Factors influencing colorectal cancer screening decision-making among average-risk US adults

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Abstract

Colorectal cancer (CRC) screening rates remain suboptimal in the US. We examined patient-focused concerns and influence of various factors (e.g., test attributes, provider recommendation) on CRC screening decision-making. We conducted a web survey with 1595 US adults aged 40–75 from a nationally representative panel in November 2019 (completion rate: 31.3%). Analyses focused on individuals aged 45–75 years at average-risk for CRC (n = 1062). All participants rated their level of concern about various CRC screening test/procedure attributes. Participants who have screened previously designated the three most important attributes for choosing a screening method and rated how various factors influenced their decision to use a particular method. The top concern for participants who have not screened previously was having an invasive procedure (54.2%) while the top concerns for participants who have screened previously were completing a colon prep (41.3%) and test/procedure accuracy (41%). Cost/insurance coverage was most frequently ranked among the most important attributes (48.5%), followed by where the test can be taken (45.7%) and test accuracy (43.6%). Provider recommendation was reported as the major motivator across screening methods. Other factors that were frequently reported as very influential included convenience and comfort for the stool-based methods and scientific/clinical evidence and insurance coverage for colonoscopy. Variations by age, sex, and race/ethnicity were noted. Findings demonstrate that along with provider recommendation, patient preferences regarding test/procedure attributes and preparation requirements are influential in screening decision-making, highlighting the need for clinicians to involve patients in shared decision-making and incorporate patient needs and preferences in establishing screening strategies.

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 (i.e., no prior diagnosis of CRC, adenomatous polyps, or inflammatory bowel disease; no personal diagnosis or family history of known genetic disorders that predispose them to a high lifetime risk of CRC) between the ages of 45–75 years (Wolf et al., 2018; U. S., 2021). Despite clear evidence that regular screening reduces CRC mortality (Edwards et al., 2010; Zauber et al., 2008) and the availability of multiple screening methods, CRC screening rates among the average-risk population remain suboptimal in the US (Steele et al., 2013; Davis et al., 2017; Singal et al., 2017). Thus, in-depth understanding of the factors influencing CRC screening decision-making is critical for improving population uptake of and adherence to guideline-endorsed screening options.

Several patient-level factors have been found to be associated with CRC screening completion and adherence (Honein-AbouHaidar et al., 2017). Preventive Medicine Reports 30 (2022) 102047

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ABBREVIATIONS

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

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perceived importance of each factor when choosing a particular sDNA, and screening colonoscopy) from three angles: 1) level of
completing this survey. The planned sample size was 1500, aiming for a
sample coverage of approximately 97% of the US household population
(AmeriSpeak Panel Design, 2022). Panelists were invited to participate
by non-response, non-coverage, and panel attrition and to allow the
margin of error around 3% at a 95% confidence level. We estimated a
completion rate of 35% and a qualification rate of 90% based on in-
formation provided by NORC regarding average completion rates of
prior survey studies using this panel. Details on sampling methodology,
survey design, pre-testing, and data collection have been reported pre-
viously (Zhu et al., 2021).

4. Measures

We focused on three sets of measures to assess how various factors
shape patients’ CRC screening decision-making. We first measured all
participants’ level of concern over 8 test/procedure factors on a 5-point
scale (1 = Not at all concerned to 5 = Extremely concerned). The
question was “When you think about your options for colorectal cancer
screening, how concerned are you about: 1) Cost to take the test/pro-
cedure, 2) Accuracy of the test/procedure, 3) Having to collect samples
of your stool, 4) Completing screening every year, 5) Completing a prep
to empty the colon, 6) Having an invasive procedure, 7) Taking time off
work or other activities to complete screening, and 8) Being sedated and
needling someone to drive you home after the screening.”

Participants who previously completed CRC screening using any of
the three methods (FIT/gFOBT, mt-sDNA, or colonoscopy) were then
told to select the three most important test/procedure qualities that
influenced their decision to choose a particular screening method from
11 attributes, including 1) How often the test needs to be done, 2) Where
the test can be taken (at home vs healthcare provider office), 3) Cost
and/or health insurance coverage of test, 4) Discomfort associated with
the test, 5) Complications associated with the test, 6) What needs to be
done to prepare for the test, 7) How long it takes to prepare for the test,
8) How long it takes to do the test, 9) How invasive the test is, 10) Ac-
curacy of the test, 11) Additional testing needed for abnormal results.

Among this same group of participants, we also measured the level of
influence a list of factors had on their decision to complete CRC
screening using each screening method on a 5-point scale (1 = Not at all
influential to 5 = Very influential). The factors included 1) family or
friend recommendation, 2) insurance coverage, 3) convenience, 4)
comfort with the procedure/test, 5) ease of use, 6) scientific/clinical
evidence, 6) test/procedure used innovative technology, and 7) provider
recommendation.

Additionally, participants self-reported whether they have personal
or familial CRC history and colorectal conditions that would make them
ineligible for average-risk CRC screening using guideline endorsed stool-
based tests (e.g., ulcerative colitis, Crohn’s disease, colorectal polyps)
(Bibbings-Domingo et al., 2016). Participants also self-reported socio-
demographic characteristics including age, sex, race, ethnicity, educa-
tion level, household income, and health insurance coverage.

4.1. Statistical analysis

A total of 1595 completed surveys (1433 by web and 162 by phone) were
obtained from 5097 panelists who were invited to participate (31.3%). Analyses were focused on the subpopulation of respondents
ages 45 to 75, for whom population screening is recommended. Partic-
ants who reported personal or familial CRC history or colorectal
conditions that would make them ineligible for average-risk CRC
screening using stool-based tests were excluded (Bibbings-Domingo et al.,
2016). The final analysis sample size was 1062.

