American Journal of
Preventive Medicine

RESEARCH ARTICLE

Changes in Breast and Colorectal Cancer Screening After Medicaid Expansion Under the Affordable Care Act

Stacey A. Fedewa, PhD,[1] K. Robin Yabroff, PhD,[1] Robert A. Smith, PhD,[2] Ann Goding Sauer, MSPH,[1] Xuesong Han, PhD,[1] Ahmedin Jemal, DVM, PhD[1]

Introduction: Medicaid expansions following the Affordable Care Act have improved insurance coverage in low-income adults, but little is known about its impact on cancer screening. This study examined associations between Medicaid expansion timing and colorectal cancer (CRC) and breast cancer (BC) screening.

Methods: Up-to-date and past 2-year CRC (n=95,400) and BC (women, n=43,279) screening prevalence were computed among low-income respondents aged 50−64 years in 2012, 2014, and 2016 Behavioral Risk Factor Surveillance System data. Respondents were grouped according to Medicaid expansion timing as: very early ([VE] six states expanding March 1, 2010−April 14, 2011), early (21 states expanding January 1, 2014−August 15, 2014), late (five states expanding January 1, 2015−July 1, 2016), and non-expansion states (19 states). Absolute adjusted difference-in-differences (aDDs) were computed in 2018−2019 (ref, non-expansion states).

Results: Between 2012 and 2016, absolute up-to-date CRC screening increased by 8.8%, 2.9%, 2.4%, and 3.8% among low-income adults in VE, early, late, and non-expansion states, respectively. Past 2−year CRC screening increased by 8.0% in VE and 2.8% in non-expansion states, with an aDD of 4.9% (p=0.041). In 2012−2016, up-to-date BC screening increased by 5.1%, 4.9%, and 3.7% among low-income women in VE, early, and non-expansion states, respectively, but aDDs were not statistically significant.

Conclusions: Prevalence of CRC and BC screening among low-income adults rose in Medicaid expansion states, though increases were significantly higher than those in non-expansion states only for recent CRC screening in VE expansion states. Large-scale improvements in cancer screening may take several years following expansion in access to care.

Am J Prev Med 2019;57(1):3−12.

INTRODUCTION

The Affordable Care Act (ACA), enacted in 2010, provided federal support for states to expand Medicaid insurance coverage to low-income adults, a group with limited access to preventive services.[1,2] Five states and the District of Columbia (hereafter referred to as a state) were very early adopters and expanded Medicaid eligibility in 2010−2011.[3] Twenty-one states expanded their Medicaid programs during 2014; an additional five states expanded in 2015−2016 and 19 states had not expanded as of January 1, 2017.[4]

Health insurance is a strong predictor of cancer screening, and the uninsured and those with lower SES are more likely to be diagnosed at late stage and die from screen-detectable cancers, including colorectal

From the [1]Surveillance and Health Services Research, American Cancer Society, Atlanta, Georgia; and [2]Cancer Control Sciences, American Cancer Society, Atlanta, Georgia

Address correspondence to: Stacey A. Fedewa, PhD, Surveillance and Health Services Research, American Cancer Society, 250 Williams Street, Atlanta GA 30303. E-mail: stacey.fedewa@cancer.org.

0749-3797/$36.00
https://doi.org/10.1016/j.amepre.2019.02.015

cancer (CRC) and breast cancer (BC).[5–7] Insurance coverage and preventive healthcare visits have improved at a faster rate in states that expanded Medicaid compared with those that have not.[8–10] Several studies also suggest that Medicaid expansion may be related to earlier stage at diagnosis for patients residing in low-income areas who are diagnosed with screen-detectable cancers.[11–13] Additionally, a new study found greater increases in recent colonoscopy among low-income residents of the 27 states expanding Medicaid between 2010 and 2014 relative to non-expansion states, but changes in mammography were not observed.[14] This previous study did not consider stool testing for CRC screening, nor did it examine whether disparities across income gradient were mitigated over time among states expanding Medicaid, and it did not account for timing of expansion.[14] The authors of the current study hypothesized that once people obtain insurance, screening utilization may not be immediate, and that low-income residents of the earliest Medicaid expansion states (2010–2011) may have greater increases in CRC and BC because once people obtain insurance, they must complete a multistep screening process that typically relies on a physician visit and recommendation, followed by the screening test itself.[15]

The current study examined temporal changes in BC and CRC screening patterns among low-income adults in all states to determine whether the timing of Medicaid expansion was related to improvements in screening prevalence. The study also examined the potential impact of Medicaid expansion on SES disparities and the absolute number of adults screened according to Medicaid expansion.

METHODS

Study Sample

Data from the 2012, 2014, and 2016 Behavioral Risk Factor Surveillance System (BRFSS), an annual state-based telephone survey overseen by the Centers for Disease Control and Prevention (CDC), were used to examine CRC and BC screening in relation to the timing of Medicaid expansion. Respondents from all states are asked about cancer screening questions biennially. The analysis began with 2012 data because the CDC altered the BRFSS sampling frame in 2011 to include cell phones and does not recommend directly comparing data before and after this change.[16] The respective response rates for the 2012, 2014, and 2016 surveys were 45.2, 47.0%, and 47.1%.[17–19]

Measures

Individuals <138% federal poverty level (FPL) were eligible for Medicaid coverage in expansion states.[20] A household income of <$25,000 was used as a proxy for <138% FPL because household size was not fully captured in the 2012 survey and this income level had a higher sensitivity (92.3%) than <$20,000 (81.7%) of capturing <138% FPL based on 2014–2016 data (Appendix Table 1, available online). Analyses were restricted to adults aged 50–64 years (women only for BC screening) with household incomes <$25,000 (hereafter referred to as low-income) and nonmissing screening data (8.9%, n=8,763 adults and 5.1%, n=3,031 were missing CRC and BC screening data, respectively). The analytic population included 95,400 adults for CRC and 43,279 women for BC screening.

