



## Barriers to utilization of three colorectal cancer screening options – Data from a national survey

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### ARTICLE INFO

#### Keywords:

Colorectal cancer screening  
Barriers to cancer screening utilization  
FIT/gFOBT  
mt-sDNA  
Screening colonoscopy

### ABSTRACT

Colorectal cancer (CRC) screening continues to be underutilized in the United States. A better understanding of existing barriers is critical for improving uptake of, and adherence to, CRC screening. Using data from a population-based panel survey, we examined barriers to utilization of three commonly used screening options (FIT/gFOBT, mt-sDNA, and screening colonoscopy) and assessed differences by socio-demographic characteristics, healthcare access, and health status. Data were obtained from a questionnaire developed by the authors and implemented through a U.S. national panel survey conducted in November 2019. Among 5,097 invited panelists, 1,595 completed the survey (31.3%). Analyses were focused on individuals ages 50–75 at average risk for CRC. Results showed that among respondents who reported no prior CRC screening with FIT/gFOBT, mt-sDNA, or colonoscopy, the top barriers were lack of knowledge (FIT/gFOBT: 42.1%, mt-sDNA: 44.9%, colonoscopy: 34.7%), lack of provider recommendation (FIT/gFOBT: 32.1%, mt-sDNA: 27.3%, colonoscopy: 18.6%), and suboptimal access (FIT/gFOBT: 20.8%, mt-sDNA: 17.8%, colonoscopy: 26%). Among participants who had used one or two of the screening options, the top barriers to FIT/gFOBT and mt-sDNA were lack of provider recommendation (31.6% & 37.5%) and lack of knowledge (24.6% & 25.6%), while for colonoscopy top barriers were psychosocial barriers (31%) and lack of provider recommendation (22.7%). Differences by sex, race/ethnicity, income level, and health status were observed. Our research identified primary barriers to the utilization of three endorsed CRC screening options and differences by patient characteristics, highlighting the importance of improving CRC screening education and considering patient preferences in screening recommendations.

### 1. Introduction

Colorectal cancer (CRC) is the second leading cause of cancer-related death in the United States (US) among women and men combined (Cronin et al., 2018; Siegel et al., 2020). Major guideline organizations recommend CRC screening among average-risk adults between the ages of 50–75 (U. S. Preventive Services Task Force et al., 2016) or 45–75 (Wolf et al., 2018). Recommended screening options include stool-based tests such as the fecal immunochemical test/guaiaic-based fecal occult blood test (FIT/gFOBT) every year and

multi-target stool DNA (mt-sDNA) test every three years, as well as direct visualization methods such as screening colonoscopy every ten years (U. S. Preventive Services Task Force et al., 2016; Wolf et al., 2018). CRC screening in the US occurs on a largely opportunistic, non-programmatic basis, where patients either self-refer for screening or receive a recommendation for screening from a healthcare provider during an unrelated healthcare visit (Schreuders et al., 2015). Despite clear evidence that regular screening reduces CRC mortality (Edwards et al., 2010; Zauber et al., 2008); screening continues to be underutilized in the US (Steele et al., 2013; Davis et al., 2017). Although

*Abbreviations:* CRC, colorectal cancer; FIT/gFOBT, fecal immunochemical test/guaiaic-based fecal occult blood test; mt-sDNA, multi-target stool DNA.

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<https://doi.org/10.1016/j.pmedr.2021.101508>

Received 14 January 2021; Received in revised form 22 July 2021; Accepted 25 July 2021

Available online 29 July 2021

2211-3355/© 2021 The Author(s).

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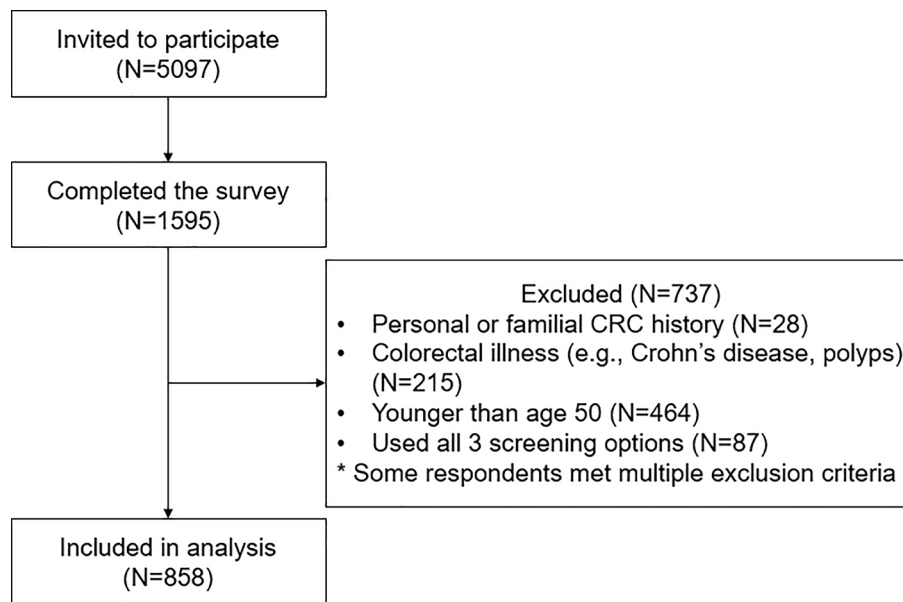


Fig. 1. Participant flow chart.

several CRC screening options are supported by evidence of net benefit (U. S. Preventive Services Task Force et al., 2016); the practical effectiveness of each option is undermined by sub-optimal population adherence to screening recommendations (Singal et al., 2017). Thus, better understanding of the barriers to CRC screening utilization is critical for improving average-risk adults' uptake of and adherence to the guideline-endorsed options.

Previous research suggests that lack of provider recommendation, low awareness and knowledge of CRC screening, lack of healthcare access, and logistical challenges to obtain screening are major patient-reported barriers to CRC screening completion and adherence, especially among racial/ethnic minorities and socioeconomically disadvantaged populations (Honein-AbouHaidar et al., 2016; Nagelhout et al., 2017; Muthukrishnan et al., 2019; Jones et al., 2010; Wilkins et al., 2012). Although patient-reported barriers to long-existing CRC screening options such as colonoscopy and FIT/gFOBT have been studied extensively, data on barriers to emerging screening options such as mt-sDNA are sparse (Redwood et al., 2019). Given that available CRC screening options vary on key test attributes including efficacy, cost, preparation requirement, and testing interval, identifying the specific barriers to each screening option could inform efforts to better align provider recommendations to the needs and preferences of screening-eligible patients to improve screening rates. To address this knowledge gap, this study aimed to examine the barriers to utilization of three commonly recommended and commonly used CRC screening options (FIT/gFOBT, mt-sDNA, and screening colonoscopy), and to examine the differences in these barriers by socio-demographics, healthcare access, and health status, among a sample of CRC screening-eligible US patients who have never used any of the three screening options and those who have used one or two of the three screening options.

