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An examination of socioeconomic and racial/ethnic disparities in the awareness, knowledge and utilization of three colorectal cancer screening modalities

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ABSTRACT

While colorectal cancer (CRC) mortality rates have been decreasing, disparities by socioeconomic status (SES) and race/ethnicity persist. CRC screening rates remain suboptimal among low SES and racial/ethnic minority populations, despite the availability of multiple screening modalities. Understanding awareness, knowledge, and utilization of common screening modalities within different racial/ethnic and SES groups is critical to inform efforts to improve population screening uptake and reduce disparities in CRC-related health outcomes. Through the theoretical lenses of diffusion of innovation and fundamental cause theory, we examined the associations of race/ethnicity and SES with awareness, knowledge, and utilization of three guideline recommended CRC screening strategies among individuals at average risk for CRC. Data were obtained from a survey of a nationally representative panel of US adults conducted in November 2019. The survey was completed by 31.3% of invited panelists (1595 of 5097). Analyses were focused on individuals at average risk for CRC, aged 45–75 for awareness and knowledge outcomes (n = 1062) and aged 50–75 for utilization outcomes (n = 858). Analyses revealed racial/ethnic and SES disparities among the three CRC screening modalities, with more racial/ethnic and SES differences observed in the awareness, knowledge, and utilization of screening colonoscopy and mt-sDNA than FIT/gFOBT. Patterns of disparities are consistent with previous research showing that inequities in social and economic resources are associated with an imbalanced adoption of medical innovations. Our findings demonstrate a need to increase awareness, knowledge, and access of various CRC screening modalities in specific populations defined by race/ethnicity or SES indicators. Efforts to increase CRC screening should be tailored to the needs and social-cultural context of populations. Interventions addressing inequalities in social and economic resources are also needed to achieve more equitable adoption of CRC screening modalities and reduce disparities in CRC-related health outcomes.

Introduction

Colorectal cancer (CRC) is the third leading cause of cancer-related deaths in the United States (US) among both women and men (Cronin et al., 2018; Siegel, Miller, & Jemal, 2020). While overall US CRC mortality rates have been steadily decreasing over the past few decades, disparities in CRC mortality by socioeconomic status (SES) and race/-ethnicity persist (Breen, Lewis, Gibson, Yu, & Harper, 2017; Jackson, Oman, Patel, & Vega, 2016; Singh & Jemal, 2017). In fact, prior research demonstrates greater declines in area-level CRC mortality in high-SES geographic areas compared to low-SES areas (Clouston et al., 2017; A.; Wang, Clouston, Rubin, Colen, & Link, 2012). Additionally, declines in CRC mortality have been slower among racial/ethnic minority populations compared to non-Hispanic White populations (Clouston et al., 2017; Robbins, Siegel, & Jemal, 2012, pp. 401–405).

Major guideline organizations recommend screening for CRC among average-risk adults between the ages of 50–75 (U. S. Preventive Services Task Force et al., 2016) or 45–75 (Rex et al., 2017; Wolf et al., 2018).

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Several stool-based and direct visualization CRC screening modalities are recommended, including fecal immunochemical test/guaiac-based fecal occult blood test (FIT/gFOBT), multi-target stool DNA assay (mt-sDNA), and screening colonoscopy. These recommended CRC screening modalities vary in terms of when they were introduced into screening guidelines, recommended screening interval, efficacy, safety, and cost. In the US, screening colonoscopy and FIT/gFOBT have been included in CRC screening guidelines since the late 1990s while mt-sDNA was initially recommended in 2016. Regarding screening interval, guidelines recommend FIT/gFOBT to be done annually, mt-sDNA to be done every three years, and screening colonoscopy to be done every ten years. Colonoscopy allows visual examination throughout the colorectum as well as removal of polyps. However, it is an invasive procedure, requires bowel preparation and time off work, and its quality may depend on the expertise of the clinician performing it. Both FIT/gFOBT and mt-sDNA are noninvasive, stool-based tests that can be done at home. Compared with FIT, mt-sDNA has superior sensitivity for detecting CRC (92.3% vs 73.8%) and advanced precancerous lesions (42.4% vs 23.8%), but inferior specificity (89.8% vs 96.4%) (Imperiale et al., 2014). In terms of cost, the Affordable Care Act mandated health insurance cover CRC screenings at no out-of-pocket cost to patients (American Cancer Society, 2020). However, for uninsured and underinsured individuals, the cost can range from $1000 to $5000 for a colonoscopy, up to $700 for mt-sDNA, and $35 or less for FIT/gFOBT (Aliferis, 2015; Imperiale et al., 2021).

Despite the availability of multiple screening modalities, CRC screening continues to be underutilized in the US, particularly among socioeconomically disadvantaged communities and racial/ethnic minority populations (Davis et al., 2017; Finney Rutten, Nelson, & Meissner, 2004; Koblinski, Jandova, & Nfonsam, 2018; Steele et al., 2013). Inequitable diffusion of CRC screening across socioeconomic status (SES) and racial/ethnic groups has been found to contribute to disparities in CRC mortality (Jackson et al., 2016; Lansdorp-Vogelaar et al., 2012; Warren Andersen et al., 2019). Understanding the current patterns of awareness, knowledge, and utilization of common CRC screening modalities within different SES and racial/ethnic groups can inform interventions to facilitate equitable diffusion of CRC screening modalities and reduce disparities in CRC-related health outcomes. Therefore, we aimed to examine the associations of SES and race/-ethnicity with the awareness, knowledge, and utilization of three CRC screening modalities – FIT/gFOBT, mt-sDNA, and screening colonoscopy – among individuals at average risk for CRC.

Diffusion of innovation (DOI) (Rogers, 2010) and fundamental cause theory (FCT) (Phelan, Link, & Tehranifar, 2010) offer a useful theoretical foundation for addressing our study aim. The DOI theory suggest that the spread of an innovation throughout a population tends to follow an S-shaped curve over time, such that after a small percentage of the population quickly adopts an innovation, the majority of the population then follows, and additional members of the population later adopt the innovation after a period of time (Rogers, 2010). FCT suggests that social and economic resources – including knowledge, money, power, prestige, and social connectedness – are multi-purposive and transportable from one situation to another. Regardless of the mechanism of the disease, people who are better positioned with respect to these resources are better able to avoid disease risks, have better access to healthcare, and are more likely to learn about and take advantage of medical innovations in disease prevention in a timely manner (Chang & Lauderdale, 2009; Link & Phelan, 1995; Polonijo & Carpiano, 2013). Variables such as SES and race/ethnicity are closely associated with social and economic resources, with low-SES and racial/ethnic minority populations having fewer social and economic resources than high-SES and non-Hispanic White populations. Given that mt-sDNA was introduced into major screening guidelines more recently than colonoscopy and FIT/gFOBT, it might be at an earlier stage in the DOI process than colonoscopy and FIT/gFOBT. Therefore, we hypothesized that:

Hypothesis 1. mt-sDNA test would be less known among lower SES (versus high SES) and race/ethnicity minority groups (versus Non-Hispanic white) compared to screening colonoscopy and FIT/gFOBT.

The relationship between SES and race/ethnicity and the utilization of each CRC screening modality may differ depending on the attributes of that modality and the values, preferences, and beliefs of individuals. DOI theory suggests that people's perceptions of an innovation's key attributes influence how quickly an innovation is adopted, including 1) its visibility compared to previously available options; 2) its consistency with the potential adopters' values and needs; 3) its ease to understand and use; 4) allowing experimentation before adoption; and 5) its outcomes are visible to potential adopters (Rogers, 2010). Although the three CRC screening modalities are equally recommended by major guidelines organizations, they differ in these key attributes. Both FIT/gFOBT and mt-sDNA are non-invasive, easy-to-use stool-based tests, and require low investment of patient time and effort. In contrast, colonoscopy is an invasive procedure requiring high investment of patient effort for bowel preparation and time for the clinic appointment, and some people may face psychosocial barriers including feeling embarrassed (Honein-AbouHaidar et al., 2016); however, it has the advantage of being able to remove cancerous and precancerous polyps.

Medical innovations with high demand for people's social and economic resources (e.g., time, effort, skills, and money) may lead to inequitable diffusion because people with greater resources would have easier access to these innovations than those with fewer resources (e.g., HIV treatments). However, medical innovations with low demand on patient resources may lead to more equitable diffusion because people with fewer resources can use these innovations without depleting their scarce resources (e.g., childhood vaccines) (Chang & Lauderdale, 2009; Goldman & Lakdawalla, 2005). Therefore, we hypothesize that:

Hypothesis 2. SES and race/ethnicity will be more influential in predicting screening colonoscopy utilization than for the two stool-based tests.

Hypothesis 3. SES and race/ethnicity will be more influential in predicting mt-sDNA testing utilization than for FIT/gFOBT utilization because mt-sDNA test is a newer technology, thus it likely remains less accessible to people with low-resources.

Methods

Survey design

Data were obtained from a survey developed by the authors and implemented by the National Opinion Research Center (NORC) at the University of Chicago. A sample of US adults aged 40–75 was selected from NORC's AmeriSpeak Panel[1] using sampling strata based on age, sex, race/Hispanic ethnicity, and education. The size of the selected

[1] 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 February 15th, 2021).

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.