The primary outcomes were U.S. Preventive Services Task Force–recommended CRC and BC screening. Up-to-date (UTD) CRC screening was defined as having a colonoscopy in the past 10 years, sigmoidoscopy in the past 5 years, or a stool test in the past year.[21] CRC testing in the past 2 years was used to capture recent procedures and individual tests were also considered. UTD BC screening was defined as having a mammogram in the past 2 years.[22] Prostate cancer screening was not examined because routine prostate-specific antigen testing was not recommended by the Task Force during the study period.[23] Cervical cancer screening was not considered because co–human papillomavirus and Pap testing was recommended beginning in 2012, but questions on human papillomavirus testing were not included in BRFSS until 2016.[24] Questions on low-dose computed tomography for lung cancer screening were not included in BRFSS.[25]

The primary predictor variables were Medicaid expansion status and survey year. Respondents were grouped into the following categories based on the timing of their states' expansion status: very early (VE; six states expanding March 1, 2010–April 14, 2011), early (21 states expanding January 1, 2014–August 15, 2014), late (five states expanding January 1, 2015–July 1, 2016), and not expanding (19 states not expanding as of January 1, 2017) (Appendix Figure 1, available online). Because of the differences in expansion timing, survey year was used to examine the maturity of expansion, shown in Appendix Figure 2 (available online). For example, 2012, 2014, and 2016 data represented the initial (1–2), 3–4, and 5–6 years following expansion for VE expansion states, respectively. For early expansion states, 2012, 2014, and 2016 data represented the pre-expansion, initial (up to the first year), and up to 2 years following expansion, respectively. For late adopters, 2012 and 2014 data represented the pre-expansion period, whereas the 2016 data captured the initial (1–2 years) following expansion.

Statistical Analysis

Absolute differences in crude screening prevalence estimates according to year and Medicaid expansion were compared using chi-square tests (α<0.05). Difference-in-differences (DDs) were used to determine whether changes in screening were greater in magnitude among Medicaid expansion states compared with non-expansion states (ref) and computed with logistic regression models with predicted marginal probabilities including year, Medicaid expansion, and Medicaid expansion X year terms.[26,27] Absolute adjusted DD (aDD), additionally accounting for state, year, age, race/ethnicity, and sex, were similarly computed. BRFSS sampling weights and absolute changes were used to estimate the number of screened individuals.

Several additional analyses were conducted. First, screening among adults aged 50–64 years with medium/high incomes (≥$25,000) according to expansion and year was assessed. To

determine if disparities between low- and medium/high-income adults narrowed more rapidly in expansion states, adjusted difference-in-difference-in-differences (aDDDs) were computed in models with a three-way interaction between Medicaid expansion X year X income. Second, changes in CRC and BC screening among low-income elderly respondents aged 65–75 and 65–74 years, respectively, were assessed, as these mostly Medicare-insured groups were not anticipated to benefit from Medicaid expansion. To explore whether patterns in 2012–2016 were a continuation of past trends, pre-ACA CRC and BC screening among low-income adults aged 50–64 years were computed using 2006, 2008, and 2010 BRFSS data; however, owing to changes in survey design and questions on CRC screening testing, these estimates could not be directly compared to those ≥2012. Analyses were conducted in 2018–2019 using SAS-callable SUDAAN, version 9.4, and accounted for complex survey designs and non-response.

RESULTS

Among low-income respondents aged 50–64 years, there were a disproportionate number of Hispanic respondents in VE and non-Hispanic blacks in non-expansion states (Table 1). Patterns were similar among women aged 50–64 years (Table 1). Age increased slightly throughout the study period among early and non-expansion states, but other factors were unchanged (Appendix Table 2, available online).

Between 2012 and 2016, the proportion of low-income adults aged 50–64 years who were UTD with CRC screening grew significantly by 8.8 percentage points in VE (from 42.3% to 51.1%, $p<0.001$), 2.9% in early (from 49.6% to 52.5%, $p=0.029$), and 3.8% in non-expansion states (from 44.2% to 48.0%, $p=0.009$) (Figure 1A, Table 2). The magnitude of this change was greatest in VE versus non-expansion states with a non-significant aDD of 5.3% ($p=0.054$). Recent CRC screening increased by 8.0% in VE ($p<0.001$) and 2.8% in non-expansion states, with a significant aDD of 4.9% ($p=0.041$) (Figure 1B, Table 2). The improvement in VE expansion states translated to an additional 236,573 low-income adults receiving recent CRC screening in 2016. If the same absolute increase was experienced in non-expansion states, 355,184 more low-income adults would have had recent CRC screening than what was observed (Table 3). Among low-income adults, UTD or recent CRC screening did not change significantly in late adopting states and prevalence estimates were similar between 2016 and 2014 across expansion status.

Colonoscopy was the most commonly used test and past 10-year and 2-year use increased only among low-income residents in VE expansion states by 7.8% ($p=0.001$) and 5.1% ($p=0.006$), respectively (Appendix Table 3, available online). Stool-based testing increased nonsignificantly in VE states (by 3.8%, $p=0.059$) and increased significantly in non-expansion states (by 1.7%, $p=0.033$). Sigmoidoscopy use was uncommon (<5%) and changed little over time (data not shown).

Between 2012 and 2016, UTD CRC prevalence was stable among middle/high-income adults across Medicaid expansion status, but recent CRC testing declined slightly among early, late, and non-expansion states (Appendix Table 4, available online). Disparities in UTD CRC screening between low- and medium/high-income groups narrowed in VE expansion states where the gap in screening prevalence decreased from 22.8% in 2012 to 15.6% in 2016 (a 7.2% change, $p=0.007$) (Appendix Figure 3A, available online). Disparities in recent CRC screening tapered between 2012 and 2016 among VE (a 10.7% change, $p<0.001$), early (a 3.4% change, $p=0.015$), and non-expansion (a 4.2% change, $p=0.006$) states, though the magnitude of change was greatest in VE state with an aDDD of 6.5% ($p=0.041$) (Appendix Figure 3B, available online). Despite this narrowing, approximately half (48.0%–52.5%) of low-income adults were UTD with CRC screening in 2016 compared with about two thirds (63.2%–68.5%) of medium/high-income adults.