## 2. Methods

### 2.1. Study population

Data were collected from a panel survey developed by the authors and implemented by the National Opinion Research Center (NORC) at the University of Chicago (<http://www.norc.org>) in November 2019,

using a national sample of US adults aged 40–75<sup>1</sup> which were selected from NORC's AmeriSpeak Panel<sup>2</sup> using sampling strata based on age, sex, race/Hispanic ethnicity, and education. The size of the selected sample per sampling stratum was determined by the population distribution for each stratum, taking into account expected differences in survey completion rates by demographic groups to ensure that the sample was representative of the U.S. population. Panelists were invited to participate in the AmeriSpeak study by web or by phone. To encourage participation, NORC sent up to 2 email reminders to sampled web-mode panelists; for the phone survey, NORC dialed the sampled phone-mode panelists throughout the field period. All sampled panelists were offered an incentive equivalent to \$5 to complete the survey. We planned to obtain completed surveys from 1500 panelists, aiming for a margin of error around 3% at a 95% confidence level. Prior studies using this panel have obtained an average response rate of 35%. We estimated a survey completion rate of 35% and a qualification rate of 90%. This

<sup>1</sup> The survey included a broad range of knowledge, attitudinal, and behavioral questions related to colorectal cancer screening. The increasing incidence rates of CRC among younger populations led to changes in ACS guidelines and recent USPSTF draft guidelines to include those aged 45–49 in recommended average risk screening guidelines. Given the breadth of topics covered in our survey and growing relevance of CRC and CRC screening for younger age groups we selected to include those aged 40–49 in our overall sample.

<sup>2</sup> AmeriSpeak® is funded and operated by NORC at the University of Chicago. It is a probability-based panel designed to be representative of the US household population. Randomly selected US households are sampled using area probability and address-based sampling, with a known, non-zero probability of selection from the NORC National Sample Frame. These sampled households are then contacted by US mail, telephone, and field interviewers (face to face). The panel provides sample coverage of approximately 97% of the U.S. household population. Those excluded from the sample include people with P.O. Box only addresses, some addresses not listed in the USPS Delivery Sequence File, and some newly constructed dwellings. While most AmeriSpeak households participate in surveys by web, non-internet households can participate in AmeriSpeak surveys by telephone. Households without conventional internet access but having web access via smartphones are allowed to participate in AmeriSpeak surveys by web. More information about AmeriSpeak panel methodology can be found at: <https://amerispeak.norc.org/about-amerispeak/Pages/Panel-Design.aspx> (accessed May 3rd, 2021)

**Table 1**  
Non-utilization of each CRC screening option by socio-demographic characteristics, health care access, and health status.<sup>a</sup>

	Had not used one or more of the three options (N = 858)	Never used any of the three options (N = 189)		Used one or two of the three options (N = 669)						
		N (%) <sup>b</sup>	N (%) <sup>c</sup>	p-value	Used mt-sDNA and/or colonoscopy, but not FIT/gFOBT		Used FIT/gFOBT and/or colonoscopy, but not mt-sDNA		Used FIT/gFOBT and/or mt-sDNA, but not colonoscopy	
					N (%) <sup>c</sup>	p-value	N (%) <sup>c</sup>	p-value	N (%) <sup>c</sup>	p-value
<b>Total</b>	858	189 (20.8)		389 (57.1)		546 (78.7)		91 (14.9)		
<b>Age in years</b>			<0.001		0.011		0.092		0.101	
50–54	186 (22.4)	75 (40.4)		70 (64.3)		96 (79.1)		30 (25.1)		
55–64	391 (45.2)	83 (19.5)		196 (62.2)		263 (83.5)		38 (14.1)		
65–75	281 (32.4)	31 (9.1)		123 (47.4)		187 (72.7)		27 (12.6)		
<b>Sex<sup>d</sup></b>			0.126		0.200		0.731		0.099	
Male	381 (45.4)	86 (23.3)		173 (60.7)		237 (79.6)		37 (12.1)		
Female	472 (54.1)	101 (18.1)		215 (54.3)		307 (78.1)		57 (17.9)		
Other	3 (0.5)	2 (94.5)		0 (0)		1 (100)		1 (100)		
<b>Race/Ethnicity</b>			0.956		0.326		0.109		0.272	
White, non-Hispanic	624 (68.3)	136 (20.6)		295 (59.9)		402 (79.9)		69 (14.6)		
Black, NH	92 (12.9)	17 (18.3)		34 (46.1)		55 (65.5)		9 (8.2)		
Hispanic	82 (11)	20 (23.1)		38 (59.6)		47 (78.0)		11 (24.7)		
Asian, NH	15 (1.6)	3 (23.0)		6 (45.4)		12 (100)		2 (27.5)		
Other or Multiple race, NH	45 (6.2)	13 (24.0)		16 (47.0)		30 (90.8)		4 (20.2)		
<b>Education</b>			0.023		0.453		<0.001		0.002	
Less than high school	43 (11)	8 (16.9)		22 (49.3)		20 (52.2)		10 (32.9)		
High school	176 (30.4)	47 (25.6)		68 (53.0)		98 (76.5)		25 (17.5)		
Some college	346 (26)	90 (25.8)		143 (60.3)		213 (83.5)		33 (9.8)		
Bachelor's degree or higher	293 (32.6)	44 (13.7)		156 (60.7)		215 (85.8)		27 (11.7)		
<b>Household Income</b>			0.614		0.003		0.011		0.010	
<\$25,000	182 (22.9)	51 (23.9)		64 (46.1)		95 (68.4)		29 (24.8)		
\$25,000-\$59,999	260 (30.4)	64 (22.2)		97 (49.9)		151 (75.0)		30 (16.9)		
\$60,000-\$124,999	295 (32.4)	54 (18.6)		158 (65.8)		209 (84.9)		26 (10.1)		
>\$125,000	121 (14.2)	20 (18.0)		70 (68.4)		91 (87.7)		10 (10.0)		
<b>Health Insurance<sup>e</sup></b>			0.001		0.489		0.863		0.293	
Private/public insurance	808 (93.5)	162 (19.2)		373 (56.7)		528 (78.7)		91 (14.8)		
No insurance	49 (6.5)	27 (44.8)		16 (66.7)		18 (80.7)		3 (26.0)		
<b>Last Healthcare Visit<sup>f</sup></b>			<0.001		0.722		0.558		0.034	
<2 years ago	790 (93.2)	146 (18.2)		374 (57.4)		524 (78.6)		91 (15.3)		
3–5 years ago	32 (3.4)	16 (41.9)		8 (44.8)		13 (71.8)		2 (4.1)		
More than 5 years ago or never	33 (3.3)	26 (73.0)		5 (51.0)		7 (100)		2 (49.0)		
<b>Self-rated General Health</b>			0.895		0.554		0.438		0.345	
Excellent	85 (9.6)	16 (22.7)		43 (57.9)		56 (74.5)		7 (12.4)		
Very good	329 (36.4)	69 (22.0)		146 (56.0)		216 (82.0)		37 (13.6)		
Good	312 (36.5)	74 (20.2)		140 (61.0)		194 (79.8)		35 (14.4)		
Fair or poor	132 (17.5)	30 (18.6)		60 (50.8)		80 (72.2)		16 (22.5)		
<b>Non-CRC Cancer History<sup>g</sup></b>			0.108		0.831		0.949		0.267	
No	739 (86.5)	169 (21.9)		329 (57.3)		466 (78.6)		86 (16.4)		
Yes	118 (13.5)	20 (13.8)		59 (55.8)		79 (79.0)		9 (9.6)		
<b>US Geographic Region</b>			0.663		0.227		0.610		0.725	
Northeast	144 (17.5)	28 (19.9)		69 (58.6)		94 (80.1)		18 (15.8)		
Midwest	220 (20.1)	53 (24.9)		107 (64.5)		138 (81.2)		22 (16.9)		

