



Race/ethnicity, sex and insurance disparities in colorectal cancer screening among individuals with and without cardiovascular disease

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ABSTRACT

Colorectal cancer (CRC) and cardiovascular diseases (CVD) share several risk factors. We examined the relationships between CRC screening and CVD history by race/ethnicity and sex. Data from 15 states across the United States with high age-adjusted CVD rates from the 2012–2016 Behavioral Risk Factor Surveillance System were used to examine prevalence of self-reported screening for CRC among 179,276 adults ages 50–75 years with and without history of CVD. Multivariable logistic regression was used to evaluate the association between socio-demographics and CRC screening in the expansion and stable phases of the Affordable Care Act (ACA) era. Prevalence of CRC screening was high among those with history of CVD. After multivariable adjustment, Whites and Hispanics with CVD had 19% (95%[CI]: 1.13–1.26) and 50% (95%[CI]: 1.10–2.06) higher odds for CRC screening, respectively, versus those without CVD. Individuals in both sexes with CVD had higher odds for CRC screening compared those without CVD. Strikingly, the odds for CRC screening in Hispanics with history of CVD were 72% higher in the stable phase of the ACA era for the fully adjusted model. Whites and Hispanics with history of CVD are more likely to undergo CRC screening, perhaps due to greater exposure to the healthcare system due to CVD. This association was not observed in Blacks. Interventions are needed to improve CRC screening rates among Blacks, especially due to their well-documented higher risk of CVD.

1. Introduction

Colorectal cancer (CRC) and cardiovascular diseases (CVD) are two major contributors of chronic disease burden and mortality in the United States (Deaths, 2016; Centers for Disease Control and Prevention (CDC), 2019). Although CRC incidence has declined in the past decade due to increase in awareness of need for screening and increases in prevalence of early detection, it is still the second most common cause of cancer-related mortality in both men and women (American Cancer Society, 2017). In 2016, the rate of CRC in Blacks, Whites and Hispanics was 42.2, 36.7 and 33.0 per 100,000 people, respectively (US Cancer Statistics Working Group, 2018). CVD is also the leading cause of all-cause mortality among both men and women, and Blacks are at higher risk of CVD compared to Whites and Hispanics (Van Dyke et al., 2018; Graham, 2015).

Several risk factors are shared between CRC and CVD, including obesity, hypertension, diabetes and use of tobacco (Koene et al., 2016). Risk assessment criteria for CRC screening overlap for most of these

factors (Muntner et al., 2014; Jahangiry et al., 2017; Bibbins-Domingo et al., 2016). However, little is known about the determinants and prevalence of CRC screening in individuals with CVD.

Adherence to screening guidelines has facilitated both the detection of CRC and removal of polyps and other precursor lesions to prevent invasive CRC (American Cancer Society, 2017). According to the American Cancer Society, prevalence of CRC screening in 2015 among Whites was 65.4% as compared to 61.8% in Blacks and 47.6% in Hispanics (American Cancer Society, 2017). Among men and women, the prevalence of CRC screening was similar. However, regardless of race/ethnicity or sex, prevalence of CRC screening was lower in people without versus with health insurance (24.0% vs. 56.8%) (American Cancer Society, 2017). This may have been alleviated with enactment and uptake of the Affordable Care Act (ACA) and it is expected that the health insurance status of individuals with and without CVD may have changed (Kominiski et al., 2017). Wyatt et al. demonstrated there was an uptick in CRC screening in the immediate post-ACA period of 2010–2012 (Wyatt et al., 2017). However, there is little evidence in the

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existing literature about the relationship(s) between racial/ethnic or sex disparities and the prevalence of CRC screening in the post ACA enactment. More recently, Blumenthal *et al.* demonstrated that following the initial phase of ACA uptake from 2010 to 2012, there was an “expansion phase” from 2012 to 2014 in which the uninsured rate rapidly decreased, followed by a “stable phase” from 2015 onwards (Blumenthal *et al.*, 2020).

Using data from the Behavioral Risk Factor Surveillance System (BRFSS) from 2012 to 2016, we aimed to determine whether those with history of CVD had a higher prevalence of CRC screening compared to those without history of CVD. In addition, we also hypothesized that there would be differences in prevalence by race/ethnicity and sex in CRC screening among those with history of CVD and that this association may differ between the expansion and stable phases of the post-ACA era, considering the potential confounding by insurance status on CRC screening.

2. Methods

2.1. Data source

Data for this study was obtained from the BRFSS from 2012 to 2016 and included adults aged 50 to 75 years (CDC). BRFSS conducts annual telephone surveys in the United States (U.S.), which gathers information on demographics, chronic health conditions, health behaviors, and the utilization of preventative services by U.S. adults aged 18 and older. A disproportionate stratified sample design was utilized to collect the nationally representative samples. Regarding surveys, landline and cell-phone telephone numbers were chosen randomly, garnering data on 400,000 adults in all 50 states, including three U.S. territories and the District of Columbia. For this analysis, we utilized data from 15 states with highest age-adjusted prevalence of CVD in 2016 including Alabama, Arkansas, Georgia, Indiana, Kentucky, Louisiana, Michigan, Mississippi, Missouri, New Mexico, North Carolina, Oklahoma, South Carolina, Tennessee, and West Virginia (Supplemental Fig. S1).