We applied sampling weights to correct for potential bias introduced
by non-response, non-coverage, and panel attrition and to allow the
estimates to be nationally representative. To account for the complex
survey design, Taylor-series linearization method was used to estimate
variance (Barrio et al., 2011; Graubard and Korn, 1996; Lumley, 2004).
We used weighted descriptive statistics to summarize participants’ level
of concern over test/procedure attributes for screening decision-making.
We used multivariable ordinal logistic regression to examine the dif-
fences in the level of concern over test/procedure attributes between

2016; Nagelhout et al., 2017; Muthukrishnan et al., 2019; Jones et al.,
2010; Wilkins et al., 2012; Beydoun and Beydoun, 2008; Bynum et al.,
2012; Vrinten et al., 2015). Frequently reported influential factors
include awareness and knowledge of CRC and CRC screening (Honein-
AbouHaidar et al., 2016; Nagelhout et al., 2017; Wilkins et al., 2012;
Beydoun and Beydoun, 2008), provider recommendation (Nagelhout
et al., 2017; Jones et al., 2010; Beydoun and Beydoun, 2008), screening
procedure or preparation requirements (Jones et al., 2010; Wilkins
et al., 2012), socioeconomic status (Honein-AbouHaidar et al., 2016;
Muthukrishnan et al., 2019; Beydoun and Beydoun, 2008), healthcare
access (Muthukrishnan et al., 2019; Jones et al., 2010; Beydoun and
Beydoun, 2008), logistical challenges to obtain screening (Muthuk-
rishnan et al., 2019; Jones et al., 2010; Wilkins et al., 2012), medical
mistrust (Nagelhout et al., 2017; Bynum et al., 2012), feelings of
embarrassment (Nagelhout et al., 2017; Wilkins et al., 2012; Beydoun
and Beydoun, 2008; Bynum et al., 2012), and fear of finding cancer
(Nagelhout et al., 2017; Wilkins et al., 2012; Beydoun and Beydoun,
2008; Bynum et al., 2012; Vrinten et al., 2015). With the emergence of
new CRC screening options, such as the mt-sDNA test, and the move-
ment toward greater engagement of patients in healthcare decisions,
there is a need for expanding our understanding of how various factors,
including CRC test efficacy, cost, preparation requirements, and
screening interval, influence patients’ CRC screening decision-making,
both in general and regarding completing CRC screening using a
particular screening method.

To address this knowledge gap, we examined how various factors
influence patients’ CRC screening decision-making in general and the
use of commonly recommended screening methods (FIT/gFOBT, mt-
sDNA, and screening colonoscopy) from three angles: 1) level of
concern over each factor when making CRC screening decisions, 2)
perceived importance of each factor when choosing a particular
screening method, and 3) level of influence of each factor on patient-
focused decisions to complete CRC screening using a particular test
method. Additionally, we examined how the level of concern vary by
previous CRC screening utilization and examined among participants
who have screened using any of the common methods how the impor-
tance and influence of various factors on their decision to use that
particular screening method vary by their sociodemographic charac-
teristics. Findings from this research will inform interventional efforts
to better align provider recommendations to the needs and preferences
of CRC screening-eligible patients to improve screening rates.

2. Methods

Data were collected from a general population survey covering a
broad range of knowledge, attitudinal, and behavioral questions related
to CRC screening. The survey was developed by the authors and carried
out by the National Opinion Research Center (NORC) at the University
of Chicago (https://www.norc.org) in November 2019.

3. Study participants

Study participants were a sample of US adults aged 40–75 from
NORC’s AmeriSpeak Panel. The increasing incidence rates of CRC
among younger populations led to changes in ACS and USPSTF guide-
lines to recommend average-risk screening among those aged 45–49
years. Given the breadth of topics covered in our survey and growing
risk of CRC and relevance of CRC screening for younger age groups, we
selected to include those aged 40–44 in our overall sample. AmeriSpeak
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. The panel provides
sample coverage of approximately 97% of the US household population
(AmeriSpeak Panel Design, 2022). Panelists were invited to participate
by web or by phone and were offered an incentive equivalent to $5 for
completing this survey. The planned sample size was 1500, aiming for a
participants who have screened using any of the methods versus those who have not, adjusting for sociodemographic characteristics.

With the subsample of participants who have screened using any of the methods, we used weighted descriptive statistics to summarize the frequency of each attribute being ranked among the three most important attributes, and the level of influence each factor had on participants’ decision to complete CRC screening using a particular method. Binary logistic regression was used to examine the associations of sociodemographic characteristics with the test/procedure attribute being selected as one of the three most important attributes. Multivariable ordinal logistic regression was used to examine the associations of sociodemographic characteristics with the level of influence each factor had on participants’ decision to complete screening using a particular method. We adjusted p-values for multiple testing using the Benjamini-Hochberg procedure (Benjamini and Hochberg, 1995). All analyses were conducted in R (R: A language and environment for statistical computing, 2021) (Version 3.6.2).

5. Results

Table 1 summarizes sample characteristics. Among the 1062 participants, 37.6% were between age 45 and 54, 36.3% were between age 55 and 64, 26.1% were between age 65 and 75, 51.6% were females, 66.2% were non-Hispanic white, 11.7% were non-Hispanic black, 14.2% were Hispanic. 12.1% did not finish high school, 23.4% had a household income less than $25,000, and 7.2% did not have health insurance.

