	
Healthcare care coverage					
Yes	1,719,905 (92.80)	92.35	92.97	92.71	<0.001
No	134,965 (7.20)	7.65	7.03	7.29	
Health care providers					
At least one	1,691,728 (91.50)	90.80	91.44	91.67	<0.001
No	161,134 (8.50)	9.20	8.56	8.33	
Mean Comorbidities ^c (S.E.)	1.02 (0.001)	1.04 (0.002)	1.15 (0.001)	0.64 (0.001)	0.8935

() Denotes row percentage.

(S.E.) Standard Error.

^a Study population consisted of respondents aged 50 years or older.^b Estimated using Chi-Square test.^c Comorbidities studied: cardiovascular disease (angina, coronary artery disease, heart attack, stroke), diabetes, high blood pressure, high cholesterol, asthma, and arthritis.

4. Discussion

We examined trends in breast and colorectal cancer screening among U.S. adults by race, healthcare coverage, and SES in the pre-recession, recession and post-recession utilizing data from the 2003–2012 BRFSS. We observed that screening trends varied most significantly by income and health care coverage across the years. Participants with higher SES (≥\$50,000 income), and those with health care coverage had significantly higher odds of screening, and Black and Hispanic participants had higher odds of receiving screening compared to Whites. Mammography screening was significantly lower during the recession compared with the pre-recession and remained low post-recession. Colorectal screening within 5 years, however, increased slightly in the recession and was significantly lower in the post-recession period. Colorectal screening within 10 years was significantly higher during both the recession and post-recession.

These results are consistent with other studies examining cancer screening trends in the U.S. A recent study observed that breast cancer screening decreased in the recession, a trend attributed to a decline in

insurance coverage caused by the recession, predominantly among White women (King et al., 2014). Contrary to our results, one study examining colorectal cancer screening, before and during the recession, observed that those with insurance reported significant declines in colonoscopy screening during the recession. The authors concluded that despite being insured, those with high out of pocket costs were less likely to receive screening. (Dorn et al., 2012). Other studies have observed different results regarding colorectal cancer screening in the post-recession and ACA period. A recent publication reported that although breast, colorectal, and cervical cancer screening rates were below Healthy People 2020 target rates in the post-recession period, colorectal screening has been increasing over the years, and there was a plateau in screening observed in the post-recession (NIH, 2015). Richman et al. also reported that the ACA's elimination of cost-sharing had little effect on increasing colonoscopy rates, though some improvement was seen through Medicaid benefits (Richman et al., 2016). Similarly, a study by Cooper et al. reported that although mammogram rates increased in the post-recession and ACA period, colonoscopy rates remained unchanged (Cooper et al., 2016). These conflicting results may be due to

Table 2
Screening rates by study period, BRFSS 2003–2012 (N = 1,858,572).

