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

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

1. Introduction
Colorectal cancer (CRC) is the second leading cause of cancer-related death in the United States (US) among women and men combined (Cronin et al., 2018; Siegel et al., 2020). Major guideline organizations recommend CRC screening among average-risk adults between the ages of 50–75 (U. S. Preventive Services Task Force et al., 2016) or 45–75 (Wolf et al., 2018). Recommended screening options include stool-based tests such as the fecal immunochemical test/guaiac-based fecal occult blood test (FIT/gFOBT) every year and multi-target stool DNA (mt-sDNA) test every three years, as well as direct visualization methods such as screening colonoscopy every ten years (U. S. Preventive Services Task Force et al., 2016; Wolf et al., 2018). CRC screening in the US occurs on a largely opportunistic, non-programmatic basis, where patients either self-refer for screening or receive a recommendation for screening from a healthcare provider during an unrelated healthcare visit (Schreuders et al., 2015). Despite clear evidence that regular screening reduces CRC mortality (Edwards et al., 2010; Zauber et al., 2008); screening continues to be underutilized in the US (Steele et al., 2013; Davis et al., 2017). Although

Abbreviations: CRC, colorectal cancer; FIT/gFOBT, fecal immunochemical test/guaiac-based fecal occult blood test; mt-sDNA, multi-target stool DNA.
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several CRC screening options are supported by evidence of net benefit (U. S. Preventive Services Task Force et al., 2016); the practical effectiveness of each option is undermined by sub-optimal population adherence to screening recommendations (Singal et al., 2017). Thus, better understanding of the barriers to CRC screening utilization is critical for improving average-risk adults’ adherence to CRC screening completion and adherence to the guideline-endorsed options.

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

2. Methods

2.1. Study population

Data were collected from a panel survey developed by the authors and implemented by the National Opinion Research Center (NORC) at the University of Chicago (http://www.norc.org) in November 2019, using a national sample of US adults aged 40–75 which were selected from NORC’s AmeriSpeak Panel using sampling strata based on age, sex, race/Hispanic ethnicity, and education. The size of the selected sample per sampling stratum was determined by the population distribution for each stratum, taking into account expected differences in survey completion rates by demographic groups to ensure that the sample was representative of the U.S. population. Panelists were invited to participate in the AmeriSpeak study by web or by phone. To encourage participation, NORC sent up to 2 email reminders to sampled web-mode panelists; for the phone survey, NORC dialed the sampled phone-mode panelists throughout the field period. All sampled panelists were offered an incentive equivalent to $5 to complete the survey. We planned to obtain completed surveys from 1500 panelists, aiming for a margin of error around 3% at a 95% confidence level. Prior studies using this panel have obtained an average response rate of 35%. We estimated a survey completion rate of 35% and a qualification rate of 90%. This

Fig. 1. Participant flow chart.

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

2 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 US household population. Those excluded from the sample include people with P.O. Box 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: http://amerispeak.norc.org/about-amerispeak/Pages/Panel-Design.aspx (accessed May 3rd, 2021)
Table 1
Non-utilization of each CRC screening option by socio-demographic characteristics, health care access, and health status.

