The Impact of Rurality and Age on Colorectal Cancer Screening Among Michigan Residents

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Abstract

Background: *Colorectal cancer (CRC) is a prevalent cause of cancer-related deaths in Michigan, but not all Michigan adults had appropriate CRC screening.*

Objective: *To assess the relationship between rurality and age on CRC screenings to inform how pharmacists could focus their efforts to educate, facilitate, or offer CRC health screenings.*

Methods: *This was a retrospective, cross-sectional study using 2018 Michigan Behavioral Risk Factor Surveillance System (MiBRFSS) survey data. Michigan participants aged ≥ 50 years were included. Outcomes included the utilization of stool-based tests, sigmoidoscopies, colonoscopies, and the most recent CRC screening. Demographic variables included age, sex, income, race/ethnicity, relationship status, education level, employment status, income, rurality, and health insurance. Representative sampling weights were used to adjust for the complex survey design. Descriptive statistics, chi-square, and multivariable logistic regression analyses were conducted. IBM SPSS version 28.0.1.0 was used and an a priori p-value of <0.05 was deemed significant.*

Results: *A weighted total of 3,762,540 participants were included, of which 21.3% (n = 781,907) reported living in a rural area and approximately 70% (n = 2,616,646) were between the ages of 50-69 years old. Most participants reported being White, non-Hispanic (n = 3,104,117, 84.5%), having health insurance (n = 3,619,801, 96.4%), and having a colonoscopy (74.6%, n= 2,620,581). There was no difference based on rurality. Compared to those aged 50-59 years, adults 60-69 years (AOR = 1.97, 95% CI: 1.58,2.45), 70-79 years (AOR = 3.29, 95% CI: 2.40,4.51), and ≥ 80 years (AOR = 2.23, 95% CI: 1.54,3.24) had higher odds of receiving a colonoscopy. Lack of insurance was associated with lower odds of receiving a colonoscopy (AOR = 0.38, 95% CI: 0.23, 0.56).*

Conclusion: *Most participants reported having a CRC screening but efforts to increase CRC screening in Michigan adults aged 50-59 are warranted.*

Keywords: Behavioral risk factor surveillance system, colorectal cancer, cancer prevention, pharmacist

Introduction

Colorectal cancer (CRC) is the fourth most prevalent form of cancer and the fourth leading cause of cancer-related deaths in Michigan as of 2018.[1] However, it is estimated that only 70% of Michigan residents have been appropriately screened for CRC.[2] The U.S. Multi-Society Task Force on Colorectal Cancer's current recommendation for CRC screening is to begin screening for people with an average risk for cancer at age 45, which was a recent change from 50 years old due to an increase in CRC prevalence in adults under age 50.[3] Colonoscopies, stool tests, sigmoidoscopies, and computed tomography (CT) colonographies are all methods of screening for CRC recommended by the U.S. Multi-Society Task Force. After age 75, the decision to be screened should be an individual one based on the patient's risks and overall health.[4]

CRC is often asymptomatic, but patients may experience changes in bowel habits, blood in the stool, or weight loss.[5] CRC screenings are essential in reducing the prevalence of CRC and have been shown to decrease the relative mortality rate of CRC by almost 50% from 1975 to 2011, with an absolute mortality rate reduction of nearly 10%.[4,6,7] They have also been shown to improve the CRC prognosis, especially when the cancer is found in its early stages.[8,9] Despite the importance of CRC screenings, they are underutilized in the United States. Almost one-third of US residents and approximately 30% of Michigan residents are not up-to-date on their CRC screening.[2,10]

There are a variety of reasons that adults may not participate in CRC screening such as the fear of the colonoscopy procedure, lack of insurance, the discomfort of completing a bowel preparation, and lack of awareness about the importance of screenings.[11,12] In addition, individuals who live in rural areas may have less access to healthcare providers and services.[13] Age has been associated with health behaviors, but there is still limited knowledge about age's impact on participating in CRC health screenings.[14]

There is a growing interest in the potential role of community pharmacists as it relates to CRC screening.[15-19] Traditionally, pharmacists have provided education about prescription and over-the-counter bowel preparations as part of the dispensing process.[15] Studies have shown that pharmacist interventions can increase CRC screening rates in patients and the positive impact pharmacies can play in stool test distribution and collection.[16-18] However, it is challenging for pharmacists to increase their role in preventive health screenings including

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DOI: https://doi.org/10.24926/iip.v14i1.5212

CRC screenings without compensation for their time and the services they provide.[19]

The state of Michigan includes both urban and rural settings with varying levels of access to pharmacy services.[20] In addition, the number and percentage of older adults have consistently increased in the past twenty years.[21] There is a lack of studies evaluating rurality and age as potential factors influencing CRC screening usage for residents of the state of Michigan. Therefore, this study aimed to compare CRC screening among Michigan residents based on their age and whether they lived in an urban or rural setting. We anticipated that the findings may help inform how pharmacists could focus their efforts on educating, facilitating, or offering CRC health screenings.