Sample characteristics	Screening											
	Breast cancer screening: mammography ^b				CRC screening within 5 years ^c				CRC screening within 10 years ^c			
	Study periods											
	Pre-recession	Recession	Post-recession	p-value ^a	Pre-recession	Recession	Post-recession	p-value ^a	Pre-recession	Recession	Post-recession ^d	p-value ^a
Socio-demographics												
Age												
50–59	84.07	83.24	80.97	<0.0001	83.62	85.81	80.64	<0.0001	92.80	95.74	95.64	<0.0001
60–69	85.22	85.05	83.34		84.08	84.15	78.01		93.40	95.61	94.87	
≥ 70	85.11	85.73	83.54		84.78	85.01	79.86		93.70	95.58	95.36	
Sex												
Male	–	–	–	–	85.37	86.03	80.93	<0.0001	93.98	96.18	95.47	0.0002
Female	84.65	84.36	82.40		83.17	83.67	78.27		92.73	95.32	95.09	
Race												
White	84.66	84.21	82.17	<0.0001	83.66	84.07	78.54	<0.0001	93.01	95.51	95.09	<0.0001
Black	87.07	87.35	86.52		89.11	89.97	85.72		96.12	97.57	97.25	
Hispanic	84.15	85.69	82.32		84.59	88.45	83.01		93.64	96.93	95.79	
Multiracial	79.96	78.74	75.73		78.27	81.88	77.013		91.61	92.61	93.17	
Other race	80.57	82.35	80.47		84.75	84.25	79.57		92.67	95.67	94.775	
Healthcare care coverage												
Yes	86.31	86.19	84.40	0.0086	84.59	85.03	79.79	<0.0001	93.58	95.95	95.56	<0.0001
No	64.87	61.74	58.47		73.59	74.54	69.20		86.54	89.07	88.75	
Health care providers												
At least one	86.44	86.32	84.43	<0.0001	84.77	85.14	79.80	0.0027	93.73	96.05	95.59	0.0008
No	60.09	58.68	53.32		71.06	73.73	69.22		84.24	88.10	88.14	
Socio-economic status												
Income level												
<\$10,000	75.84	74.84	73.51	<0.0001	79.28	82.77	79.31	<0.0001	90.41	93.59	92.61	<0.0001
\$10,000–<\$20,000	78.48	76.88	73.91		80.38	82.16	78.94		90.50	93.48	93.24	
\$20,000–<\$50,000	84.23	83.27	81.08		83.37	83.96	78.73		93.01	95.23	94.88	
≥\$50,000	89.26	88.84	87.46		86.34	85.58	79.74		94.56	96.62	96.22	
Education												
<High school	78.94	79.46	76.50	<0.0001	83.51	86.33	82.56	<0.0001	92.86	95.56	94.92	<0.0001
High school grad	83.86	83.07	80.76		83.58	84.80	80.18		93.08	95.42	95.15	
Some college	84.16	83.68	81.47		83.24	83.77	78.80		92.49	95.05	94.84	
College	88.18	87.73	86.09		85.13	84.64	78.49		93.96	96.27	95.64	
Employment												
Employed	85.97	85.48	83.93	<0.0001	84.91	85.05	79.78	<0.0001	93.44	95.99	95.76	<0.0001
Self-Employed	80.58	78.95	77.21		82.65	83.07	77.33		92.26	94.74	94.33	
Unemployed	77.08	75.58	73.55		79.44	82.48	76.84		90.06	93.58	93.03	
Student/homemaker/retired	86.18	86.51	84.56		84.34	84.64	79.11		93.76	95.86	95.47	
Unable to work	77.72	77.40	75.86		81.46	84.47	81.44		91.21	94.66	93.97	
Overall	84.65	84.36	82.40	<0.0001	84.04	84.57	79.30	<0.0001	93.22	95.64	95.23	<0.0001

^a Estimated using Chi-Square test.

^b Mammography among women age 50–74.

^c CRC among adults ages 50–75 based on sigmoidoscopy within the past 5 years and colonoscopy within the past 10 years.

^d BRFSS mammography data was not available for 2011; therefore, the mammography post-recession only included 2010 and 2012 data.