2.2. Dependent variable

The dependent variable of interest is self-reported colorectal cancer (CRC) screening which has previously been demonstrated to have high validity (Baier *et al.*, 2000). This variable was defined based on responses to an item asking if respondents ever had sigmoidoscopy or colonoscopy. Participants who responded “don’t know/not sure”, “refused” or “missing” were excluded from the analysis. Other methods of CRC screening such as Fecal Occult Blood Test were not used because sigmoidoscopy / colonoscopy is considered the gold standard for CRC screening (Bevan and Rutter, 2018).

2.3. Independent variable and covariates

History of CVD was defined by responses to questions about being ever told by a doctor or health professional that they had a “heart attack”, “coronary heart disease” or “stroke”. Participants who responded “don’t know/not sure”, “refused” or “missing” were excluded from the analysis. Demographic variables including age, sex, race/ethnicity and marital status were assessed through the responses to the BRFSS questionnaire. Additionally, socioeconomic status was assessed based on responses for level of education and residential area. Chronic health conditions including self-reported history of diabetes and chronic kidney disease (CKD) as well as behavioral measures including current smoking status and drinking alcohol in past 30 days were also assessed. Health care coverage was also assessed using the BRFSS data based on self-reported response to the question if the participant had “any kind of health care coverage, including health insurance, prepaid plans such as HMOs or government plans such as Medicare, or Indian Health Service.” Additionally, healthcare access was measured by the question: “Was

there a time in the past 12 months when you needed to see a doctor but could not because of cost?”.

2.4. Statistical analysis

All analyses were conducted stratified by race/ethnicity and sex, separately. Chi-square tests were used to compare demographic, socioeconomic, chronic health conditions, behavioral measures, healthcare coverage and access characteristics and CRC screening by CVD history. Additionally, CRC screening prevalence was assessed for all characteristics separately, by race/ethnicity and sex. Multivariable logistic regression analysis was performed to examine the association between the covariates with adjustment for all variables. These relationships were also evaluated in two subsets: the expansion phase of the ACA era (2012–2014) and the stable phase of the ACA era (2015–2016), to assess potential differences based on the insurance status changes that may have occurred with the ACA. Additionally, in full population and population stratified by the two phases, tests for interaction between race/ethnicity and sex, separately, and history of CVD were conducted using models that include the respective full population, main effect terms, and the product term. For all analyses, p values ≤ 0.05 were considered statistically significant. All analyses were conducted using survey statistical procedures in SAS Version 9.4 (SAS Institute, Inc., Cary, NC) incorporating individual weights, strata and cluster variables to account for survey sampling strategy. Participants with missing data were excluded from the analysis.

3. Results

3.1. Participant characteristics

In both race/ethnicity- and sex-stratified analysis, there were statistically significant differences in the prevalence of different participant characteristics by history of CVD (Table 1- p -values: <0.001). Overall, individuals with history of CVD were more likely to be older, divorced, separated, or widowed, males, with less than high-school education, and compared to those without history of CVD. Moreover, those with versus without history of CVD were more likely to have diabetes and CKD, less likely to drink alcohol and smoke, more likely to have a health insurance plan and more likely not to have seen a doctor within the past year due to cost. Screening for CRC was more prevalent among those with versus without history of CVD. The prevalence of CRC screening by race/ethnicity and sex are shown in Fig. 1.

3.2. CRC screening and history of CVD by Race/ethnicity and sex

The association between history of CVD and CRC screening differed by race/ethnicity and sex (p value for interaction: 0.0001 and 0.0003, respectively). In race/ethnicity stratified analysis, the odds for CRC screening among those with versus without history of CVD were higher by 10% in Blacks (95% CI: 0.98–1.24), 50% in Hispanics (95% CI: 1.10–2.06) and 19% in Whites (95% CI: 1.13–1.26) [Table 2]. Blacks and Whites who had diabetes had higher odds of CRC screening than those without diabetes, but these associations were not observed in the Hispanics. Additionally, there was lower prevalence of screening in males among Whites and Blacks but not among Hispanics. There existed a lower odds of CRC screening if a doctor was not seen in the past year due to cost for Blacks (OR: 0.76, 95% CI: 0.68, 0.86) and Whites (OR: 0.87, 95% CI: 0.81, 0.93), but not for Hispanics (OR: 0.78, 95% CI: 0.57, 1.06). Living outside the city center or in the suburbs also resulted in increased odds of CRC screening for both Blacks and Whites, but not for Hispanics.

In the sex-stratified analysis, after adjusting for all variables, men with versus without history of CVD had 15% higher odds for CRC screening (95% CI: 1.07–1.24), while women with versus without history of CVD had 21% higher odds of CRC screening (95% CI: 1.13–1.29)

Table 1

Baseline characteristics of survey participants with and without history of cardiovascular disease by race/ethnicity and sex, separately: Data from Behavioral Risk Factor Surveillance System in the United States (2012–2016).