|                            | Had not used one or more of the three options (N = 858) | Never used any of the three options (N = 189) | Used one or two of the three options (N = 669) | Used mt-sDNA and/or colonoscopy, but not FIT/gFOBT | Used FIT/gFOBT and/or colonoscopy, but not mt-sDNA | Used mt-sDNA and/or colonoscopy, but not FIT/gFOBT |
|---------------------------|--------------------------------------------------------|---------------------------------------------|---------------------------------------------|-------------------------------------------------|-------------------------------------------------|-------------------------------------------------|
|                            | N (%)                                                  | p-value                                     | N (%)                                      | p-value                                         | N (%)                                          | p-value                                         |
| **Total**                 | 858                                                    |                                             | 189                                        | 389                                             | 546                                             | 91                                              |
| **Age in years**          |                                                        |                                             |                                             |                                                 |                                                 |                                                 |
| 50–54                     | 186 (22.4)                                             | <0.001                                      | 75 (40.4)                                  | 70 (64.3)                                       | 96 (79.1)                                      | 0.092                                           | 0.101                                           |
| 55–64                     | 391 (45.2)                                             |                                             | 83 (19.5)                                  | 196 (62.2)                                      | 263 (83.5)                                      | 38                                              | (14.1)                                          |
| 65–75                     | 281 (32.4)                                             |                                             | 31 (9.1)                                   | 123 (47.4)                                      | 187 (72.7)                                      | 27                                              | (12.6)                                          |
| **Sex**                   |                                                        |                                             |                                             |                                                 |                                                 |                                                 |
| Male                      | 381 (45.4)                                             | 0.126                                       | 173 (40.7)                                  | 237 (79.6)                                      | 37                                              | 37                                              | (12.1)                                          |
| Female                    | 472 (54.1)                                             |                                             | 215 (54.3)                                  | 307 (78.1)                                      | 57                                              |                                                 | (17.9)                                          |
| **Other**                 | 3 (0.5)                                                |                                             | 2 (94.5)                                    | 0 (0)                                           | 1 (100)                                         |                                                 | (100)                                           |
| **Race/Ethnicity**        |                                                        |                                             |                                             |                                                 |                                                 |                                                 |
| White, non-Hispanic       | 624 (68.3)                                             | 0.956                                       | 295 (46.1)                                  | 402 (79.9)                                      | 69                                              | (14.6)                                          |
| Black, NH                 | 92 (12.9)                                              |                                             | 34 (46.1)                                   | 55 (65.5)                                       | 9 (8.2)                                         | 11                                              | (24.7)                                          |
| Hispanic                  | 82 (11)                                                |                                             | 38 (59.6)                                   | 47 (78.0)                                       | 38                                              | 38                                              | (10.4)                                          |
| Asian, NH                 | 15 (1.6)                                               | 0.023                                       | 6 (45.4)                                    | 12 (100)                                        | 2 (27.5)                                        | 4 (20.2)                                        | (20.2)                                          |
| Other or Multiple race, NH| 45 (6.2)                                               |                                             | 16 (47.0)                                   | 30 (96.8)                                       | 37                                              | 37                                              | (12.1)                                          |
| **Education**             |                                                        |                                             |                                             |                                                 |                                                 |                                                 |
| Less than high school     | 43 (11)                                                | 0.096                                       | 22 (49.3)                                   | 20 (52.2)                                       | 10                                              | (32.9)                                          |
| High school               | 176 (30.4)                                             |                                             | 68 (53.0)                                   | 98 (76.5)                                       | 25                                              | (17.5)                                          | (33.9)                                          |
| Some college              | 346 (26)                                              |                                             | 143 (42.0)                                  | 213 (61.4)                                      | 27                                              | (11.7)                                          | (33.9)                                          |
| Bachelor’s degree or higher| 293 (32.6)                                           |                                             | 156 (50.7)                                  | 215 (69.8)                                      | 27                                              | (11.7)                                          | (33.9)                                          |
| **Household Income**      |                                                        |                                             |                                             |                                                 |                                                 |                                                 |
| <$25,000                  | 182 (22.9)                                             |                                             | 51 (23.9)                                   | 64 (46.1)                                       | 95 (68.4)                                       | 29                                              | (24.8)                                          |
| $25,000–$49,999           | 260 (30.4)                                             |                                             | 64 (22.2)                                   | 97 (49.9)                                       | 151                                             | (75.0)                                          | (16.9)                                          |
| $60,000–$124,999          | 295 (32.4)                                             |                                             | 54 (18.6)                                   | 158 (65.8)                                      | 209                                             | (84.9)                                          | (26)                                            |
| >$125,000                 | 121 (14.2)                                             |                                             | 100 (18.0)                                  | 70 (56.8)                                       | 91 (87.7)                                       | 10                                              | (10.0)                                          |
| **Health Insurance**      |                                                        |                                             |                                             |                                                 |                                                 |                                                 |
| Private/public insurance  | 808 (93.5)                                             | 0.001                                       | 373 (56.7)                                  | 528 (78.7)                                      | 91                                              | (11.8)                                          | (3.0)                                           |
| No insurance              | 49 (6.5)                                               |                                             | 16 (66.7)                                   | 18 (80.7)                                       | 3 (26.0)                                        | 3 (26.0)                                        | (0.3)                                           |
| **Last Healthcare Visit**|                                                        |                                             |                                             |                                                 |                                                 |                                                 |
| <2 years ago              | 790 (93.2)                                             | <0.001                                      | 374 (57.4)                                  | 524 (78.6)                                      | 91                                              | (15.3)                                          | (2.4)                                           |
| 3–5 years ago             | 32 (3.4)                                               |                                             | 8 (44.8)                                    | 13 (71.8)                                       | 2 (41.1)                                        | 2 (41.1)                                        | (2.4)                                           |
| More than 5 years ago or never| 33 (3.3)                                               |                                             | 5 (51.0)                                    | 7 (100)                                         | 2 (49.0)                                        | 2 (49.0)                                        | (2.4)                                           |
| **Self-rated General Health**|                                                     |                                             |                                             |                                                 |                                                 |                                                 |
| Excellent                 | 85 (9.6)                                               | 0.895                                       | 43 (57.9)                                   | 56 (74.5)                                       | 7 (12.4)                                        | 37                                              | (13.6)                                          |
| Very good                 | 329 (36.4)                                             |                                             | 146 (56.0)                                  | 216 (82.0)                                      | 37                                              | (13.6)                                          | (13.6)                                          |
| Good                      | 312 (36.5)                                             |                                             | 140 (61.0)                                  | 194 (79.8)                                      | 35                                              | (14.4)                                          | (14.4)                                          |
| Fair or poor              | 132 (17.5)                                             |                                             | 60 (50.8)                                   | 80 (72.2)                                       | 16                                              | (22.5)                                          | (22.5)                                          |
| **Non-CRC Cancer History**|                                                        |                                             |                                             |                                                 |                                                 |                                                 |
| No                        | 739 (86.5)                                             | 0.108                                       | 329 (57.3)                                  | 466 (78.6)                                      | 86                                              | (16.4)                                          | (9.6)                                           |
| Yes                       | 118 (13.5)                                             |                                             | 59 (55.8)                                   | 79 (79.0)                                       | 9 (9.6)                                         | 18                                              | (15.8)                                          |
| **US Geographic Region**  |                                                        |                                             |                                             |                                                 |                                                 |                                                 |
| Northeast                 | 144 (17.5)                                             | 0.663                                       | 69 (58.6)                                   | 94 (80.1)                                       | 18                                              | (15.8)                                          | (15.8)                                          |
| Midwest                   | 220 (26.1)                                             |                                             | 53 (24.9)                                   | 138 (81.2)                                      | 22                                              | (16.9)                                          | (16.9)                                          |

