RESEARCH ARTICLE

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Disparities in Compliance with Colorectal Cancer Screening: Evidence from Two US National Surveys

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Abstract

Objective: Colorectal cancer (CRC) is the most preventable cancer if adherence to its screening guidelines through compliance with physician recommendations are met. Lack of access to care is the most significant barrier which was decreased by the Affordable Care Act (ACA), that may influence healthcare behaviors/practices. The aim of this study was to determine the factors affecting compliance with recommendations for CRC screening between two US National Health Interview Surveys (NHIS) in 2010 and 2015. **Methods:** We used individual data of adults aged ≥50 years from the Cancer Module of NHIS that repeats every-5-years. Multiple logistic regression analyses were employed to identify the compliance associated factors and their changes after five years. **Results:** We included final data of 1,553 and 2259 and individual from 2010 and 2015, respectively. Overall, compliance to physician recommendations for colorectal cancer was 85.70% in 2010 and 81.54%. Men compiled more in 2010 than women which was reversed in 2015. The multivariable-adjusted odds of compliance were increased with age; lower for female [Odds ratio (OR)= 0.45 Confidence Interval (CI 95% 0.27, 0.75), having a family history of CRC [OR=3.05 CI:1.02, 9.05], having insurance [OR 3.58 CI:1.4, 9.12], and Odds increased with the number of doctor visit in 2010. However, in 2015 the odds were substantially increased with the increasing age, reversed odds for female [OR= 3.49 CI: 1.67, 7.29)], increased for non-Hispanic Blacks [OR= 4.87 CI: 2.05, 11.55] and lower for Asian [OR=0.33 CI:0.15, 0.74], higher for family history of colorectal cancer [OR=3.31 CI:1.92, 5.69]. Although insurance coverage and the number of doctor visits were significant predictors of compliance in 2010, those became non-significant in 2015. **Conclusions:** Compliance disparities by gender and access to healthcare either reduced in strength or reversed between 2010 and 2015. The non-Hispanic Black significantly higher in compliance than other race-ethnicities in 2015.

Keywords: Colorectal cancer- colonoscopy compliance- racial and gender disparities- affordable care act

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Introduction

Colorectal cancer (CRC) is the 2nd leading cause of cancer mortality accounting for 53,200 deaths of US men and women in 2020 with 147,950 new cases (Howlader et al., 2017; Seigel, 2020). The 5-year survival rate of CRC is 90% if detected at the early localized stage. In contrast, if diagnosed at a late stage, the survival rate goes down to only about 11.7% (Siegel et al., 2012). The US Preventive Services Task Force (USPSTF) recommended that adults aged 50-75 years should screen for CRC to detect and prevent CRC at an early stage. However, 60.6% of the US adults 50-75 years or above were up to date with CRC screening (Joseph et al., 2020). Surprisingly, only 37% of CRC is detected at an early localized stage, and 21% are diagnosed at a distant stage (Seigel, 2020). Improving strategies to increase screening adherence could decrease morbidity and mortality from colorectal cancer.

Colonoscopy can view the entire colon. It can detect presence of any polyps which can be removed during the same procedure which established it the gold standard for prevention (Seigel, 2020). The national polyp study has shown that colonoscopies were effective in reducing CRC incidence up to 90% as compared with the historical controls (Winawer et al., 2000). Endoscopic screening has also been found to be more effective in reducing mortality than fecal occult blood test (FOBT) alone (Crespi et al., 2001). The national guidelines have recommended that persons aged ≥50 years should be screened for colorectal cancer using the gold standard-- colonoscopy once every ten years or sigmoidoscopy once in every five years (Smith et al., 2006). Despite a consensus among experts regarding

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the effectiveness of colorectal screening (Crespi et al., 2001; Pignone et al., 2002; Walsh et al., 2003), screening rates remain low (Ioannou et al., 2003; Janz et al., 2003; Seeff et al., 2002). The benefits of CRC screening are not fully realized due to a lack of adoption and compliance with the screening guidelines by US populations. In 2018, the Centers for Disease Control and Prevention (CDC) reported that around 40% of eligible adults did not receive the Gold Standard test- colonoscopy in the past decade (Clarke et al., 2020).