(continued on next page)

Table 1 (continued)

	Had not used one or more of the three options (N = 858)	Never used any of the three options (N = 189)		Used one or two of the three options (N = 669)					
				Used mt-sDNA and/or colonoscopy, but not FIT/gFOBT		Used FIT/gFOBT and/or colonoscopy, but not mt-sDNA		Used FIT/gFOBT and/or mt-sDNA, but not colonoscopy	
		N (%) <sup>b</sup>	p-value	N (%) <sup>c</sup>	p-value	N (%) <sup>c</sup>	p-value	N (%) <sup>c</sup>	p-value
South	293 (40)		69 (19.2)		134 (57.4)		178 (75.3)		24 (12.2)
West	201 (22.4)		39 (20.9)		79 (49.1)		136 (81.7)		27 (17.2)

P-values obtained from Rao-Scott chi-square test.

FIT/gFOBT: fecal immunochemical test/guaiac-based fecal occult blood test.

mt-sDNA: multi-target stool DNA.

<sup>a</sup> N is unweighted, % is weighted.

<sup>b</sup> The denominator of these percentages is the total number of participants who had not used one or more of the three options (N = 858).

<sup>c</sup> The denominator of these percentages is the number of participants in each sample characteristic category who have not used one or more of the three options (i.e., column 2 of this table).

<sup>d</sup> missing response = 2.

<sup>e</sup> missing response = 1.

<sup>f</sup> missing response = 3.

<sup>g</sup> missing response = 1.

study was deemed exempt by the NORC Institutional Review Board.

## 2.2. Measures

Participants self-reported use of each of the CRC screening options. Participants who reported they had not completed screening using a particular CRC screening option were asked about the barriers to utilization of that screening option “Is there any particular reason why you haven’t completed a [FIT/gFOBT stool-based test; Cologuard test; colonoscopy]?” We referred to mt-sDNA as “Cologuard®” in the survey because it is the only mt-sDNA test currently approved by the FDA for clinical application. We provided the following eleven response options based on questions previously included in the National Health Interview Survey (National Center for Health Statistics, 2020) and the Health Information National Trends Survey: (Institute and Survey, 2013) 1. Didn’t need/didn’t know I needed this test; 2. Doctor or healthcare provider didn’t order it/didn’t say I needed it; 3. Haven’t had any problems/no symptoms; 4. Put it off/didn’t get around to it; 5. Too expensive/no insurance/cost; 6. Too painful, unpleasant, or embarrassing; 7. Had another type of colon exam; 8. Don’t have a doctor/healthcare provider; 9. Never heard of it/never thought about it; 10. Had stool blood test done at doctor/healthcare provider’s office; 11. Age/thought they were too young. A text field option was also included for respondents to write in additional reasons. Participants could select more than one option.

We grouped the non-utilization reasons, including those provided by the respondents, into five categories: 1) lack of knowledge (e.g., Didn’t need/didn’t know I needed this test; Haven’t had any problems/symptoms; Never heard of it, never thought about it; Age/Thought I was too young), 2) lack of provider recommendation (e.g., Doctor/healthcare provider didn’t order it or didn’t say I needed it), 3) suboptimal access (e.g., Too expensive, no insurance, cost; Don’t have a doctor or healthcare provider; Put it off, didn’t get around to it; No transportation), 4) psychosocial barriers (e.g., Too painful, unpleasant, or embarrassing; Worry or fear about positive result), and 5) used another screening option.

The following socio-demographic characteristics were measured: age, sex, race/ethnicity, education level, and household income. We also assessed health insurance coverage, time since last healthcare visit, self-rated health status, and cancer history.

## 2.3. Inclusion and exclusion criteria

Analyses were focused on the subpopulation of survey respondents

ages 50 to 75 (for whom population screening is recommended) and had not been previously screened with one or more of the three queried options. Exclusions included personal or familial CRC history or colorectal health issues that would make them ineligible for stool-based tests (e.g., ulcerative colitis, Crohn’s disease, colorectal polyps) (Bibbins-Domingo et al., 2016).

## 2.4. Statistical analysis

A total of 1,595 completed surveys (1433 by web and 162 by phone) were obtained from 5,097 panelists who were invited to participate (31.3%). The survey’s margin of error was 3.14% at a 95% confidence level. The margin of error was calculated by NORC assuming we have a binomial variable where 50% of respondents give each answer (giving the most conservative margin of error). The margin of error for this hypothetical variable was then calculated at a 95% confidence level assuming all completed surveys answered the question and taking into account the design effect, which is the amount of variance under the complex design divided by the variance under the simple random sampling. The final analysis sample size was 858, after excluding respondents with personal or familial CRC history (n = 28) or colorectal health issues that would make them ineligible for stool-based tests (e.g., ulcerative colitis, Crohn’s disease, colorectal polyps) (n = 215), who are younger than age 50 (n = 464), or have used all three screening options previously (n = 87) (Fig. 1).