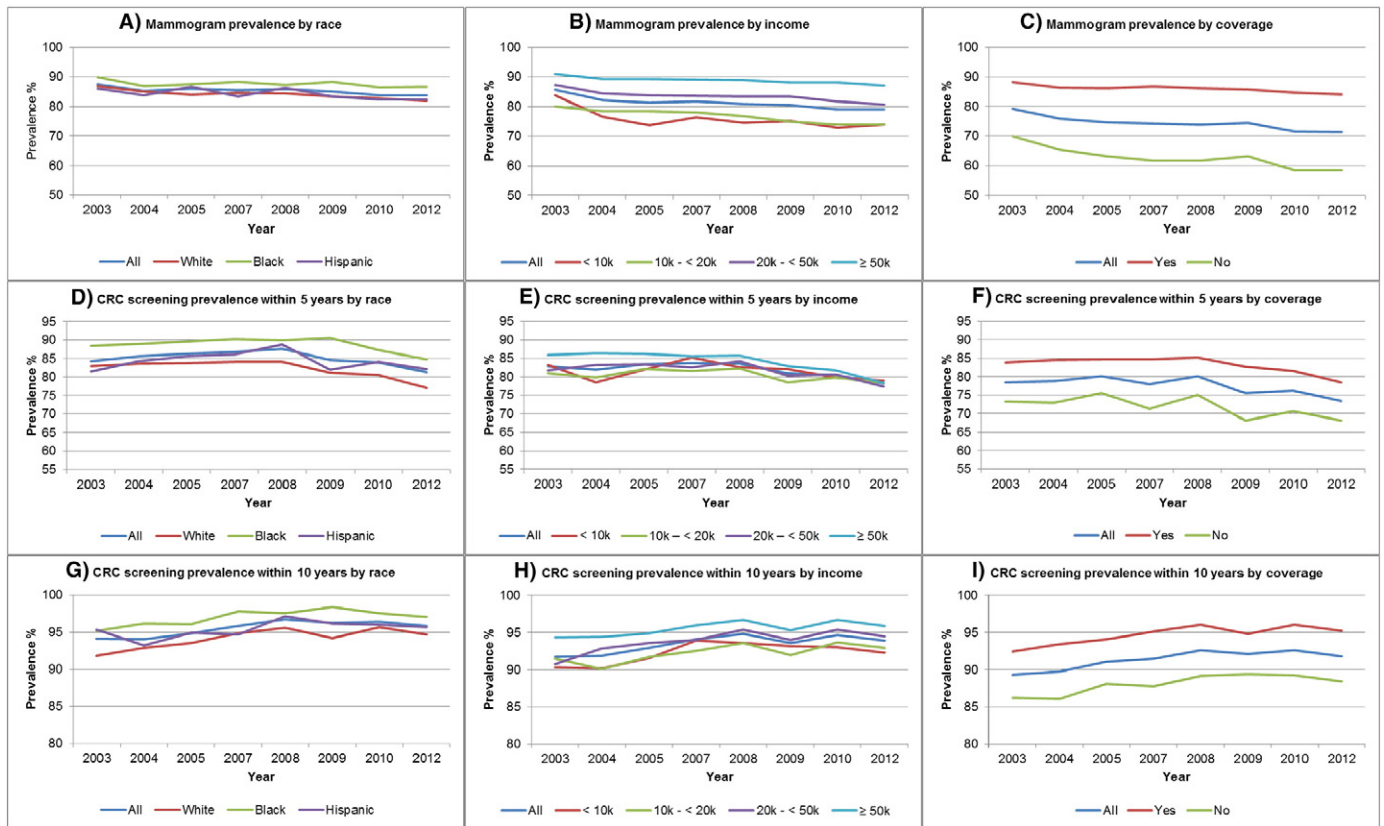


Fig. 1. Annual Trends in Breast and Colorectal Cancer Screening by race and income, BRFSS 2003–2012.

differences in the study population, time periods being examined, and lack of adequate control of potential confounders such as comorbidities, which may influence the likelihood of screening.

Other studies have also reported racial differences in cancer screening similar to our findings. For instance, King et al. observed that mammography screening was higher among Black participants in comparison to Whites before and during the recession. They postulated that this may be due to less severe income reductions for Blacks, and/or a higher percentage of Blacks qualifying for public insurance (King et al., 2014). Alternatively, Akinyemiju et al. reported that screening rates were actually higher for White participants compared Black participants after adjusting for misclassification in self-reported screening rates (Akinyemiju et al., 2012). Misclassification may occur if participants do not fully understand which screening procedure is being evaluated or if recall bias occurs, where the participant remembers having the procedure at a more recent date than it actually occurred (Akinyemiju et al., 2012; Richman et al., 2016). In a study examining racial differences in mammography trends among rural U.S. women, Paskett et al. reported that rural Black women received fewer recommendations for screening from physicians or family, had less accurate breast cancer knowledge, and misjudged their risk of cancer in comparison to White women (Paskett et al., 2004). These findings, taken together with our observation of higher odds of screening among Blacks over the study period, suggest that objective measures of cancer screening, e.g. from medical records or insurance claims, may be needed to reliably characterize cancer screening rates and trends by race in the US.

We also observed that the SES variable with the largest influence on mammography and colorectal cancer screening rates was income; 87.5% of those with income >\$50,000 received mammograms in the post-recession compared with 73.5% of those with income <\$10,000. A prior study, which examined cancer screening between 1987 and 2002 including mammograms and sigmoidoscopies, also found that lower income, as well as less education, contributed to decreased

screening rates (Breen et al., 2001). Similarly, a study using data from 2013 also found that education and income were significant predictors of mammogram, colorectal, and cervical cancer screening (NIH, 2015), and several other studies, examining colorectal and/or breast cancer screening, have reported that lower income or education play significant roles in influencing screening (Garcia et al., 2012; Rahman et al., 2003; Trivers et al., 2008; Swan et al., 2010). Having higher education can increase the likelihood of employment in jobs with employer-associated health insurance and paid time off necessary for routine screening (CDC, 2014b). Low income adults may lack insurance through work but earn above the minimum amount needed to qualify for low-income insurance programs, such as Medicaid (Garfield et al., 2014).