Data collection

We planned to obtain completed surveys from 1500 panelists. Prior studies using this panel have obtained an average survey completion rate of 35%. We estimated a survey completion rate of 35% and a qualification rate of 90%. The survey was pre-tested on a small sample of English-speaking AmeriSpeak web-mode panelists (n = 50) and no changes were made. The survey was fielded between November 8th and 25th, 2019. All sampled panelists were offered the cash equivalent of $5 to complete the survey.

A total of 1595 completed surveys (1433 by web and 162 by phone) were obtained from 5097 panelists who were invited to participate, resulting in a survey completion rate of 31.3% (Table 1). 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.

Table 1
Survey completion rate for each sampling stratum.

Socio-demographic Categories	Number in Stratum Completed Survey	Number in Stratum Sampled for Survey	Completed Rate within Stratum
Age in years			
40–49	464	1811	25.62%
50–64	738	2294	32.17%
65–75	393	992	39.62%
Sex			
Male	743	2445	30.39%
Female	852	2652	32.13%
Race/Ethnicity			
White, non-Hispanic (NH)	1146	2669	42.94%
Black, NH	161	805	20.00%
Hispanic	180	1251	14.39%
Asian, NH	28	100	28.00%
Other/Multi-race, NH	80	272	29.41%
Education			
Less than High School	68	661	10.29%
High School Equivalent	302	1181	25.57%
Some College/ Associate Degree	635	1941	32.72%
Bachelor's Degree	323	735	43.95%
Graduate Degree	267	579	46.11%
Household Income			
Less than $29,999	383	1655	23.14%
$30,000 to $74,999	594	1877	31.65%
$75,000 to $124,999	384	1014	37.87%
$125,000 or more	234	551	42.47%
Marital Status			
Currently Married	902	2566	35.15%
Separated/ Divorced/ Widowed	693	2531	27.38%
Household Ownership			
Owner Occupied	1160	3138	36.97%
Renter Occupied/ Other	435	1959	22.21%
Children in Household			
With one or more children under age 18	332	1328	25.00%
Without children under age 18	1263	3769	33.51%
	Number of Completed Survey in Total	**Number Sampled for Survey in Total**	**Overall Survey Completion Rate**
	1595	5097	31.29%

Measures

The primary outcomes in our analyses were awareness, knowledge, and utilization of FIT/gFOBT, mt-sDNA test, and screening colonoscopy. Questions about mt-sDNA referred to the test as Cologuard®, as it was the only mt-sDNA test available during the field period. Awareness of each screening modality was measured by the question, "Have you ever heard of a FIT/gFOBT stool-based test/the Cologuard test/a colonoscopy?" Knowledge was measured by two questions for each screening modality. Knowledge of the recommended age to initiate CRC screening was measured by the question, "At what age are people supposed to start completing stool-based colorectal cancer screening tests/doing Cologuard tests/start having colonoscopy exams for colorectal cancer screening?", with "45 years" or "50 years" as the correct answers (U. S. Preventive Services Task Force et al., 2016; Wolf et al., 2018). Knowledge of the recommended testing interval for each screening modality was measured by the question, "In general, once people start completing stool-based colorectal cancer screening tests/completing Cologuard tests/having colonoscopy exams, about how often should they complete them if they receive a negative result/if their colonoscopy is negative and they remain at average risk for developing colorectal cancer?", with "Every year," "Every three years," and "Every 10 years" as correct answers for FIT/gFOBT, mt-sDNA test, and colonoscopy, respectively. Utilization of each screening modality was measured by the question, "Have you ever completed a FIT/gFOBT stool-based test using a home test kit/a Cologuard test/a colonoscopy?"

The independent variables were SES and race/ethnicity. SES was measured by three variables: household income, education level, and health insurance status. All three variables are relevant to CRC screening because they can influence an individual's access to healthcare, ability to bear the cost of CRC screening and follow-up care, and ability to understand relevant health information such as screening recommendations. We coded household income according to the 2019 federal poverty level (FPL) based on the number of household members (Department of Health and Human Services, 2019). We also measured additional socio-demographic, health, and healthcare characteristics to be used as covariates, including age, sex, marital status, self-rating of general health (National Cancer Institue, 2013), Body Mass Index (BMI; calculated from self-reported weight and height), non-CRC cancer history, recent routine checkup, and provider recommendation of each screening modality in the past 12 months. All variables were categorical and are specified in Table 2.

Data analysis

All data were weighted to be nationally representative and corrected for potential bias introduced by nonresponse, non-coverage, and panel attrition. Participants were excluded from analysis if they reported having a personal or familial history of CRC (n = 28) or any colorectal health issues that would make them ineligible for stool-based tests (e.g., ulcerative colitis, Crohn's disease) according to CRC screening guidelines for average-risk adults (U. S. Preventive Services Task Force et al., 2016; Wolf et al., 2018) (n = 215). All respondents who reported having not heard of each CRC screening modality were coded as "Incorrect/-Don't know" for the corresponding knowledge questions and as "No" for the corresponding provider recommendation and the utilization

Table 2
Weighted[a] estimates of awareness and knowledge of initiation age of each CRC screening modality by socio-demographic, health, and healthcare characteristics.

		Awareness (Ever heard of the screening modality)						Knowledge of the recommended initiation age					
	Total	FIT/gFOBT (N = 1062)		mt-sDNA (N = 1060)		Colonoscopy (N = 1061)		FIT/gFOBT (N = 725)		mt-sDNA (N = 646)		Colonoscopy (N = 963)	
	N (%)	N (%)	p-value	N (%)	p-value	N (%)	p-value	N (%)	p-value	N (%)	p-value	N (%)	p-value
Total	1062	725 (67.1)		646 (60.9)		963 (90.5)		482 (63.6)		442 (65.0)		703 (70.2)	
Independent Variables													
Race/Ethnicity			.058		.001		.280		.010		<.001		.002
White, non-Hispanic (NH)	765 (66.2)	530 (69.3)		497 (66)		689 (90.5)		374 (69.3)		354 (71.8)		528 (74.4)	
Black, NH	108 (11.7)	76 (61.4)		66 (62.2)		100 (92.9)		38 (49.9)		32 (31)		57 (52.4)	
Hispanic	114 (14.2)	62 (55.9)		55 (48.4)		103 (85.7)		36 (51.5)		36 (59)		67 (70)	
Asian, NH	18 (1.6)	12 (69.7)		4 (22.8)		16 (86.8)		7 (69.3)		3 (87.8)		13 (84.6)	
Other/Multi-race, NH	57 (6.3)	45 (79.2)		24 (43.4)		55 (96.7)		27 (48.5)		16 (60.8)		37 (57)	
Education			.684		.906		.565		.020		.001		.014
Less than high school	54 (12.2)	33 (66)		35 (64)		48 (87.4)		17 (45.2)		20 (47.6)		28 (58.9)	
High school	211 (29.6)	136 (63.7)		135 (62)		186 (89.2)		85 (59.7)		81 (56.5)		117 (63.6)	
Some college	424 (25.7)	298 (68.2)		257 (60.6)		385 (90.9)		204 (70.4)		176 (69.8)		285 (75.5)	
Bachelor's degree or higher	373 (32.6)	258 (69.7)		219 (59.2)		344 (92.5)		176 (68)		164 (76.3)		272 (75.8)	
Household Income Compared to Federal Poverty Level (FPL)			.319		.696		.630		.010		.034		<.001
<100% of FPL	113 (13)	66 (62.2)		67 (66.3)		98 (87.8)		44 (56.1)		43 (50.4)		64 (61.1)	
100% to <150% of FPL	96 (8.7)	65 (59.3)		56 (51.8)		85 (87.4)		37 (51.8)		34 (59.8)		48 (48.8)	
150% to <200% of FPL	128 (12.1)	92 (70.5)		85 (63.1)		113 (88.8)		58 (51.6)		56 (60.5)		73 (56.9)	
200% to <300% of FPL	149 (13.9)	108 (75)		91 (59.8)		139 (93.1)		68 (56.7)		58 (57.7)		97 (68.6)	
300% to <400% of FPL	187 (16)	122 (65.9)		105 (58)		170 (91.8)		81 (70.2)		67 (66.2)		130 (76.8)	
400% to <600% of FPL	203 (18)	137 (62.8)		126 (63.9)		182 (88.6)		107 (78.9)		97 (76.5)		143 (75)	
≥600% of FPL	186 (18.3)	135 (71.2)		116 (60.5)		176 (93.7)		87 (67.6)		86 (74.4)		147 (85.3)	
Health Insurance [b]			.049		.736		.614		.163		.499		.313
Private/public insurance	995 (92.8)	690 (68.2)		611 (61.1)		904 (90.7)		459 (64.5)		418 (65.6)		665 (70.7)	
No insurance	66 (7.2)	34 (52.7)		34 (58.4)		59 (88.2)		22 (48.2)		22 (57.8)		37 (62.7)	
Covariates													
Other Socio-demographics													
Age in years			<.001		<.001		<.001		.190		<.001		.005
45-54	390 (37.6)	223 (53.8)		193 (50.5)		328 (83.7)		167 (69.5)		150 (69.3)		253 (75.9)	
55-64	391 (36.3)	282 (73.1)		249 (63.3)		361 (92.2)		182 (63.2)		179 (73.5)		271 (72.3)	
65-75	281 (26.1)	220 (77.8)		204 (72.8)		274 (97.8)		133 (58.2)		112 (50.6)		178 (60.3)	
Sex [c]			.159		.177		.498		.599		.364		.704
Male	491 (48)	322 (64.2)		287 (58.5)		443 (89.6)		211 (62.1)		201 (67.5)		318 (69.2)	
Female	565 (51.6)	398 (69.5)		357 (63.7)		514 (91.2)		268 (64.6)		239 (63)		379 (70.7)	
Employment Status			<.001		<.001		<.001		.434		.076		.090
Currently employed	574 (52.2)	363 (59.7)		301 (53.1)		508 (88.5)		248 (66.5)		225 (69.7)		389 (74.5)	
Not currently employed	212 (22.2)	147 (70.3)		136 (60.8)		185 (86)		106 (63.5)		98 (68)		128 (65.8)	
Retired	276 (25.6)	215 (79.3)		209 (77.1)		270 (98.3)		128 (59.1)		118 (56.5)		185 (65.6)	
Marital Status			.688		.500		.964		.089		<.001		<.001
Married or living with a partner	666 (63.3)	452 (67.9)		398 (61.5)		606 (90.4)		313 (67.4)		288 (73)		473 (77.5)	
Widowed, divorced, separated													