(continued on next page)
2.3. Inclusion and exclusion criteria

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

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

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

2.4. Statistical analysis

A total of 1,595 completed surveys (1433 by web and 162 by phone) were obtained from 5,097 panelists who were invited to participate (31.3%). The survey’s margin of error was 3.14% at a 95% confidence level. The margin of error was calculated by NORC assuming we have a binomial variable where 50% of respondents give each answer (giving the most conservative margin of error). The margin of error for this hypothetical variable was then calculated at a 95% confidence level assuming all completed surveys answered the question and taking into account the design effect, which is the amount of variance under the complex design divided by the variance under the simple random sampling. The final analysis sample size was 858, after excluding respondents with personal or familial CRC history or colorectal health issues that would make them ineligible for stool-based tests (e.g., ulcerative colitis, Crohn’s disease, colorectal polyps) (Bibbins-Domingo et al., 2016).

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

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

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

2.3. Inclusion and exclusion criteria

Analyses were focused on the subgroup of survey respondents ages 50 to 75 (for whom population screening is recommended) and had not been previously screened with one or more of the three queried options. Exclusions included personal or familial CRC history or colorectal health issues that would make them ineligible for stool-based tests (e.g., ulcerative colitis, Crohn’s disease, colorectal polyps) (Bibbins-Domingo et al., 2016).
using the Benjamini-Hochberg procedure (Benjamini and Hochberg, 1995). All analyses were conducted in R.