Methods

The Michigan Behavioral Risk Factor Surveillance System (MiBRFSS) is an annual telephone survey of Michigan residents aged 18 years and older, which is a state-specific version of the national Behavioral Risk Factor Surveillance System (BRFSS).[22] The MiBRFSS is the only source of Michigan resident population estimates for preventive care usage and prevalence of other health behaviors.[23] This study focused on the questions from the CRC screening section of the 2018 MiBRFSS, which were only asked to participants aged 50 years and above. Participant age was self-identified in the demographic section of the survey.[24]

Colorectal Cancer Screening Outcomes

We included all five CRC screening questions in this study:

- Whether participants had ever had a home blood stool test with response options of yes or no.
- Among participants who said yes to receiving a home blood stool test, when the test occurred. This was originally reported as being within the past year, the past 2 years, the past 3 years, the past 5 years, or never. We re-coded this into a binary response of yes if the test was within the past 3 years or no as this aligns with the current guideline recommendation from the U.S. Preventive Services Task Force recommendation for the frequency of stool tests.[3]
- Whether participants reported ever having a colonoscopy or sigmoidoscopy with the response options of yes or no.
- Among participants who said yes to having had a colonoscopy or sigmoidoscopy, whether it was a colonoscopy or sigmoidoscopy.
- Among participants who said yes to having had a colonoscopy or sigmoidoscopy, when the test occurred. This was originally reported as being within the past year, the past 2 years, the past 3 years, the past 5 years, the past 10 years, or 10 or more years. We re-coded this into the binary response of yes if the test was within the past 10 years or no if it had been longer than 10 years based on the U.S. Preventive Services Task Force recommendation for the frequency of these tests.[3]

Demographics

We included sex, race and ethnicity, marital status, education level, employment status, income, and health insurance status as demographic variables. Rurality was assigned from the participant's self-reported zip code and matched with the corresponding 2013 Rural-Urban Continuum Code (RUCC), designed by the United States Department of Agriculture.[25] The RUCC categories assign a number from 1 to 9 based on the total population and how adjacent the area is to another metro area, with a number of 1 being the most urban and 9 being the most rural. Rurality was collapsed from 9 unique rural urban continuum codes into a binary outcome, where numbers 1 through 3 were classified as urban and numbers 4 through 9 were classified as rural. The race variable was collapsed from 5 categories (White, Black/African American, American Indian or Alaska Native, Asian, and Pacific Islander) into 3 (White, Black/African American, or multiracial/other) due to small sample sizes. Age was self-identified in the survey and categorized as 50-59, 60-69, 70-79, or ≥ 80 years old to analyze differences by age groups for CRC screening. The relationship status variable had 6 unique relationship responses (married, divorced, widowed, separated, never married, or member of an unmarried couple) and was collapsed into two variables (having a partner or not having a partner). Education status was collapsed from 6 education level options into 4 categories (less than high school, high school graduate, some college, or college graduate). Employment status was collapsed from 8 unique responses into employed or unemployed, where the responses employed for wages, self-employed, homemaker, and student were considered employed. The responses out of work for one year or more, out of work for less than one year, retired, and unable to work were considered unemployed. Income levels were collapsed from 8 levels of income into 3 more broad levels (<$25,000, $25,000-$49,999, and >$50,000). Health insurance was a binary variable on the survey that asked if participants had any kind of health care coverage (yes or no).

Analysis

Each variable response was recoded to missing if the participant did not know the answer to the question or declined to answer. We accounted for the sampling weights and the complex sample survey design in all analyses. Descriptive statistics (mean (SD), frequency (%)) were used to analyze the characteristics of the respondents. We examined the relationship between respondent demographics and our outcome variables using chi-square analyses as well as unadjusted and adjusted multivariable logistic regression models. The multivariable logistic regression models included gender, age, race and ethnicity, relationship status, the highest level of education received, employment status, income level, health insurance status, and rurality variables. We considered an *a priori* p-value of <0.05 to be significant. The data was analyzed using IBM SPSS version 28.0.1.0 (IBM Corp., Armonk, N.Y., USA).

DOI: https://doi.org/10.24926/iip.v14i1.5212

All data received under a data use agreement was de-identified and this project was considered not regulated by the University of Michigan Institutional Review Board.