(*continued on next page*)

Table 2 (*continued*)

	Total	Awareness (Ever heard of the screening modality)						Knowledge of the recommended initiation age					
		FIT/gFOBT (N = 1062)		mt-sDNA (N = 1060)		Colonoscopy (N = 1061)		FIT/gFOBT (N = 725)		mt-sDNA (N = 646)		Colonoscopy (N = 963)	
	N (%)	N (%)	p-value	N (%)	p-value	N (%)	p-value	N (%)	p-value	N (%)	p-value	N (%)	p-value
	262 (24.6)	184 (67.3)		168 (62.5)		237 (90.2)		113 (56.7)		102 (48.5)		153 (57.5)	
Never married	134 (12.2)	89 (62.7)		80 (54.9)		120 (91.3)		56 (56.6)		51 (56.9)		76 (57.5)	
Self-reported Health Status													
Self-rated General Health			.098		.996		.870		.080		.129		.014
Excellent	112 (10.7)	73 (55.1)		70 (61.2)		102 (91.6)		49 (67.5)		49 (73.6)		79 (78.9)	
Very good	394 (34.5)	275 (69.8)		231 (60.7)		360 (90.8)		191 (70.9)		158 (66.5)		280 (76.4)	
Good	382 (36.6)	265 (65.9)		241 (60.7)		350 (89.3)		172 (59.2)		170 (67.1)		242 (63.8)	
Fair or poor	174 (18.2)	112 (71.4)		104 (61.9)		151 (91.5)		70 (56.3)		64 (53.4)		101 (65.7)	
Body Mass Index[d]			.078		.406		.681		.660		.430		.358
Underweight	14 (1)	8 (52.3)		10 (87.2)		14 (100)		5 (61.9)		6 (50.3)		9 (55.8)	
Normal weight	236 (22.9)	146 (61.8)		140 (62.6)		207 (90)		98 (58.7)		92 (59.6)		146 (66.2)	
Overweight	378 (36.1)	261 (64.7)		233 (60.8)		345 (89.5)		178 (66.5)		162 (69.3)		256 (74)	
Obese	417 (40)	300 (72.5)		254 (59.5)		384 (91.6)		195 (63.2)		176 (64.7)		280 (69)	
Non-CRC Cancer History[e]			.247		.094		.003		.926		.950		.715
Yes	129 (12.8)	91 (72.8)		91 (69.6)		122 (96.9)		62 (62.9)		60 (64.5)		84 (68.2)	
No	931 (87.2)	633 (66.4)		553 (59.5)		839 (89.5)		419 (63.7)		379 (64.9)		616 (70.4)	
Healthcare Access													
Recent Routine Checkup[f]			.774		.207		.050		.713		.052		.485
Less than 2 years ago	967 (92.5)	668 (67.3)		597 (61.8)		884 (91)		442 (64)		405 (64.1)		644 (70.3)	
3–5 years ago	49 (4.4)	32 (66.1)		26 (54.2)		40 (79.6)		24 (62.4)		21 (86)		32 (75.7)	
More than 5 years ago or never	41 (3.1)	23 (60.7)		21 (46.3)		34 (88.2)		15 (52.8)		14 (70.9)		22 (58.8)	
Provider recommended FIT/gFOBT during past 12 months			–						.937				
Yes	194 (18.5)	194 (100)		–		–		123 (63.5)		–		–	
No	866 (81.5)	529 (59.5)		–		–		358 (63.9)		–		–	
Provider recommended mt-sDNA during past 12 months					–						.478		
Yes	94 (9.1)	–		94 (100)		–		–		63 (60.2)		–	
No	965 (90.9)	–		550 (57)		–		–		376 (65.8)		–	
Provider recommended a colonoscopy during past 12 months							–						.284
Yes	265 (26.4)	–		–		265 (100)		–		–		202 (73.6)	
No	797 (73.6)	–		–		698 (87)		–		–		500 (68.8)	

Note.

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

[a] N is unweighted, % is weighted.

[b] Missing = 1; we combined private and public insurance into one category because the distinction between private and public insurance reflects participant age rather than SES as the majority of people with private insurance were younger than age 65 while the majority of people with public insurance were age 65 or older.

[c] Missing = 2; the "Other or prefer not to answer" category was omitted from analysis because it was rarely selected (n = 4).

[d] Missing = 17.

[e] Missing = 2.

[f] Missing = 5.

questions. Analyses were focused on participants aged 45–75 for awareness and knowledge of screening modalities (n = 1062) and focused on participants aged 50–75 for utilization of CRC screening modalities (n = 858). We assessed whether there were any significant differences in the primary outcome variables by survey mode (web versus phone) or by language of survey completion (English versus Spanish) using chi-square test and found no significant differences (data not shown). Weighted descriptive statistics and Rao-Scott chi-square test

(Rao & Scott, 1987) were used to examine differences in outcomes by socio-demographic, health, and healthcare characteristics.

Binary logistic regression was conducted to examine the associations of SES and race/ethnicity with awareness, knowledge, and utilization of each CRC screening modality. Independent variables in each model included education level, household income, health insurance status, and race/ethnicity. Analyses on knowledge and utilization were limited to participants who were aware of the screening modality. All models were adjusted for covariates, including other sociodemographic, health, and healthcare characteristics. Models on utilization also adjusted for knowledge of the screening modality. To determine how the predicted probabilities of awareness, knowledge, and utilization of each screening modality differ by SES and race/ethnicity, we calculated the average marginal effects (AME) of each predictor variable on the predicted probability of awareness, knowledge, and utilization of each CRC screening modality. Specifically, we reported the average change in the predicted probabilities (percentage increase or decrease) of the outcome across all participants when the predictor variable changed by one level with regard to the referent level, keeping all other variables in the model at observed values. We chose to report marginal effects instead of odds ratios because they are in the natural units of the outcome variable (predicted probabilities) thus the interpretation is more intuitive and they are less sensitive than odds ratios to changes in model specification and study samples (Long & Mustillo, 2018; Norton & Dowd, 2018). We estimated variance using the Taylor-series linearization method to account for the complex survey design (Barrio, Rodriguez, Abad, & Blesa, 2011). Given that 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 & Korn, 1996; Lumley, 2004; West, Berglund, & Heeringa, 2008). P-values $<.05$ were considered statistically significant. The data that support the findings of this study are available from the corresponding author upon reasonable request.

Results

Table 1 summarized survey completion rates for each sampling stratum. We observed lower completion rates among individuals younger than age 50, racial/ethnic minorities, individuals with high school education or lower, individuals with a household income less than $30,000, individuals who rent rather than own their homes, and individuals with one or more children younger than age 18.

Sample characteristics were reported in Table 2. Tables 2 and 3 summarize weighted estimates of awareness, knowledge, and utilization of each CRC screening modality by race/ethnicity and SES indicators, and other socio-demographic, health, and healthcare characteristics. Awareness of colonoscopy (90.5%) was higher than FIT/gFOBT (67.1%) and mt-sDNA (61.1%). Among people who have heard of each screening modality, knowledge of initiation age was higher for colonoscopy (70.2%) than for the stool-based tests (63.6%, 65%). However, knowledge of the screening intervals was low across the three screening modalities (FIT/gFOBT: 31.9%; mt-sDNA: 19.5%; colonoscopy: 27.4%). Nearly 3/4 of people ages 50–75 reported having had a colonoscopy (72.2%), while utilization of FIT/gFOBT (47.5%) and mt-sDNA test (25.8%) was less frequent.

Hispanic, Asian, and other/multi-race (versus non-Hispanic white) participants less frequently reported awareness of mt-sDNA and less frequently knew the recommended screening interval for colonoscopy, while black participants less frequently knew the initiation age for all modalities (all $p \leq .01$). Regarding SES indicators, people with less than high school education less frequently knew the initiation age for all modalities and screening interval for mt-sDNA and colonoscopy. People with an income $<300\%$ (versus $<300\%$) of FPL less frequently knew the initiation age for all modalities and screening interval for colonoscopy (all $p < .05$). People with an income $\geq 300\%$ (versus $<300\%$) of FPL less frequently reported having used FIT/gFOBT but more frequently reported having used colonoscopy (all $p < .05$). Uninsured individuals less frequently knew the screening interval for mt-sDNA and colonoscopy and less frequently reported having used colonoscopy (all $p < .05$).