Receiving physician recommendations for CRC screening is associated with sociodemographic characteristics and healthcare access in the US population (Ahmed et al., 2013). Insurance coverage has been found to play a critical role in both healthcare access and utilization (Buchmueller et al., 2005). Healthcare access may be the central conduit to involved physicians (Ahmed et al., 2013). Physicians play a crucial role in identifying and recommending eligible persons for CRC screening (Ahmed et al., 2013; Janz et al., 2003). However, not all those who received the recommendation complied. It is well recognized that the concept of health is quite complex, however, understanding how social determinants actively playing a role in compliance and impacting the inequities within their pathways is imperative (Shokouh et al., 2017). With no true gold standard, one proposed method is to include multiple indicators along with the life-course approach for social determinants as well as socio-economic factors (Shokouh et al., 2017). Thus, non-compliance related factors need to be further explored and identified.

The purpose of this study is to identify the predictors of compliance with physician recommendation (prescription) of colonoscopy for CRC screening among the screen-eligible US population and to examine the changes among these factors between in the year 2010 and after five years in 2015.

Materials and Methods

Data source and study population

We used publicly available data from the National Health Interview Survey (NHIS) for the years 2010 and 2015. The National Center for Health Statistics (NCHS) of the CDC house the data and made the survey data file available for research via internet and other electronic media. The cancer module of this survey is done only once every 5 years within the NHIS. The NHIS is a cross-sectional household survey where the sample design is multistage probability sampling. In the sample, basic information on the health and demographics of all household members was collected by an in-person interview.

The NHIS cancer module is collected as a supplement which is given to individuals over the age of 40. Of the 35,153 eligible adults, a total of 27,157 were interviewed in 2010, resulting in a final sample adult response rate of 60.8%. Of the 42,270 eligible adults, a total of 33,673 were interviewed in 2015, yielding a final sample adult response rate of 55.2%. There was a high percentage of missing data in cancer module potentially due to the reason that the cancer module was in the near end of the survey, which may have contributed to respondent fatigue, or they became reluctant to answer questions. However, missing data issues had been addressed by the NHIS technical team using non-response, design effect, and post-stratification adjustments. The details on the design of NHIS can be found elsewhere. (Centers for Disease Control and Prevention, 2022)

For this analysis, the inclusion criteria (Fig 1) were as follows: a) Age 50 years or older; b) No history of colon or rectal cancer; c) Visited doctor in the last 12 months; and d) Received recommendation from a physician to perform colonoscopy within last twelve months. The exclusion criteria were a) The participants less than 50 years old; b) Sigmoidoscopy screening done within 5 years before the survey, c) Colonoscopy screening done within 10 years before the survey, d) Those diagnosed with colon or rectal cancer, or e) The participant did not visit a doctor within the last 12 months.

Variables and Measures

Compliance with colorectal screening was measured by whether a person who is 50 years or older had completed either a colonoscopy or sigmoidoscopy after receiving a recommendation from a physician. We created a dichotomous outcome variable (complied-yes or no). Participants who had the screening done in the last year were measured as complied. Based on the literature, we classified independent variables into three thematic groups: i) Sociodemographic (age, sex, race/ethnicity, education, and marital status); ii) Health care access (insurance coverage and doctor's visit in the past 12 months); and iii) Health risk and health status (family history of any cancer, citizenship, income, and region).

Statistical analysis

We performed a descriptive analysis of demographic and other variables by calculating the proportion of compliance for colorectal cancer by adjusting the sampling weight of the survey. Pearson Chi-square test was used to assess the relationship between the outcome variable (compliance) and the co-variates. We estimated crude odds ratios to assess patients' compliance with physician recommendations for colorectal cancer screening using bivariate logistic regression models. Then we built adjusted models using the stepwise forward-backward variable selection method with purposeful criteria of $p \leq 0.20$ as inclusion and $p \leq 0.25$ as exclusion criterion for each sample. Thus, in the final model 12 variables: age, sex, race/ethnicity, education, marital status, family history of CRC, citizenship, income, insurance coverage, usual source of care, number of doctor visits in the past 12 months, and region of residence were included. Data were analyzed separately for each survey year. The data sets contained the national weights to address the design and post-stratification effect of oversampling of a certain race, region, interviewer effect, and non-response. The complex multistage cluster sampling adjustment was done using the Taylor Series Linearization technique for the NHIS nationally representative sample. All estimates were generated using SAS version 9.4, which allows deriving

correct standard errors for estimates of complex surveys.