Variables	Blacks		Hispanics		Whites		Males		Females	
	CVD+	CVD-	CVD+	CVD-	CVD+	CVD-	CVD+	CVD-	CVD+	CVD-
N	5,651	25,357	787	4,886	26,011	130,506	15,559	59,531	16,902	101,284
Colorectal Cancer Screening prevalence	71.52	68.72	64.96	54.83	74.90	72.08	72.74	69.04	75.47	72.34
Socio-demographics										
Age										
50–59	31.82	42.69	32.42	51.18	23.51	37.30	24.40	40.79	25.75	37.10
60–69	48.13	43.01	45.01	37.25	46.72	43.61	47.68	42.88	46.18	43.62
70–75	20.05	14.30	22.56	11.57	29.77	19.09	27.92	16.32	28.07	19.28
Marital status										
Married	30.44	38.53	48.97	58.24	55.21	63.29	60.92	66.15	41.17	55.13
Divorced/separated/widowed	53.31	43.84	44.53	31.24	39.19	29.76	31.47	23.76	51.67	37.03
Member of unmarried couple	15.64	16.84	6.33	8.14	4.59	5.82	6.50	8.80	6.43	6.82
Never married	0.60	0.78	0.17	2.38	1.00	1.15	1.12	1.29	0.73	1.02
Race/Ethnicity										
White	–	–	–	–	–	–	85.06	83.35	77.42	80.92
Blacks	–	–	–	–	–	–	12.85	13.58	20.31	16.46
Hispanics	–	–	–	–	–	–	2.09	3.07	2.26	2.62
Males	38.34	33.74	47.59	41.95	51.90	38.87	–	–	–	–
Education										
Less than High School	22.68	14.24	26.06	23.80	13.62	6.20	13.61	8.19	17.15	7.76
High School graduate	37.53	35.31	33.01	29.35	34.31	30.02	33.63	29.60	35.97	31.56
Attended college/Technical school	24.44	26.13	24.64	23.08	28.28	27.58	25.91	25.08	29.20	28.56
College/Technical School graduate	15.35	24.31	16.28	23.77	23.78	36.20	26.84	37.13	17.68	32.12
Metropolitan Statistical Area										
In city center	42.97	44.23	29.23	35.50	27.05	29.65	29.43	31.88	30.06	32.15
Outside city center but in county with city center	10.47	11.23	15.13	15.36	16.47	17.77	16.92	17.61	14.22	16.24
In suburban county	9.48	11.34	9.95	10.08	16.07	15.80	15.08	15.15	14.65	14.88
Not in MSA	37.09	33.20	45.70	39.05	40.41	36.79	38.57	35.36	40.07	36.72
Other Covariates										
Diabetes	44.74	26.72	38.38	22.40	34.85	15.42	35.56	17.97	37.56	16.97
Chronic Kidney Disease	13.80	4.22	13.90	3.87	10.80	3.40	10.02	3.30	12.69	3.69
Consumed alcohol in past 30 days	25.43	32.39	30.86	40.95	31.13	44.87	39.31	52.22	21.24	37.09
Current smoker	76.21	81.97	78.35	83.99	77.19	84.33	77.86	82.59	76.25	84.80
Have a Health Plan	92.57	90.40	90.62	86.35	96.11	94.99	95.34	93.25	95.46	94.54
Did not see a doctor because of cost past year	21.26	14.83	22.60	17.44	13.70	8.66	12.70	8.30	17.55	10.83
Post ACA phases*										
Expansion (2012–2014)	32.88	31.61	38.41	39.18	33.88	34.20	32.95	33.63	34.69	34.16
Stable (2015–2016)	67.12	68.39	61.59	60.82	66.12	65.80	67.05	66.37	65.31	65.84

*P value > 0.05 by race/ethnicity. All other p values < 0.001; CVD: cardiovascular disease; + and – refer to the presence and absence of CVD history, respectively. MSA: Metropolitan Statistical Area; ACA: Affordable Care Act.

[Table 3]. Additionally, college-educated men had significantly higher odds for CRC screening (OR: 2.60, 95% CI: 2.32–2.90) than college-educated women (OR: 1.99, 95% CI: 1.83–2.16). Irrespective of sex, Blacks were more likely and Hispanics were less likely to be screened for CRC as compared to Whites.

3.3. CRC screening and history of CVD Post-ACA

The association between history of CVD and CRC screening differed by race/ethnicity in the stable but not in the expansion phase (p value for interaction: 0.0009 and 0.2035, respectively). After full multivariable adjustment, among Blacks and Whites separately, the odds for CRC screening were similar during both phases (Table 4). However, in Hispanics, the associations were not statistically significant in the expansion phase. In the stable phase, the odds for CRC screening for Hispanics were higher by 72% (95% CI: 1.05–2.82) among those with versus without history of CVD. Whites who were members of an unmarried couple were less likely to be screened in the expansion phase but not in the stable phase, while Hispanics were less likely to be screened in the stable phase but not in the expansion phase if they were members of an unmarried couple. In the stable phase, unlike Blacks and Whites, Hispanics were not less likely to have CRC screening if they did not see a doctor because of cost in the past year.

The association between history of CVD and CRC screening differed by sex in both expansion and stable phases (p value for interaction: 0.0309 and 0.0042, respectively). In the expansion phase, after full multivariable adjustment, men and women with CVD were 12% (95% CI: 1.02–1.23) and 17% (95% CI: 1.08–1.27), respectively, more likely to undergo screening for CRC (Table 5). Similar associations were observed for both men and women in the stable post-ACA phase.

4. Discussion

In the current analysis, Hispanics as compared to Whites and Blacks are less likely to be screened for CRC, irrespective of history of CVD. However, for all races/ethnicities, those with versus without CVD are more likely to be screened for CRC. Patients with prevalent CVD had significantly higher odds of CRC screening compared to those with no history of CVD in Whites and Hispanics, whereas the associations were not statistically significant among Blacks. Additionally, men and women with versus without history of CVD were more likely to be screened for CRC. Moreover, in the expansion phase of the post-ACA era, the odds for CRC screening did not differ by history of CVD for any race/ethnic group; however, in the stable phase, Hispanics with history of CVD were more likely to be screened for CRC as compared to those without history of CVD.