From 2012 to 2016, UTD and recent CRC screening was similar among low-income adults aged 65–75 years in each expansion group (Appendix Table 5, available online). Between 2006 and 2010 among low-income adults aged 50–64 years, receipt of endoscopy in the past 10 years or past-year stool testing grew significantly in early states only. During this time, recent CRC testing increased by 6.3% in VE, with an aDD of 7.7% ($p=0.002$) (Appendix Table 6, available online).

Between 2012 and 2016, BC screening among low-income women significantly increased by 4.9% ($p=0.002$) and 3.7% ($p=0.047$) in early and non-expansion states, respectively (Figure 1C, Table 2). The aDDs were not statistically significant.

Screening for BC declined by 2.9%, 2.4%, and 3.6% among middle/high-income women in VE, early, and late expansion states, respectively (Appendix Table 4, available online). Disparities in mammography use between low- and medium/high-income groups narrowed by 8.4% ($p=0.008$), 7.4% ($p<0.001$), and 4.6% ($p=0.027$), in VE early, and non-expansion states, respectively, but aDDDs were not significant (Appendix Figure 3C, available online).

Among low-income women aged 65–74 years, BC screening remained stable in each expansion group between 2012 and 2016 (Appendix Table 5, available online). Between 2006 and 2010, BC screening increased significantly by 10.6% and 3.7% among low-income women aged 50–64 years in VE and early states (Appendix Table 6, available online).

Table 1. Characteristics of Low-Income Respondents Aged 50–64 Years According to Medicaid Expansion Status, BRFSS 2012, 2014, and 2016

Characteristics	Very early[a]	Early[b]	Late[c]	Not expanding[d]	*p*-value[e]
Men and women aged 50–64 years[f]					—
2012 respondents, *n*	4,157	12,242	4,275	13,128	
2014 respondents, *n*	3,401	11,989	3,097	12,480	
2016 respondents, *n*	3,324	12,826	2,306	12,175	
2012 weighted *n*	2,850,000	5,000,800	1,307,412	6,452,380	
2014 weighted *n*	2,929,800	5,209,950	1,362,426	6,763,740	
2016 weighted *n*	2,957,160	5,170,000	1,360,779	6,830,460	
Sex, male, %	46.8	48.0	44.9	46.4	**0.023**
Age, years, %					0.624
50–54	37.6	35.8	36.3	35.9	
55–59	31.9	32.6	32.9	32.0	
60–64	30.5	31.6	30.9	32.0	
Race/ethnicity, %					<**0.001**
NH white	39.0	60.0	67.7	53.3	
NH black	10.4	16.6	23.2	23.0	
Hispanic	40.5	16.5	4.5	18.7	
Other	10.1	6.9	4.7	5.0	
Women aged 50–64 years[g]					—
2012 respondents, *n*	2,296	7,227	2,576	7,989	
2014 respondents, *n*	1,813	6,871	1,822	7,312	
2016 respondents, *n*	1,735	6,957	1,309	6,834	
2012 weighted *n*	1,216,656	2,203,875	636,300	3,009,732	
2014 weighted *n*	1,336,255	2,341,172	630,564	3,065,732	
2016 weighted *n*	1,194,818	2,219,120	628,835	2,854,571	
Age, years, %					0.289
50–54	35.9	35.6	35.8	35.9	
55–59	32.7	33.3	31.0	31.5	
60–64	31.4	31.1	33.2	32.7	
Race/ethnicity, %					<**0.001**
NH white	39.3	59.8	67.2	52.1	
NH black	10.4	16.7	23.3	24.3	
Hispanic	39.1	16.5	5.2	19.0	
Other	11.1	7.0	4.3	4.6	

Note: Boldface indicates statistical significance ($p<0.05$).
[a]Includes respondents from Minnesota, Connecticut, District of Columbia, California, Washington, and New Jersey.
[b]Includes respondents from Arizona, Arkansas, Colorado, Delaware, Hawaii, Illinois, Iowa, Kentucky, Maryland, Massachusetts, Nevada, New Mexico, New York, North Dakota, Ohio, Oregon, Rhode Island, Vermont, West Virginia, Michigan, and New Hampshire.
[c]Includes respondents from Pennsylvania, Indiana, Alaska, Montana, and Louisiana.
[d]Includes respondents from Alabama, Florida, Georgia, Idaho, Kansas, Maine, Mississippi, Missouri, Nebraska, North Carolina, Oklahoma, South Carolina, South Dakota, Tennessee, Texas, Utah, Virginia, Wisconsin, and Wyoming.
[e]*p*-Value compares differences across the four Medicaid expansion groups using χ^2 tests.
[f]Men and women missing colorectal cancer screening data were not included. Low-income defined as a household income <$25,000.
[g]Women missing breast cancer screening data were not included. Low-income defined as a household income <$25,000.
BRFSS, Behavioral Risk Factor Surveillance System; NH, non-Hispanic.

DISCUSSION

In this large population-based study, increases in recent CRC screening prevalence were greater in magnitude among low-income adults aged 50–64 years residing in the six VE expansion states compared with non-expansion states. Growth in CRC screening prevalence among these VE expansion states was not immediate and changes in CRC screening among those expanding Medicaid later were comparable to non-expansion states. BC screening increased only modestly among low-income women residing in expansion states.