Results

A total of 10,322 participants completed the 2018 MiBRFSS and the total weighted sample was 7,826,345 participants. We excluded participants who were less than 50 years of age since they were not asked the CRC screening questions. Therefore, our total sample size for the CRC screening cohort was 3,762,540 participants. Respondents were slightly more female than male, the majority were between 50-69 years of age, and were 84.5 % white (Table 1). Most participants (N=3,619,801, 96.4%) reported having health insurance.

Blood stool tests

Approximately one-third of participants (N=1,162,106) reported using a blood stool test at any time (Appendix A). The odds of receiving a stool test were higher in adults aged 60-69 years, 70-79 years, and 80 years and older compared to adults aged 50-59 years (Adjusted Odds Ratio (AOR) = 1.61, 95% Confidence Interval (CI): 1.31,1.98; AOR = 2.44, 95% CI: 1.91,3.12; and AOR = 1.82, 95% CI: 1.31,2.54, respectively). Those who were unemployed compared to employed (AOR = 1.40, 95% CI: 1.15,1.71) and those with an education level of high school and above compared to less than high school (High school graduate: AOR = 1.71, 95% CI: 1.11, 2.62; Some college: AOR = 2.12, 95% CI: 1.38,3.25; College graduate: AOR = 2.14, 95% CI: 1.38, 3.30) were more likely to receive a prior blood stool test. (Table 2).

Of those participants who have had a home blood stool test before, 53.9% of participants (N=603,000) had one within the past 3 years (Appendix B). Those who were 80 years or older were less likely to receive a stool test within the past 3 years compared to those who were 50-59 years old (AOR = 0.40, 95% CI: 0.24,0.68) (Table 3).

Sigmoidoscopy and Colonoscopy

A total of 76.5% of participants (N=2,750,798) reported having had a prior sigmoidoscopy or colonoscopy (Appendix C). Those aged 60-69 years old (AOR = 1.98, 95% CI: 1.59,2.47); 70-79 years old (AOR = 3.28, 95% CI: 2.40,4.49); 80 years old and older (AOR = 2.24, 95% CI: 1.54,3.25) compared to 50-59 years old, those with an education level of at least some college (Some college: AOR = 1.77, 95% CI: 1.15,2.71; College graduate: AOR = 1.94, 95% CI: 1.25,3.00) compared to less than high school, those who were unemployed (AOR = 1.36, 95% CI: 1.08,1.72) compared to employed, and those with an income of $50,000 and above (AOR = 1.52, 95% CI: 1.12,2.06) compared to less than $25,000 were more likely to have a prior colonoscopy or sigmoidoscopy. Those who were not in a relationship (AOR = 0.69, 95% CI: 0.55,0.86) and those without health insurance (AOR = 0.36, 95% CI; 0.23,0.56) were less likely to have a prior colonoscopy or sigmoidoscopy (Table 4).

Of the participants who reported having a prior sigmoidoscopy or colonoscopy, 97.5% (N=2,620,581) reported that their most recent exam was a colonoscopy (Appendix D). Therefore, the focus of the analysis was on colonoscopy. Of those who had a prior colonoscopy, 93.2% of participants (N=2,418,236) had it within the past 10 years (Table 5, Appendix E). Of those who have had a previous colonoscopy, people who identified as Black non-Hispanic were more likely to be up to date within the past 10 years compared to those who identified as White non-Hispanic (AOR = 2.01, 95% CI: 1.02,3.96) were more likely to have a colonoscopy in the past 10 years. Those who were aged 60 to 69 (AOR = 0.47, 95% CI: 0.28-0.79); Aged 70 to 79 (AOR = 0.51, 95% CI; 0.28,0.92); aged 80 and above (AOR = 0.18, 95% CI: 0.09,0.34) were less likely to receive their most recent colonoscopy in the past 10 years compared to those aged 50 to 59 (Table 5).

There were no significant findings regarding the association between rurality status for the logistic regression analyses for both the blood stool and colonoscopy variables.

Discussion

Colonoscopies were the most common form of CRC screening utilized by Michigan residents, representing nearly three-fourths of screenings. Many participants in our study likely went to a pharmacy to obtain at least one prescription or over-the-counter medication in advance of the procedure. Pharmacists are well positioned to provide education about strategies for increasing the effectiveness of the bowel preparation while minimizing adverse effects. We also found that people who were 60-years and older were more likely to have received CRC screening, but they were often not up-to-date on their screening. There is an opportunity for pharmacists and pharmacies to provide patient or population-level education about the importance of timely preventive health screenings, including for CRC, in their local communities. We found that people without health insurance were the least likely to have received a prior colonoscopy or sigmoidoscopy. Therefore, if pharmacists plan to promote preventive health screenings, such as for CRC, in their local communities they should consider identifying local resources with whom to connect uninsured or underinsured patients. Finally, we found that a person's residence location (from an urban or rural area) was not associated with the likelihood of receiving CRC screening. This suggests that pharmacists throughout the state have opportunities to support CRC screening.