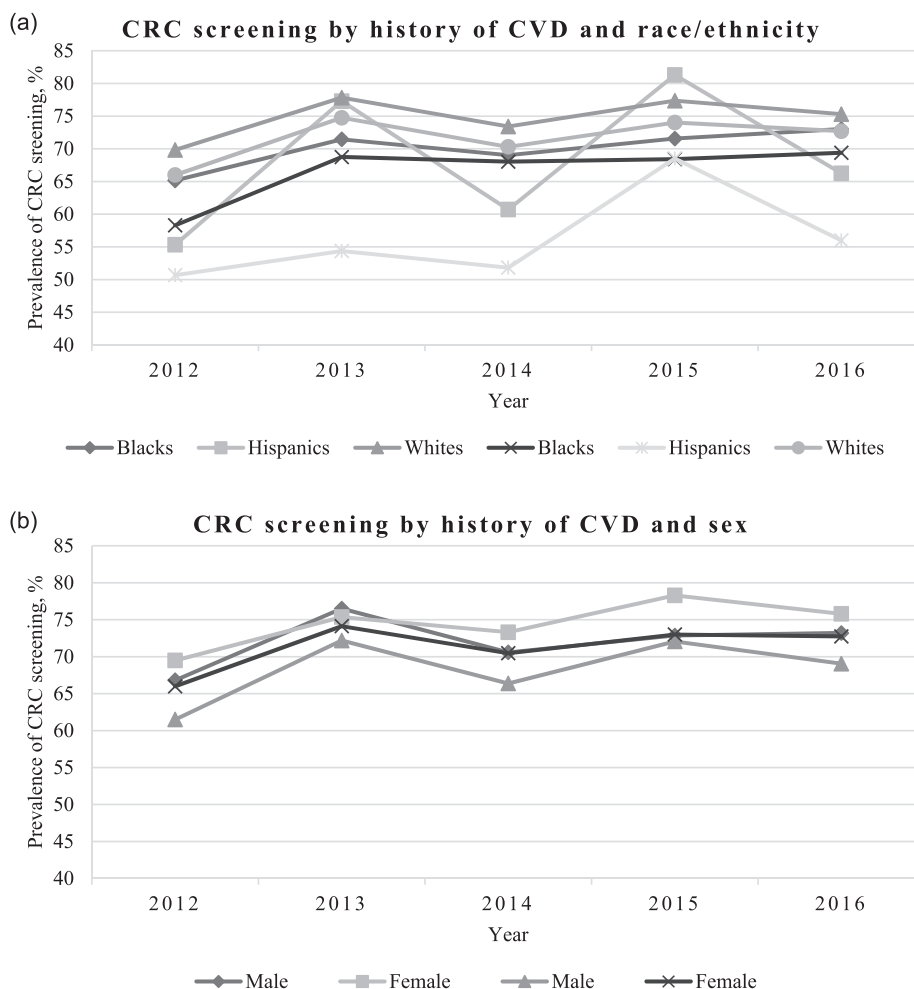


Fig. 1. Colorectal cancer screening rates in individuals in 15 states of the United States with and without cardiovascular disease by (a) race/ethnicity and (b) sex. The proportion of respondents who underwent CRC screening are based on all respondents in the analytic dataset with CVD (n = 32,449) and without CVD (n = 160,749).

Prior studies have shown that higher risk for CVD increases the risk for CRC. In a population-based study on 3,144 asymptomatic individuals, those with 10-year risk for coronary artery disease $\geq 10\%$ were shown to benefit from CRC screening (Lee et al., 2013). Another cross-sectional study of 235 participants without CVD who underwent screening for CRC showed that those at higher risk for CVD were more likely to be at a higher risk for CRC (Basyigit et al., 2015). Based on common risk factors shared between CVD and CRC including but not limited to age, male sex, cigarette smoking, obesity and diabetes, most studies recommend screening for CRC among individuals with CVD (Chan et al., 2006; Yang et al., 2013; Hee et al., 2016; Botteri et al., 2008).

There is limited data on prevalence of CRC screening stratified by CVD status, and the United States Preventive Services Task Force (USPSTF) guidelines do not have specific recommendations for CRC screening among CVD patients (Bibbins-Domingo et al., 2016). In the current study, we found that for both men and women, those with history of CVD were more likely to get screened for CRC after adjustments for demographics and SES, with the associations holding after further model adjustments. This may be due to increased awareness for CRC screening among those who have regular visits to a doctor's office and have a health insurance plan, in addition to shared risk factors between CVD and CRC.

Interestingly, in the current study, while the prevalence of CRC screening among Whites and Blacks was higher if they were married or had diabetes, these associations were not observed in Hispanics. Moreover, not seeing a doctor in the past year due to cost significantly

decreased the odds of CRC screening among both Blacks and Whites, but had no effect in Hispanics. Living outside the city center or in the suburbs was associated with increased odds of CRC screening in Blacks and Whites, but again this was not seen in Hispanics. It is well known that screening for CRC leads to reduction in incident CRC cases, and improvement in survival (Schoen et al., 2012; Shaukat et al., 2013; Pinheiro et al., 2009). Therefore, considering that Blacks have a higher risk of CVD, (Mensah et al., 2005; Kramer et al., 2004) and we observed no difference in the odds of CRC screening in Blacks with CVD history compared to Blacks without CVD, it is important to have set recommendations for those at high risk for CVD to undergo CRC screening and prevent new CRC cases, especially among Blacks.