Regarding other socio-demographic, health, and healthcare characteristics, older adults age 55 or older (versus age 45–54) more frequently reported awareness of all modalities and utilization of FIT/gFOBT and colonoscopy but less frequently knew the initiation age for mt-sDNA and colonoscopy (all $p < .01$). Married individuals more frequently knew the initiation age for mt-sDNA and colonoscopy and the screening interval for colonoscopy (all $p < .01$). Unemployed individuals and those with no recent routine checkup less frequently knew the screening interval for colonoscopy or reported having used colonoscopy (all $p < .01$). Males and people with fair/poor health less frequently knew the screening interval for colonoscopy (all $p < .01$). People who received a provider recommendation for FIT/gFOBT and mt-sDNA during past year more frequently reported having used the stool-based tests (all $p < .001$).

Tables 4 and 5 summarize the average marginal effect of race/ethnicity and SES on the predicted probability of awareness, knowledge, and utilization of each CRC screening modality after adjusting for other socio-demographic, health, and healthcare characteristics. Analyses on utilization also adjusted for knowledge of the screening modality.

Awareness

Being Hispanic, Asian, or other/multi-race (versus non-Hispanic white) was associated with a decrease of 16%, 44%, and 19% in the probability of having heard of mt-sDNA, respectively (all $p < .05$). Regarding covariates, older age (55–75 versus 45–54) remained associated with higher awareness of FIT/gFOBT and colonoscopy.

Knowledge of recommended age to initiate CRC screening

Being other/multi-race was associated with a decrease of 23% in the probability of knowing the age to initiate FIT/gFOBT while being black was associated with a decrease of 24% in the probability of knowing the age to initiate mt-sDNA (all $p < .01$). Having a high school degree (versus bachelor's degree or higher) was associated with a decrease of 14% in the probability of knowing the age to initiate mt-sDNA ($p < .05$). Having an income $<300\%$ (versus $\geq 600\%$) of FPL was associated with a decrease between 27% and 17% in the probability of knowing the age to initiate screening colonoscopy (all $p < .05$). Regarding covariates, being of age 65–75 remained associated with lower probability of knowing the age to initiate mt-sDNA and colonoscopy.

Knowledge of recommended screening interval

Being Asian was associated with a decrease of 23% in the probability of knowing the screening interval for colonoscopy ($p < .01$). Having less than high school education was associated with a decrease of 16% and 28% in the probability of knowing the screening interval for mt-sDNA and colonoscopy, respectively (both $p < .05$). Having a high school degree or some college education was associated with a decrease of 14% and 11% in the probability of knowing the recommended testing interval of screening colonoscopy, respectively (both $p < .01$). Having an income within 100%–150% of FPL and within 150%–200% of FPL was associated with a decrease of 17% and 14% in the probability of knowing the screening interval for colonoscopy (both $p < .05$). Having no health insurance was associated with a decrease of 14% in the probability of knowing the screening interval of mt-sDNA ($p < .01$).

Regarding covariates, being of age 55–64 and female were associated with higher probability of knowing the screening interval for colonoscopy, while being never married, having fair/poor health, having no recent routine checkup was associated with lower probability of

Table 3
Weighted[a] estimates of knowledge of testing interval and utilization of each CRC screening modality by socio-demographic, health, and healthcare characteristics.

	Knowledge of the recommended screening interval						Utilization (Ever completed the screening modality)[b]						
	FIT/gFOBT (N = 725)		mt-sDNA (N = 646)		Colonoscopy (N = 963)		Total	FIT/gFOBT (N = 626)		mt-sDNA (N = 561)		Colonoscopy (N = 796)	
	N (%)	p-value	N (%)	p-value	N (%)	p-value	N (%)	N (%)	p-value	N (%)	p-value	N (%)	p-value
Total	238 (31.9)		133 (19.5)		283 (27.4)		858	280 (47.5)		123 (25.8)		574 (72.2)	
Independent Variables													
Race/Ethnicity		.890		.185		.019			.044		.113		.444
White, non-Hispanic (NH)	165 (30.4)		106 (21.1)		226 (31.5)		624 (68.3)	193 (43.1)		86 (22.7)		419 (73.2)	
Black, NH	31 (37.3)		10 (15.5)		24 (24.3)		92 (12.9)	41 (68)		20 (42.1)		66 (77.8)	
Hispanic	22 (33.5)		9 (11.4)		16 (17.6)		82 (11)	24 (51.7)		15 (31.4)		51 (65.9)	
Asian, NH	7 (39.9)		2 (68.1)		2 (6.9)		15 (1.6)	6 (58.9)		0 (0)		10 (62.6)	
Other/Multi-race, NH	13 (33.3)		6 (18.8)		15 (17.3)		45 (6.2)	16 (49.5)		2 (16.9)		28 (62)	
Education		.702		.037		<.001			.273		<.001		.078
Less than high school	13 (28.7)		3 (7)		2 (5.6)		43 (11)	13 (58.8)		15 (61.1)		25 (62.4)	
High school	44 (32.8)		23 (14.9)		36 (22.3)		176 (30.4)	61 (51.3)		31 (25.8)		104 (67.7)	
Some college	88 (28.3)		54 (22.7)		106 (26.1)		346 (26)	113 (41.1)		43 (18.9)		223 (72)	
Bachelor's degree or higher	93 (35)		53 (26.3)		139 (40.7)		293 (32.6)	93 (45.4)		34 (19.2)		222 (79.3)	
Household Income Compared to Federal Poverty Level (FPL)		.720		.214		<.001			.011		.150		.005
<100% of FPL	29 (32.4)		10 (10.5)		13 (20)		88 (11.9)	27 (58.3)		17 (38.4)		41 (57.8)	
100% to <150% of FPL	21 (22)		10 (19.7)		15 (9.9)		78 (8.4)	25 (45.7)		15 (29.9)		47 (75.1)	
150% to <200% of FPL	28 (32.8)		19 (17.4)		21 (11.9)		105 (13)	49 (66.7)		19 (34.6)		65 (57.9)	
200% to <300% of FPL	35 (33.3)		19 (22.1)		46 (30.9)		119 (13.9)	46 (52.6)		18 (29.1)		81 (74.3)	
300% to <400% of FPL	32 (26)		29 (25.6)		56 (35.8)		145 (15.7)	42 (40.8)		16 (19.6)		97 (72.8)	
400% to <600% of FPL	45 (35.1)		18 (14.2)		60 (29.2)		162 (17.4)	49 (41)		22 (18.9)		116 (76.6)	
≥600% of FPL	48 (35.8)		28 (26.1)		72 (38.4)		161 (19.7)	42 (36)		16 (18.5)		127 (82.7)	
Health Insurance[c]		.841		.007		.017			.473		.665		.001
Private/public insurance	228 (31.8)		130 (20.6)		276 (28.7)		808 (93.5)	273 (47.9)		118 (26)		555 (74)	
No insurance	10 (34.1)		3 (4.8)		7 (10.2)		49 (6.5)	6 (37.4)		4 (20.4)		19 (45.2)	
Covariates													
Other Socio-demographics													
Age in years		.515		.901		.064			<.001		.057		<.001
45-54	81 (35.6)		40 (20.1)		70 (21.6)		186 (22.4)	41 (35.7)		15 (21.2)		81 (51.3)	
55-64	87 (31.2)		55 (20.1)		124 (29.9)		391 (45.2)	112 (41.6)		45 (21)		270 (75)	
65-75	70 (29.2)		38 (18.2)		89 (31.4)		281 (32.4)	127 (61.4)		63 (34.1)		223 (81.2)	
Sex[d]		.169		.928		.003			.165		.560		.978
Male	111 (34.8)		56 (19.7)		103 (21.8)		381 (45.4)	122 (43.8)		58 (24.1)		258 (72.5)	
Female	125 (28.7)		77 (19.3)		179 (32.7)		472 (54.1)	156 (50.9)		64 (27.1)		314 (72.6)	
Employment Status		.989		.362		.001			.046		.093		<.001
Currently employed	116 (32.2)		64 (21.2)		146 (26.1)		419 (47.9)	116 (40)		40 (19.2)		266 (68.5)	
Not currently employed	55 (31.4)		23 (14.2)		35 (17.9)		166 (20.7)	57 (53.8)		29 (32.4)		88 (61.3)	
Retired	67 (31.8)		46 (20.7)		102 (37)		273 (31.4)	107 (52.6)		54 (29.6)		220 (83.7)	
Marital Status		.250		.284		.001			.259		.632		.077
Married or living with a partner	156 (34.6)		79 (19.3)		198 (32.4)		531 (62.8)	161 (44.8)		71 (24.9)		369 (75.7)	
Widowed, divorced, separated													

(*continued on next page*)

Table 3 (*continued*)