We examined the barriers to each screening option for individuals who had not used any of the three options, and separately for those who had used one or two of the three options. Multivariable, binary logistic regression analyses were performed to examine the associations between barriers and socio-demographic characteristics, health care access, and health status. Sampling weights were applied to the data to correct for potential bias introduced by non-responsiveness, non-coverage, and panel attrition and to allow the estimates to be nationally representative (Appendix 1). We estimated variance using the Taylor-series linearization method to account for the complex survey design (Barrio et al., 2011). Because the sampling weights were dependent on the demographic make-up of the full sample compared to the population, to ensure correct variance estimation, we took into account the complex design of the entire sample when analyzing the subpopulation by including all observations in the analysis but assigning zero weight to observations not in the subpopulation (Graubard and Korn, 1996; Lumley, 2004). We report Odds Ratio (OR) and 95% Confidence Interval (CI) of results with a p-value < 0.05 after adjusting for multiple testing

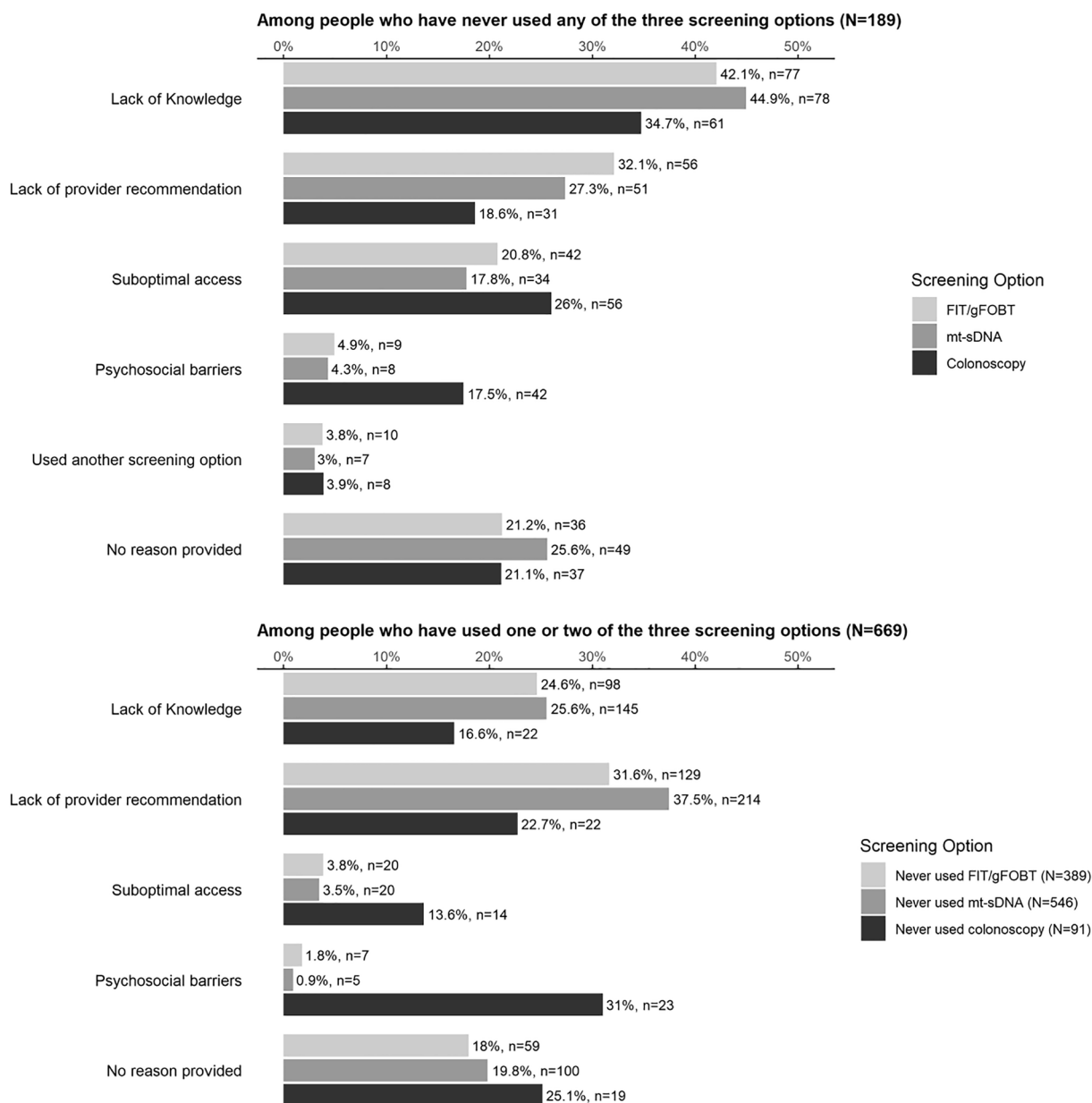


Fig. 2. Barriers to use each CRC screening option (percentage endorsed by participants)<sup>a</sup>. <sup>a</sup>N is unweighted, % is weighted. FIT/gFOBT: fecal immunochemical test/guaiac-based fecal occult blood test. mt-sDNA: multi-target stool DNA.

using the Benjamini-Hochberg procedure (Benjamini and Hochberg, 1995). All analyses were conducted in R.

### 3. Results

Table 1 summarizes sample characteristics. Of the 858 respondents included in this analysis, 22.4% were between age 50 and 54, 45.2% were between age 55 and 64, 32.4% were between age 65 and 75, 54.1% were females, 68.3% were non-Hispanic white, 12.9% were non-Hispanic black, 11% were Hispanic, 11% did not finish high school, and 22.9% had a household income less than \$25,000. Regarding health and healthcare related characteristics, 93.5% had public or private health insurance, 93.2% reported having had a healthcare visit in the last 2 years, and 17.5% rated their general health as fair or poor.

Fig. 2 summarizes barriers to utilization of each screening option. Overall, 189 (20.8%) respondents had not been previously screened with any of the three queried options while 669 had used one or two of

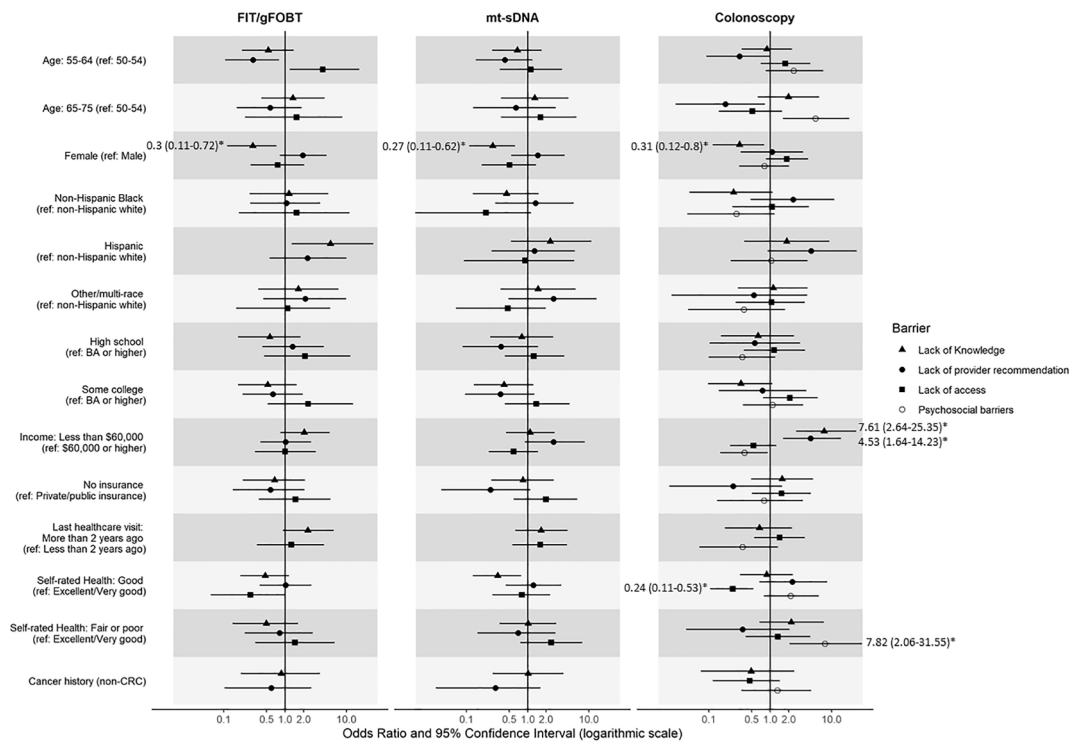
the three options. Among people who had not been previously screened with any of the three queried options, the most common barrier reported was lack of knowledge (FIT/gFOBT: 42.1%, mt-sDNA: 44.9%, colonoscopy: 34.7%). For FIT/gFOBT and mt-sDNA, other frequently selected barriers included lack of provider recommendation (32.1% and 27.3%) and suboptimal access (20.8% and 17.8%). For colonoscopy, additional frequently selected barriers included suboptimal access (26%), lack of provider recommendation (18.6%), and psychosocial barriers (17.5%). Among people who had used one or two of the three options, the top barrier for FIT/gFOBT and mt-sDNA was lack of provider recommendation (31.6% and 37.5%), followed by lack of knowledge (24.6% and 25.6%). For colonoscopy, the top barriers were psychosocial barriers (31%), lack of provider recommendation (22.7%), and lack of knowledge (16.6%). Around 20% of the participants did not specify a barrier.