The disparities observed for Hispanics should be interpreted with caution due to the relatively small sample size for Hispanics, but this does provide interesting insights. Several studies have suggested cultural and socio-economic barriers to cancer screening among Hispanics. One study by Castañeda et al. in 2019, suggested that having had a recent physician visit was predictive of receiving CRC screening (Castañeda et al., 2019). This supports our finding that Hispanics with CVD are more likely to undergo CRC screening assuming that CVD status results in more frequent physician visits. However, in contrast, we also observed that not having had a physician visit in the past year due to cost did not influence odds of CRC screening among Hispanics. Other research have suggested that fear and embarrassment may be a barrier to CRC screening in Hispanics, which could result in some of the discrepancies in our findings compared to other races/ethnicities (Byrd et al., 2019; Walsh et al., 2004).

Table 2

Odds ratios (ORs) and 95% Confidence Intervals (95% CI) for Colorectal Cancer Screening stratified by race/ethnicity in fully-adjusted model: Data from Behavioral Risk Factor Surveillance System in the United States (2012–2016).

	OR (95% CI)		
	Blacks	Hispanics	Whites
History of cardiovascular disease	1.10 (0.98, 1.24)	1.50 (1.10, 2.06)	1.19 (1.13, 1.26)
Age			
50–59	1.00 (Ref)	1.00 (Ref)	1.00 (Ref)
60–69	1.88 (1.71, 2.06)	1.85 (1.47, 2.34)	1.94 (1.86, 2.02)
70–75	1.97 (1.71, 2.25)	2.07 (1.53, 2.80)	2.57 (2.43, 2.71)
Marital status			
Never married	1.00 (Ref)	1.00 (Ref)	1.00 (Ref)
Married	2.00 (1.16, 3.46)	0.95 (0.46, 1.98)	1.56 (1.30, 1.87)
Divorced/separated/widowed	1.72 (1.00, 2.96)	0.83 (0.39, 1.76)	1.15 (0.96, 1.38)
Member of unmarried couple	1.97 (0.69, 2.07)	0.59 (0.26, 1.30)	0.83 (0.69, 1.01)
Males	0.86 (0.78, 0.94)	1.02 (0.82, 1.27)	0.87 (0.83, 0.90)
Education			
Less than High School	1.00 (Ref)	1.00 (Ref)	1.00 (Ref)
High School graduate	1.58 (1.39, 1.78)	2.42 (1.79, 3.26)	1.27 (1.18, 1.37)
Attended college/Technical school	2.09 (1.83, 2.39)	2.99 (2.16, 4.15)	1.51 (1.40, 1.63)
College/Technical School graduate	2.75 (2.38, 3.19)	3.68 (2.63, 5.15)	1.97 (1.83, 2.13)
Metropolitan Statistical Area (MSA)			
Not in MSA	1.00 (Ref)	1.00 (Ref)	1.00 (Ref)
In city center	1.38 (1.26, 1.52)	1.49 (1.17, 1.90)	1.36 (1.30, 1.43)
Outside city center but in county with city center	1.85 (1.57, 2.16)	1.29 (0.95, 1.74)	1.34 (1.27, 1.42)
In suburban county	1.25 (1.08, 1.44)	1.06 (0.74, 1.52)	1.19 (1.13, 1.26)
Diabetes	1.39 (1.26, 1.53)	1.18 (0.92, 1.51)	1.11 (1.05, 1.17)
Chronic Kidney Disease	1.38 (1.13, 1.67)	2.03 (1.24, 3.31)	1.55 (1.40, 1.71)
Consumed alcohol in past 30 days	1.06 (0.96, 1.16)	1.21 (0.97, 1.51)	1.21 (1.16, 1.26)
Current smoker	1.32 (1.18, 1.48)	1.53 (1.15, 2.04)	1.63 (1.55, 1.72)
Have a Health Plan	2.35 (2.02, 2.73)	3.86 (2.63, 5.67)	2.82 (2.58, 3.08)
Did not see a doctor because of cost past year	0.76 (0.68, 0.86)	0.78 (0.57, 1.06)	0.87 (0.81, 0.93)

The ACA was designed to increase access to healthcare across the United States. It would be expected that the odds of CRC screening among CVD patients would increase after enactment of the ACA due to greater access to healthcare. In race/ethnicity-stratified analyses, there was no association between CVD status and CRC screening in Blacks and Hispanics in the expansion phase. However, Whites displayed higher odds like that observed in the overall trends. Interestingly, in the stable ACA phase, although Blacks and Whites had similar odds like those observed in the overall trends, the odds for CRC screening in Hispanics were statistically significantly higher by 72%. This may indicate that more Hispanics with CVD had access to healthcare following the stabilization of ACA uptake, resulting in greater utilization of CRC screening opportunities. These may be attributed to quality of communal engagement and social support in Hispanics as compared to other racial/ethnic groups that favors coping with stress associated with different health outcomes (Shallcross et al., 2015; Dominic et al., 2020). In sex-stratified analyses, similar overall trends were seen to that observed in

Table 3

Odds ratios (ORs) and 95% Confidence Intervals (95% CI) for Colorectal Cancer Screening stratified by sex in fully adjusted model: Data from Behavioral Risk Factor Surveillance System in the United States (2012–2016).