The larger improvements in CRC screening among the residents VE expansion states could be a result of

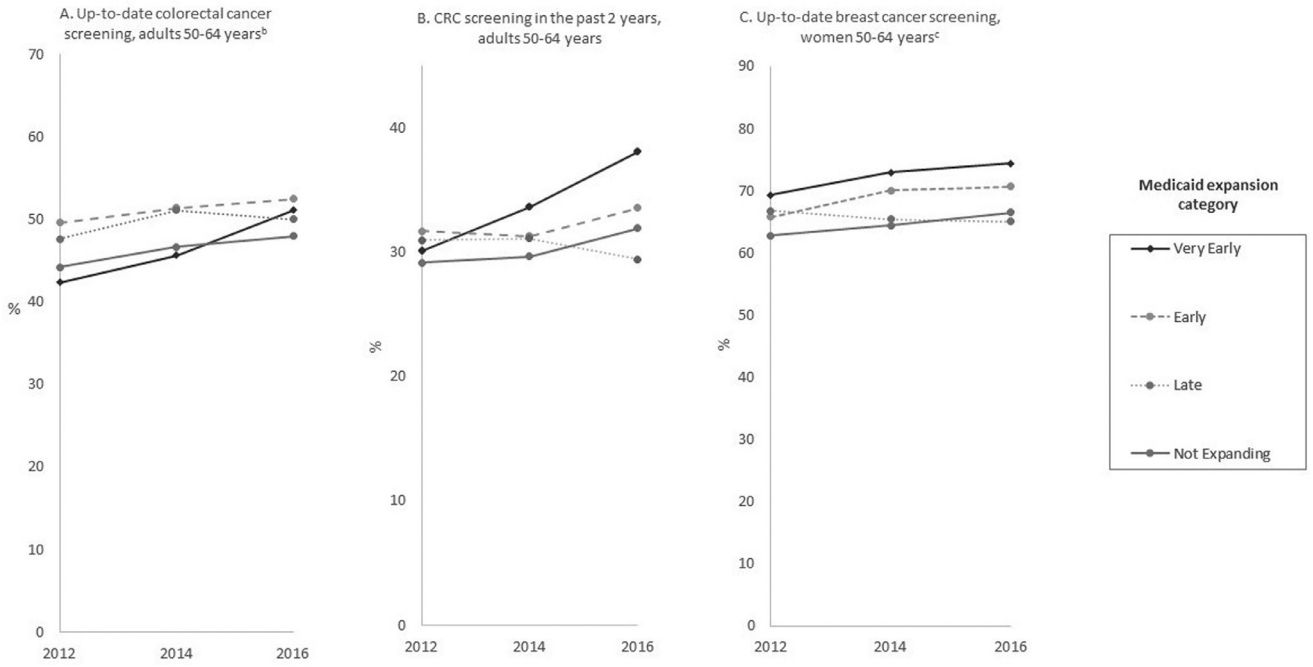

Figure 1. Crude colorectal and breast cancer screening among low-income adults aged 50–64 years by Medicaid expansion status, and year, BRFSS 2012, 2014, and 2016.[a]

[a]Low-income defined as self-reported household income of <$25,000.

[b]Up-to-date colorectal cancer screening: colonoscopy in the past 10 years, sigmoidoscopy in the past 5 years, and/or stool testing in the past year.

[c]Mammogram in the past 2 years.

BRFSS, Behavioral Risk Factor Surveillance System.

increased insurance coverage through Medicaid, as having insurance is a strong predictor of CRC screening.[28,29] The current study aligns with findings from Oregon's Medicaid lottery, where low-income residents randomly selected to receive insurance benefits experienced a 10% increase in colonoscopy use compared with controls.[30] Four years after Massachusetts extended insurance benefits to low-income residents, CRC screening rates were approximately 4% higher than in neighboring states.[31] According to a new BRFSS study, recent colonoscopy increased at a faster pace among 27 states expanding Medicaid through 2014 relative to non-expansion states.[14] The current findings extend beyond these to show that the increase was confined to the six states expanding Medicaid by 2011. The absence of immediate increases in CRC screening following Medicaid expansion may reflect the lag time between people gaining insurance and completing the multistep screening process that typically relies on a physician visit, followed by a recommendation, and then a follow-up visit with a specialist if a colonoscopy is performed.[15] Furthermore, once people obtain insurance, there is pent-up demand to address more-immediate health conditions or symptoms.[32] In line with the current study, others report that improvements in preventive services (e.g., diabetes screening) were larger 2 years following Medicaid expansion than the initial year.[8] It is likely that the full impact of Medicaid expansions on cancer screening may not yet be fully visible and the previously reported modest improvements in early stage at diagnosis for screen detectable cancers could progress further.[11–13]

Alternate explanations for the steep rise in CRC screening among low-income adults in VE states is that baseline screening prevalence was lower, leaving greater room for improvement. However, non-expansion states had similarly depressed CRC screening prevalence and only modest improvements in this group were observed. VE states also had a relatively high proportion of Hispanics (18.3%) and increases in CRC screening could be a result of this subpopulation's screening uptake unrelated to policy change, though results accounting for race/ethnicity were similar. Finally, the observed patterns could be a result of a previous upward trend in CRC testing among low-income adults, but owing to changes in the BRFSS sampling frame and questionnaire, historical patterns could not be directly compared with more current estimates.

This study is the first to report the number of low-income adults who may have been screened under different scenarios according to expansion. If non-expansion

Table 2. CRC and BC Screening Prevalence Among Low-Income Respondents, Medicaid Expansion, and Year Among Adults Aged 50–64 Years, BRFSS 2012, 2014, and 2016