	Knowledge of the recommended screening interval						Utilization (Ever completed the screening modality)[b]					
	FIT/gFOBT (N = 725)		mt-sDNA (N = 646)		Colonoscopy (N = 963)		Total	FIT/gFOBT (N = 626)		mt-sDNA (N = 561)		Colonoscopy (N = 796)	
	N (%)	p-value	N (%)	p-value	N (%)	p-value	N (%)	N (%)	p-value	N (%)	p-value	N (%)	p-value
	57 (26.7)		34 (16.5)		58 (21.1)		225 (25.8)	84 (54.4)		38 (29.8)		144 (67.8)	
Never married	25 (27.9)		20 (27.2)		27 (14.7)		102 (11.4)	35 (46.4)		14 (22.1)		61 (63)	
Self-reported Health Status													
Self-rated General Health		.292		.842		<.001			.594		.449		.629
Excellent	30 (41.7)		14 (24.5)		41 (37.8)		85 (9.6)	26 (50.1)		13 (26.9)		62 (72)	
Very good	89 (33.8)		47 (19.5)		114 (28.1)		329 (36.4)	114 (47.1)		44 (21.9)		223 (72.3)	
Good	83 (31)		53 (18.5)		99 (31.3)		312 (36.5)	98 (44)		44 (25.3)		203 (74.8)	
Fair or poor	36 (25.4)		19 (18.6)		29 (12.6)		132 (17.5)	42 (54)		22 (34.1)		86 (66.6)	
Body Mass Index [e]		.468		.650		.196			.786		.311		.066
Underweight	3 (44.3)		2 (21.1)		5 (27.9)		10 (0.8)	2 (21.5)		2 (20.9)		8 (91.3)	
Normal weight	52 (37.4)		33 (17.7)		64 (27.8)		195 (23.3)	56 (46.1)		17 (21.2)		118 (64.1)	
Overweight	83 (32.4)		43 (17.6)		109 (31.4)		307 (36.4)	105 (47.6)		47 (22.8)		209 (72.4)	
Obese	98 (28.9)		54 (22.4)		100 (23.1)		334 (39.5)	112 (47.7)		55 (31.6)		230 (75.9)	
Non-CRC Cancer History [c]		.319		.222		.763			.512		.934		.138
Yes	27 (26.1)		22 (25.9)		42 (28.5)		118 (13.5)	39 (51.7)		19 (25.3)		89 (80)	
No	211 (32.8)		111 (18.5)		240 (27)		739 (86.5)	241 (46.8)		104 (25.9)		484 (70.9)	
Healthcare Access													
Recent Routine Checkup [f]		.565		.867		<.001			.271		.228		<.001
Less than 2 years ago	223 (32.1)		122 (19.7)		274 (29)		790 (93.2)	270 (48.5)		120 (26.4)		553 (74.5)	
3–5 years ago	8 (23.2)		7 (15.6)		3 (5.2)		32 (3.4)	8 (42.8)		3 (29.4)		14 (60)	
More than 5 years ago or never	7 (40.4)		4 (19.6)		5 (7.3)		33 (3.3)	2 (20.6)		–		5 (15.7)	
Provider recommended FIT/gFOBT during past 12 months		.053							<.001				
Yes	82 (39.3)		–		–		189 (22.6)	144 (77.9)		–		–	
No	156 (29.3)		–		–		668 (77.4)	136 (33.5)		–		–	
Provider recommended mt-sDNA during past 12 months				.674							<.001		
Yes	–		20 (17.7)		–		93 (11.2)	–		64 (77.8)		–	
No	–		113 (19.9)		–		763 (88.8)	–		59 (15.1)		–	
Provider recommended a colonoscopy during past 12 months						.884							.769
Yes	–		–		80 (27.8)		247 (30.1)	–		–		181 (73.1)	
No	–		–		203 (27.2)		611 (69.9)	–		–		393 (71.7)	

Note.
*N is unweighted, % is weighted.
P-values obtained from Rao-Scott chi-square test.
[a] N is unweighted, % is weighted.
[b] Analyses on screening utilization were focused on individuals aged 50-75.
[c] Missing=1 for individuals aged 50-75.
[d] Missing=2; the "Other or prefer not to answer" category was omitted from analysis because it was rarely selected (n=3 for individuals aged 50-75).
[e] Missing=12 for individuals aged 50-75.
[f] Missing = 3 for individuals aged 50–75.

knowing the screening interval for colonoscopy. Having received a provider recommendation for FIT/gFOBT was associated with higher probability of knowing its screening interval.

Utilization

None of our Asian participants reported having ever used mt-sDNA. Being black was associated with an increase of 16% in the probability of FIT/gFOBT utilization ($p < .05$). Having an income within 150%–200% of FPL was associated with an increase of 24% in the probability of FIT/

Table 4
Average marginal effect of race/ethnicity and SES on the predicted probability of awareness and knowledge of the initiation age of each CRC screening modality.

	Awareness			Knowledge of Initiation Age		
	FIT/gFOBT	mt-sDNA	Colonoscopy	FIT/gFOBT	mt-sDNA	Colonoscopy
	AME (95% CI)	AME (95% CI)	AME (95% CI)	AME (95% CI)	AME (95% CI)	AME (95% CI)
Independent Variables						
Race/Ethnicity						
White, NH	Reference	Reference	Reference	Reference	Reference	Reference
Black, NH	−0.10 (−0.23, 0.02)	−0.04 (−0.17, 0.09)	0.03 (−0.05, 0.10)	−0.11 (−0.27, 0.05)	**−0.24 (-0.39, -0.07)** **	−0.08 (−0.21, 0.05)
Hispanic	−0.06 (−0.19, 0.07)	**−0.16 (-0.29, -0.04)** *	0.01 (−0.07, 0.08)	−0.14 (−0.31, 0.03)	−0.12 (−0.28, 0.04)	−0.02 (−0.14, 0.10)
Asian, NH	0.05 (−0.16, 0.25)	**−0.44 (-0.69, -0.19)** **	−0.05 (−0.24, 0.14)	0.01 (−0.30, 0.32)	0.17 (−0.11, 0.43)	0.03 (−0.24, 0.30)
Other/Multi-race, NH	0.12 (−0.02, 0.25)	**−0.19 (-0.37, -0.01)** *	0.07 (0, 0.12)	**−0.23 (-0.40, -0.06)** **	−0.13 (−0.34, 0.09)	−0.14 (−0.29, 0.01)
Education						
Less than high school	0.02 (−0.13, 0.16)	0.10 (−0.06, 0.25)	−0.03 (−0.13, 0.06)	−0.12 (−0.35, 0.11)	−0.20 (−0.41, 0)	−0.02 (−0.19, 0.14)
High school	−0.04 (−0.14, 0.06)	0.07 (−0.04, 0.17)	−0.03 (−0.09, 0.04)	−0.04 (−0.17, 0.09)	**−0.14 (-0.26, -0.03)** *	−0.03 (−0.12, 0.07)
Some college	−0.01 (−0.09, 0.07)	0.04 (−0.04, 0.13)	−0.01 (−0.06, 0.04)	0.07 (−0.03, 0.17)	−0.01 (−0.11, 0.08)	0.06 (−0.03, 0.14)
Bachelor's degree or higher	Reference	Reference	Reference	Reference	Reference	Reference
Household Income Compared to Federal Poverty Level (FPL)						
<100% of FPL	−0.05 (−0.19, 0.10)	0.02 (−0.14, 0.17)	−0.03 (−0.13, 0.06)	−0.01 (−0.21, 0.19)	−0.05 (−0.23, 0.13)	**−0.18 (-0.34, -0.002)** *
100% to <150% of FPL	−0.13 (−0.29, 0.03)	−0.12 (−0.29, 0.05)	−0.05 (−0.15, 0.06)	−0.05 (−0.25, 0.15)	−0.03 (−0.23, 0.17)	**−0.27 (-0.42, -0.11)** ***
150% to <200% of FPL	0.01 (−0.13, 0.14)	−0.01 (−0.15, 0.14)	−0.04 (−0.13, 0.05)	−0.08 (−0.25, 0.10)	0.04 (−0.12, 0.19)	**−0.19 (-0.30, -0.05)** **
200% to <300% of FPL	0.05 (−0.07, 0.17)	−0.03 (−0.16, 0.10)	0.01 (−0.06, 0.09)	−0.11 (−0.27, 0.05)	−0.08 (−0.25, 0.08)	**−0.17 (-0.29, -0.04)** **
300% to <400% of FPL	−0.03 (−0.15, 0.09)	−0.06 (−0.19, 0.06)	0 (−0.08, 0.07)	0.03 (−0.12, 0.17)	−0.03 (−0.18, 0.12)	−0.09 (−0.19, 0.02)
400% to <600% of FPL	−0.04 (−0.16, 0.07)	0.01 (−0.10, 0.13)	−0.05 (−0.12, 0.03)	0.12 (−0.02, 0.25)	0.07 (−0.07, 0.20)	−0.09 (−0.19, 0.01)
≥600% of FPL	Reference	Reference	Reference	Reference	Reference	Reference
Health Insurance						
Private/public insurance	Reference	Reference	Reference	Reference	Reference	Reference
No insurance	−0.1 (−0.26, 0.06)	0.07 (−0.09, 0.22)	0.05 (−0.02, 0.11)	−0.06 (−0.29, 0.18)	−0.02 (−0.21, 0.17)	−0.04 (−0.20, 0.11)
Covariates						
Other Socio-demographics						
Age in years						
45-54	Reference	Reference	Reference	Reference	Reference	Reference
55-64	**0.17 (0.08, 0.25)** ***	0.08 (0, 0.17)	**0.08 (0.02, 0.13)** **	−0.09 (−0.19, 0.02)	0.02 (−0.08, 0.12)	−0.05 (−0.13, 0.03)
65-75	**0.16 (0.05, 0.27)** **	0.08 (−0.04, 0.20)	**0.11 (0.05, 0.17)** **	−0.13 (−0.27, 0.02)	**−0.17 (-0.31, -0.03)** *	**−0.18 (-0.28, -0.06)** **
Sex						
Male	Reference	Reference	Reference	Reference	Reference	Reference
Female	0.05 (−0.01, 0.12)	0.05 (−0.03, 0.12)	0 (−0.04, 0.05)	0.04 (−0.05, 0.13)	0 (−0.08, 0.09)	0.06 (−0.01, 0.13)
Employment Status						
Currently employed	Reference	Reference	Reference	Reference	Reference	Reference
Not currently employed	0.10 (0, 0.20)	0.07 (−0.04, 0.18)	−0.03 (−0.10, 0.04)	0.12 (0, 0.24)	0.10 (−0.02, 0.21)	0.03 (−0.07, 0.13)
Retired	**0.13 (0.03, 0.22)***	**0.19 (0.10, 0.29)*****	**0.06 (0.02, 0.10)***	0 (−0.12, 0.11)	−0.03 (−0.14, 0.08)	0.02 (−0.07, 0.11)
Marital Status						
Married or living with a partner	Reference	Reference	Reference	Reference	Reference	Reference
Widowed, divorced, separated	−0.03 (−0.12, 0.06)	−0.02 (−0.12, 0.07)	−0.01 (−0.08, 0.05)	−0.01 (−0.13, 0.10)	−0.12 (−0.23, 0)	−0.08 (−0.17, 0.01)
Never married	0 (−0.11, 0.10)	−0.05 (−0.17, 0.07)	0.03 (−0.03, 0.09)	−0.09 (−0.23, 0.05)	−0.12 (−0.26, 0.03)	**−0.17 (-0.29, -0.04)** **
Self-reported Health Status						
Self-rated General Health						
Excellent	Reference	Reference	Reference	Reference	Reference	Reference
Very good	0.10 (−0.02, 0.22)	−0.01 (−0.14, 0.12)	−0.03 (−0.10, 0.04)	0 (−0.15, 0.15)	−0.10 (−0.24, 0.05)	−0.03 (−0.14, 0.08)
Good	0.06 (−0.07, 0.18)	−0.02 (−0.16, 0.11)	−0.04 (−0.11, 0.02)	−0.10 (−0.25, 0.06)	−0.07 (−0.22, 0.09)	**−0.13 (-0.24, -0.01)***
Fair or poor	0.11 (−0.03, 0.26)	−0.03 (−0.19, 0.13)	0 (−0.07, 0.08)	−0.10 (−0.29, 0.08)	−0.16 (−0.34, 0.02)	−0.05 (−0.19, 0.09)
Body Mass Index						
Underweight	−0.07 (−0.37, 0.22)	0.24 (0, 0.43)	–[a]	−0.11 (−0.64, 0.42)	−0.07 (−0.43, 0.28)	−0.04 (−0.35, 0.27)
Normal weight	Reference	Reference	Reference	Reference	Reference	Reference