Results

The nationally representative sample consisted of 1,553 participants in NHIS 2010 and 2,259 in NHIS 2015, aged 50 years and older, who were never diagnosed with colorectal cancer (Figure 1). Demographics were similar for both 2010 and 2015, with three-fourth of the sample being non-Hispanic White, one-third of the sample were college graduates, and notable about one-fifth of the participants had a family history of cancer. The descriptive statistics, bivariate and multivariable analyses Table 1 for the year 2010 and Table 2 for the year 2015 are shown,

Table 1. Sociodemographic Characteristics of Complied to Physician Recommendation for Colorectal Cancer Screening among Eligible United States Population: National Health Interview Survey, 2010

Characteristics	Total n=1553 Sample (%)	Complied (%) n=1331	Crude OR (95%CI)	Multivariate OR (95%CI)
Age, years				
50-54	324 (25.42)	79.01	Ref	Ref
55 -59	266 (17.24)	85.71	1.82* (1.13, 2.91)	1.79* (1.02, 3.22)
60- 64	297 (18.8)	86.2	1.96** (1.26, 3.03)	2.44* (1.04, 5.7)
65-74	417 (25.09)	86.81	1.64* (1.10, 2.42)	1.25 (0.67, 2.35)
≥75	249 (13.45)	91.97	3.24*** (1.9, 5.52)	--
Sex				
Female	858 (50.97)	84.62	Ref	Ref
Male	695 (49.03)	87.05	1.24 (0.9, 1.72)	2.25*** (1.36, 3.73)
Race/ Ethnicity				
Non-Hispanic White	1048 (78.72)	84.35	Ref	Ref
Hispanic	168 (7.73)	87.5	1.29 (0.71, 2.33)	1.07 (0.42, 2.74)
Non-Hispanic Black	259 (9.91)	91.12	2.26*** (1.4, 3.65)	2.49 (0.96, 6.47)
Non-Hispanic Asian	68 (3.09)	80.88	0.86 (0.47, 1.56)	2.22 (0.28, 17.56)
Education				
Non-High school	240 (12.01)	90.42	Ref	Ref
High school	402 (24.52)	82.84	0.63 (0.38, 1.07)	0.68 (0.06, 8.45)
Some college	440 (28.82)	86.14	0.87 (0.51, 1.49)	0.60 (0.05, 7.76)
College graduate	463 (34.65)	85.1	0.74 (0.46, 1.2)	0.74 (0.06, 9.67)
Marital status				
Married/living together	848 (70.28)	86.44	Ref	Ref
Widowed/Separated	293 (11.64)	88.4	0.97 (0.62, 1.51)	1.07 (0.41, 2.79)
Divorced	304 (13.21)	81.91	0.61*** (0.43, 0.87)	0.54 (0.3, 0.98)
Never married	106 (4.87)	83.02	0.81 (0.44, 1.52)	0.61 (0.25, 1.53)
Family History				
No	778 (84.53)	83.8	Ref	Ref
Yes	148 (14.71)	91.22	1.55 (0.8, 3.0)	3.05* (1.02, 9.05)
Income				
> $20,000	184 (25.9)	80.43	Ref	Ref
$20,000-$64999	316 (47.26)	83.86	1.14 (0.74, 1.74)	1.11 (0.63, 1.95)
>$65000	164 (26.84)	82.93	1.2 (0.69, 2.1)	1.19 (0.49, 2.88)
Insurance coverage				
Not Insured	43 (2.53)	67.44	Ref	Ref
Insured	1506 (97.47)	86.19	2.05*** (0.82, 5.1)	3.58 ** (1.4, 9.12)
Usual source of care				
No	20 (1.12)	75	Ref	Ref
Yes	1533 (98.88)	85.84	1.42 (0.44, 4.6)	1.01 (0.42, 2.43)
Doctor visit in 12 mo				
1	143 (10.1)	79.02	Ref	Ref
2-3	413 (26.93)	82.57	1.35 (0.76, 2.39)	3.21*** (1.97, 5.24)
≥4	997 (62.97)	87.96	2.09*** (1.25, 3.48)	3.88*** (2.15, 7)