Variable	Crude prevalence					Crude DD[b]				Adjusted DD[c]			
	2012	2014	2016	2016 vs 2012	*p*-value[a]	2014 v 2012		2016 v 2012		2014 v 2012		2016 v 2012	
						DD	*p*-value	DD	*p*-value	DD	*p*-value	DD	*p*-value
Up-to-date CRC screening, adults aged 50–64 years[d]													
Very early	42.3	45.6	51.1	**8.8**	**<0.001**	0.9	0.770	5.0	0.083	1.8	0.508	5.3	0.054
Early	49.6	51.4	52.5	**2.9**	**0.029**	−0.6	0.738	−0.9	0.653	−0.5	0.799	−0.2	0.899
Late	47.7	51.2	50.0	2.4	0.293	1.1	0.651	−1.4	0.588	1.5	0.513	−1.6	0.550
Not expanding	44.2	46.6	48.0	**3.8**	**0.009**	—	—	—	—	—	—	—	—
CRC screening in the past 2 years, adults aged 50–64 years													
Very early	30.1	33.6	38.1	**8.0**	**<0.001**	3.0	0.273	5.2	0.054	3.1	0.223	**4.9**	**0.041**
Early	31.7	31.3	33.5	1.8	0.141	−0.9	0.603	−1.0	0.590	−0.7	0.715	−0.6	0.721
Late	31.0	31.1	29.4	−1.6	0.427	−0.4	0.851	−4.4	0.063	0.1	0.948	−4.2	0.087
Not expanding	29.1	29.6	31.9	**2.8**	**0.031**	—	—	—	—	—	—	—	—
Up-to-date BC screening, women aged 50–64 years[e]													
Very early	69.3	73.0	74.4	5.1	0.073	2.2	0.543	1.4	0.666	2.5	0.512	3.0	0.411
Early	65.8	70.1	70.7	**4.9**	**0.002**	2.7	0.233	1.2	0.612	2.8	0.205	2.0	0.404
Late	66.8	65.4	65.0	−1.8	0.512	−3.0	0.285	−5.5	0.097	−2.1	0.422	−4.8	0.112
Not expanding	62.8	64.4	66.5	**3.7**	**0.047**	—	—	—	—	—	—	—	—

Note: Boldface indicates statistical significance ($p<0.05$).
[a]Differences between 2016 and 2012 were calculated using unrounded prevalence. The *p*-values are based on χ^2 tests comparing 2016 prevalence estimates with 2012.
[b]Based on crude logistic regression models with predicted marginal probabilities including the following: Medicaid expansion, year, and Medicaid expansion X year terms. *p*-Value–based interaction-term *t*-tests.
[c]Adjusted for age, race/ethnicity, sex (CRC models only), state, Medicaid expansion group, Year, Medicaid X year interaction terms. *p*-Value–based interaction-term *t*-tests.
[d]Colonoscopy in the past 10 years, sigmoidoscopy in the past 5 years, or stool-test in the past year.
[e]Mammogram in the past 2 years.
BC, breast cancer; BRFSS, Behavioral Risk Factor Surveillance System; CRC, colorectal cancer; DD, differences in differences.

Table 3. Weighted Number of Low-Income Respondents with CRC Screening in the Past 2 Years by Year and Medicaid Expansion Status, BRFSS 2012, 2014, and 2016

Variable	Very early	Early	Late	No expansion
Low-income adults aged 50–64 years, weighted *n*				
2012[a]	2,850,000	5,000,800	1,307,412	6,452,380
2014[a]	2,929,800	5,209,950	1,362,426	6,763,740
2016[a]	2,957,160	5,170,000	1,360,779	6,830,460
With CRC screening in past 2 years				
2012[b]	857,850	1,585,254	405,298	1,877,643
2012[b]	984,413	1,630,714	423,714	2,002,067
2016[b]	1,126,678	1,731,950	400,069	2,178,917
Absolute change in recent CRC screening between 2016–2012,[c] %	8.0	1.8	−1.6	2.8
Additional screened, *n*				
In 2016–2012, including increases in CRC screening prevalence and number of low-income adults[d]	268,828	146,696	[e]	301,274
In 2016 attributed to increases in CRC screening alone[f]	236,573	93,060	[e]	191,253
In 2016–2012 if growth in CRC screening was the same as VE states (8.0%)[g]	—	413,600	108,862	546,437
Difference in additional number of low-income respondents that would have been screened if other states had the same growth in CRC screening as VE[h]	—	320,540	130,635	355,184

[a]Number of respondents eligible for cancer screening computed using BRFSS survey weights.
[b]Weighted number of survey respondents with colonoscopy, sigmoidoscopy, or stool testing in the past 2 years.
[c]Percent change between 2016 and 2012 calculated using crude prevalence estimates.
[d]The additional number screened was calculated by subtracting the number with recent screening in 2012 from 2016 estimates (weighted number low-income adults aged 50–64 years with recent CRC screening, 2016-weighted number low-income adults aged 50–64 years UTD with CRC screening, 2012) (e.g., among very early states 1,126,678–857,850=268,828).
[e]Due to declines in recent CRC screening, number not displayed, negative number.
[f]Additional number screened in 2016 due to increases in screening alone estimated by multiplying the number of low-income respondents in 2016 by percent change in CRC screening. For example, among low-income residents in very early expansion states: 2,957,160 × 0.08=236,573.
[g]Additional number screened in 2016 if an 8% growth was observed estimated by multiplying (number of low-income respondents in 2016 by 0.080). For example, among low-income residents in early expansion states: 5,170,000 × 0.080=413,600.
[h]Difference in additional number of low-income respondents that would have been screened if other states had the same growth in CRC screening as VE calculated using the following equation: Additional number screened (2016–2012) if growth in CRC screening was the same as VE states (8.0%)—additional number screened in 2016 attributed to increases in CRC screening alone. For example, among early expansion states: 413,600–93,060=320,540.
BRFSS, Behavioral Risk Factor Surveillance System; CRC, colorectal cancer; UTD, up-to-date VE, very early.

states observed the same increase in recent CRC screening as VE expansion states, an additional 355,184 people would have been screened, mostly through colonoscopy. Although the potential impact of expansion on reducing mortality or saving lives is unknown, a recent model-based study estimates that for every 5,646 lifetime colonoscopies, 37 deaths would be averted.[33] If this figure were applied to the additional screened individuals, 2,327 deaths would have been averted in non-expansion states. However, these calculations should be interpreted with caution, as other factors, such as local programs aimed at improving CRC screening, likely differ by state.