	OR (95% CI)	
	Males	Females
History of Cardiovascular disease	1.15 (1.07, 1.24)	1.21 (1.13, 1.29)
Age		
50–59	1.00 (Ref)	1.00 (Ref)
60–69	1.99 (1.86, 2.12)	1.87 (1.79, 1.97)
70–75	2.61 (2.40, 2.84)	2.35 (2.21, 2.50)
Marital status		
Never married	1.00 (Ref)	1.00 (Ref)
Married	1.67 (1.29, 2.17)	1.52 (1.22, 1.90)
Divorced/separated/widowed	1.11 (0.85, 1.44)	1.24 (0.99, 1.54)
Member of unmarried couple	0.90 (0.69, 1.19)	0.85 (0.67, 1.07)
Race/Ethnicity		
Whites	1.00 (Ref)	1.00 (Ref)
Blacks	1.19 (1.09, 1.30)	1.17 (1.11, 1.24)
Hispanics	0.73 (0.61, 0.86)	0.59 (0.52, 0.68)
Education		
Less than High School	1.00 (Ref)	1.00 (Ref)
High School graduate	1.50 (1.35, 1.66)	1.35 (1.25, 1.45)
Attended college/Technical school	1.82 (1.64, 2.04)	1.61 (1.49, 1.74)
College/Technical School graduate	2.60 (2.32, 2.90)	1.99 (1.83, 2.16)
Metropolitan Statistical Area (MSA)		
Not in MSA	1.00 (Ref)	1.00 (Ref)
In city center	1.39 (1.29, 1.49)	1.35 (1.28, 1.43)
Outside city center but in county with city center	1.41 (1.30, 1.54)	1.37 (1.28, 1.46)
In suburban county	1.24 (1.13, 1.35)	1.18 (1.10, 1.25)
Diabetes	1.15 (1.07, 1.24)	1.16 (1.10, 1.22)
Chronic Kidney Disease	1.52 (1.31, 1.77)	1.51 (1.35, 1.68)
Consumed alcohol in past 30 days	1.18 (1.11, 1.25)	1.21 (1.15, 1.27)
Current smoker	1.59 (1.48, 1.71)	1.56 (1.48, 1.65)
Have a Health Plan	2.69 (2.37, 3.05)	2.77 (2.53, 3.04)
Did not see a doctor because of cost past year	0.81 (0.73, 0.90)	0.85 (0.79, 0.91)

the analyses for both the expansion and stable phases of the ACA era. However, the odds of CRC screening among those with CVD increased approximately 6% for both men and women in the stable phase.

Studies have shown that rates of CRC screening have increased over the years among all races/ethnicities. Among Hispanics, the incidence rates for CRC have shown the greatest increase during 1993–2007 (Siegel et al., 2009). However, there is limited data on CRC screening among those with and without CVD. In the current analysis, after multivariable adjustments, Hispanics with a history of CVD were more likely to undergo CRC screening as compared to those without history of CVD. It is well known that screening for CRC leads to reduction in incident CRC cases, and improvement in survival (Schoen et al., 2012; Shaukat et al., 2013; Pinheiro et al., 2009). Therefore, considering that Blacks have a higher risk of CVD, (Mensah et al., 2005; Kramer et al.,

Table 4

Odds ratios (ORs) and 95% Confidence Intervals (95% CI) for Colorectal Cancer Screening for racial/ethnic groups stratified by post-ACA phases in fully-adjusted model: Data from Behavioral Risk Factor Surveillance System in the United States (2012–2016).

	Expansion phase (2012–2014)		
	Blacks	Hispanics OR (95% CI)	Whites
History of Cardiovascular disease	1.03 (0.90–1.13)	1.28 (0.87–1.89)	1.17 (1.10–1.25)
Age			
50–59	1.00 (Ref)	1.00 (Ref)	1.00 (Ref)
60–69	1.78 (1.57–2.01)	1.72 (1.30–2.26)	1.97 (1.87–2.08)
70–75	1.32 (1.61–2.28)	1.69 (1.18–2.42)	2.53 (2.36–2.71)
Marital status			
Never married	1.00 (Ref)	1.00 (Ref)	1.00 (Ref)
Married	1.67 (0.92–3.04)	1.51 (0.56–4.04)	1.39 (1.11–1.73)
Divorced/separated/widowed	1.40 (0.77–2.55)	1.51 (0.56–4.12)	1.02 (0.81–1.28)
Member of unmarried couple	0.96 (0.52–1.76)	1.05 (0.37–2.98)	0.74 (0.58–0.94)
Males	0.84 (0.74–0.95)	1.08 (0.83–1.41)	0.85 (0.81–0.90)
Education			
Less than High School	1.00 (Ref)	1.00 (Ref)	1.00 (Ref)
High School graduate	1.59 (1.36–1.86)	2.17 (1.52–3.08)	1.29 (1.18–1.41)
Attended college/Technical school	2.11 (1.77–2.52)	2.88 (1.96–4.22)	1.50 (1.37–1.64)
College/Technical School graduate	2.93 (2.42–3.55)	2.74 (1.85–4.06)	1.97 (1.79–2.17)
Metropolitan Statistical Area (MSA)			
Not in MSA	1.00 (Ref)	1.00 (Ref)	1.00 (Ref)
In city center	1.44 (1.27–1.36)	1.45 (1.09–1.92)	1.34 (1.26–1.42)
Outside city center but in county with city center	1.70 (1.37–2.10)	1.01 (0.70–1.45)	1.35 (1.26–1.45)
In suburban county	1.29 (1.07–1.55)	1.28 (0.82–1.99)	1.22 (1.14–1.31)
Diabetes	1.48 (1.30–1.68)	1.07 (0.79–1.45)	1.14 (1.07–1.22)
Chronic Kidney Disease	1.32 (1.02–1.71)	2.04 (1.19–3.49)	1.66 (1.45–1.89)
Consumed alcohol in past 30 days	1.12 (0.98–1.27)	1.02 (0.77–1.34)	1.25 (1.19–1.32)
Current smoker	1.46 (1.27–1.69)	1.42 (1.00–2.01)	1.62 (1.52–1.72)
Have a Health Plan	2.47 (2.05–2.98)	3.89 (2.44–6.22)	2.88 (2.60–3.20)
Did not see a doctor because of cost past year	0.82 (0.71–0.96)	0.62 (0.43–0.88)	0.87 (0.80–0.95)
	Stable phase (2015–2016)		
	Blacks	Hispanics OR (95% CI)	Whites
History of Cardiovascular disease	1.16 (0.98–1.36)	1.72 (1.05–2.82)	1.21 (1.12–1.31)
Age			
50–59	1.00 (Ref)	1.00 (Ref)	1.00 (Ref)
60–69	1.94 (1.70–2.21)	1.97 (1.37–2.84)	1.91 (1.79–2.03)
70–75	2.00 (1.68–2.40)	2.49 (1.53–4.06)	2.58 (2.39–2.79)
Marital status			
Never married	1.00 (Ref)	1.00 (Ref)	1.00 (Ref)
Married	2.27 (1.02–5.06)	0.47 (0.15–1.42)	1.67 (1.29–2.16)
Divorced/separated/widowed	1.98 (0.89–4.40)	0.37 (0.12–1.15)	1.24 (0.96–1.60)