Table 2 and Fig. 3 summarize the differences in utilization barriers by patient characteristics among people who had never used any of the three options. Across all three screening options, females were less likely

**Table 2**Weighted estimates of barriers to utilizing each CRC screening method by socio-demographic characteristics, health care access, and health status among individuals who have never used any of the three methods.<sup>a</sup>

	Never used any of the three methods (N = 189)									
	Barriers to use FIT/gFOBt			Barriers to use mt-sDNA			Barriers to use colonoscopy			
	Lack of knowledge	Lack of provider recommendation	Suboptimal access	Lack of knowledge	Lack of provider recommendation	Suboptimal access	Lack of knowledge	Lack of provider recommendation	Suboptimal access	Psychosocial barriers
	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
<b>Age in years</b>										
50–54	31 (44.2)	27 (43.4)	15 (15.0)	30 (47.1)	23 (32.0)	13 (17.4)	21 (32.7)	15 (25.9)	22 (26.9)	15 (13.3)
55–64	31 (36.5)	20 (19.1)	23 (28.9)	34 (41.1)	20 (19.9)	17 (18.9)	27 (32.8)	11 (13.7)	29 (29.5)	17 (17.9)
65–75	15 (52.1)	9 (36.7)	4 (14.5)	14 (49.7)	8 (35.6)	4 (15.5)	13 (46.6)	5 (10.8)	5 (13.1)	10 (28.8)
<b>Sex</b>										
Male	41 (51.6)	19 (25.3)	24 (25.1)	44 (56.8)	21 (24.8)	18 (20.9)	34 (43.2)	13 (17.0)	23 (23.5)	20 (18.5)
Female	35 (32.6)	37 (41.2)	17 (15.9)	33 (33.1)	30 (31.5)	15 (13.9)	26 (25.9)	18 (21.2)	33 (30.0)	21 (15.8)
<b>Race/Ethnicity</b>										
White, non-Hispanic	51 (35.7)	37 (26.8)	31 (21.9)	55 (42.3)	35 (25)	27 (19.8)	44 (33.3)	18 (14.7)	48 (30.7)	32 (19.3)
Black, NH	7 (48.5)	5 (33.3)	5 (29.8)	5 (40.8)	5 (33.3)	2 (5.9)	3 (27.6)	4 (30.7)	4 (27.4)	3 (7.4)
Hispanic	12 (60.6)	8 (54.8)	1 (2.5)	11 (54.0)	5 (27.8)	2 (16.6)	9 (39.9)	6 (36.5)	0 (0)	3 (17)
Other or Multiple race, NH	7 (56.8)	6 (39.8)	5 (25.9)	7 (57.7)	6 (37.1)	3 (18.9)	5 (47.5)	3 (7.7)	4 (24.1)	4 (17.3)
<b>Education</b>										
≤High school	21 (43.1)	20 (38.4)	13 (19.8)	24 (48)	15 (25.6)	9 (15.5)	20 (40.8)	10 (19.5)	12 (18.1)	8 (10.6)
Some college	33 (33.6)	22 (24.2)	23 (25.1)	30 (31.7)	22 (24.1)	18 (20.6)	27 (26.9)	15 (18.4)	30 (37.3)	24 (23.4)
≥Bachelor's degree	23 (52.5)	14 (30.5)	6 (16.4)	24 (58.2)	14 (35.9)	7 (18.3)	14 (33.6)	6 (16.8)	14 (26)	10 (23.5)
<b>Household Income</b>										
<\$60,000	48 (45.6)	32 (31.3)	26 (23.3)	46 (44.4)	33 (31)	18 (16.1)	48 (48.5)	22 (23.5)	33 (23.4)	21 (12.9)
≥\$60,000	29 (37.1)	24 (33.3)	16 (17.3)	32 (45.7)	18 (22.1)	16 (20.2)	13 (15.1)	9 (11.6)	23 (29.8)	21 (23.9)
<b>Health Insurance</b>										
Private/public insurance	68 (42.6)	49 (32.5)	34 (20.6)	70 (46.1)	45 (29.2)	25 (16.7)	53 (33.3)	27 (19.3)	46 (25.0)	38 (18.9)
No insurance	9 (38.9)	7 (29.5)	8 (21.9)	8 (37.5)	6 (16.1)	9 (24.3)	8 (43.6)	4 (13.9)	10 (32.0)	4 (8.9)
<b>Last Healthcare Visit</b>										
<2 years ago	55 (40.6)	52 (37.5)	29 (19)	57 (44.3)	47 (31.9)	23 (16)	48 (35.8)	28 (21.2)	39 (23.8)	36 (18.9)
More than 2 years ago	21 (48.1)	4 (8.7)	13 (28.7)	20 (47.2)	4 (7.4)	11 (25.7)	13 (30.1)	3 (7.3)	17 (35.9)	5 (11)
<b>Self-rated General Health</b>										
Excellent or very good	39 (46.3)	26 (33.5)	21 (22.7)	41 (50.4)	24 (29)	15 (15.3)	25 (30.1)	12 (15.7)	30 (32.1)	17 (12.4)
Good	28 (37)	19 (31.9)	11 (13.4)	25 (33.1)	18 (28)	10 (17)	26 (34.1)	14 (25.3)	14 (13.9)	15 (20.1)
Fair or poor	10 (40.2)	11 (28.4)	10 (31.6)	12 (54.7)	9 (20.5)	9 (27.3)	10 (50.6)	5 (12.3)	12 (34.7)	10 (27.5)
<b>Non-CRC Cancer History</b>										
No	71 (41.8)	49 (32.7)	40 (22.4)	70 (44.1)	46 (28.4)	31 (18.7)	57 (35.4)	29 (19.9)	51 (27.3)	36 (16.3)
Yes	6 (44.8)	7 (26.2)	2 (4.4)	8 (53.4)	5 (16.2)	3 (8.1)	4 (28.4)	2 (5.5)	5 (12.6)	6 (29.1)

<sup>a</sup> N is unweighted, % is weighted. Respondents could select all reasons that apply. We limited these analyses to the most common reasons in Table 2. Analysis on differences in lack of provider recommendation by time since last healthcare visit was omitted as frequency of healthcare visits confounds the relationship.