The modest gains in BC screening among low-income women in this study were comparable to findings from Massachusetts and a previous study of BRFSS data,[14,31] though greater improvements were observed in Oregon.[30] The lack of significant DD could be due to more widespread and historical support for mammography in low-income populations through initiatives like CDC's National Breast and Cervical Cancer Early Detection Program, programs offered by non-profits, and mobile mammography clinics.[34,35] Baseline BC screening prevalence was also higher among low-income women compared with CRC screening, leaving less room for improvement. Furthermore, there may be more financial and logistic barriers for colonoscopy as it is more expensive and requires more preparation than mammography.[36,37]

Despite improvements in CRC screening among low-income adults, inequalities in screening remain substantial, even in states that expanded Medicaid. Overall, in 2016, about half of low-income adults were UTD with CRC screening compared with about two thirds among those with higher incomes. BC screening disparities were less pronounced, but considerable. Provider recommendation is a strong facilitator of cancer screening,[38,39] and there may be missed opportunities within healthcare encounters to recommend screening in this population.[40–42] Further, a recent study found that physicians ordered fewer preventive services in Medicaid than

privately insured patients.[43] It is also possible that some patients may have received a recommendation to be screened, but did not follow through. Other barriers include lack of awareness, logistic hurdles, and cultural beliefs about screening.[44–47]

The focus of the current study was to examine the association between CRC and BC screening and the timing of Medicaid expansion in low-income adults. Other ACA provisions could influence results as the ACA provided subsidies to low- and middle-income adults without alternatives to purchase insurance beginning in 2014. Use of marketplace insurance has grown faster in non-expansion than expansion states, but <4% of adults nationwide have purchased insurance through this mechanism.[48,49] Further, the ACA removed cost sharing for preventive services for privately insured adults in 2012, though its impact on screening use has been modest.[50,51]

Limitations

Several limitations influence the interpretation of the current findings. First, screening data were self-reported and subject to recall bias, though the sensitivity for mammography and colonoscopy, the most commonly used CRC screening test, is relatively high at 90% and 79%, respectively.[52] The authors also assessed recent colonoscopy as an outcome and found similar results. BRFSS response rates were approximately 50%, but analyses were weighted to account for non-response, mitigating this bias. Further, there may be unmeasured confounders such as local programs aimed at improving screening rates not captured in adjusted models. Major changes in BRFSS sampling precluded direct comparison before and after 2011; thus, data were not available for pre-expansion VE states. Furthermore, the authors were not able to examine changes in insurance type (e.g., Medicaid versus private plans), as these data were not collected throughout the study period. A person could have been insured previously and received a colonoscopy, but this was not captured in the current study. Additionally, household income was used as a proxy for FPL, though an income <$25,000 had a sensitivity and specificity of ≥90% as a surrogate of <138% FPL.

CONCLUSIONS

Following the ACA, CRC and BC screening among low-income adults aged 50–64 years increased in Medicaid expansion states. However, the increases were largest and significantly greater for recent CRC screening in VE states compared with non-expansion states, suggesting that large-scale improvements in cancer screening following expansion of insurance coverage may take several years. In addition, by 2016, socioeconomic disparities in CRC and BC screening narrowed more rapidly in Medicaid expansion states than in non-expansion states, though inequalities persist in all states. In addition to expanding insurance, other strategies, including physician recommendation and outreach, are needed to improve cancer screening in underserved populations. Further research on the potential public health impact of expansions is needed.

ACKNOWLEDGMENTS

Stacey Fedewa, Robin Yabroff, Ann Goding Sauer, Xuesong Han, and Ahmedin Jemal are employed by the American Cancer Society as part of the Surveillance and Health Services Research Program, which received a grant from Merck, Inc. for intramural research. However, their salaries are funded solely through American Cancer Society funds.

All authors are employed by the American Cancer Society, which receives grants from private and corporate foundations, including foundations associated with companies in the health sector for research outside of the submitted work. The authors are not funded by or key personnel for any of these grants and their salary is solely funded through American Cancer Society funds. No other financial disclosures were reported.

SUPPLEMENTAL MATERIAL

Supplemental materials associated with this article can be found in the online version at https://doi.org/10.1016/j.amepre.2019.02.015.

REFERENCES

1. Koh HK, Sebelius KG. Promoting prevention through the Affordable Care Act. *N Engl J Med.* 2010;363(14):1296–1299. https://doi.org/10.1056/NEJMp1008560.
2. McMorrow S, Kenney GM, Goin D. Determinants of receipt of recommended preventive services: implications for the Affordable Care Act. *Am J Public Health.* 2014;104(12):2392–2399. https://doi.org/10.2105/AJPH.2013.301569.
3. The Advisory Board. Where the states stand on Medicaid Expansion. www.advisory.com/daily-briefing/resources/primers/medicaidmap. Published 2018. Accessed June 19, 2018.
4. Henry J, Kaiser Family Foundation. Status of State Action on the Medicaid Expansion Decision. www.kff.org/health-reform/state-indicator/state-activity-around-expanding-medicaid-under-the-affordable-care-act/?currentTimeframe=0&sortModel=%7B%22colId%22:%22Location%22,%22sort%22:%22asc%22%7D. Published 2018. Accessed February 28, 2019.
5. Halpern MT, Ward EM, Pavluck AL, Schrag NM, Bian J, Chen AY. Association of insurance status and ethnicity with cancer stage at diagnosis for 12 cancer sites: a retrospective analysis. *Lancet Oncol.* 2008;9(3):222–231. https://doi.org/10.1016/S1470-2045(08)70032-9.
6. Siegel RL, Jemal A, Wender RC, Gansler T, Ma J, Brawley OW. An assessment of progress in cancer control. *CA Cancer J Clin.* 2018;68(5):329–339. https://doi.org/10.3322/caac.21460.
7. Ward E, Halpern M, Schrag N, et al. Association of insurance with cancer care utilization and outcomes. *CA Cancer J Clin.* 2008;58(1):9–31. https://doi.org/10.3322/CA.2007.0011.
8. Wherry LR, Miller S. Early coverage, access, utilization, and health effects associated with the Affordable Care Act Medicaid expansions:

a quasi-experimental study. *Ann Intern Med.* 2016;164(12):795–803. https://doi.org/10.7326/M15-2234.
9. Sommers BD, Blendon RJ, Orav EJ, Epstein AM. Changes in utilization and health among low-income adults after Medicaid expansion or expanded private insurance. *JAMA Intern Med.* 2016;176 (10):1501–1509. https://doi.org/10.1001/jamainternmed.2016.4419.
10. Mazurenko O, Balio CP, Agarwal R, Carroll AE, Menachemi N. The effects of Medicaid expansion under the ACA: a systematic review. *Health Aff (Millwood).* 2018;37(6):944–950. https://doi.org/10.1377/hlthaff.2017.1491.
11. Jemal A, Lin CC, Davidoff AJ, Han X. Changes in insurance coverage and stage at diagnosis among nonelderly patients with cancer after the Affordable Care Act. *J Clin Oncol.* 2017;35(35):3906–3915. https://doi.org/10.1200/JCO.2017.73.7817.
12. Han X, Yabroff R, Ward E, Brawley OW, Jemal A. Comparison of insurance status and diagnosis stage among patients with newly diagnosed cancer before vs after implementation of the Patient Protection and Affordable Care Act. *JAMA Oncol.* 2018;4(12):1713–1720. https://doi.org/10.1001/jamaoncol.2018.3467.
13. Soni A, Simon K, Cawley J, Sabik L. Effect of Medicaid expansions of 2014 on overall and early-stage cancer diagnoses. *Am J Public Health.* 2018;108(2):216–218. https://doi.org/10.2105/AJPH.2017.304166.
14. Hendryx M, Luo J. Increased cancer screening for low-income adults under the Affordable Care Act Medicaid expansion. *Med Care.* 2018;56 (11):944–949. https://doi.org/10.1097/MLR.0000000000000984.
15. Beaber EF, Kim JJ, Schapira MM, et al. Unifying screening processes within the PROSPR consortium: a conceptual model for breast, cervical, and colorectal cancer screening. *J Natl Cancer Inst.* 2015;107(6): djv120. https://doi.org/10.1093/jnci/djv120.
16. CDC. Methodologic changes in the Behavioral Risk Factor Surveillance System in 2011 and potential effects on prevalence estimates. *MMWR Morb Mortal Wkly Rep.* 2012;61(22):410–413.
17. CDC. Behavioral Risk Factor Surveillance System: 2012 Summary Data Quality Report. Atlanta, GA: CDC, 2013.
18. CDC. Behavioral Risk Factor Surveillance System: 2014 Summary Data Quality Report. Atlanta, GA: CDC, 2015.
19. CDC. Behavioral Risk Factor Surveillance System 2016 Summary Data Quality Report. www.cdc.gov/brfss/annual_data/2016/pdf/2016-sdqr.pdf. Accessed February 28, 2019.
20. Henry J, Kaiser Family Foundation. Where are states today? Medicaid and CHIP eligibility levels for children, pregnant women, and adults. www.kff.org/medicaid/fact-sheet/where-are-states-today-medicaid-and-chip/. Published 2018. Accessed February 28, 2019.
21. U.S. Preventive Services Task Force, Bibbins-Domingo K, Grossman DC, et al. Screening for colorectal cancer: U.S. Preventive Services Task Force recommendation statement. *JAMA.* 2016;315(23):2564–2575. https://doi.org/10.1001/jama.2016.5989.
22. Siu AL, U.S. Preventive Services Task Force. Screening for breast cancer: U.S. Preventive Services Task Force recommendation statement. *Ann Intern Med.* 2016;164(4):279–296. https://doi.org/10.7326/M15-2886.
23. Moyer VA, U.S. Preventive Services Task Force. Screening for prostate cancer: U.S. Preventive Services Task Force recommendation statement. *Ann Intern Med.* 2012;157(2):120–134. https://doi.org/10.7326/0003-4819-157-2-201207170-00459.
24. Moyer VA, U.S. Preventive Services Task Force. Screening for cervical cancer: U.S. Preventive Services Task Force recommendation statement. *Ann Intern Med.* 2012;156(12):880–891. https://doi.org/10.7326/0003-4819-156-12-201206190-00424.
25. Moyer VA, U.S. Preventive Services Task Force. Screening for lung cancer: U.S. Preventive Services Task Force recommendation statement. *Ann Intern Med.* 2014;160(5):330–338. https://doi.org/10.7326/M13-2771.
26. Dimick JB, Ryan AM. Methods for evaluating changes in health care policy: the difference-in-differences approach. *JAMA.* 2014;312 (22):2401–2412. https://doi.org/10.1001/jama.2014.16153.
27. Bieler GS, Brown GG, Williams RL, Brogan DJ. Estimating model-adjusted risks, risk differences, and risk ratios from complex survey data. *Am J Epidemiol.* 2010;171(5):618–623. https://doi.org/10.1093/aje/kwp440.
28. de Moor JS, Cohen RA, Shapiro JA, et al. Colorectal cancer screening in the United States: trends from 2008 to 2015 and variation by health insurance coverage. *Prev Med.* 2018;112:199–206. https://doi.org/10.1016/j.ypmed.2018.05.001.
29. Sauer AG, Siegel RL, Jemal A, Fedewa SA. Updated review of prevalence of major risk factors and use of screening tests for cancer in the United States. *Cancer Epidemiol Biomarkers Prev.* 2017;26(8):1192–1208. https://doi.org/10.1158/1055-9965.EPI-17-0219.
30. Wright BJ, Conlin AK, Allen HL, Tsui J, Carlson MJ, Li HF. What does Medicaid expansion mean for cancer screening and prevention? Results from a randomized trial on the impacts of acquiring Medicaid coverage. *Cancer.* 2016;122(5):791–797. https://doi.org/10.1002/cncr.29802.
31. Okoro CA, Dhingra SS, Coates RJ, Zack M, Simoes EJ. Effects of Massachusetts health reform on the use of clinical preventive services. *J Gen Intern Med.* 2014;29(9):1287–1295. https://doi.org/10.1007/s11606-014-2865-2.
32. Gold R, Bailey SR, O'Malley JP, et al. Estimating demand for care after a Medicaid expansion: lessons from Oregon. *J Ambul Care Manage.* 2014;37(4):282–292. https://doi.org/10.1097/JAC.0000000000000023.
33. Peterse EFP, Meester RGS, Siegel RL, et al. The impact of the rising colorectal cancer incidence in young adults on the optimal age to start screening: microsimulation analysis I to inform the American Cancer Society colorectal cancer screening guideline. *Cancer.* 2018;124 (14):2964–2973. https://doi.org/10.1002/cncr.31543.
34. Howard DH, Tangka FK, Royalty J, et al. Breast cancer screening of underserved women in the USA: results from the National Breast and Cervical Cancer Early Detection Program, 1998–2012. *Cancer Causes Control.* 2015;26(5):657–668. https://doi.org/10.1007/s10552-015-0553-0.
35. Massin-Short SB, Grullon MA, Judge CM, Ruderman KR, Grullon M, Lora V. A mobile mammography pilot project to increase screening among Latina women of low socioeconomic status. *Public Health Rep.* 2010;125(5):765–771. https://doi.org/10.1177/003335491012500521.
36. Zauber AG. Cost-effectiveness of colonoscopy. *Gastrointest Endosc Clin N Am.* 2010;20(4):751–770. https://doi.org/10.1016/j.giec.2010.07.008.
37. LeMasters T, Sambamoorthi U. A national study of out-of-pocket expenditures for mammography screening. *J Womens Health (Larchmt).* 2011;20(12):1775–1783. https://doi.org/10.1089/jwh.2010.2251.
38. Guessous I, Dash C, Lapin P, et al. Colorectal cancer screening barriers and facilitators in older persons. *Prev Med.* 2010;50(1–2):3–10. https://doi.org/10.1016/j.ypmed.2009.12.005.
39. Seeff LC, Nadel MR, Klabunde CN, et al. Patterns and predictors of colorectal cancer test use in the adult U.S. population. *Cancer.* 2004;100(10):2093–2103. https://doi.org/10.1002/cncr.20276.
40. Davis MM, Renfro S, Pham R, et al. Geographic and population-level disparities in colorectal cancer testing: a multilevel analysis of Medicaid and commercial claims data. *Prev Med.* 2017;101:44–52. https://doi.org/10.1016/j.ypmed.2017.05.001.
41. Ahmed NU, Pelletier V, Winter K, Albatineh AN. Factors explaining racial/ethnic disparities in rates of physician recommendation for colorectal cancer screening. *Am J Public Health.* 2013;103(7):e91–e99. https://doi.org/10.2105/AJPH.2012.301034.
42. Peterson EB, Ostroff JS, DuHamel KN, et al. Impact of provider-patient communication on cancer screening adherence: a systematic review. *Prev Med.* 2016;93:96–105. https://doi.org/10.1016/j.ypmed.2016.09.034.
43. McMorrow S, Long SK, Fogel A. Primary care providers ordered fewer preventive services for women with Medicaid than for women with