Our findings of CRC screening in Michigan residents showed similar results to CRC screening patterns in the United States as a whole. A study that examined the results of the 2018 BRFSS for the entire United States observed that CRC screening was lowest in those who were uninsured.[10] In addition, CRC screening was lowest in the 50-64-year-old group and that screening increased with age, as it did with our study.[10] Our study also replicated the findings of a study using 2019 National

DOI: https://doi.org/10.24926/iip.v14i1.5212

Health Interview Survey data with colonoscopy as the most utilized form of CRC screening, followed by stool tests, and <3% of people using sigmoidoscopies as their CRC screening method.[26]

Multiple studies showed that people with higher incomes were more likely to utilize CRC screening.[10,27] In one study, which looked at CRC screening use in the United States, those with an income greater than $75,000 had the highest rates of CRC screenings of all income groups.[10] In another study, those considered middle or high income, which was considered those with an income more than 200% of the poverty level, had greater increases in colonoscopy use compared to those who were lower income.[27] However, income did not have a consistent effect in our study. We found that respondents with an income of $50,000 or more had 1.52 times higher odds of receiving a colonoscopy or sigmoidoscopy but had no impact on blood stool test utilization or on how recently a person had a CRC screening.

A study on the racial disparities and other factors impacting Michigan resident's CRC screening utilization using 2010 MiBRFSS data also observed that minorities, which were defined as all those who did not self-identify as non-Hispanic white, were less likely than non-Hispanic whites to have never received a prior colonoscopy or sigmoidoscopy.[28] However, we did not observe any significant racial differences other than Black non-Hispanic respondents were more likely to have received a colonoscopy within the past 10 years among those who received a prior colonoscopy. We acknowledge that due to the limited sample size, we reported only three race and ethnicity categories which may have impacted our results.

A recent change since this survey was collected in 2018 was new guidelines from the United States Preventive Services Task Force, which decreased the recommended age to start CRC screening from 50 to 45 years old in 2021.[3,27] While our study did not ask CRC screening questions in those who were 45-49 years of age, this is significant as our study and the literature observed that CRC screening usage increases with age and that Michigan respondents aged 50-59 were less likely to utilize CRC screening. In addition, those older than 59 years old were less likely to report receiving a prior colonoscopy within the past 10 years compared to the 50- to 59-year-old age group. Due to this imbalance, more work needs to be done to target the younger age groups to engage in CRC screenings and to engage the older age groups to ensure they are up to date on screening, even if they have received a prior CRC screening.

While community pharmacists have the foundational knowledge necessary to encourage and facilitate preventive health screenings, implementation science studies are needed to explore strategies for adoption and uptake in clinical practice. Further research is needed to identify additional training needs for pharmacists and their teams as well as how receptive patients are to preventive health recommendations, including for CRC screening, by community pharmacists.

Limitations

The MiBRFSS was conducted over the phone, with the questions asked and coded by an interviewer. There is a potential for social desirability bias. The MiBRFSS only asked objective questions regarding CRC, such as if participants had received a prior CRC screening method or when their last CRC screening occurred. Therefore, subjective aspects that may inhibit people from engaging in CRC screenings were outside this study's scope. We know that misconceptions about CRC screening, fear, and a lack of awareness regarding the importance of CRC screening may limit people from receiving CRC screenings. Still, it is important to continue researching this area to know how we can encourage more people to engage with CRC screenings.[11,12]

Conclusion

Most participants reported receiving a colonoscopy within the last 10 years. More work is needed to encourage adults in the 50-59-year-old age group to utilize CRC screening services. Not having insurance was a risk factor for not receiving a colonoscopy, even though this group was less than 4% of our population. More research is needed to explore opportunities for pharmacists and pharmacies to provide patient or population-level education about the importance of timely preventive health screenings, including for CRC, in their local communities. However, widespread uptake of CRC screening programs in pharmacies is likely dependent on changes in the practice model to ensure compensation for services delivered.

Funding: None
Conflicts of interest: None
Treatment of Human Subjects: The University of Michigan Institutional Review Board reviewed and determined this study to be not regulated due to the use of fully de-identified, publicly available data.

The opinions expressed in this paper are those of the authors.