Table 2 summarizes participants’ level of concern over each factor when making CRC screening decisions. Participants who have never used any of the three methods most frequently reported moderate or extreme concern about having an invasive procedure (54.2%), followed by completing a colon prep (42%), being sedated and needing someone to drive them home after screening (41%), and taking time off work or other activities (36%). Participants who have used one or more of the three methods most frequently reported moderate or extreme concern about completing a colon prep (41.3%) and accuracy of the test/procedure (41%), followed by having an invasive procedure (35.4%). Regardless of whether they have used the three screening methods previously, participants were least concerned about having to collect stool samples (19.6% and 14.5% reported moderately/extremely concern).

Table 3 summarizes the associations between participants’ CRC screening utilization and their level of concern over each factor when making CRC screening decisions in general, adjusting for participant sociodemographic characteristics. Compared with participants who have not screened using any of the three methods, those who have used any of the methods reported lower concern over being sedated and needing someone to drive them home after screening (Adjusted Odds Ratio [aOR] = 0.56, 95%CI [0.39, 0.81]), taking time off work or other activities (aOR = 0.61, 95%CI [0.42, 0.88]), having an invasive procedure (aOR = 0.47, 95%CI [0.33, 0.67]), and having to collect samples of their stool (aOR = 0.63, 95%CI [0.43, 0.91]).

Fig. 1 summarizes the three most important test/procedure attributes participants reported for choosing a particular screening method. Among participants who have used any of the three methods, cost and/or health insurance coverage was most frequently ranked among the three most important attributes to consider when choosing a particular screening method (48.5%), followed by accuracy of the test (45.7%), how often the test needs to be done (43.6%), and where the test can be taken (34.7%). How long it takes to do the test, how long it takes to prepare for the test, and complications associated with the test were least frequently reported among the top three most important attributes to consider (7%, 12.3%, 13%).

Fig. 2 summarizes the associations between participant characteristics and each attribute being ranked among the three most important test/procedure attributes for choosing a particular screening method.

Table 1: Sample characteristics overall and by type of screening used.  a

| Type of screening used previously | Total | FIT/gFOBT | mt-sDNA | Colono scope |
|----------------------------------|-------|----------|---------|------------|
| Total                            | N (%) | N (%)    | N (%)   | N (%)      |
| Age 45–54                        | 390   | 234 (70.6) | 58 (15.8) | 22 (6.0)  |
| 55–64                            | 391   | 83 (21.5)  | 120 (41.6) | 47 (21.7) |
| 65–75                            | 281   | 32 (7.9)   | 130 (46.2) | 65 (22.8) |
| Sex                              |       |           |         |            |
| Male                             | 491   | 173 (54.7) | 138 (46.5) | 67 (23.1) |
| Female                           | 565   | 173 (44.0) | 168 (42.4) | 70 (23.2) |
| Household income                 |       |           |         |            |
| <$25,000                         | 220   | 78 (35.5)  | 75 (33.8) | 39 (17.7) |
| ≥$25,000                         | 917   | 476 (52.2) | 367 (39.9) | 174 (19.0) |
| Race/ethnicity                   |       |           |         |            |
| White, non-Hispanic              | 765   | 249 (62.4) | 209 (62.9) | 92 (36.1) |
| Hispanic                         | 118   | 26 (8.1)   | 45 (16.8)  | 23 (20.1) |
| Asian, NH                        | 18    | 4 (1.3)    | 7 (22.2)   | 0 (0.0)   |
| Other/multi-ethnic, NH           | 57    | 23 (7.0)   | 17 (7.2)   | 2 (2.4)   |
| Education                        |       |           |         |            |
| Less than high school            | 54    | 18 (14.3)  | 13 (12.3)  | 15 (24.2) |
| High school                      | 211   | 73 (35.9)  | 69 (32.8)  | 32 (15.3) |
| Some college                     | 424   | 152 (28.3) | 121 (28.8) | 49 (23.0) |
| Bachelor’s degree or higher      | 373   | 106 (28.8) | 95 (25.6)  | 10 (2.7)  |
| Health insurance                 |       |           |         |            |
| Private                          | 525   | 210 (57.4) | 112 (33.4) | 38 (26.8) |
| Public                           | 470   | 97 (29.5)  | 187 (62.9) | 91 (30.7) |
| No insurance                     | 66    | 42 (13.0)  | 8 (3.7)    | 3 (0.9)   |

* N is unweighted and % is weighted. Sampling weights were applied to the data to correct for potential bias introduced by non-responsiveness, noncoverage, and panel attrition and to allow the estimates to be nationally representative.

a Missing = 2.

b Include 59 participants who have used FIT/gFOBT only, 36 participants who have used both FIT/gFOBT and mt-sDNA but not colonoscopy, 144 participants who have used both FIT/gFOBT and colonoscopy but not mt-sDNA, and 69 participants who have used all three methods before.

c Include 6 participants who have used mt-sDNA only, 36 participants who have used both FIT/gFOBT and mt-sDNA but not colonoscopy, 23 participants who have used both mt-sDNA and colonoscopy but not FIT/gFOBT, and 69 participants who have used all three methods before.
4. Include 376 participants who have used colonoscopy only, 144 participants who have used both FIT/gFOBT and colonoscopy but not mt-sDNA, 23 participants who have used both mt-sDNA and colonoscopy but not FIT/gFOBT, and 69 participants who have used all three methods before.

5. Missing = 2, the “Other or prefer not to answer” category was omitted from analysis because it was rarely selected (n = 4).

6. Missing = 1.

Compared with non-Hispanic white participants, black participants and Hispanic participants more frequently ranked how often the test needs to be done among the top three most important attributes to consider (OR = 2.54, 95 %CI [1.29, 5]; OR = 3, 95 %CI [1.41, 6.41]). Hispanic participants also less frequently ranked accuracy of the test among the top three most important attributes to consider (OR = 0.24, 95 %CI [0.1, 0.55]). We did not observe statistically significant associations between participant characteristics and the rest of the attributes.