*P<0.05; **P<0.01; ***P<0.001

Table 2. Sociodemographic Characteristics of Complied to Physician Recommendation for Colorectal Cancer Screening Among Eligible United States Population: NHS 2015

Characteristics	Total n=2259 Sample (%)	Complied (%) n=1842	Crude OR (95%CI)	Multivariate OR (95%CI)
Age, years				
50-54	448 (23.76)	73.44	Ref	Ref
55 -59	396 (19.61)	79.8	1.59* (1.04, 2.44)	5.4** (1.79, 16.28)
60- 64	387 (17.23)	80.88	1.8** (1.18, 2.74)	4.6 *** (2.25, 9.41)
65-74	751 (28.81)	85.89	2.09*** (1.4, 3.1)	8.82*** (3.75, 20.72)
≥75	277 (10.59)	86.28	2.68*** (1.65, 4.35)	6.77** (1.64, 27.87)
Sex				
Female	1199 (50.04)	82.9	Ref	Ref
Male	1060 (49.96)	80	0.83 (0.63, 1.1)	0.29*** (0.14, 0.59)
Race-Ethnicity				
Non-Hispanic White	1608 (75.94)	80.97	Ref	Ref
Hispanic	202 (7.46)	81.68	0.88 (0.53, 1.47)	0.4 (0.11, 1.48)
Non-Hispanic Black	354 (12.4)	85.31	1.76** (1.22, 2.53)	4.87*** (2.05, 11.55)
Non-Hispanic Asian	70 (3.43)	78.57	0.95 (0.46, 1.96)	0.37* (0.16, 0.84)
Education				
Non-High school	293 (10.81)	79.52	Ref	Ref
High school	573 (25.13)	81.15	0.78 (0.49, 1.21)	2.01(0.72, 5.62)
Some college	699 (29.54)	79.97	0.75 (0.49, 1.15)	5.07** (1.81, 14.18)
College graduate	689 (34.52)	84.33	1.03 (0.65, 1.63)	1.23 (0.45, 3.37)
Marital status				
Married/living together	1168 (66.96)	84.5	Ref	Ref
Widowed/Separated	390 (12.16)	81.03	0.69 (0.46, 1.04)	0.15** (0.06, 0.41)
Divorced	483 (14.88)	77.85	0.78 (0.55, 1.09)	0.45* (0.24, 0.85)
Never married	213 (6)	74.65	0.72 (0.46, 1.12)	0.61 (0.21, 1.82)
Family History				
No	1117 (81.47)	81.56	Ref	Ref
Yes	255 (18.53)	91.37	3.19*** (1.94, .26)	3.32*** (1.92, 5.75)
Income				
> $20,000	195 (19.84)	80.51	Ref	Ref
$20,000-$64999	460 (46.19)	79.35	1.08 (0.59, 1.95)	1.97(0.88, 4.38)
>$65000	252 (33.97)	80.56	1.23 (0.69, 2.22)	4.35*** (1.87, 10.12)
Insurance coverage				
Not Insured	40 (1.9)	65	Ref	Ref
Insured	2213 (98.1)	81.83	2.05 (0.82, 5.1)	0.9 (0.27, 2.95)
Usual source of care				
No	53 (2.14)	66.04	Ref	Ref
Doctor visit in 12 mo				
1	276 (10.86)	74.64	Ref	Ref
2-3	601 (27.63)	81.53	1.34 (0.88, 2.06)	0.79 (0.32, 1.99)
≥4	1382 (61.51)	82.92	1.71** (1.18, 2.47)	2.61 (0.97, 7.07)

*P<0.05; **P<0.01; ***P<0.001

respectively.