**Fig. 3.** Results from logistic regression analyses among individuals who had never used any of the three options<sup>a</sup>. <sup>a</sup>We limited analyses to the most common reasons in Fig. 2. Time since last healthcare visit was omitted from analysis on lack of provider recommendation as frequency of healthcare visits confounds the relationship. Non-CRC cancer history was omitted from analyses where it was rarely reported by participants. \* P-value < 0.05 after adjusting for multiple testing using the Benjamini-Hochberg procedure). FIT/gFOBT: fecal immunochemical test/guaiac-based fecal occult blood test. mt-sDNA: multi-target stool DNA.

than males to report lack of knowledge (FIT/gFOBT: 32.6% versus 51.6%, aOR = 0.3, 95% CI = 0.11–0.72; mt-sDNA: 33.1% versus 56.8%, aOR = 0.27, 95% CI = 0.11–0.62; colonoscopy: 25.9% versus 43.2%, aOR = 0.31, 95% CI = 0.12–0.8). Regarding colonoscopy, people with an income lower than \$60,000 (versus \$60,000 or higher) were more likely to report lack of knowledge (48.5% versus 15.1%, aOR = 7.61, 95% CI = 2.64–25.35) and lack of provider recommendation (23.5% versus 11.6%, aOR = 4.53, 95% CI = 1.64–14.23). People who reported good health (versus excellent or very good health) were less likely to report suboptimal access (13.9% versus 32.1%, aOR = 0.24, 95% CI = 0.11–0.53) while those with fair or poor health were more likely to report psychosocial barriers (27.5% versus 12.4%, aOR = 7.82, 95% CI = 2.06–31.55).

Table 3 and Fig. 4 summarize the differences in utilization barriers by sample characteristics among individuals who had used one or two of the three screening options. For FIT/gFOBT, non-Hispanic black and Hispanic participants were more likely to report lack of knowledge than non-Hispanic white participants (40.8% and 38.6% versus 19.9%, aOR = 4.04, 95% CI = 1.45–11.34; aOR = 3.31, 95% CI = 1.22–8.85). For mt-sDNA, non-Hispanic black participants were more likely to report lack of knowledge than non-Hispanic white participants (40.2% versus 21.6%, aOR = 2.8, 95% CI = 1.23–6.32), while Hispanic participants were more likely to report lack of provider recommendation than non-Hispanic white participants (49.1% versus 34.1%, aOR = 2.63, 95% CI = 1.14–6.11).

#### 4. Discussion

Our national survey data demonstrated lack of knowledge and lack of provider recommendation as the primary barriers to CRC screening, particularly for the stool-based tests: FIT/gFOBT and mt-sDNA, whereas, psychosocial barriers were commonly identified obstacles to colonoscopy. Additionally, a sizable percentage of never-screeners reported suboptimal access across all three screening options. Our findings are

consistent with past research on barriers to FIT/gFOBT and colonoscopy (Honein-AbouHaidar et al., 2016; Nagelhout et al., 2017; Muthukrishnan et al., 2019; Jones et al., 2010; Wilkins et al., 2012) and extend the literature on barriers to mt-sDNA which is a critical and timely strength of this study.

These findings demonstrate a need for multi-level interventions to address deficiencies in patient knowledge and provider recommendations and to improve access to CRC screening programs, particularly among never-screeners in low-resource communities. Given the largely opportunistic, non-programmatic nature of cancer screening in the US, population-level interventions such as mass media campaigns maybe beneficial in improving the public’s awareness and knowledge of various CRC screening options and encouraging initiating discussion with healthcare providers about CRC screening (Worthington et al., 2020; Wakefield et al., 2010). Such education and communication campaign efforts may benefit from tailoring to population groups and addressing each screening option’s specific attributes. Motivation to change cannot convert to behavior change if the individual lacks opportunity or resources to act on the motivation (Fishbein and Ajzen, 2010). Therefore, interventions aimed at improving patient awareness and knowledge of CRC screening should be accompanied with efforts to reduce access barriers, for example, mailed outreach of stool-based tests and patient navigation to guide screening completion and follow-up testing when stool-based tests return abnormal findings (Jean-Jacques et al., 2012; Gupta et al., 2020; Hendren et al., 2014; Nelson et al., 2020). Recent systematic reviews showed that direct-mailing of stool-based CRC testing kits was consistently effective in improving CRC screening rates (Issaka et al., 2019; Rat et al., 2018; Jager et al., 2019; Dougherty et al., 2018). To address the lack of provider recommendation, particularly regarding stool-based tests, clinician training and education may be needed to improve clinicians’ knowledge, familiarity, and experiences with all available CRC screening options, with the goal to effectively engage patients in informed decision-making regarding CRC screening and aligning screening recommendations with patient

**Table 3**

Weighted estimates of non-utilization reasons of each CRC screening method by socio-demographic characteristics, health care access, and health status among individuals who have used one or two of the three methods.<sup>a</sup>