(*continued on next page*)

Table 4 (*continued*)

	Awareness			Knowledge of Initiation Age		
	FIT/gFOBT	mt-sDNA	Colonoscopy	FIT/gFOBT	mt-sDNA	Colonoscopy
	AME (95% CI)	AME (95% CI)	AME (95% CI)	AME (95% CI)	AME (95% CI)	AME (95% CI)
Overweight	0.01 (−0.08, 0.11)	0 (−0.10, 0.10)	0.01 (−0.06, 0.07)	0.06 (−0.07, 0.18)	0.08 (−0.04, 0.20)	0.08 (−0.02, 0.18)
Obese	**0.11 (0.01, 0.20)***	−0.01 (−0.11, 0.08)	0.03 (−0.03, 0.09)	0.06 (−0.07, 0.18)	0.08 (−0.05, 0.20)	0.06 (−0.04, 0.16)
Non-CRC Cancer History						
Yes	0.01 (−0.11, 0.12)	0.04 (−0.07, 0.15)	0.06 (0, 0.11)	0.06 (−0.08, 0.19)	0.06 (−0.06, 0.17)	0.01 (−0.10, 0.13)
No	Reference	Reference	Reference	Reference	Reference	Reference
Healthcare Access						
Recent Routine Checkup						
Less than 2 years ago	Reference	Reference	Reference	Reference	Reference	Reference
3–5 years ago	0.04 (−0.10, 0.18)	−0.06 (−0.23, 0.12)	−0.09 (−0.21, 0.04)	−0.08 (−0.29, 0.13)	0.18 (−0.02, 0.36)	0.07 (−0.13, 0.26)
More than 5 years ago or never	−0.02 (−0.18, 0.13)	−0.18 (−0.36, 0.01)	−0.04 (−0.14, 0.07)	−0.05 (−0.27, 0.17)	−0.01 (−0.23, 0.21)	−0.09 (−0.28, 0.10)
Provider recommended FIT/gFOBT during past 12 months [b]						
Yes	–	–	–	0.01 (−0.09, 0.12)		
No	–	–	–	Reference	Reference	Reference
Provider recommended mt-sDNA during past 12 months [b]						
Yes	–	–	–	–	0.04 (−0.07, 0.14)	–
No	–	–	–	Reference	Reference	Reference
Provider recommended a screening colonoscopy during past 12 months [b]						
Yes	–	–	–	–	–	0.04 (−0.04, 0.12)
No	–	–	–	Reference	Reference	Reference

Note.

$^{***}p < .001$, $^{**}p < .01$, $^{*}p < .05$.

AME is the discrete change in the predicted probability of the outcome when moving from the referent group to each other group. All estimates are weighted.

[a] The group "Underweight" was omitted because no underweight participants reported being unaware of colonoscopy.

[b] Provider recommendation was omitted from analyses on awareness because all participants who reported unaware of the screening modality were coded as "No" for provider recommendation.

gFOBT utilization, while having an income <100% of FPL and within 150%–200% of FPL were associated with a decrease in the probability of colonoscopy utilization (all $p < .01$).

Regarding covariates, being of age 65–75 and having a provider recommendation were associated with higher FIT/gFOBT utilization, being obese and having a provider recommendation was associated with higher mt-sDNA utilization, while having no recent routine checkup in last 5 years was associated with lower colonoscopy utilization. Additionally, knowing the initiation age only was associated with lower utilization of FIT/gFOBT and mt-sDNA while knowing the screening interval only or knowing both the initiation age and screening interval was associated with higher colonoscopy utilization.

Discussion

We examined the associations of race/ethnicity and SES with awareness, knowledge, and utilization of three CRC screening modalities recommended by major CRC screening guidelines: FIT/gFOBT, mt-sDNA, and screening colonoscopy. Consistent with Hypothesis 1, our findings revealed racial/ethnic and SES disparities in awareness and knowledge of CRC screening modalities, particularly for mt-sDNA, the most recently introduced of the guideline-recommended modalities. Compared to non-Hispanic white participants, Hispanic, Asian, and other/multi-race participants were less likely to be aware of mt-sDNA and black participants were less likely to know the recommended age to initiate screening using mt-sDNA. Notably, for the two screening modalities that have been available for much longer, FIT/gFOBT and colonoscopy, racial/ethnic disparities in knowledge still exist – other/multi-race participants were less likely to know the initiation age for FIT/gFOBT and Asian participants were less likely to know the screening interval for colonoscopy. These findings were consistent with previous research (Gu & Thapa, 2020; Jerant, Arellanes, & Franks, 2008; Juon, Guo, Kim, & Lee, 2018; J.; Wang, Moehring, Stuhr, & Krug, 2013), suggesting racial/ethnic minorities face persistent barriers to access information about all CRC screening modalities, not just newly introduced modalities like mt-sDNA. For racial/ethnic minority immigrant communities, English proficiency and knowledge of US healthcare systems are additional barriers to CRC screening (Diaz, Roberts, Goldman, Weitzen, & Eaton, 2008; Sentell, Braun, Davis, & Davis, 2013). Community-based interventions utilizing media platforms and lay health workers that share common language and cultural backgrounds with the community members may help overcome language and cultural barriers to increase CRC screening awareness, knowledge, and eventually utilization (Mojica, Parra-Medina, & Vernon, 2018; Moralez, Rao, Livaudais, & Thompson, 2012; Nguyen et al., 2017; Wu et al., 2010).

In terms of utilization, none of our Asian participants had ever used mt-sDNA, likely a result of low awareness and knowledge of this modality. Contrary to our findings regarding other racial/ethnic minorities, black participants in this study showed comparable or higher levels of utilization of all three screening modalities when compared with non-Hispanic white participants, a finding consistent with other recent national surveys (Goding Sauer, Siegel, Jemal, & Fedewa, 2019; Joseph, King, Dowling, Thomas, & Richardson, 2020). Historically, black populations had lower CRC screening rates than non-Hispanic white populations. The improving black-white disparities in CRC screening likely resulted from targeted education about CRC risk factors among black communities and concerted efforts to reduce inequities in CRC screening access (Luque, Ross, & Gwede, 2014; Naylor, Ward, & Polite, 2012; Roy et al., 2021).

Regarding SES factors, lower educational attainment was associated with lower probability of knowing the initiation age and screening interval for mt-sDNA and the screening interval for colonoscopy. Meanwhile, lower household income (<200% of FPL) was associated with lower probability of knowing the initiation age and screening interval for colonoscopy. Additionally, no insurance with associated with lower probability of knowing the screening interval for mt-sDNA. In terms of utilization, lower income individuals (income <200% of FPL) were more likely to have used FIT/gFOBT while less likely to have used colonoscopy. It is worth noting that no SES differences were found regarding FIT/gFOBT awareness or knowledge and lower income individuals were more likely to have used it, likely because FIT/gFOBT has been on the market for much longer than mt-sDNA and is cheaper and more

Table 5
Average marginal effect of race/ethnicity and SES on the predicted probability of knowledge of the testing interval and utilization of each CRC screening modality.