Gender and racial disparities

In multiple logistic regression analyses, after controlling for all other variables, females were less likely (OR: 0.45, 95% CI: 0.27, 0.75) to adhere to a recommendation for CRC screening as compared with males in 2010. However, in 2015, the odds of compliance with the screening recommendation among females were 3.49 (95% CI: 1.67, 7.29) compared to males. In 2015, after adjusting for the predictor variables, CRC screening recommendations compliance differed by race/ethnicity.

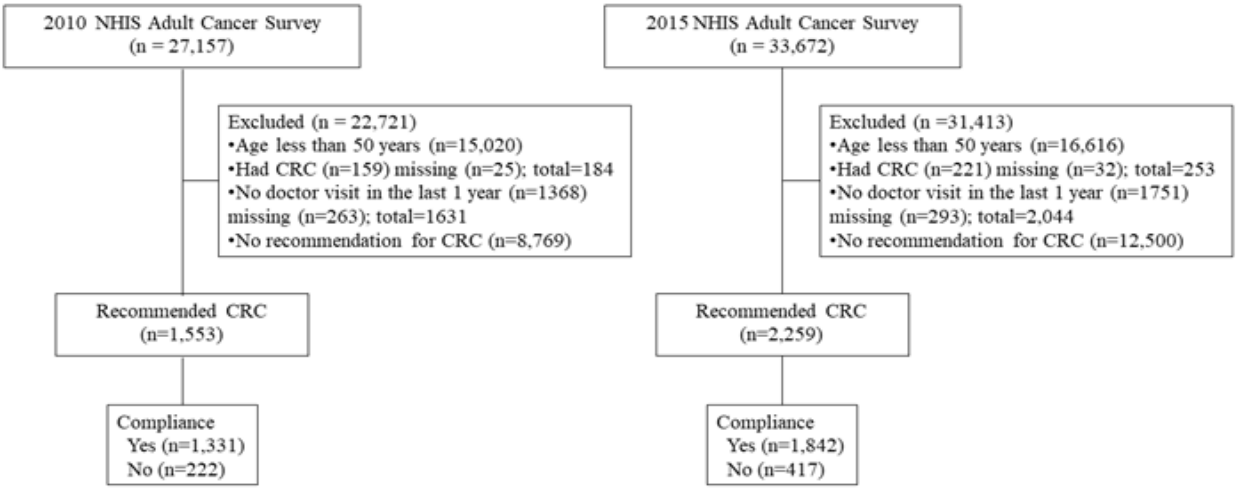

Figure 1. Study Flow Chart

Non-Hispanic Blacks are almost five-fold odds (OR: 4.87, CI: 2.05, 11.55) of adhering to the recommendation in 2015 compared to non-Hispanic Whites. A decrease in compliance with recommendations is observed among Asians (OR: 0.37, CI: 0.16, 0.84).

Comparison between 2010 and 2015

The models for each of the two survey years showed differences in several factors that explained compliance with a physician recommendation for CRC screening. In both 2010 and 2015, factors significantly associated with compliance for screening were family history of colorectal cancer and the age of participants. Those who had a family history of colorectal cancer were at least three times odds of compliance with a physician recommendation in each of the two survey years: (in 2010, OR 3.05 vs. 3.32 in 2015). The odds of participants' age on compliance to physician recommendations were almost doubled from 2010 to 2015. In 2010, 55-59 years old participants were 79% more likely, and 60-64 years old were 144% more likely to adhere to the physician recommendation compared to 50-54 years old. However, in 2015, there is a significant increase of odds 5.4 times and 4.6 times to adhere to the physician recommendation among 55-59 years and 60-64 years, respectively. A higher frequency of physician visits was significantly positively associated with compliance with physician recommended screening in 2010; however, this association was not observed in 2015. In 2010, those who had 2-3 visits were 3.21 times odds of compliance, and those who had more than four visits were 3.88 odds of compliance with physician recommendation in comparison to with a single physician visit during a year. However, in 2015, there was no significant association with the physician visit frequency with compliance after adjusting for other factors.