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Table 1. Demographic information for Michigan participants who responded to colorectal screening questions

Variable	Weighted number (%)
Sex	
Male	1,757,564 (46.7)
Female	2,004,323 (53.3)
Age (years)	
50-59 years	1,332,707 (35.4)
60-69 years	1,283,939 (34.1)
70-79 years	768,751 (20.4)
80 or more	377,142 (10.0)
Race and Ethnicity	
White, non-Hispanic	3,104,117 (84.5)
Black, non-Hispanic	401,967 (10.9)
Other and multiracial, non-Hispanic	168,675 (4.6)
Partnered Status	
Partnered	2,272,018 (60.7)
Non-partnered	1,469,511 (39.3)
Education Level	
Less than high school	387,812 (10.4)
High school graduate	1,126,466 (30.1)
Some college	1,280,348 (34.2)
College graduate	951,682 (25.4)
Employment	
Employed	1,419,226 (38.0)
Unemployed	2,317,347 (62.0)
Income	
$24,999 or less	784,708 (25.4)
$25,000 - $49,999	825,879 (52.1)
$50,000 and higher	1,480,587 (47.9)
Healthcare coverage	
Yes	3,619,801 (96.4)
No	133,850 (3.6)
Location of residence	
Urban	2,885,250 (78.7)
Rural	781,907 (21.3)

Table 2. Participants use of a home blood stool test at any time using unadjusted and adjusted logistic regression analysis

Variable	Unadjusted Odds Ratio	Adjusted Odds Ratio
Sex		
Male	REF	REF
Female	1.10 (0.96-1.23)	1.01 (0.87-1.18)
Age (years)		
50-59	REF	REF
60-69	2.03 (1.69-2.43)	1.61 (1.31-1.98)
70-79	3.32 (2.74-4.03)	2.44 (1.91-3.12)
80 or more	2.34 (1.81-3.01)	1.82 (1.31-2.54)
Race and Ethnicity		
White, non-Hispanic	REF	REF
Black, non-Hispanic	1.00 (0.78-1.29)	1.09 (0.81-1.46)
Other and multiracial, non-Hispanic	0.93 (0.67-1.30)	1.21 (0.81-1.81)
Partnered Status		
Partnered	REF	REF
Non-partnered	1.04 (0.90-1.19)	0.97 (0.82-1.19)
Education Level		
Less than high school	REF	REF
High school graduate	1.66 (1.16-2.37)	1.71 (1.11-2.62)
Some college	1.97 (1.38-2.80)	2.12 (1.38-3.25)
College graduate	1.86 (1.32-2.64)	2.14 (1.38-3.30)
Employment		
Employed	REF	REF
Unemployed	1.89 (1.63-2.18)	1.40 (1.15-1.71)
Income		
$24,999 or less	REF	REF
$25,000 - $49,999	1.04 (0.84-1.28)	0.94 (0.74-1.18)
$50,000 and higher	0.93 (0.77-1.12)	0.90 (0.70-1.16)
Healthcare coverage		
Yes	REF	REF
No	0.48 (0.310-0.75)	0.64 (0.39-1.05)
Location of residence		
Urban	REF	REF
Rural	1.04 (0.88-1.22)	0.99 (0.88-1.20)

Table 3. Participant reported use of a stool test within the past three years using unadjusted and adjusted logistic regression analysis

Variable	Unadjusted Odds Ratio	Adjusted Odds Ratio
Sex		
Male	REF	REF
Female	0.96 (0.77-1.20)	0.89 (0.62-1.13)
Age (years)		
50-59	REF	REF
60-69	0.94 (0.69-1.28)	0.89 (0.62-1.26)
70-79	0.78 (0.57-1.06)	0.73 (0.50-1.07)
80 or more	0.49 (0.32-0.76)	0.40 (0.24-0.68)
Race and Ethnicity		
White, non-Hispanic	REF	REF
Black, non-Hispanic	1.19 (0.77-1.83)	1.07 (0.65-1.77)
Other and multiracial, Hispanic	0.98 (0.57-1.70)	0.86 (0.45-1.65)
Partnered Status		
Partnered	REF	REF
Non-partnered	1.09 (0.87-1.37)	1.00 (0.75-1.33)
Education Level		
Less than high school	REF	REF
High school graduate	1.15 (0.61-2.17)	0.94 (0.45-1.97)
Some college	1.17 (0.63-2.18)	0.95 (0.45-1.99)
College graduate	0.92 (0.50-1.70)	0.77 (0.37-1.63)
Employment		
Employed	REF	REF
Unemployed	0.81 (0.63-1.03)	0.83 (0.61-1.13)
Income		
$24,999 and less	REF	REF
$25,000 - $49,999	0.93 (0.66-1.31)	0.99 (0.68-1.43)
$50,000 and higher	0.84 (0.62-1.14)	0.84 (0.57-1.26)
Healthcare coverage		
Yes	REF	REF
No	1.01 (0.47-2.19)	1.01 (0.41-2.46)
Location of residence		
Urban	REF	REF
Rural	1.17 (0.90-1.52)	1.17 (0.87-1.58)