	Knowledge of Testing Interval			Utilization		
	FIT/gFOBT	mt-sDNA	Colonoscopy	FIT/gFOBT	mt-sDNA	Colonoscopy
	AME (95% CI)	AME (95% CI)	AME (95% CI)	AME (95% CI)	AME (95% CI)	AME (95% CI)
Independent Variables						
Race/Ethnicity						
White, NH	Reference	Reference	Reference	Reference	Reference	Reference
Black, NH	0.13 (−0.04, 0.29)	−0.03 (−0.15, 0.07)	0.05 (−0.07, 0.18)	**0.16 (0.01, 0.31)***	−0.02 (−0.13, 0.09)	0.11 (0, 0.20)
Hispanic	0.02 (−0.14, 0.19)	−0.04 (−0.20, 0.12)	−0.02 (−0.14, 0.11)	0.08 (−0.10, 0.25)	0.01 (−0.11, 0.13)	0.08 (−0.04, 0.20)
Asian, NH	−0.03 (−0.31, 0.26)	0.33 (−0.14, 0.83)	**−0.23 (-0.32, -0.17)** **	0.09 (−0.18, 0.37)	–[a]	−0.04 (−0.35, 0.28)
Other or Multiple race, NH	0.02 (−0.14, 0.19)	0.02 (−0.17, 0.23)	−0.06 (−0.19, 0.06)	0.04 (−0.16, 0.23)	−0.09 (−0.31, 0.14)	−0.02 (−0.18, 0.14)
Education						
Less than high school	−0.03 (−0.26, 0.20)	**−0.16 (-0.29, -0.03)** *	**−0.28 (-0.40, -0.16)** **	−0.01 (−0.20, 0.18)	0.21 (−0.01, 0.42)	−0.01 (−0.16, 0.15)
High school	−0.03 (−0.15, 0.08)	−0.10 (−0.20, 0)	**−0.14 (-0.23, -0.05)** **	−0.02 (−0.14, 0.09)	0.02 (−0.08, 0.12)	−0.04 (−0.14, 0.06)
Some college	−0.04 (−0.14, 0.06)	−0.03 (−0.12, 0.07)	**−0.11 (-0.18, -0.03)** **	−0.09 (−0.20, 0.02)	−0.05 (−0.13, 0.03)	−0.01 (−0.10, 0.07)
Bachelor's degree or higher	Reference	Reference	Reference	Reference	Reference	Reference
Household Income Compared to Federal Poverty Level (FPL)						
<100% of FPL	0.02 (−0.17, 0.21)	−0.03 (−0.18, 0.11)	−0.01 (−0.17, 0.14)	0.18 (−0.02, 0.36)	0.14 (−0.04, 0.30)	**−0.21 (-0.35, -0.05)** **
100% to <150% of FPL	−0.04 (−0.24, 0.15)	0.01 (−0.16, 0.18)	**−0.17 (-0.29, -0.06)** *	0.11 (−0.09, 0.31)	0.05 (−0.09, 0.19)	−0.05 (−0.19, 0.09)
150% to <200% of FPL	0.03 (−0.15, 0.20)	−0.01 (−0.15, 0.12)	**−0.14 (-0.26, -0.05)** **	**0.24 (0.06, 0.42)****	0.10 (−0.06, 0.24)	**−0.19 (-0.32, -0.05)** **
200% to <300% of FPL	0.02 (−0.13, 0.18)	0.03 (−0.11, 0.17)	−0.01 (−0.13, 0.10)	0.09 (−0.07, 0.24)	0.10 (−0.03, 0.23)	−0.07 (−0.18, 0.05)
300% to <400% of FPL	−0.07 (−0.21, 0.06)	0.05 (−0.07, 0.18)	0.04 (−0.07, 0.15)	0.08 (−0.06, 0.22)	0.02 (−0.09, 0.12)	−0.11 (−0.22, 0.01)
400% to <600% of FPL	0.02 (−0.12, 0.15)	−0.07 (−0.18, 0.02)	−0.04 (−0.14, 0.06)	0.08 (−0.05, 0.22)	0.06 (−0.04, 0.16)	−0.06 (−0.16, 0.04)
≥600% of FPL	Reference	Reference	Reference	Reference	Reference	Reference
Health Insurance						
Private/public insurance	Reference	Reference	Reference	Reference	Reference	Reference
No insurance	0.06 (−0.17, 0.30)	**−0.14 (-0.25, -0.05)** **	−0.07 (−0.26, 0.11)	−0.13 (−0.30, 0.05)	−0.09 (−0.21, 0.05)	−0.08 (−0.24, 0.08)
Covariates						
Other Socio-demographics						
Age in years						
45–54	Reference	Reference	Reference	Reference	Reference	Reference
55–64	−0.09 (−0.20, 0.02)	0 (−0.10, 0.10)	**0.08 (0.01, 0.16)***	0.08 (−0.03, 0.19)	0.02 (−0.09, 0.13)	**0.25 (0.14, 0.35)*****
65–75	−0.11 (−0.24, 0.02)	−0.04 (−0.15, 0.07)	0.02 (−0.08, 0.12)	**0.23 (0.10, 0.36)****	0.04 (−0.09, 0.16)	**0.27 (0.14, 0.39)*****
Sex						
Male	Reference	Reference	Reference	Reference	Reference	Reference
Female	−0.07 (−0.16, 0.01)	0 (−0.08, 0.07)	**0.11 (0.05, 0.18)*****	0.06 (−0.02, 0.14)	−0.02 (−0.09, 0.05)	0 (−0.07, 0.07)
Employment Status						
Currently employed	Reference	Reference	Reference	Reference	Reference	Reference
Not currently employed	0.04 (−0.09, 0.16)	−0.03 (−0.13, 0.06)	0.03 (−0.07, 0.12)	0 (−0.13, 0.13)	−0.02 (−0.12, 0.08)	−0.01 (−0.12, 0.10)
Retired	0.06 (−0.05, 0.17)	−0.02 (−0.11, 0.07)	0.08 (0, 0.18)	0.01 (−0.09, 0.12)	0.04 (−0.05, 0.13)	0.05 (−0.05, 0.14)
Marital Status						
Married or living with a partner	Reference	Reference	Reference	Reference	Reference	Reference
Widowed, divorced, separated	−0.08 (−0.18, 0.03)	0.01 (−0.08, 0.11)	−0.06 (−0.14, 0.02)	−0.09 (−0.19, 0.02)	−0.02 (−0.11, 0.07)	−0.07 (−0.16, 0.03)
Never married	−0.1 (−0.23, 0.02)	0.07 (−0.05, 0.20)	**−0.13 (-0.22, -0.06)** **	0 (−0.14, 0.13)	−0.02 (−0.13, 0.10)	−0.03 (−0.14, 0.08)
Self-reported Health Status						
Self-rated General Health						
Excellent	Reference	Reference	Reference	Reference	Reference	Reference
Very good	−0.06 (−0.22, 0.10)	−0.04 (−0.17, 0.08)	−0.10 (−0.21, 0)*	−0.01 (−0.15, 0.12)	−0.07 (−0.19, 0.06)	0.01 (−0.11, 0.13)
Good	−0.09 (−0.25, 0.08)	−0.04 (−0.18, 0.10)	−0.04 (−0.15, 0.07)	−0.04 (−0.18, 0.09)	−0.07 (−0.19, 0.06)	0.04 (−0.09, 0.16)
Fair or poor	−0.14 (−0.33, 0.04)	−0.02 (−0.18, 0.14)	**−0.14 (-0.28, -0.02)** *	−0.05 (−0.22, 0.12)	−0.11 (−0.25, 0.04)	0.05 (−0.10, 0.19)
Body Mass Index						
Underweight	0.04 (−0.42, 0.49)	0.08 (−0.24, 0.41)	0.02 (−0.25, 0.29)	−0.20 (−0.43, 0.04)	−0.07 (−0.18, 0.06)	0.16 (−0.05, 0.36)
Normal weight	Reference	Reference	Reference	Reference	Reference	Reference
Overweight	−0.06 (−0.18, 0.06)	0.01 (−0.08, 0.11)	0.05 (−0.04, 0.14)	0.07 (−0.05, 0.18)	0.04 (−0.04, 0.11)	0.04 (−0.06, 0.13)
Obese	−0.09 (−0.21, 0.04)	0.06 (−0.04, 0.16)	−0.04 (−0.13, 0.05)	0.03 (−0.08, 0.15)	**0.14 (0.04, 0.22)****	0.10 (0, 0.20)

(*continued on next page*)

Table 5 (*continued*)