Disparities were also observed in participants with a college education and higher income (more than $65,000) in 2015. Participants with a college education were 5.07 times as likely to adhere to physician recommendations for CRC screening than participants with no high school education. Similarly, participants with an income of more than $65,000 were 4.35 times as likely to adhere to the physician recommendation. In contrast, in 2010, no significant disparities in income or education were observed. In 2010, those who were insured were 3.58 times as likely to comply with physician recommendations for CRC screening compared to those who were not insured. However, in 2015, no significant association of health insurance has been found with CRC screening compliance.

Discussion

In the present study, we found a substantial change among factors between 2010 and 2015 in compliance with colorectal cancer recommendations. Our findings of an increase in compliance are strongly associated with increasing age in both 2010 and 2015. This association may be attributed to receiving more attention from family members as well as frequent doctor visits by older individuals. Several other studies also found higher screening adherence among the older age group (Beydoun et al., 2008). Some research documented that older patient with three or more comorbidities had early and repeat-colonoscopy (Parsons, 2014). In our study, the younger group is less compliant with physician recommendations for CRC screening. Increasing physician recommendations for the younger eligible population plays a crucial role in reaching the National Colorectal Cancer Roundtable's goal for CRC screening of 80% by 2024.

Age plays a substantial role in human health and well-being. Almost a quarter of the total global burden of disease is attributed to disorders in those 60 years and older (Hudson et al., 2012). Studies have shown that healthcare utilization increases with those older groups compared with their younger counterparts (Buchmueller et al., 2005). It is known that aging adults have varying health conditions; however, the vast majority have at least one chronic condition that requires medical care (Goodwin et al., 2011). The establishment of Medicare in 1966 allowed for increased healthcare access among

the older, eligible adults. With the implementation of the Affordable Care Act (ACA) in 2010, the additional provisions created in conjunction with Medicare led to a significant increase in the number of diagnosed early-stage CRC among older adults (Prince et al., 2015).

There are gender differences in screening, detection, treatment, and survival of colorectal cancer. Our study has found that the odds of adherence to CRC screening have substantially increased among females compared with males between 2010 and 2015. There was an almost three folds increase in compliance among females as compared with that in males in five years. One possible explanation is that the ACA might have provided availability of affordable insurance plans and, by nature of females' health-seeking behavior, took advantage of the opportunity and thus improved their ability to get access to health care, including preventive services (Lissenden et al., 2017) and utilized it. The signs and symptoms of CRC present differently for women. Women present with right-sided colon cancer at a higher rate than men and are often diagnosed at a later stage due to the location (Gunja et al., 2017). When compared to left-sided rectal cancer presents as polyps, right-sided colon cancer often presents as flat tumors, making it difficult to distinguish (Gunja et al., 2017) and diagnosis for women. Therefore, it was known as a non-female disease, despite women over age 65 and older have higher mortality and lower 5-year survival rates when compared with men (Gunja et al., 2017). Due to the advancement of diagnostic procedures, the perception of CRC being solely a man's disease changed, and CRC is recognized as women's disease too. Mounted nationwide awareness campaigns and promotions resulted in a substantial expansion of CRC screening recommendations to women (Eom et al., 2020). This may lead to being another explanation for our findings showing the much higher rate of compliance for women.

Other factors for the decline in compliance among men could be the perceived threat of loss of masculinity or sexuality, fear of cancer diagnosis, or discomfort of CRC screening procedure (Eom et al., 2020; Kim et al., 2015). A study in the UK also found significantly higher screening adherence among females compared with males (Gwede et al., 2015). Addressing sex differences in CRC screening is challenging. A higher rate of recommendation for CRC screening played a significant role for men to adhere to CRC screening (Beydoun et al., 2008), but lack of awareness regarding screening could be a reason for lower screening among this study population. It is essential to have an increased level of conversation between health care providers and patients to increase CRC screening and compliance among males (Friedemann-Sánchez et al., 2007). A study conducted in Australia found that a notification letter before the fecal immunochemical test (FIT) increases the CRC screening by 12% among males compared with those who were not contacted (A White et al., 2018).