3. Results

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

Fig. 2 summarizes barriers to utilization of each screening option. Overall, 189 (20.8%) respondents had not been previously screened with any of the three queried options while 669 had used one or two of the three options. Among people who had not been previously screened with any of the three queried options, the most common barrier reported was lack of knowledge (FIT/gFOBT: 42.1%, mt-sDNA: 44.9%, colonoscopy: 34.7%). For FIT/gFOBT and mt-sDNA, other frequently selected barriers included lack of provider recommendation (32.1% and 27.3%) and suboptimal access (20.8% and 17.8%). For colonoscopy, additional frequently selected barriers included suboptimal access (26%), lack of provider recommendation (18.6%), and psychosocial barriers (17.5%). Among people who had used one or two of the three options, the top barrier for FIT/gFOBT and mt-sDNA was lack of provider recommendation (31.6% and 37.5%), followed by lack of knowledge (24.6% and 25.6%). For colonoscopy, the top barriers were psychosocial barriers (31%), lack of provider recommendation (22.7%), and lack of knowledge (16.6%). Around 20% of the participants did not specify a barrier.

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

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

| Age in years | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) |
|--------------|-------|-------|-------|-------|-------|-------|-------|-------|-------|-------|
| 50–54        | 31 (44.2) | 27 (43.4) | 15 (15.0) | 30 (47.1) | 23 (32.0) | 13 (17.4) | 21 (32.7) | 15 (25.9) | 22 (26.9) | 15 (13.3) |
| 55–64        | 31 (36.5) | 20 (19.1) | 23 (28.9) | 34 (41.1) | 20 (19.9) | 17 (18.9) | 27 (32.8) | 11 (13.7) | 29 (29.5) | 17 (19.7) |
| 65–75        | 15 (52.1) | 9 (36.7) | 4 (14.5) | 14 (49.7) | 8 (35.6) | 4 (15.5) | 13 (46.6) | 5 (10.8) | 5 (13.1) | 10 (28.8) |
| Sex          |        |       |        |        |       |       |       |       |       |       |
| Male         | 41 (51.6) | 21 (25.3) | 24 (29.1) | 44 (56.8) | 21 (24.8) | 18 (20.9) | 34 (43.2) | 13 (17.0) | 23 (23.5) | 20 (18.5) |
| Female       | 35 (32.6) | 37 (34.2) | 17 (15.9) | 33 (33.1) | 30 (31.5) | 15 (13.9) | 26 (25.9) | 18 (21.2) | 33 (30.0) | 21 (15.8) |
| Race/Ethnicity |      |       |        |       |       |       |       |       |       |       |
| White, non-Hispanic | 51 (35.7) | 37 (26.8) | 31 (21.9) | 55 (42.3) | 35 (25) | 27 (19.8) | 44 (33.3) | 18 (14.7) | 48 (30.7) | 32 (19.3) |
| Black, NH    | 7 (48.5) | 5 (33.3) | 5 (29.8) | 5 (40.8) | 5 (33.3) | 2 (5.9) | 3 (27.6) | 4 (30.7) | 4 (27.4) | 3 (7.4) |
| Hispanic     | 12 (60.6) | 8 (54.8) | 1 (2.5) | 11 (54.0) | 5 (27.8) | 2 (16.6) | 9 (39.9) | 6 (36.5) | 0 (0) | 3 (17) |
| Other or Multiple race, NH | 7 (56.8) | 6 (39.8) | 5 (25.9) | 7 (57.7) | 6 (37.1) | 3 (18.9) | 5 (47.5) | 3 (7.7) | 4 (24.1) | 4 (17.3) |
| Education    |        |       |        |       |       |       |       |       |       |       |
| ≤High school | 21 (43.1) | 20 (38.4) | 13 (19.8) | 24 (48) | 15 (25.6) | 9 (15.5) | 20 (40.8) | 10 (19.5) | 12 (18.1) | 8 (10.6) |
| Some college | 33 (33.6) | 22 (24.2) | 23 (25.1) | 30 (31.7) | 22 (24.1) | 18 (20.6) | 27 (26.9) | 15 (18.4) | 30 (37.3) | 24 (23.4) |