Fig. 3 summarizes the level of influence each factor had over participants’ decisions to complete CRC screening using each particular method. Across all three methods, provider recommendation was most frequently reported as very influential (52.8 % for FIT/gFOBT, 57.4 % for mt-sDNA, 57.4 % for colonoscopy). Other factors that were frequently reported as very influential include ease of use, convenience, and comfort with procedure for the stool-based tests (FIT/gFOBT: 36.3 %, 33.1 %, 32.8 %; mt-sDNA: 50.1 %, 50.1 %, 45.2 %) and scientific/clinical evidence and insurance coverage for colonoscopy (35.9 %, 35.4 %, 33.1 %, 35.4 %). Family or friend recommendation was least frequently reported as very influential across all three methods (10.5 % for FIT/gFOBT, 17.2 % for mt-sDNA, 12.1 % for colonoscopy). ORs and CIs of all models are reported in Appendix 1.

Fig. 4 summarizes the associations between participant characteristics and level of influence each factor had over their decision to complete CRC screening using each method. Regarding participants’ decisions to complete screening using colonoscopy, provider recommendation and insurance coverage were rated more influential by females than by males (OR = 1.8, 95 %CI [1.21, 2.69]; OR = 2.16, 95 %CI [1.48, 3.15]). Scientific/clinical evidence was rated less influential by people with high school or lower levels of education than by people with a bachelor’s degree or higher (OR = 0.46, 95 %CI [0.27, 0.79]). We did not observe statistically significant associations between participant characteristics and level of influence each factor had over decisions to use FIT/gFOBT or mt-sDNA. ORs and CIs of all models are reported in Appendix 2.

Table 2
Level of concern over each factor when making CRC screening decisions.a, b

| Concerns | Adjusted OR (95 % CI) a | Adjusted p-value b |
|----------|------------------------|-------------------|
| Cost to take the test/procedure (N = 1049) | 0.75 (0.52, 1.09) | 0.187 |
| Accuracy of the test/procedure (N = 1042) | 1.25 (0.89, 1.76) | 0.227 |
| Having to collect samples of your stool (N = 1046) | 0.63 (0.43, 0.91) | 0.030 |
| Completing screening every year (N = 1037) | 0.76 (0.52, 1.10) | 0.187 |
| Completing a prep to empty the colon (N = 1043) | 0.87 (0.61, 1.23) | 0.425 |
| Having an invasive procedure (N = 1042) | 0.47 (0.33, 0.67) | <0.001 |
| Taking time off work or other activities (N = 1040) | 0.61 (0.42, 0.88) | 0.022 |
| Being sedated and needing someone to drive you home after screening (N = 1044) | 0.56 (0.39, 0.81) | 0.007 |

a All models adjusted for participant age, sex, race/ethnicity, education level, income level, and health insurance status.

b Adjusted for multiple testing using the Benjamini-Hochberg procedure.

6. Discussion

Our national survey examined average-risk patients’ level of concern and the perceived importance of various test attributes for CRC screening decision-making, as well as the influence of patient-level factors on patients’ decisions to complete CRC screening using each of three commonly recommended screening methods (FIT/gFOBT, mt-sDNA, and screening colonoscopy). Additionally, we examined variations in the importance and influence of these factors on patients’ CRC screening decision-making across sociodemographic characteristics. Our research extends the literature on patient CRC screening decision-making by updating the understanding of patient concerns and the relative importance of various factors and test/procedure attributes for CRC screening decision-making, including the use of emerging screening methods such as mt-sDNA. Providers and health systems can use these findings to understand which concerns may be more prevalent in their patient population and therefore may require more attention and

Table 3
Associations of CRC screening utilization (used any of the three methods previously) with level of concern over each factor when making CRC screening decisions.

| Concerns | Adjusted OR (95 % CI) a | Adjusted p-value b |
|----------|------------------------|-------------------|
| Cost to take the test/procedure (N = 1049) | 0.75 (0.52, 1.09) | 0.187 |
| Accuracy of the test/procedure (N = 1042) | 1.25 (0.89, 1.76) | 0.227 |
| Having to collect samples of your stool (N = 1046) | 0.63 (0.43, 0.91) | 0.030 |
| Completing screening every year (N = 1037) | 0.76 (0.52, 1.10) | 0.187 |
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| Being sedated and needing someone to drive you home after screening (N = 1044) | 0.56 (0.39, 0.81) | 0.007 |

a All models adjusted for participant age, sex, race/ethnicity, education level, income level, and health insurance status.

b Adjusted for multiple testing using the Benjamini-Hochberg procedure.
intervention. Additionally, these findings can be used to inform development of decision aids to elicit patient preferences and concerns regarding test/procedure attributes and facilitate selecting CRC screening methods that align with the needs and preferences of patients with the goal of maximizing CRC screening uptake and adherence (Burry and Edgman-Levitan, 2012).