Table 4. Participant report of ever obtaining a colonoscopy or sigmoidoscopy using unadjusted and adjusted logistic regression analysis

Variable	Unadjusted Odds Ratio	Adjusted Odds Ratio
Sex		
Male	REF	REF
Female	1.10 (0.94-1.29)	1.07 (0.89-1.28)
Age (years)		
50-59	REF	REF
60-69	2.03 (1.68-2.46)	1.98 (1.59-2.47)
70-79	3.40 (2.67-4.32)	3.28 (2.40-4.49)
80 or more	1.43 (1.09-1.87)	2.24 (1.54-3.25)
Race and Ethnicity		
White, non-Hispanic	REF	REF
Black, non-Hispanic	0.64 (0.49-0.84)	0.88 (0.63-1.23)
Other and multiracial, Hispanic	0.70 (0.48-1.01)	1.05 (0.69-1.61)
Partnered Status		
Partnered	REF	REF
Non-partnered	0.58 (0.49-0.68)	0.69 (0.55-0.86)
Education Level		
Less than high school	REF	REF
High school graduate	1.34 (0.97-1.85)	1.36 (0.90-2.07)
Some college	2.08 (1.50-2.89)	1.77 (1.15-2.71)
College graduate	2.33 (1.69-3.12)	1.94 (1.25-3.00)
Employment		
Employed	REF	REF
Unemployed	1.50 (1.28-1.76)	1.36 (1.08-1.72)
Income		
$24,999 and less	REF	REF
$25,000 - $49,999	1.57 (1.28-1.99)	1.21 (0.91-1.61)
$50,000 and higher	1.93 (1.58-2.37)	1.52 (1.12-2.06)
Healthcare coverage		
Yes	REF	REF
No	0.28 (0.19-0.40)	0.36 (0.23-0.56)
Location of residence		
Urban	REF	REF
Rural	0.98 (0.82-1.17)	0.97 (0.78-1.22)

Table 5. Participant report of obtaining a colonoscopy within the past 10 years using unadjusted and adjusted logistic regression analysis

Variable	Unadjusted Odds Ratio	Adjusted Odds Ratio
Sex		
Male	REF	REF
Female	0.76 (0.57-1.01)	0.85 (0.61-1.19)
Age (years)		
50-59	REF	REF
60-69	0.48 (0.30-0.75)	0.47 (0.28-0.79)
70-79	0.60 (0.37-0.98)	0.51 (0.28-0.92)
80	0.21 (0.13-0.35)	0.18 (0.10-0.34)
Race and Ethnicity		
White, non-Hispanic	REF	REF
Black, non-Hispanic	2.10 (1.15-3.82)	2.01 (1.02-3.96)
Other and multiracial, Hispanic	1.23 (0.41-3.67)	1.05 (0.30-3.71)
Partnered Status		
Partnered	REF	REF
Non-partnered	0.90 (0.68-1.20)	1.04 (0.70-1.54)
Education Level		
Less than high school	REF	REF
High school graduate	0.77 (0.33-1.85)	1.11 (0.42-2.90)
Some college	0.79 (0.33-1.86)	1.07 (0.40-2.84)
College graduate	1.07 (0.45-2.53)	1.28 (0.48-3.47)
Employment		
Employed	REF	REF
Unemployed	0.80 (0.59-1.09)	1.37 (0.87-2.17)
Income		
$24,999 and less	REF	REF
$25,000 - $49,999	0.94 (0.60-1.46)	1.06 (0.62-1.79)
$50,000 and higher	1.26 (0.82-1.94)	1.24 (0.67-2.30)
Healthcare coverage		
Yes	REF	REF)
No	0.64 (0.28-1.43)	0.51 (0.18-1.42)
Location of residence		
Urban	REF	REF
Rural	0.84 (0.60-1.19)	0.92 (0.63-1.34)