Overall, the decreases seen in breast and colorectal cancer screening within 5 years were also attributed to healthcare access differences, especially healthcare coverage. Other studies have also reported both healthcare coverage and usual source of care as important factors affecting screening (Breen et al., 2001; Garcia et al., 2012; Rahman et al., 2003; Akinyemiju et al., 2012; Selvin & Brett, 2003; DeVoe et al., 2003). Screening recommendations by one's physician or usual source of care play a significant role in increasing the likelihood of receiving cancer screening (Breen et al., 2001; Triantafyllidis et al., 2016). Through the ACA, health care insurance coverage was projected to increase, and in this study, we observed that 92.4% of adults had health insurance in the pre-recession period, compared with 93.0% during the recession and 92.7% post-recession. According to the U.S. Department of Health and Human Services, the ACA aimed to improve coverage of screening services, and the 2010 provisions specified that all individual and work-sponsored health plans allow for mammogram and colorectal cancer screening to be cost free for those in the recommended age ranges. However, there were exceptions that may have prevented these benefits from being realized, such as grandfathered plans, out-of-network providers, or office visit fees. Some studies have found that although these changes to the health insurance landscape nationwide

Table 3
Multivariable logistic regression analysis of screening among U.S. adults by study period, BRFSS 2003–2012 (N = 1,858,572).

Sample characteristics	Screening: odds ratio (95% CI) ^a		
	Breast cancer screening: mammography ^b	CRC screening within 5 years ^c	CRC screening within 10 years ^c
Wave			
Pre-recession	1 [Reference]	1 [Reference]	1 [Reference]
Recession	0.94 (0.91–0.96)	1.05 (1.03–1.08)	1.58 (1.51–1.65)
Post-recession	0.80 (0.78–0.82)	0.73 (0.72–0.75)	1.45 (1.40–1.51)
<i>P-trend</i>	<0.0001	<0.0001	<0.0001
Race			
White	1 [Reference]	1 [Reference]	1 [Reference]
Black	2.03 (1.95–2.11)	1.75 (1.68–1.81)	2.23 (2.11–2.45)
Hispanic	1.59 (1.52–1.67)	1.35 (1.29–1.41)	1.45 (1.34–1.58)
Multiracial	0.86 (0.80–0.91)	0.91 (0.86–0.97)	0.79 (0.71–0.87)
Other race	1.09 (1.04–1.16)	1.08 (1.03–1.14)	1.08 (0.98–1.18)
Income level			
<\$10,000	0.57 (0.55–0.60)	0.94 (0.89–0.98)	0.65 (0.60–0.70)
\$10,000–<\$20,000	0.56 (0.54–0.58)	0.94 (0.91–0.97)	0.66 (0.63–0.70)
\$20,000–<\$50,000	0.71 (0.69–0.73)	0.96 (0.94–0.98)	0.81 (0.78–0.84)
≥\$50,000	1 [Reference]	1 [Reference]	1 [Reference]
Education			
< High school	0.79 (0.76–0.83)	1.25 (1.20–1.30)	1.12 (1.05–1.21)
High School grad	0.86 (0.83–0.88)	1.13 (1.10–1.15)	1.04 (1.00–1.08)
Some college	0.84 (0.82–0.87)	1.03 (1.01–1.05)	0.92 (0.88–0.95)
College	1 [Reference]	1 [Reference]	1 [Reference]
Employment			
Employed	1 [Reference]	1 [Reference]	1 [Reference]
Self-Employed	0.75 (0.72–0.77)	0.91 (0.88–0.93)	0.84 (0.80–0.89)
Unemployed	0.90 (0.86–0.93)	0.97 (0.93–1.01)	0.93 (0.86–1.00)
Student/homemaker/retired	1.09 (1.06–1.11)	0.98 (0.96–1.01)	1.08 (1.03–1.12)
Unable to work	0.80 (0.77–0.82)	1.06 (1.02–1.10)	0.95 (0.89–1.01)
Healthcare care coverage			
Yes	1 [Reference]	1 [Reference]	1 [Reference]
No	0.41 (0.40–0.42)	0.57 (0.55–0.60)	0.49 (0.46–0.52)
Health care providers			
At least one	1 [Reference]	1 [Reference]	1 [Reference]
No	0.28 (0.28–0.29)	0.59 (0.57–0.61)	0.40 (0.38–0.42)
Mean Comorbidities	0.97 (0.96–0.98)	1.02 (1.01–1.03)	0.96 (0.95–0.98)

^a Odds ratios and CI calculated using logistic regression model, which was fully adjusted.

^b Mammography among women age 50–74.