Our results showed that having an invasive procedure, completing a colon prep, and being sedated were the top concerns for patients who have not screened previously while for patients who have screened previously with colonoscopy or a stool-based test, completing a colon prep and accuracy of the test/procedure were top concerns when making CRC screening decisions. Regardless of previous screening utilization, patients were the least concerned about having to collect samples of their stool. These findings concur with previous research showing that perceived burden, discomfort, and anxiety associated with bowel preparation and the colonoscopy procedure are major barriers to completing colonoscopy for CRC screening (McLachlan et al., 2012; Jones et al., 2010; Yang et al., 2018). Although previous research suggests that perceived disgust and unpleasantness from collecting and handling stool samples are associated with avoiding stool-based tests for CRC screening (Jones et al., 2010; Scaglioni et al., 2021; Chapple et al., 2008), our data suggest that patients in general were less concerned about having to collect stool samples compared with other test/procedure related factors. Our data also showed that previous screening utilization was associated with lower concern over having an invasive procedure, being sedated, taking time off work, and having to collect samples of stool. Lower concerns reported by these patients may reflect the development of decision aids to elicit patient preferences and concerns regarding test/procedure attributes and facilitate selecting CRC screening methods that align with the needs and preferences of patients with the goal of maximizing CRC screening uptake and adherence (Burry and Edgman-Levitan, 2012).

When choosing a particular screening method, accuracy of the test, how often the test needs to be done, where the test can be taken, what needs to be done to prepare for the test, discomfort associated with the test, how invasive the test is, additional testing needed for abnormal results, complications associated with the test, how long it takes to prepare for the test, and how long it takes to do the test were ranked as most important test/procedure attributes (Fig. 1).

Fig. 1. Three most important test/procedure attributes for choosing a particular screening method. N is unweighted and % is weighted. Missing = 2.
test needs to be done among the three most important attributes to consider when choosing a particular screening method. Hispanic participants also more frequently ranked how often the test needs to be done among the three most important attributes, while less frequently ranking accuracy of the test among the three most important attributes. These findings are consistent with research demonstrating persistent racial/ethnic disparities in healthcare access and therefore awareness and knowledge of newer CRC screening methods (Link and Phelan, 1995; Polonijo and Carpiano, 2013; Chang and Lauderdale, 2009). Continuing efforts to improve CRC screening awareness, knowledge, and access among racial/ethnic minority populations are needed and research is encouraged to better understand how observed variations may reflect cultural differences in test/procedure attribute preferences. Multiple intervention strategies have been shown to be effective at improving CRC screening rates among racial/ethnic minority communities, including mailed outreach of stool-based tests augmented by reminders (Issaka et al., 2019) and patient navigation (Roy et al., 2021; Naylor et al., 2012), culturally tailored educational materials disseminated through culturally appropriate venues (Naylor et al., 2012; Mojica et al., 2018; Luque et al., 2014), and training community health workers to deliver education, navigate patients through screening and follow-up, and provide social support (Roy et al., 2021; Mojica et al., 2018; Roland

**Fig. 2.** Associations of participant characteristics with the attribute being ranked among the three most important test/procedure attributes for choosing a particular screening method. a,b OR (95% CI) with a superscript * denotes that the association is statistically significant (p<0.05) after adjusting for multiple testing using the Benjamini-Hochberg procedure. Outcome variables were recoded into two categories: ranked among the top three important attributes versus not among the top three. Analysis on complications associated with the test, how long it takes to prepare for the test, and how long it takes to do the test were omitted due to low frequency. For clarity of presentation, we only display factors that had a statistically significant association with participant characteristics. Sample size = 708 for all models.

b No insurance category omitted for analysis on discomfort associated with the test and accuracy of test due to low frequency.
7. Limitations

Because of the breadth of topics covered in our survey, to reduce respondent burden, we only surveyed the three most commonly used screening options for the average-risk population. Therefore, we were unable to capture perspectives regarding other less commonly used options. Additionally, we provided a limited list of test/procedure attributes and influencing factors that has been frequently reported in previous research. Future research examining factors influencing CRC screening decision-making may benefit from including all recommended screening options and a more comprehensive list of test/procedure attributes and influencing factors to obtain a complete understanding of CRC screening decision-making. Participants were asked to select most important test/procedure qualities for screening decision-making rather than for using each method specifically. Because of the overlap between users of the screening methods, we cannot meaningfully compare the importance of the test/procedure qualities between methods. Future research can revise the measure to be repeated for each method to enable comparison by method. The majority (93%) of our survey participants reported health insurance coverage, thus findings of this study may not generalize to uninsured patient populations. Future research with uninsured and underinsured patient samples is needed to understand these populations’ specific preferences and concerns related to CRC screening decision-making. Measures in our survey were adapted from existing national surveys or developed based on previous research. Future research adopting our measures may consider further refining these measures based on evaluation of psychometric properties. Lastly, our findings’ generalizability may be impacted by non-response bias given the low response rate (Maitland et al., 2017). However, our sample was selected using rigorous stratification to ensure adequate population representation.

8. Conclusions

Our research identified patient-focused factors and the relative importance of test/procedure preferences that can influence CRC screening decision-making. Although provider recommendation appears to be the major driving factor for CRC screening decision-making, patient preferences regarding test/procedure attributes and preparation requirements also influence screening decisions and may consequently impact completion and adherence. Our findings highlight an immediate opportunity for clinicians to involve patients in CRC screening shared decision-making and incorporate patient needs and preferences into defining more personalized strategies to increase the initiation and completion of this important preventive service.

Ethics approval and informed consent

This study was deemed exempt by the National Opinion Research Center (NORC) institutional review board (IRB). Informed consent was obtained from all participants prior to participation.

Data availability

Data supporting the findings of this article are available from the corresponding author upon reasonable request.