Our study findings confirm previous studies on the association between family history of colorectal cancer and adherence to CRC screening recommendations (Wilkins, 2011). The research documented that a family history of colorectal cancer positively influenced CRC screening (B White et al., 2015). A systematic review identified that an individual with a positive family history of CRC has 1.4 to 3.3 times more likely to perform CRC screening than those with no family history (Holden et al., 2010). It has been found that first-degree relatives are 70% more likely to perform a colonoscopy compared to non-first-degree relatives. More studies supported higher CRC screening among first-degree relatives compared with non-first-degree relatives (Henrikson et al., 2015; Shapiro et al., 2012; Townsend et al., 2013). The reasons behind higher screening adherence among those individuals with family history could be due to a combination of self-awareness of the susceptibility, familiarity of this disease, family encouragement, and physician recommendation (Perencevich et al., 2013).

One of our key findings that insurance coverage became non-significance in predicting CRC compliance in 2015, whereas it was significant in 2010. It has been reported that insurance plays a significant role in physician recommendations (Perencevich et al., 2013). Insurance coverage, including copayments, may have been a key factor for compliance prior to 2010. The Medicaid expansion under the ACA made impacts on the affordability of care, access to care, utilization of services, especially for the underserved population (Dillon et al., 2018). This expansion includes preventive services, including CRC (Lissenden et al., 2017). This may have in part reduced the variability and perhaps one reason for not observing any significant association of insurance coverage with compliance CRC screening in 2015. The ACA and other forms of health insurance are referred to as a financial mechanism for paying for healthcare, while access refers to the receiving of care (Buchmueller et al., 2016). The ACA has been found to be associated with increased healthcare access, use of preventative and outpatient services (Tangka et al., 2019). The initial implementation of the ACA in 2010 might have been playing some role in decreasing the insurance barrier yielding an impact on access to care and healthcare delivery, which in turn, perhaps influenced compliance with the CRC screening recommendation in 2015.

We also observed the reduction of health disparities in the complying recommendation to CRC screening by race. We found increased compliance with CRC recommendations among non-Hispanic Black in 2015 than that in 2010. It has been reported that ACA decreased racial and ethnic disparities (Brawarsky et al., 2004). After the ACA Medicaid expansion, the insurance coverage gap significantly decreased for non-Hispanic Black Medicaid colorectal cancer patients (Antonisse et al., 2018). We found that Blacks have a higher rate of compliance than the White population, which may be of interest. Several programs or initiatives targeted to reduce health disparities, such as community health centers, Colorectal Cancer Control Program, and the National Colorectal Cancer Roundtable Initiative, could facilitate the reduction of racial disparities and increase access to CRC screenings (Antonisse et al., 2018; Buchmueller et al., 2016; Tangka et al., 2019).

This study has a few limitations the main one self-

reported information such as income and completion of CRC screening. The income missing information has been adjusted with a standard statistical method by the National Health Statistics Technical Team. Colonoscopy and sigmoidoscopy procedures require substantial preparatory involvements by the patients and these tests are quite invasive in nature. It is unlikely not to recall correctly that tests were done or not within a year of timeframe. Moreover, a satisfactory agreement was found between self-reported information and medical records of CRC screenings (Hoover et al., 2019). Despite all, one must exercise caution in making any causal inference based on the cross-sectional nature of the data.

In Conclusion, the disparities in compliance with CRC recommendations by education, and income which widened in 2015. Interestingly, gender and healthcare access variables showed reduced strength or reversed comparative disparities with compliance in 2015.

Author Contribution Statement

N. Ahmed conceptualized the study, designed the analytic approach, drafted, led and supervised the study. M.A.B. Chowdhury and S.I. Azim designed the analytic approach, managed and analyzed the data, and interpreted the results. N. Ahmed, M.A.B. Chowdhury, and S. I. Azim drafted the article. A. Rodriguez, T. Taskin, and S. Ahmed reviewed, edited, and updated the manuscript. All authors reviewed and approved the final version of the manuscript for submission.

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Availability of data and material

All data presented here in the manuscript is freely available at cdc.gov

Data availability

Data is freely available at https://www.cdc.gov/nchs/nhis/index.htm

Ethics approval

This study was exempt from the ethical review approval as we used publicly available de-identified data.

Disclosures/Conflict of Interest

There are no potential conflicts (financial, professional, or personal) to disclose by any of the authors.

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