^c CRC among adults ages 50–75 based on sigmoidoscopy within the past 5 years and colonoscopy within the past 10 years.

may have improved mammogram screening rates, colonoscopy rates have remained the same (NIH, 2015; Richman et al., 2016; Cooper et al., 2016). This may have been due to low awareness of screening guidelines, lack of information about the availability of new screening benefits, cultural beliefs about screening, perception of risk, or lack of access to facilities with colorectal cancer screening programs (Richman et al., 2016). Additionally, Medicaid had not expanded in many states, with 23 states yet to expand by October 2014 (Garfield et al., 2014). As a result of non-expansion, those who had incomes above the current Medicaid level, but below the level for marketplace premiums, would be left in a “coverage gap,” leaving many without insurance (Garfield et al., 2014). More research is needed to better characterize and intervene among population sub-groups lacking preventive healthcare such as routine cancer screening due to socio-demographic or access to healthcare barriers.

With the decline in income rates experienced during the recession and the association between income and cancer screening, it is understandable that mammogram rates were lower in the recession. Decreased income may have resulted in fewer women willing to pay out of pocket costs associated with mammograms. Although the economy improved and the ACA was introduced in the post-recession, a lower mammography rate may have persisted due to lack of awareness of cancer screening services being cost-free, office visit fees discouraging those without healthcare insurance, or lack of Medicaid expansion in many states. In addition, the unemployment rate recovered very slowly in the post-recession and just reached the pre-recession rate of 5% in 2015 (Farber, 2015; Center for Budget Policy and Priorities, 2017). Despite these circumstances, colonoscopy screening within 10 years

were higher during the recession and post-recession in comparison to the pre-recession. One reason may be that participants interviewed in the recession period included colonoscopies they received within 10 years, which includes pre-recession times, where income and other factors were more favorable. The longer time frame to receive a colonoscopy may also be more manageable to achieve, in terms of cost and frequency of visits. Conversely, mammograms are recommended every 2 years, and only respondents in the recession year, 2007, could include mammograms they received in 2005 or 2006.

Some limitations were present in this study. First, mammography data was not collected by BRFSS in 2011; therefore, when analyzing the post-recession, only 2010 and 2012 data were considered. In addition, the colorectal cancer screening variable in 2011 was assessed as part of an optional module, resulting in significantly lower response rates; therefore, data from this year was excluded from analysis. There was also a change in BRFSS methodology; prior to 2011, surveys were exclusively landline telephone based; however, surveys taken by cellular telephone were included in 2011 as more households were primarily using cell-phones. A new weighting method was introduced in 2011 to account for the new sampling strategy and replaced the previous post-stratification method. The CDC predicts that the two changes in the surveys may have caused changes in screening rate estimates from 2011 onwards, which could affect comparison to previous years (Anon, 2012). Another factor to consider is the change in USPSTF screening guidelines for mammograms in 2009 and colorectal cancer in 2008. Mammograms guidelines were updated to exclude regular screening for women ages 40–49 (USPSTF, 2008), instead recommending screening every 2 years starting at age 50, and the recommended age to

receive colorectal screening was changed from 50 or older, with no upper limit on age, to ages 50–75 (USPSTF, 2009). This study was based on current screening recommendations, which represents the scientific consensus on screening intervals most likely to reduce cancer mortality. Lastly, although the ACA was introduced in 2010 and access to screening was improved in early provisions, the full effects of the ACA had not been widely disseminated by 2012 (Washington Hospital-ity Association, 2015). Analysis of screening data after 2012 may help to better account for changes in cancer screening and the influence of the ACA.

5. Conclusion

Overall, breast cancer screening rates were lower in the recession and post-recession compared with pre-recession period, while colorectal cancer screening rates increased in the recession and decreased in the post-recession. These trends varied significantly by socioeconomic status and health insurance coverage, implying that more work remains in ensuring that information on new screening benefits through the ACA and Medicaid expansion are being transmitted to U.S. adults, and that other structural barriers to receiving screening such as the availability and accessibility of screening facilities is being improved. Although our data suggests that Blacks were more likely to receive cancer screening compared with Whites, future studies using objective sources of screening, e.g. medical records or claims data by race, will be important for definitive results on racial disparities in screening. Significant progress has been made in ensuring access to preventive healthcare due to the ACA; however, continued research on cancer screening rates after 2012 may help to better outline the influence of the ACA on screening, and highlight population groups where efforts are needed to improve utilization, and focused screening programs to improve early detection of cancer.

Financial support and acknowledgements

Ms. Wyatt was supported by the NIH National Cancer Institute award number U54 CA118948 for this research. The content of this article is solely the responsibility of the authors and does not necessarily represent the official views of NIH. Ms. Wyatt conducted statistical analysis and drafting of the manuscript. Dr. Akinyemiju oversaw the design, analysis, interpretation of data and writing of the manuscript. Mr. Perenkil contributed to the interpretation of data and writing of the manuscript.

Transparency document

The [Transparency document](#) associated with this article can be found, in online version.

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