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CRediT authorship contribution statement

Xuan Zhu: Conceptualization, Formal analysis, Writing – original draft, 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

The authors declare the following financial interests/personal

Fig. 3. Level of influence each factor had over participants’ decision to complete CRC screening using each method a, b. a N is unweighted and % is weighted. b Number of missing responses range from 1 to 11.

| Provider recommendation | Test/procedure used innovative technology | Scientific/clinical evidence | Ease of use | Comfort with procedure/test | Convenience | Insurance coverage | Family/friend recommendation |
|-------------------------|------------------------------------------|-----------------------------|------------|---------------------------|------------|-------------------|-----------------------------|
| 52.8% (n=349)           | 26.2% (n=170)                           | 28.3% (n=137)              | 30.1% (n=110) | 33.1% (n=116)           | 50.1% (n=119) | 30.1% (n=109) | 10.5% (n=19)               |
| 5.5% (n=25)             | 20.3% (n=53)                            | 17.4% (n=46)              | 17.1% (n=36) | 18.6% (n=46)           | 12.0% (n=42) | 36.8% (n=109) | 9.4% (n=17)                |
| 17.1% (n=36)            | 19.7% (n=50)                            | 12.9% (n=42)              | 19.6% (n=50) | 20.6% (n=46)           | 12.6% (n=42) | 19.4% (n=50) | 11.2% (n=19)               |
| 8.5% (n=25)             | 11.7% (n=31)                            | 8.7% (n=25)               | 28.1% (n=49) | 28.1% (n=49)           | 30.8% (n=50) | 53.5% (n=159) | 12.1% (n=21)               |
| 17.2% (n=34)            | 15.9% (n=30)                            | 16.3% (n=30)              | 28.1% (n=49) | 28.1% (n=49)           | 30.8% (n=50) | 53.5% (n=159) | 12.1% (n=21)               |
| 59.4% (n=188)           | 19.6% (n=46)                            | 12.9% (n=42)              | 19.6% (n=50) | 20.6% (n=46)           | 12.6% (n=42) | 19.4% (n=50) | 11.2% (n=19)               |
| 10.5% (n=19)            | 15.9% (n=30)                            | 16.3% (n=30)              | 28.1% (n=49) | 28.1% (n=49)           | 30.8% (n=50) | 53.5% (n=159) | 12.1% (n=21)               |

a Number of missing responses range from 1 to 11.
relationships which may be considered as potential competing interests: EW is an employee of Exact Sciences Corporation. At the time of the study, PJL served 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. At the time of the study, LJFR offered scientific input to research studies through a contracted services agreement between Mayo Clinic and Exact Sciences. Currently, PJL and LJFR are employees of Exact Sciences Corporation. JMG and XZ offer scientific input to research studies through a contracted services agreement between Mayo Clinic and Exact Sciences. Administrative support was provided by William K. Johnson, employee of Exact Sciences Corporation.

Data availability

Data will be made available on request.

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Appendix 1. Associations of participant characteristics with the attribute being ranked among the three most important test/procedure attributes for choosing a particular screening method (N = 708).\textsuperscript{a}