APPENDICES

Appendix A. Participant reported use of a home blood stool test at any time

Variable	Yes N (%)	No N (%)	P value
Sex			
Male	526,249 (45.3)	1,147,011 (47.5)	<0.01
Female	635,847 (54.7)	1,265,855 (52.5)	
Age (years)			
50-59	259,259 (22.3)	992,782 (41.1)	<0.01
60-69	427,615 (36.8)	807,729 (33.5)	
70-79	340,514 (29.3)	392,262 (16.3)	
80 or more	134,718 (11.6)	220,744 (9.1)	
Race and Ethnicity			
White, non-Hispanic	968,489 (85.0)	2,010,138 (84.5)	<0.01
Black, non-Hispanic	116,930 (10.3)	253,096 (10.3)	
Other and multiracial, Hispanic	47,763 (4.4)	110,754 (4.7)	
Partnered Status			
Partnered	705,672 (61.0)	1,485,316 (61.8)	<0.01
Non-partnered	451,410 (39.0)	916,634 (38.2)	
Education Level			
Less than high school	77,094 (6.6)	277,677 (11.5)	<0.01
High school graduate	335,239 (28.9)	748,953 (30.3)	
Some college	435,699 (37.6)	797,759 (33.1)	
College graduate	311,413 (26.9)	602,673 (25.0)	
Employment			
Employed	329,540 (28.5)	1,030,890 (44.9)	<0.01
Unemployed	827,756 (71.5)	1,372,228 (57.1)	
Income Categories			
$24,999 or less	242,211 (24.9)	489,121 (24.3)	<0.01
$25,000 - $49,999	274,859 (28.3)	534,172 (26.5)	
$50,000 and higher	455,486 (46.8)	989,879 (49.2)	
Healthcare coverage			
Yes	1,136,148 (97.9)	2,306,283 (95.8)	<0.01
No	23,852 (2.1)	100,582 (4.2)	
Location of residence			
Rural	891,428 (78.1)	1,847,711 (78.9)	<0.01
Urban	249,708 (21.9)	500,157 (21.5)	

Appendix B. Participant reported time since last blood stool test using a home kit

Variable	Less than 3 years N (%)	3 or more years N (%)	P value
Sex			
Male	280,073 (46.4)	232,778 (45.2)	<0.01
Female	322,927 (53.6)	282,376 (54.8)	
Age (years)			
50-59	148,585 (24.6)	106,391 (20.7)	
60-69	234,099 (38.8)	178,744 (34.7)	<0.01
70-79	168,387 (28.1)	156,179 (30.3)	
80 or more	50,929 (8.4)	73,841 (14.3)	
Race and Ethnicity			
White, non-Hispanic	495,694 (84.7)	437,432 (86.1)	
Black, non-Hispanic	64,135 (11.2)	47,666 (9.4)	<0.01
Other and multiracial, Hispanic	25,534 (4.3)	22,898 (4.5)	
Partnered Status			
Partnered	364,268 (60.6)	318,111 (62.1)	<0.01
Non-partnered	237,208 (39.4)	193,913 (37.9)	
Education Level			
Less than high school	38,229 (6.4)	36,745 (7.1)	
High school graduate	177,659 (29.5)	141,536 (27.5)	<0.01
Some college	237,261 (39.5)	186,292 (36.2)	
College graduate	148,263 (24.7)	149,508 (29.1)	
Employment			
Employed	184,855 (30.9)	136,475 (26.5)	<0.01
Unemployed	413,803 (69.1)	378,112 (73.5)	
Income			
$24,999 or less	131,252 (26.0)	102,907 (23.6)	
$25,000 - $49,999	143,832 (28.7)	120,649 (27.6)	<0.01
$50,000 and higher	228,985 (45.9)	212,848 (48.8)	
Healthcare coverage			
Yes	588,646 (97.9)	503,965 (97.1)	0.02
No	12,804 (2.1)	10,633 (2.1)	
Location of residence			
Urban	454,479 (76.5)	400,985 (79.4)	<0.01
Rural	139,809 (23.5)	104,197 (20.6)	

Appendix C. Participant reported obtaining a colonoscopy or sigmoidoscopy at any time

Variable	Yes N (%)	No N (%)	P value
Sex			
Male	1,282,337 (46.6)	403,322 (47.8)	<0.01
Female	1,468,461 (53.4)	440,118 (52.2)	
Age (years)			
50-59	840,659 (30.6)	415,000 (49.2)	<0.01
60-69	997,953 (36.3)	242,299 (28.7)	
70-79	646,096 (23.5)	93,924 (11.1)	
80 or more	266,090 (9.7)	91,868 (10.9)	
Race and Ethnicity			
White, non-Hispanic	2,326,589 (86.5)	667,122 (80.7)	<0.01
Black, non-Hispanic	252,603 (9.4)	113,019 (13.7)	
Other and multiracial, non-Hispanic	111,779 (4.2)	26,281 (3.2)	
Partnered Status			
Partnered	1,763,048 (64.5)	431,395 (51.4)	<0.01
Non-partnered	971,652 (35.5)	407,394 (48.6)	
Education Level			
Less than high school	235,399 (8.6)	126,539 (15.1)	<0.01
High school graduate	769,337 (28.1)	295,475 (35.2)	
Some college	985,417 (35.9)	251,259 (30.0)	
College graduate	752,232 (27.4)	165,406 (19.7)	
Employment			
Employed	983,669 (35.9)	380,474 (45.5)	<0.01
Unemployed	1,758,132 (64.1)	456,405 (54.5)	
Income			
$24,999 and less	506,645 (22.0)	234,817 (33.5)	<0.01
$25,000 - $49,999	621,681 (27.0)	186,201 (26.6)	
$50,000 and higher	1,172,758 (51.0)	279,879 (39.9)	
Healthcare coverage			
Yes	2,684,710 (97.8)	775,248 (92.3)	<0.01
No	60,842 (2.2)	64,273 (7.7)	
Location of residence			
Urban	2,114,620 (78.6)	641,120 (78.3)	<0.01
Rural	575,153 (21.4)	177,921 (21.7)	