	Used mt-sDNA and/or colonoscopy, but not FIT/gFOBT (N = 389)		Used FIT/gFOBT and/or colonoscopy, but not mt-sDNA (N = 546)		Used FIT/gFOBT and/or mt-sDNA, but not colonoscopy (N = 91)		
	Barriers to use FIT/gFOBT		Barriers to use mt-sDNA		Barriers to use colonoscopy		
	Lack of knowledge	Lack of provider recommendation	Lack of knowledge	Lack of provider recommendation	Lack of knowledge	Lack of provider recommendation	Psychosocial barriers
	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)	N (%)
<b>Age in years</b>							
50–54	15 (26.8)	17 (26.5)	23 (23.4)	30 (33.6)	9 (31.6)	9 (37.4)	7 (31.7)
55–64	49 (22.5)	68 (31.6)	69 (24.7)	106 (36.1)	7 (10.9)	7 (12.9)	9 (29.8)
65–75	34 (27.5)	44 (35.9)	53 (28.1)	78 (41.8)	6 (11.5)	6 (23.8)	7 (32.9)
<b>Sex</b>							
Male	50 (25.8)	62 (33.7)	65 (22.0)	93 (36.7)	12 (28.0)	9 (17.6)	11 (36.2)
Female	48 (24.0)	66 (30.4)	80 (28.7)	120 (38.3)	9 (10.8)	13 (25.6)	12 (28.9)
<b>Race/Ethnicity</b>							
White, non-Hispanic	66 (19.9)	102 (31.4)	97 (21.6)	152 (34.1)	17 (20)	19 (29.6)	10 (14.2)
Black, NH	13 (40.8)	11 (46.2)	18 (40.2)	21 (46.0)	5 (10.6) <sup>b</sup>	3 (10.6) <sup>b</sup>	4 (12.6) <sup>b</sup>
Hispanic	12 (38.6)	9 (26.5)	14 (33.8)	23 (49.1)			
Other or Multiple race, NH	7 (29.8)	7 (22.7)	16 (29.6)	18 (40.7)			
<b>Education</b>							
≤High school	19 (19.8)	22 (30.5)	25 (22.2)	43 (35.5)	4 (5.7)	9 (22.1)	7 (27.7)
Some college	38 (26.7)	48 (32.4)	58 (25.6)	82 (36.6)	11 (37.8)	6 (27.7)	5 (16.3)
>Bachelor's degree	41 (27.8)	59 (32.1)	62 (28.6)	89 (39.9)	7 (29.3)	7 (21.3)	11 (46.5)
<b>Household Income</b>							
<\$60,000	38 (23.9)	49 (31.7)	64 (24.9)	91 (35.4)	13 (11.7)	10 (17.4)	13 (28.2)
≥\$60,000	60 (25.1)	80 (31.6)	81 (26.2)	123 (39.4)	9 (28.4)	12 (35.7)	10 (37.8)
<b>Health Insurance</b>							
Private/public insurance	91 (23.7)	127 (32.3)	141 (26)	210 (38.3)	22 (18.1)	22 (24.8)	22 (33.3)
No insurance	7 (40.8)	2 (19.5)	4 (16.9)	4 (19.6)	0 (0)	0 (0)	0 (0)
<b>Last Healthcare Visit</b>							
<2 years ago	93 (24.5)	127 (32.5)	138 (25.4)	210 (38.5)	22 (17.3)	21 (23.5)	23 (32.5)
More than 2 years ago	4 (28.2)	1 (4.7)	7 (31)	3 (10)	0 (0)	1 (5.8)	0 (0)
<b>Self-rated General Health</b>							
Excellent or very good	47 (22.4)	64 (29.2)	69 (24.9)	109 (35)	11 (22.5)	12 (23.7)	11 (32.7)
Good	36 (29.1)	47 (34.9)	56 (31.8)	74 (39.3)	11 (23)	8 (22.4)	8 (23.3)
Fair or poor	15 (19.7)	18 (30.5)	20 (13.4)	31 (40.1)	0 (0)	2 (21.7)	4 (37.8)
<b>Non-CRC Cancer History</b>							
No	85 (25.9)	105 (30)	125 (26.5)	178 (36.6)	20 (16.8)	19 (19.5)	23 (34.3)
Yes	13 (17.1)	23 (41.1)	20 (20.2)	35 (42.2)	2 (14)	3 (53.2)	0 (0)

<sup>a</sup> N is unweighted, % is weighted. Respondents could select all reasons that apply. We limited these analyses to the most common reasons in Fig. 2.

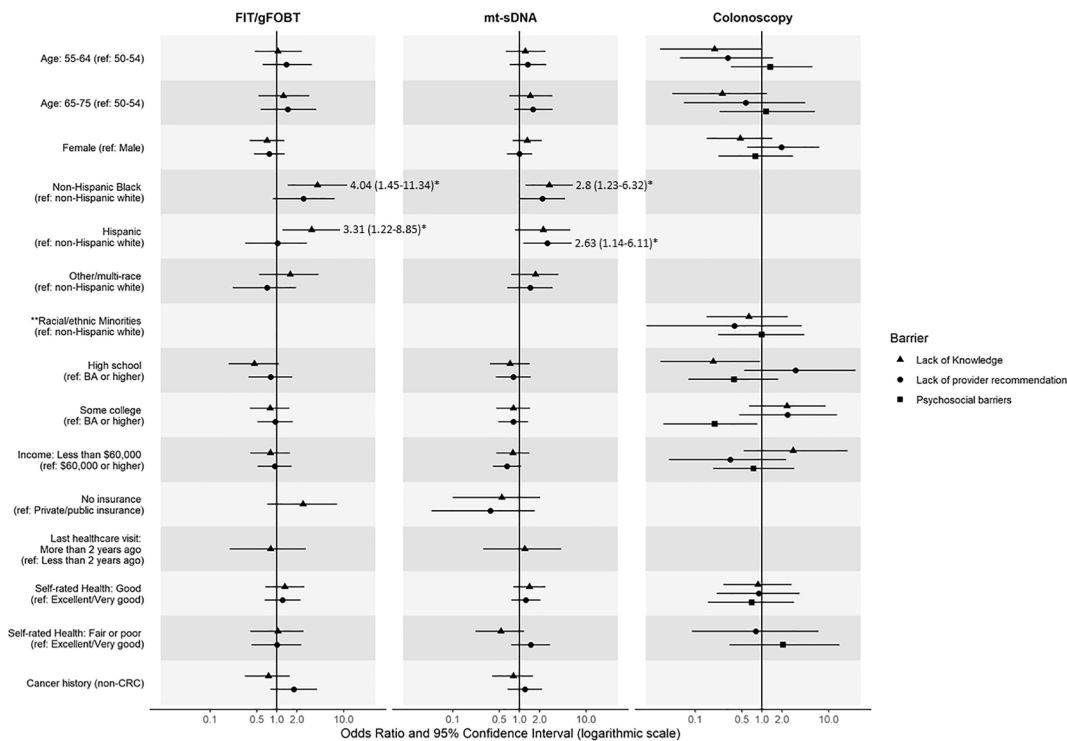
<sup>b</sup> Racial/ethnic minorities were combined into one group due to small sample size.

preferences, needs, and values. There is evidence that academic detailing is effective in increasing CRC screening rates when implemented as part of multicomponent interventions (Dougherty et al., 2018). Additionally, provider reminder and recall interventions where automated systems inform healthcare providers when individual patients are due (reminder) or overdue (recall) for specific cancer screening has been shown to be effective in increasing breast, cervical, and CRC screening participation (Dougherty et al., 2018; Baron et al., 2010).