| Age group | How often the test needs to be done (OR (95 % CI)) | Where the test can be taken (OR (95 % CI)) | Cost and/or health insurance coverage of test (OR (95 % CI)) | Discomfort associated with the test (OR (95 % CI)) |
|-----------|-----------------------------------------------|-----------------------------------------------|------------------------------------------------|-----------------------------------------------|
| 45-54     | Reference                                     | Reference                                     | Reference                                     | Reference                                     |
| 55-64     | 1.01 (0.61, 1.66)                             | 0.74 (0.43, 1.28)                             | 1.17 (0.71, 1.92)                             | 0.70 (0.39, 1.24)                            |
| 65-75     | 0.68 (0.36, 1.29)                             | 0.85 (0.45, 1.61)                             | 0.89 (0.48, 1.65)                             | 0.56 (0.27, 1.16)                            |
| Sex       | Female 0.79 (0.53, 1.18)                       | 0.90 (0.60, 1.36)                             | 1.04 (0.71, 1.53)                             | 1.31 (0.82, 2.11)                            |
|           | Male Reference                                | Reference                                     | Reference                                     | Reference                                     |
| Race/ethnicity | Non-Hispanic white Reference Reference Reference Reference |
|           | Non-Hispanic black                           | 2.54 (1.29, 5.00)*                           | 1.55 (0.77, 3.11)                             | 1.68 (0.85, 3.33)                            |
|           | Hispanic                                     | 3.00 (1.41, 6.41)*                           | 1.35 (0.61, 3.01)                             | 1.07 (0.52, 2.19)                            |
|           | Other races                                  | 1.24 (0.59, 2.60)                            | 1.32 (0.64, 2.75)                             | 1.41 (0.69, 2.89)                            |
| Education level | Less than high school Reference Reference Reference Reference |
|           | High school graduate or equivalent            | 1.05 (0.41, 2.71)                            | 0.82 (0.29, 2.36)                             | 1.00 (0.39, 2.55)                            |
|           | Some college                                | 0.97 (0.62, 1.51)                            | 1.34 (0.84, 2.15)                             | 0.76 (0.49, 1.19)                            |
|           | BA or above Reference                        | Reference                                     | Reference                                     | Reference                                     |
| Household income | $< 25,000 Reference Reference Reference Reference |
|           | $25,000-$59,999                              | 0.89 (0.49, 1.61)                            | 0.81 (0.43, 1.50)                             | 1.53 (0.83, 2.83)                            |
|           | $60,000-$124,999                             | 0.85 (0.46, 1.57)                            | 0.88 (0.46, 1.67)                             | 1.66 (0.90, 3.09)                            |
|           | $> 125,000                                  | 0.70 (0.34, 1.46)                            | 0.71 (0.32, 1.59)                             | 1.85 (0.89, 3.86)                            |
| Health insurance | Private insurance Reference Reference Reference Reference |
|           | Public insurance                             | 1.19 (0.71, 2.00)                            | 1.09 (0.63, 1.88)                             | 0.81 (0.48, 1.37)                            |
|           | No insurance                                 | 1.05 (0.37, 3.00)                            | 1.17 (0.36, 3.75)                             | 1.20 (0.40, 3.60)                            |
| What needs to be done to prepare for the test (OR (95 % CI)) | How invasive the test is (OR (95 % CI)) | Accuracy of the test (OR (95 % CI)) | Additional testing needed for abnormal results (OR (95 % CI)) |
| Age group |                                 |                                 |                                 |                                 |
| 45-54     | Reference                                     | Reference                                     | Reference                                     | Reference                                     |
| 55-64     | 0.70 (0.39, 1.27)                             | 1.05 (0.56, 1.98)                             | 1.21 (0.73, 2.02)                             | 1.25 (0.63, 2.46)                            |
| 65-75     | 0.76 (0.38, 1.52)                             | 1.22 (0.57, 2.64)                             | 0.92 (0.48, 1.76)                             | 0.65 (0.27, 1.55)                            |
| Sex       | Female 1.15 (0.74, 1.81)                      | 1.05 (0.65, 1.70)                             | 1.07 (0.72, 1.60)                             | 0.96 (0.56, 1.67)                            |
|           | Male Reference                                | Reference                                     | Reference                                     | Reference                                     |
| Race/ethnicity | Non-Hispanic white Reference Reference Reference Reference |
|           | Non-Hispanic black                           | 0.40 (0.19, 0.83)                            | 0.66 (0.30, 1.44)                             | 0.61 (0.30, 1.22)                            |
|           | Hispanic                                     | 0.50 (0.18, 1.41)                            | 0.50 (0.19, 1.28)                             | 0.24 (0.10, 0.55)*                           |
|           | Other races                                  | 0.65 (0.26, 1.58)                            | 0.41 (0.17, 0.97)                             | 0.63 (0.30, 1.33)                            |
| Education level | Less than high school Reference Reference Reference Reference |
|           | High school graduate or equivalent            | 1.01 (0.32, 3.26)                            | 0.34 (0.11, 1.11)                             | 0.34 (0.11, 1.05)                            |
|           | Some college                                | 0.72 (0.38, 1.36)                            | 0.45 (0.22, 0.90)                             | 0.68 (0.40, 1.17)                            |
|           | BA or above Reference                        | 1.36 (0.82, 2.25)                            | 0.75 (0.45, 1.25)                             | 0.70 (0.44, 1.09)                            |
| Household income | $< 25,000 Reference Reference Reference Reference |
|           | $25,000-$59,999                              | 1.50 (0.65, 3.49)                            | 0.87 (0.42, 1.79)                             | 1.38 (0.73, 2.61)                            |
|           | $60,000-$124,999                             | 1.34 (0.57, 3.12)                            | 0.49 (0.22, 1.06)                             | 1.64 (0.83, 3.26)                            |
|           | $> 125,000                                  | 1.67 (0.64, 4.33)                            | 1.02 (0.44, 2.36)                             | 2.52 (1.17, 5.40)                            |
| Health insurance | Private insurance Reference Reference Reference Reference |
|           | Public insurance                             | 0.60 (0.33, 1.09)                            | 1.07 (0.60, 1.91)                             | 1.49 (0.88, 2.53)                            |
|           | None                                         | 0.46 (0.12, 1.72)                            | 2.52 (0.69, 9.22)                             | 1.24 (0.30, 5.22)                            |

\textsuperscript{a} OR (95 % CI) with a superscript * denotes that the association is statistically significant (p < 0.05) after adjusting for multiple testing using the Benjamini-Hochberg procedure. Outcome variables were recoded into two categories: ranked among the top three important attributes versus not among the top three (reference category). Analysis on complications associated with the test, how long it takes to prepare for the test, and how long it takes to do the test were omitted due to low frequency.

\textsuperscript{b} Category omitted due to low frequency.
Appendix 2. Associations of participant characteristics with level of influence each factor had over their decision to complete CRC screening using each method  

### Family/friend recommendation

| Age group | Method | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) |
|-----------|--------|-------------|-------------|-------------|-------------|-------------|-------------|
| 45-54     | FIT/gFOBT | Reference | Reference | Reference | Reference | Reference | Reference |
| 55-64     | mt-sDNA | 0.92 (0.36, 2.31) | 0.69 (0.16, 3.08) | 1.49 (0.84, 2.64) |             |             |             |
| 65-75     | Colonoscopy | 1.77 (0.64, 4.91) | 1.11 (0.21, 5.83) | 0.90 (0.45, 1.80) |             |             |             |
| Sex       | Male | 1.03 (0.55, 1.94) | 1.6 (0.56, 4.55) | 1.09 (0.73, 1.64) |             |             |             |
|           | Female | Reference | Reference | Reference | Reference | Reference | Reference |

### Race/ethnicity

| Race/ethnicity | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) |
|---------------|-------------|-------------|-------------|-------------|-------------|-------------|
| Hispanic      | 3.56 (1.23, 10.3) | 4.72 (1.14, 19.49) | 2.57 (0.97, 6.78) |             |             |             |
| Non-Hispanic black | 1.81 (0.68, 4.79) |             |             |             |             |             |
| Non-Hispanic white |             |             |             |             |             |             |
| Non-Hispanic black |             |             |             |             |             |             |