| ≥Bachelor’s degree | 23 (52.5) | 14 (30.5) | 6 (16.4) | 24 (58.2) | 14 (35.9) | 7 (18.3) | 14 (33.6) | 6 (16.8) | 14 (26) | 10 (23.5) |
| Household Income |        |       |        |       |       |       |       |       |       |       |
| <$60,000     | 48 (45.6) | 32 (31.3) | 26 (23.3) | 46 (44.4) | 33 (31) | 18 (16.1) | 48 (48.5) | 22 (23.5) | 33 (23.4) | 21 (12.9) |
| ≥$60,000    | 29 (37.1) | 24 (33.3) | 16 (17.3) | 32 (45.7) | 18 (22.1) | 16 (20.2) | 13 (15.1) | 9 (11.6) | 23 (29.8) | 21 (29.3) |
| Health Insurance |      |       |        |       |       |       |       |       |       |       |
| Private/public insurance | 68 (42.6) | 49 (32.5) | 34 (20.6) | 70 (46.1) | 45 (29.2) | 25 (16.7) | 53 (33.3) | 27 (19.3) | 46 (25.0) | 38 (18.9) |
| No insurance | 9 (38.9) | 7 (29.5) | 8 (21.9) | 8 (37.5) | 6 (16.1) | 9 (24.3) | 8 (43.6) | 4 (13.9) | 10 (32.0) | 4 (8.9) |
| Last Healthcare Visit |        |       |        |       |       |       |       |       |       |       |
| <2 years ago | 55 (40.6) | 52 (37.5) | 29 (19) | 57 (44.3) | 47 (31.9) | 23 (16) | 48 (35.8) | 28 (21.2) | 39 (23.8) | 36 (18.9) |
| More than 2 years ago | 21 (48.1) | 4 (8.7) | 13 (28.7) | 20 (47.2) | 4 (7.4) | 11 (25.7) | 18 (30.1) | 3 (7.3) | 17 (35.9) | 5 (11) |
| Self-rated General Health   |        |       |        |       |       |       |       |       |       |       |
| Excellent or very good | 39 (46.3) | 26 (33.5) | 21 (22.7) | 41 (50.4) | 24 (29) | 15 (15.3) | 25 (30.1) | 12 (15.7) | 30 (32.1) | 17 (12.4) |
| Good         | 28 (37) | 19 (31.9) | 11 (13.4) | 25 (33.1) | 18 (28) | 10 (17) | 26 (34.1) | 14 (25.3) | 14 (13.9) | 15 (20.1) |
| Fair or poor | 10 (40.2) | 11 (28.4) | 10 (31.6) | 12 (54.7) | 9 (20.5) | 9 (27.3) | 10 (50.6) | 5 (12.3) | 12 (34.7) | 10 (27.5) |
| Non-CRC Cancer History |        |       |        |       |       |       |       |       |       |       |
| No           | 71 (41.8) | 49 (32.7) | 40 (22.4) | 70 (44.1) | 46 (28.4) | 31 (18.7) | 57 (35.4) | 29 (19.9) | 51 (27.3) | 36 (16.3) |
| Yes          | 6 (44.8) | 7 (26.2) | 2 (4.4) | 8 (53.4) | 5 (16.2) | 3 (8.1) | 4 (28.4) | 2 (5.5) | 5 (12.6) | 6 (20.1) |

a N is unweighted, % is weighted. Respondents could select all reasons that apply. We limited these analyses to the most common reasons in Table 2. Analysis on differences in lack of provider recommendation by time since last healthcare visit was omitted as frequency of healthcare visits confounds the relationship.
than males to report lack of knowledge (FIT/gFOBT: 32.6% versus 51.6%, aOR = 0.3, 95% CI = 0.11–0.72; mt-sDNA: 33.1% versus 56.8%, aOR = 0.27, 95% CI = 0.11–0.62; colonoscopy: 25.9% versus 43.2%, aOR = 0.31, 95% CI = 0.12–0.8). Regarding colonoscopy, people with an income lower than $60,000 (versus $60,000 or higher) were more likely to report lack of knowledge (48.5% versus 15.1%, aOR = 7.61, 95% CI = 2.64–25.35) and lack of provider recommendation (23.5% versus 11.6%, aOR = 4.53, 95% CI = 1.64–14.23). People who reported good health (versus excellent or very good health) were less likely to report suboptimal access (13.9% versus 32.1%, aOR = 0.24, 95% CI = 0.11–0.53) while those with fair or poor health were more likely to report psychosocial barriers (27.5% versus 12.4%, aOR = 7.82, 95% CI = 2.06–31.55).