Table 4 (continued)

	Expansion phase (2012–2014)		
	Blacks	Hispanics OR (95% CI)	Whites
Member of unmarried couple	1.38 (0.62–3.08)	0.25 (0.08–0.82)	0.89 (0.68–1.17)
Males	0.87 (0.76–0.99)	0.96 (0.69–1.34)	0.88 (0.83–0.93)
Education			
Less than High School	1.00 (Ref)	1.00 (Ref)	1.00 (Ref)
High School graduate	1.57 (1.32–1.86)	2.61 (1.60–4.26)	1.26 (1.13–1.40)
Attended college/Technical school	2.08 (1.72–2.51)	3.06 (1.80–5.22)	1.51 (1.35–1.69)
College/Technical School graduate	2.66 (2.17–3.27)	4.93 (2.84–8.57)	1.96 (1.75–2.20)
Metropolitan Statistical Area (MSA)			
Not in MSA	1.00 (Ref)	1.00 (Ref)	1.00 (Ref)
In city center	1.36 (1.19–1.55)	1.48 (1.00–2.20)	1.37 (1.28–1.47)
Outside city center but in county with city center	1.90 (1.54–2.35)	1.44 (0.90–2.29)	1.33 (1.23–1.44)
In suburban county	1.23 (1.05–1.45)	0.84 (0.48–1.47)	1.18 (1.08–1.28)
Diabetes	1.35 (1.18–1.54)	1.30 (0.88–1.92)	1.09 (1.01–1.17)
Chronic Kidney Disease	1.39 (1.07–1.82)	1.90 (0.77–4.69)	1.48 (1.29–1.71)
Consumed alcohol in past 30 days	1.02 (0.89–1.17)	1.37 (0.97–1.95)	1.18 (1.12–1.26)
Current smoker	1.23 (1.05–1.45)	1.59 (1.03–2.47)	1.64 (1.53–1.77)
Have a Health Plan	2.28 (1.83–2.83)	3.87 (2.10–7.13)	2.76 (2.41–3.16)
Did not see a doctor because of cost past year	0.73 (0.62–0.87)	0.95 (0.57–1.59)	0.86 (0.79–0.96)

2004) and we observed no difference in the odds of CRC screening in Blacks with CVD history compared to Blacks without CVD, it is important to have set recommendations for those at high risk for CVD to undergo CRC screening and prevent new CRC cases, especially among Blacks.

This study has several strengths. To our knowledge, this is the first analysis examining odds of CRC screening among individuals with and without history of CVD. The use of the latest nationally representative BRFSS 2012–2016 dataset provided consistent and standardized data on socio-economic, demographic, and CRC screening variables. In addition, stratification and weighting techniques were applied to each study year, allowing for more accurate generalizability of study results to the general U.S. population for the trends analysis. The study was limited by the fact that the BRFSS data is obtained via telephone survey and those who were at home during the day, had access to a telephone, willing to take the survey, and/or residing in the 15 states examined in this analysis which may potentially be different from those in the general population. The self-report nature of the BRFSS also limited the ability to assess other common risk factors for CRC and CVD such as obesity. Additionally, the survey is based on non-institutionalized populations and excludes individuals with risk for CVD who reside elsewhere like nursing homes or are in long-term care facilities. We only included states with highest prevalence of CVD. However, we recognize that geographic disparities within these states and beyond may exist. There is also no way to know whether respondents were queried more than once over the years. Furthermore, differences in recall and reporting which are inherent in using cross-sectional survey questionnaires may lead to overestimation of the actual testing behavior. Finally, the relatively small number of Hispanics in the sample may have affected some of the comparisons between racial/ethnic groups. Despite these limitations, the BRFSS dataset is the most comprehensive system for monitoring health behaviors, chronic diseases, healthcare utilization, and other

Table 5

Odds ratios (ORs) and 95% Confidence Intervals (95% CI) for Colorectal Cancer Screening for males and females stratified by post-ACA phases in fully adjusted model: Data from Behavioral Risk Factor Surveillance System in the United States (2012–2016).