### Age group

| Age group | Method | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) |
|-----------|--------|-------------|-------------|-------------|-------------|-------------|-------------|
| 45-54     | FIT/gFOBT | Reference | Reference | Reference | Reference | Reference | Reference |
| 55-64     | mt-sDNA | 0.92 (0.36, 2.31) | 0.72 (0.15, 3.27) | 1.14 (0.68, 1.91) |             |             |             |
| 65-75     | Colonoscopy | 0.82 (0.37, 1.81) | 0.85 (0.20, 3.52) | 1.40 (0.71, 2.76) |             |             |             |
| Sex       | Male | 1.21 (0.71, 2.05) | 1.17 (0.48, 2.86) | 1.23 (0.85, 1.77) |             |             |             |
|           | Female | Reference | Reference | Reference | Reference | Reference | Reference |

### Household income

| Household income | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) |
|-----------------|-------------|-------------|-------------|-------------|-------------|-------------|
| <$60,000        | Reference | Reference | Reference | Reference | Reference | Reference |
| $60,000 or higher | 0.61 (0.31, 1.20) | 0.60 (0.24, 1.51) | 1.09 (0.71, 1.68) |             |             |             |

### Convenience

| Method | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) |
|--------|-------------|-------------|-------------|-------------|-------------|-------------|
| FIT/gFOBT | Reference | Reference | Reference | Reference | Reference | Reference |
| mt-sDNA | 0.73 (0.35, 1.51) | 0.46 (0.15, 1.43) | 1.14 (0.68, 1.91) |             |             |             |
| Colonoscopy | 0.82 (0.37, 1.81) | 0.85 (0.20, 3.52) | 1.40 (0.71, 2.76) |             |             |             |

### Health insurance

| Health insurance | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) |
|-----------------|-------------|-------------|-------------|-------------|-------------|-------------|
| Public | 0.63 (0.30, 1.31) | 4.30 (1.21, 15.25) | 1.23 (0.76, 1.98) |             |             |             |
| None | Reference | Reference | Reference | Reference | Reference | Reference |

### Ease of use

| Method | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) |
|--------|-------------|-------------|-------------|-------------|-------------|-------------|
| FIT/gFOBT | Reference | Reference | Reference | Reference | Reference | Reference |
| mt-sDNA | 0.73 (0.39, 1.43) | 0.73 (0.43, 1.23) | 0.60 (0.32, 1.12) |             |             |             |
| Colonoscopy | Reference | Reference | Reference | Reference | Reference | Reference |

### Scientific/clinical evidence

| Method | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) |
|--------|-------------|-------------|-------------|-------------|-------------|-------------|
| FIT/gFOBT | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) |
| mt-sDNA | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) |
| Colonoscopy | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) | OR (95% CI) |

(continued on next page)
AmeriSpeak Panel Design. NORC at the University of Chicago. https://amerispeak.norc.org/us/en/about-amerispeak/panel-design.html. Accessed August 4th, 2022.

Barrio, R., Rodriguez, M., Abad, A., Blesa, F., 2011. Breaking the limits: The Taylor series method. Appl. Math. Comput. 217 (20), 7940–7954.

Barry, M.J., Edgman-Levitan, S., 2012. Shared decision making.

Benjamini, Y., Hochberg, Y., 1995. Controlling the false discovery rate: a practical and powerful approach to multiple testing. J. Roy. Stat. Soc.: Ser. B (Methodol.) 57 (1), 289–300.

Beydoun, H.A., Beydoun, M.A., 2008. Predictors of colorectal cancer screening behaviors: examining fears, attitudes, and medical mistrust in an ethnically diverse sample of adults 50 years and older. Am. J. Health Promot.: AJHP. 26 (5), 295–300.

Bibbins-Domingo, K., Grossman, D.C., Curry, S.J., et al., 2016. Screening for colorectal cancer: US preventive services task force recommendation statement. JAMA 315 (23), 2564–2575.

Bynum, S.A., Davis, J.L., Green, B.L., Katz, R.V., 2012. Unwillingness to participate in colorectal cancer screening: examining fears, attitudes, and medical mistrust in an ethnically diverse sample of adults 50 years and older. Am. J. Health Promot.: AJHP. 26 (5), 295–300.

Chang, V.W., Lauderdale, D.S., 2009. Fundamental cause theory, technological innovation, and health disparities: the case of cholesterol in the era of statins. J. Health Soc. Behav. 50 (3), 245–260.

Chapple, A., Zielbändl, S., Hewitt, P., McPherson, A., 2008. What affects the uptake of screening for bowel cancer using a faecal occult blood test (FOBT)? A qualitative study. Soc. Sci. Med. 66 (12), 2425–2435.

Cronin, K.A., Lake, A.J., Scott, S., et al., 2018. Annual Report to the Nation on the Status of Cancer, part I: National cancer statistics. Cancer 124 (13), 2785–2806.

Davis, M.M., Renfro, S., Pham, R., et al., 2017. Geographic and population-level disparities in colorectal cancer testing: A multilevel analysis of Medicaid and commercial claims data. Prev. Med. 101, 44–52.

Edwards, B.K., Ward, E., Kohler, B.A., et al., 2010. Annual report to the nation on the status of cancer, 1975–2006, featuring colorectal cancer trends and impact of interventions (risk factors, screening, and treatment) to reduce future rates. Cancer 116 (3), 544–573.

Graubard, B.I., Korn, E.L., 1996. Survey inference for subpopulations. Am. J. Epidemiol. 144 (1), 102–116.

Honein-AbouHaidar, G.N., Kastner, M., Vuong, V., et al., 2016. Systematic review and meta-study synthesis of qualitative studies evaluating facilitators and barriers to participation in colorectal cancer screening. Cancer Epidemi Biomark. 25 (6), 907–917.

Inadomi, J.M., Vikan, S., Janz, N.K., et al., 2012. Adherence to colorectal cancer screening: a randomized clinical trial of competing strategies. Arch. Intern. Med. 172 (7), 575–582.