Appendix D. Participant reported type of procedural colorectal cancer screening test

Variable	Sigmoidoscopy N (%)	Colonoscopy N (%)	P value
Sex			
Male	35,893 (52.6)	1,210,963 (46.2)	<0.01
Female	32,376 (47.4)	1,409,618 (53.8)	
Age (years)			
50-59	17,048 (25.0)	812,177 (31.0)	
60-69	17,706 (25.9)	967,002 (36.9)	<0.01
70-79	22,690 (33.2)	606,362 (23.1)	
80 or more	10,825 (15.9)	235,040 (9.0)	
Race and Ethnicity			
White, non-Hispanic	54,185 (84.4)	2,215,895 (86.3)	
Black, non-Hispanic	6,340 (9.9)	243,304 (9.5)	<0.01
Other and multiracial, non-Hispanic	3,705 (5.8)	107,586 (4.2)	
Partnered Status			
Partnered	38,133 (55.9)	1,694,093 (65.0)	<0.01
Non-partnered	30,135 (44.1)	910,487 (35.0)	
Education Level			
Less than high school	13,419 (19.9)	207,172 (7.9)	
High school graduate	13,774 (20.4)	734,157 (28.1)	<0.01
Some college	23,603 (35.0)	943,539 (36.1)	
College graduate	16,668 (24.7)	728,102 (27.9)	
Employment			
Employed	13,694 (20.4)	957,724 (36.7)	<0.01
Unemployed	53,594 (79.6)	1,654,885 (63.3)	
Income Categories			
$24,999 and less	18,559 (30.1)	469,493 (19.9)	
$25,000 - $49,999	15,260 (24.8)	585,427 (26.7)	<0.01
$50,000 and higher	27,739 (45.1)	1,134,161 (51.8)	
Healthcare coverage			
Yes	67,180 (98.4)	2,559,411 (97.9)	<0.01
No	1,088 (1.6)	55,924 (2.1)	
Location of residence			
Urban	50,962 (77.2)	2,025,612 (79.0)	<0.01
Rural	15,054 (22.8)	537,121 (21.0)	

Appendix E. Participant reported time since most recent colonoscopy

Variable	Less than 10 years N (%)	10 or more years N (%)	P value
Sex			
Male	955,053 (47.8)	245,320 (40.4)	<0.01
Female	1,043,344 (52.2)	350,443 (58.8)	
Age (years)			
50-59	676,942 (33.9)	132,665 (22.3)	
60-69	733,946 (36.7)	226,265 (38.0)	<0.01
70-79	452,325 (22.6)	142,058 (23.8)	
80 or more	135,185 (6.8)	94,775 (15.9)	
Race and Ethnicity			
White, non-Hispanic	1,671,797 (85.6)	525,922 (89.2)	
Black, non-Hispanic	204,846 (10.5)	32,736 (5.6)	<0.001
Other and multiracial, non-Hispanic	75,536 (3.9)	30,742 (5.2)	
Partnered Status			
Partnered	1,291,998 (65.0)	388,318 (65.5)	<0.01
Non-partnered	694,527 (35.0)	204,872 (34.5)	
Education Level			
Less than high school	169,760 (8.5)	35,786 (6.0)	
High school graduate	544,585 (27.3)	176,933 (29.8)	<0.01
Some college	714,863 (35.9)	221,456 (37.3)	
College graduate	563,518 (28.3)	159,647 (26.9)	
Employment			
Employed	759,431 (38.1)	195,741 (32.9)	<0.01
Unemployed	1,232,463 (61.9)	398,552 (67.1)	
Income			
$24,999 and less	356,944 (21.4)	105,827 (21.1)	
$25,000 - $49,999	435,383 (26.1)	142,594 (28.5)	<0.01
$50,000 and higher	877,853 (52.6)	252,077 (50.4)	
Healthcare coverage			
Yes	1,948,650 (97.7)	584,340 (98.3)	<0.01
No	45,915 (2.3)	10,009 (1.7)	
Location of residence			
Urban	1,547,976 (79.3)	457,462 (78.1)	<0.01
Rural	402,914 (20.7)	128,357 (21.9)	