	Knowledge of Testing Interval			Utilization		
	FIT/gFOBT	mt-sDNA	Colonoscopy	FIT/gFOBT	mt-sDNA	Colonoscopy
	AME (95% CI)	AME (95% CI)	AME (95% CI)	AME (95% CI)	AME (95% CI)	AME (95% CI)
Non-CRC Cancer History						
Yes	−0.05 (−0.18, 0.09)	0.09 (−0.05, 0.25)	0.01 (−0.08, 0.10)	0.08 (−0.04, 0.20)	0.03 (−0.08, 0.14)	0.07 (−0.04, 0.16)
No	Reference	Reference	Reference	Reference	Reference	Reference
Healthcare Access						
Recent Routine Checkup						
Less than 2 years ago	Reference	Reference	Reference	Reference	Reference	Reference
3–5 years ago	−0.09 (−0.28, 0.11)	−0.01 (−0.17, 0.15)	**−0.22 (-0.32, -0.15)** **	0.05 (−0.19, 0.29)	0.18 (−0.09, 0.44)	−0.01 (−0.20, 0.17)
More than 5 years ago or never	0.12 (−0.19, 0.42)	0.02 (−0.18, 0.21)	**−0.21 (-0.31, -0.14)** **	−0.14 (−0.41, 0.14)	–[b]	**−0.46 (-0.65, -0.26)** *
Provider recommended FIT/gFOBT during past 12 months						
Yes	**0.10 (0.01, 0.20)***	–	–	**0.44 (0.36, 0.53)** ***		−0.02 (−0.10, 0.05)
No	Reference	Reference	Reference	Reference	Reference	Reference
Provider recommended mt-sDNA during past 12 months						
Yes	–	0 (−0.11, 0.11)	–	–	**0.60 (0.49, 0.70)*****	–
No	Reference	Reference	Reference	Reference	Reference	Reference
Provider recommended a colonoscopy during past 12 months						
Yes	–	–	−0.02 (−0.09, 0.05)	–	–	−0.02 (−0.10, 0.05)
No	Reference	Reference	Reference	Reference	Reference	Reference
Knowledge of FIT/gFOBT Initiation Age and Testing Interval						
None	–	–	–	Reference	Reference	Reference
Know initiation age only	–	–	–	**−0.15 (-0.26, -0.04)***	–	–
Know testing interval only	–	–	–	−0.11 (−0.27, 0.05)	–	–
Know both	–	–	–	−0.10 (−0.23, 0.02)	–	–
Knowledge of Mt-sDNA Initiation Age and Testing Interval						
None	–	–	–	Reference	Reference	Reference
Know initiation age only	–	–	–	–	**−0.14 (-0.22, -0.04)** **	–
Know testing interval only	–	–	–	–	−0.06 (−0.21, 0.10)	–
Know both	–	–	–	–	−0.07 (−0.20, 0.06)	–
Knowledge of Colonoscopy Initiation Age and Testing Interval						
None	–	–	–	Reference	Reference	Reference
Know initiation age only	–	–	–	–	–	0.03 (−0.07, 0.13)
Know testing interval only	–	–	–	–	–	**0.30 (0.18, 0.40)****
Know both	–	–	–	–	–	**0.24 (0.14, 0.34)*****

Note.
AME is the discrete change in the predicted probability of the outcome when moving from the referent group to each other group. All estimates are weighted.
***$p < .001$, **$p < .01$, *$p < .05$.
[a] The group "Asian, NH" was omitted because no Asian participants reported mt-sDNA utilization.
[b] The group "More than 5 years ago or never" was omitted because no individuals in this group reported mt-sDNA utilization.

accessible than screening colonoscopy.

Although CRC screening guidelines recommend initiating CRC screening at age 45 or 50 regardless of the screening modality, we found that many participants inaccurately assumed that the age to initiate CRC screening differs by screening modality. This finding has important implications for outreach and education efforts to improve CRC screening uptake, demonstrating a need to emphasize in CRC screening messaging the uniform initiation age for all modalities.

Comparing across CRC screening modalities, more racial/ethnic and SES differences were observed in awareness, knowledge, and utilization of screening colonoscopy and mt-sDNA than FIT/gFOBT. This finding aligns with Hypothesis 2 and 3 and supports the argument that people's perceptions of the attributes of the medical innovations may moderate their diffusion across different segments of the population (Chang & Lauderdale, 2009; Goldman & Lakdawalla, 2005); a complex medical innovation with high demand on patient time, effort, skills, and/or money (e.g., colonoscopy) may disproportionally benefit people with more social and economic resources and this disparity may persist for a long time after its introduction into clinical practice, while innovations with low demand on patient time, effort, skills, and/or money (e.g., stool-based tests) may lead to more equitable diffusion and uptake across sections of society.

Overall, our findings on the racial/ethnic and SES disparities in the awareness, knowledge, and utilization of CRC screening modalities are consistent with previous FCT and DOI research that inequities in social and economic resources are associated with imbalanced diffusion of medical innovations (Chang & Lauderdale, 2009; Korda, Clements, & Dixon, 2011; Polonijo & Carpiano, 2013). Race/ethnicity and education level embody social and economic resources, these factors influence where people live and work, who they have social connections with, and their abilities to access information about disease prevention and control (Link & Phelan, 1995). Similarly, health insurance and people's awareness of cancer screening coverage represents economic resources by reducing the financial burden of healthcare utilization, thus allowing greater access to healthcare providers and more opportunities to learn about medical innovations.

These findings demonstrate a need to improve awareness, knowledge, and access to various CRC screening modalities among certain populations as defined by race/ethnicity or SES indicators. Education efforts to improve CRC screening awareness and knowledge among racial/ethnic minorities and lower SES populations should consider tailoring content and implementation strategies to the needs and social-cultural context of specific communities. Example intervention strategies that have been shown to be effective at reducing CRC screening disparities include 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 stool-based tests with as-needed patient navigation (Issaka, Avila, Whitaker, Bent, & Somsouk, 2019; Luque et al., 2014; Mojica et al., 2018; Naylor et al., 2012; Roland et al., 2017). When choosing communication channels for outreach and education efforts, it is also important to take into account the complex and competitive nature of the information environment and the target audience's media use habits, values, and preferences. Innovative communication strategies and unconventional venues may be required to deliver messages to communities and sub-populations who are difficult to reach via traditional mass media channels. Additionally, efforts to improve CRC screening access among racial/ethnic minorities and lower SES populations should take into consideration the nature of different screening modalities. Screening modalities with lower demand on patient time, effort, skills, and/or money may be more likely to achieve widespread, equitable adoption, and therefore be more likely to reduce disparities in CRC-related health outcomes. Healthcare policies that address inequities in social and economic resources, such as expanding health insurance coverage, would facilitate more widespread, equitable CRC screening uptake as well. Additionally, policymakers may consider requiring state Medicaid agencies to track and measure CRC screening uptake by different screening modalities, as is currently required for commercial and Medicare plans.

Limitations

First, the cross-sectional survey design limits our ability to examine the causal relationships between different stages of medical innovation adoption and precludes examination of trends of CRC screening adoption over time. Future research with a longitudinal design is encouraged. Second, we relied on self-reported data to measure CRC screening utilization, which may contain misreporting. However, previous research demonstrates that self-reports of CRC screening behaviors are generally accurate, though may differ by modality (Partin et al., 2008). We were unable to examine potential interaction effects between race/ethnicity, SES indicators, and other socio-demographic, health, and healthcare characteristics with adequate statistical power due to the limited number of participants in some of the race/ethnicity and SES categories. Future research could consider oversampling racial/ethnic minorities and certain SES categories to enable examination of interaction effects on adoption of different CRC screening modalities. Although the final socio-demographic distribution of our sample closely aligns with that of the US adult population, lower survey completion rates among socially and economically disadvantaged subpopulation groups suggest these communities face more barriers to participation in health research, such as mistrust and competing demands in life (George, Duran, & Norris, 2014). Future research may benefit from adopting community-based strategies to enhance research participation in disadvantaged communities by building trusting relationships, addressing participant concerns, and improving access to health research (Bonevski et al., 2014; George et al., 2014). Due to the need to reduce response burden, we were unable to capture more information on health insurance coverage that may be influential to CRC screening. Future research could make use of electronic medical record and administrative data to capture individuals' access to network of providers, access to screening modalities, and out-of-pocket costs. Finally, future research is encouraged to examine additional factors that are indicative of social and economic resources beyond those described here, such as immigration status, rural-urban status, and area-level deprivation.

Conclusions

SES and racial/ethnic disparities exist in the awareness, knowledge, and utilization of three commonly used CRC screening modalities recommended by major CRC screening guidelines: FIT/gFOBT, mt-sDNA, and screening colonoscopy. Patterns of these disparities are consistent with previous FCT and DOI research showing that inequities in social and economic resources are associated with an imbalanced diffusion of medical innovations. These findings demonstrate a need to increase awareness, knowledge, and access of various CRC screening modalities in specific populations defined by race/ethnicity and/or SES indicators. Efforts to increase CRC screening uptake in racial/ethnic minorities and lower SES populations should be tailored to the needs and social-cultural context of those communities. Interventions addressing inequalities in social and economic resources are also needed to achieve more equitable diffusion of CRC screening technologies and reduce disparities in CRC-related health outcomes.

Ethical statement

This study was deemed exempt by the NORC IRB.

Each listed author contributed significantly to the manuscript and all have complied with the Committee on Publication Ethics (COPE) guidelines on ethical responsibilities of authors. The findings reported herein have not been published previously, and the manuscript is not simultaneously under consideration elsewhere. The content has been reviewed and approved by all authors for submission to your journal.

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Author contributions (CRediT roles)

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. **Joan M. Griffin**: 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

EW is an employee of Exact Sciences Corporation. PDP was an employee of Exact Sciences Corporation at the time of manuscript developemnt. PJL serves as Chief Medical Officer for Screening at Exact Sciences through a contracted services agreement with Mayo Clinic. PJL and Mayo Clinic have contractual rights to receive royalties through this agreement. LJFR and JMG offer scientific input to research studies through a contracted services agreement between Mayo Clinic and Exact Sciences. XZ reports no competing interests.

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