Our study also revealed variations in barriers by patient characteristics. There were knowledge gaps by sex across all three screening options among people who have never screened with any of the three options, such that females were less likely to report lack of knowledge as a barrier to screening than males. Previous findings on sex differences in CRC screening awareness and knowledge have been mixed, with some studies reporting females have greater knowledge (Ritvo et al., 2013; Carnahan et al., 2021); others finding males have greater knowledge (McKinney and Palmer, 2014) or no sex differences (Ford et al., 2006). Additionally, we found racial/ethnic disparities in barriers to both stool-

based tests, with non-Hispanic black and Hispanic participants more likely to report lack of knowledge and lack of provider recommendation than non-Hispanic white individuals. There were also differences in knowledge and provider recommendation by income level. These findings are concordant with prior research (Nagelhout et al., 2017; Wilkins et al., 2012; Klabunde et al., 2006; Wang et al., 2013); likely reflecting persistent racial/ethnic and socio-economic (SES) disparities in access to healthcare. These findings suggest a need for continuing efforts to improve CRC screening awareness, knowledge, and access among racial/ethnic minorities and lower SES populations. Such efforts should consider tailoring interventions to the social-cultural context of specific communities. Multiple intervention strategies have been shown to be effective at reducing CRC screening disparities, including disseminating culturally tailored educational materials through culturally appropriate venues, training community health workers to deliver education, navigate patients through screening and follow-up, and provide social support, and reducing access barriers through mailed outreach of stool-based tests with as-needed patient navigation (Issaka et al., 2019;





**Fig. 4.** Results from logistic regression analyses among individuals who had used one or two of the three options<sup>a</sup>. <sup>a</sup>We limited analyses to the most common reasons in Fig. 2. Time since last healthcare visit was omitted from analysis on lack of provider recommendation as frequency of healthcare visits confounds the relationship. Insurance status, fair or poor self-rated general health, and non-CRC cancer history were omitted from the analyses where uninsured status, fair or poor self-rated general health, and/or cancer history were rarely reported by participants. \* P-value < 0.05 after adjusting for multiple testing using the Benjamini-Hochberg procedure. \*\* For analyses on barriers to colonoscopy, racial/ethnic minorities were combined into one group due to small sample size. FIT/gFOBT: fecal immunochemical test/guaiac-based fecal occult blood test. mt-sDNA: multi-target stool DNA.

Naylor et al., 2012; Luque et al., 2014; Mojica et al., 2018; Roland et al., 2017).

**4.1. Limitations**

We relied on self-reported data rather than objective measures of CRC screening and provider recommendation, which may contain misreporting due to inaccuracies in participants’ memory or tendency to provide socially desirable responses. Future research may benefit from using electronic health record data to confirm CRC screening and provider recommendation. Additionally, to reduce respondent burden, we limited our study to the three most commonly recommended and commonly used screening options, thus we were unable to capture patient preferences regarding other less widely used CRC screening options including computed tomography colonography and flexible sigmoidoscopy. Future research may benefit from including all recommended screening options to obtain a more comprehensive understanding of barriers to CRC screening. Moreover, we did not quantify the extent to which each barrier may prevent the use of a particular CRC screening option. Future research should consider assessing the relative importance of these barriers to each screening option. Such information would be useful for guiding intervention design in low-resource contexts by pinpointing which barriers should be targeted in the intervention in order to bring maximum improvement to screening completion. The majority (93%) of our survey participants reported private or public health insurance coverage, thus findings of this study may not generalize to uninsured patient populations. Future research with uninsured and underinsured patient samples are needed to understand these populations’ specific needs and barriers related to each screening option. Last, although consistent with the gradual decline in response rate of cross-sectional national surveys, our response rate is low, thus our findings’ generalizability may be impacted by non-response bias

(Maitland et al., 2017). However, our sample was selected using rigorous stratification to ensure adequate population representation.

**5. Conclusions**

Our research identified primary barriers to the utilization of three commonly recommended and commonly used CRC screening options and delineated differences by patient characteristics. These findings suggest that continued efforts to overcome barriers to CRC screening are needed among diverse patient populations and underscore the critical need to examine barriers by specific screening options, in order to align healthcare provider screening recommendations to the needs and preferences of patients.

**Funding**

This work was supported by the Exact Sciences Corporation, Madison, WI, USA. The funding agreement ensured author independence when developing the survey questions, interpreting and analyzing the data, and writing and submitting the publication.

**CRedit authorship contribution statement**

**Xuan Zhu:** Conceptualization, Formal analysis, Writing – original draft, Writing - review & editing. **Philip D. Parks:** Conceptualization, Methodology, Writing - review & editing. **Emily Weiser:** Conceptualization, Funding acquisition, Methodology, Project administration, Resources, Writing - review & editing. **Debra J. Jacobson:** Writing - review & editing. **Paul J. Limburg:** Conceptualization, Funding acquisition, Methodology, Project administration, Resources, Supervision, Writing - review & editing. **Lila J. Finney Rutten:** Conceptualization, Methodology, Project administration, Resources, Supervision, Writing -

review & editing.

### Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: EW is an employee of Exact Sciences Corporation. PDP is now an employee of Cardinal Health and was an employee of Exact Sciences Corporation at the time of the survey and manuscript preparation. PJJ serves as Chief Medical Officer for Screening at Exact Sciences through a contracted services agreement with Mayo Clinic. PJJ and Mayo Clinic have contractual rights to receive royalties through this agreement. LJFR offers scientific input to research studies through a contracted services agreement between Mayo Clinic and Exact Sciences. All other authors (XZ & DJJ) report no competing interests. Writing and administrative support were provided by William K. Johnson, employee of Exact Sciences Corporation.

### Acknowledgements

Medical writing and editorial support were provided William K Johnson, PhD, an employee of Exact Sciences (Madison, WI).

### Appendix 1. . Statistical weighting

Panel-specific base sampling weights for all sampled housing units are computed as the inverse of probability of selection from the NORC National Frame (the sampling frame that is used to sample housing units for AmeriSpeak) or address-based sample. The base sampling weights are further adjusted to account for unknown eligibility and nonresponse among eligible housing units. The household-level nonresponse adjusted weights are then post-stratified to external counts for number of households obtained from the Current Population Survey. Then, these household-level post-stratified weights are assigned to each eligible adult in every recruited household. Furthermore, a person-level nonresponse adjustment accounts for nonresponding adults within a recruited household. Finally, panel weights are raked to external population totals associated with age, sex, education, race/Hispanic ethnicity, housing tenure, telephone status, and Census Division. The external population totals are obtained from the Current Population Survey. The weights adjusted to the external population totals are the final panel weights.

Study-specific base sampling weights are derived using a combination of the final panel weight and the probability of selection associated with the sampled panel member. Adjustment was made to account for survey non-respondents. The nonresponse adjusted survey weights for the study are adjusted via a raking ratio method to adult ages 40–75 population totals associated with the following socio-demographic characteristics: age, sex, education, race/Hispanic ethnicity, and Census Division. The weights adjusted to the external population totals are the final study weights. At the final stage of weighting, any extreme weights were trimmed based on a criterion of minimizing the mean squared error associated with key survey estimates, and then, weights re-raked to the same population totals. Raking and re-raking is done during the weighting process such that the weighted demographic distribution of the survey completes resemble the demographic distribution in the target population.

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