private coverage. *Health Aff (Millwood).* 2015;34(6):1001–1009. https://doi.org/10.1377/hlthaff.2014.0907.

44. Jones RM, Woolf SH, Cunningham TD, et al. The relative importance of patient-reported barriers to colorectal cancer screening. *Am J Prev Med.* 2010;38(5):499–507. https://doi.org/10.1016/j.amepre.2010.01.020.
45. Shapiro JA, Klabunde CN, Thompson TD, Nadel MR, Seeff LC, White A. Patterns of colorectal cancer test use, including CT colonography, in the 2010 National Health Interview Survey. *Cancer Epidemiol Biomarkers Prev.* 2012;21(6):895–904. https://doi.org/10.1158/1055-9965.EPI-12-0192.
46. Robinson CM, Cassells AN, Greene MA, Beach ML, Tobin JN, Dietrich AJ. Barriers to colorectal cancer screening among publicly insured urban women: no knowledge of tests and no clinician recommendation. *J Natl Med Assoc.* 2011;103(8):746–753. https://doi.org/10.1016/S0027-9684(15)30414-4.
47. Alexandraki I, Mooradian AD. Barriers related to mammography use for breast cancer screening among minority women. *J Natl Med Assoc.* 2010;102(3):206–218. https://doi.org/10.1016/S0027-9684(15)30527-7.
48. Cohen RA, Zammitti EP, Martinez ME. *Health insurance coverage: early release of estimates from the National Health Interview Survey, 2017.* www.cdc.gov/nchs/data/nhis/earlyrelease/insur201805.pdf. Published 2017. Accessed December 27, 2018.
49. Huguet N, Hoopes MJ, Angier H, Marino M, Holderness H, DeVoe JE. Medicaid expansion produces long-term impact on insurance coverage rates in community health centers. *J Prim Care Community Health.* 2017;8(4):206–212. https://doi.org/10.1177/2150131917709403.
50. Fedewa SA, Goodman M, Flanders WD, et al. Elimination of cost-sharing and receipt of screening for colorectal and breast cancer. *Cancer.* 2015;121(18):3272–3280. https://doi.org/10.1002/cncr.29494.
51. Han X, Yabroff RK, Guy GP Jr, Zheng Z, Jemal A. Has recommended preventive service use increased after elimination of cost-sharing as part of the Affordable Care Act in the United States? *Prev Med.* 2015;78:85–91. https://doi.org/10.1016/j.ypmed.2015.07.012.
52. Rauscher GH, Johnson TP, Cho YI, Walk JA. Accuracy of self-reported cancer-screening histories: a meta-analysis. *Cancer Epidemiol Biomarkers Prev.* 2008;17(4):748–757. https://doi.org/10.1158/1055-9965.EPI-07-2629.