	Expansion phase (2012–2014)	
	Males	Females
	OR (95% CI)	
History of Cardiovascular disease	1.12 (1.02–1.23)	1.17 (1.08–1.27)
Age		
50–59	1.00 (Ref)	1.00 (Ref)
60–69	2.00 (1.84–2.16)	1.87 (1.76–1.99)
70–75	2.72 (2.45–3.03)	2.22 (2.05–2.40)
Marital status		
Never married	1.00 (Ref)	1.00 (Ref)
Married	1.32 (0.94–1.84)	1.50 (1.16–1.94)
Divorced/separated/widowed	0.92 (0.65–1.29)	1.19 (0.92–1.54)
Member of unmarried couple	0.75 (0.52–1.06)	0.80 (0.61–1.06)
Race/Ethnicity		
Whites	1.00 (Ref)	1.00 (Ref)
Blacks	1.19 (1.06–1.33)	1.19 (1.10–1.29)
Hispanics	0.69 (0.56–0.84)	0.55 (0.47–0.64)
Education		
Less than High School	1.00 (Ref)	1.00 (Ref)
High School graduate	1.53 (1.35–1.74)	1.36 (1.24–1.49)
Attended college/Technical school	1.97 (1.72–2.25)	1.55 (1.40–1.70)
College/Technical School graduate	2.70 (2.35–3.09)	1.95 (1.77–2.16)
Metropolitan Statistical Area (MSA)		
Not in MSA	1.00 (Ref)	1.00 (Ref)
In city center	1.35 (1.23–1.52)	1.35 (1.27–1.45)
Outside city center but in county with city center	1.37 (1.23–1.52)	1.35 (1.25–1.47)
In suburban county	1.24 (1.11–1.37)	1.22 (1.13–1.32)
Diabetes	1.14 (1.04–1.26)	1.22 (1.13–1.30)
Chronic Kidney Disease	1.62 (1.34–1.98)	1.57 (1.37–1.81)
Consumed alcohol in past 30 days	1.20 (1.12–1.30)	1.24 (1.17–1.32)
Current smoker	1.55 (1.42–1.70)	1.60 (1.49–1.71)
Have a Health Plan	2.78 (2.39–3.22)	2.88 (2.57–3.12)
Did not see a doctor because of cost past year	0.86 (0.76–0.98)	0.84 (0.77–0.91)
	Stable phase (2015–2016)	
	Males	Females
	OR (95% CI)	
History of Cardiovascular disease	1.17 (1.05–1.30)	1.24 (1.13–1.36)
Age		
50–59	1.00 (Ref)	1.00 (Ref)
60–69	1.97 (1.79–2.16)	1.87 (1.75–2.01)
70–75	2.54 (2.25–2.86)	2.42 (2.22–2.65)
Marital status		
Never married	1.00 (Ref)	1.00 (Ref)
Married		

Table 5 (continued)

	Expansion phase (2012–2014)	
	Males	Females
	OR (95% CI)	
Divorced/separated/widowed	1.91 (1.35–2.71)	1.53 (1.10–2.13)
Member of unmarried couple	1.22 (0.86–1.74)	1.26 (0.91–1.76)
	1.00 (0.69–1.44)	0.88 (0.62–1.24)
Race/Ethnicity		
Whites	1.00 (Ref)	1.00 (Ref)
Blacks	1.19 (1.05–1.35)	1.16 (1.07–1.26)
Hispanics	0.76 (0.59–0.99)	0.64 (0.52–0.79)
Education		
Less than High School	1.00 (Ref)	1.00 (Ref)
High School graduate	1.47 (1.26–1.71)	1.34 (1.20–1.49)
Attended college/Technical school	1.73 (1.47–2.03)	1.65 (1.47–1.85)
College/Technical School graduate	2.52 (2.14–2.97)	2.00 (1.78–2.26)
Metropolitan statistical area (MSA)		
Not in MSA	1.00 (Ref)	1.00 (Ref)
In city center	1.41 (1.27–1.56)	1.35 (1.26–1.46)
Outside city center but in county with city center	1.44 (1.27–1.62)	1.37 (1.25–1.50)
In suburban county	1.24 (1.09–1.41)	1.15 (1.04–1.27)
Diabetes	1.15 (1.03–1.28)	1.12 (1.04–1.21)
Chronic Kidney Disease	1.46 (1.19–1.80)	1.47 (1.26–1.71)
Consumed alcohol in past 30 days	1.15 (1.06–1.26)	1.18 (1.10–1.27)
Current smoker	1.61 (1.45–1.80)	1.54 (1.42–1.67)
Have a Health Plan	2.63 (2.17–3.19)	2.67 (2.33–3.08)
Did not see a doctor because of cost past year	0.78 (0.67–0.91)	0.86 (0.77–0.95)

factors influencing the health of the general population in addition to being a reliable database with good generalizability.

In conclusion, individuals with history of CVD are more likely to be screened for CRC regardless of race/ethnicity or sex. Additionally, Hispanics and Whites with history of CVD and women with history of CVD are more likely to be screened for CRC. Moreover, the stabilization of ACA uptake seems to have a greater impact on CRC screening in Hispanics as compared to Whites or Blacks with history of CVD. Further analyses should be conducted using data from prospective cohorts to obtain a more definitive conclusion to promote screening recommendations for CRC among those at high risk for CVD.

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CRedit authorship contribution statement

Swati Sakhuja: Conceptualization, Formal analysis, Methodology, Writing - original draft, Writing - review & editing. **Mackenzie E. Fowler:** Conceptualization, Formal analysis, Methodology, Writing - original draft, Writing - review & editing. **Akinoyemi I. Ojesina:** Conceptualization, Funding acquisition, Supervision, Writing - review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.pmedr.2020.101263>.

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