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

4. Discussion

Our national survey data demonstrated lack of knowledge and lack of provider recommendation as the primary barriers to CRC screening, particularly for the stool-based tests: FIT/gFOBT and mt-sDNA, whereas, psychosocial barriers were commonly identified obstacles to colonoscopy. Additionally, a sizable percentage of never-screeners reported suboptimal access across all three screening options. Our findings are consistent with past research on barriers to FIT/gFOBT and colonoscopy (Honein-AbouHaidar et al., 2016; Nagelhout et al., 2017; Muthukrishnan et al., 2019; Jones et al., 2010; Wilkins et al., 2012) and extend the literature on barriers to mt-sDNA which is a critical and timely strength of this study.

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

Table 3

| Age in years | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) |
|--------------|-------|-------|-------|-------|-------|-------|-------|
| 50-54        | 15 (26.8) | 17 (26.5) | 23 (23.4) | 30 (33.6) | 9 (31.6) | 9 (37.4) | 7 (31.7) |
| 55-64        | 49 (22.5) | 68 (31.6) | 69 (24.7) | 106 (36.1) | 7 (10.9) | 7 (12.9) | 9 (29.8) |
| 65-75        | 34 (27.5) | 44 (35.9) | 53 (28.1) | 78 (41.8) | 6 (11.5) | 6 (23.8) | 7 (32.9) |

| Sex          | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) |
|--------------|-------|-------|-------|-------|-------|-------|-------|
| Male         | 50 (25.8) | 62 (33.7) | 65 (22.0) | 93 (36.7) | 12 (28.0) | 9 (17.6) | 11 (36.2) |
| Female       | 48 (24.0) | 66 (30.4) | 80 (28.7) | 120 (38.3) | 9 (10.8) | 13 (25.6) | 12 (28.9) |

| Race/Ethnicity | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) |
|----------------|-------|-------|-------|-------|-------|-------|-------|
| White, non-Hispanic | 66 (19.9) | 102 (31.4) | 97 (21.6) | 152 (34.1) | 17 (20) | 19 (29.6) | 10 (14.2) |
| Black, NH       | 13 (40.8) | 11 (46.2) | 18 (40.2) | 21 (46.0) | 5 (10.6) | 3 (10.6) | 4 (12.6) |
| Hispanic        | 12 (38.6) | 9 (26.5) | 14 (33.8) | 23 (49.1) | 7 (29.3) | 7 (21.3) | 11 (46.5) |
| Other or Multiple race, NH | 7 (29.8) | 7 (22.7) | 16 (29.6) | 18 (40.7) | 4 (5.7) | 9 (22.1) | 7 (27.7) |

| Household Income | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) |
|------------------|-------|-------|-------|-------|-------|-------|-------|
| $<60,000         | 38 (23.9) | 49 (31.7) | 64 (24.9) | 91 (35.4) | 13 (11.7) | 10 (17.4) | 13 (28.2) |
| $≥60,000         | 60 (25.1) | 80 (31.6) | 81 (26.2) | 123 (39.4) | 9 (28.4) | 12 (35.7) | 10 (37.8) |

| Health Insurance | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) |
|------------------|-------|-------|-------|-------|-------|-------|-------|
| Private/public insurance | 91 (23.7) | 127 (32.3) | 141 (26) | 210 (38.3) | 22 (18.1) | 22 (24.8) | 22 (33.3) |
| No insurance     | 7 (40.8) | 2 (19.5) | 4 (16.9) | 4 (19.6) | 0 (0) | 0 (0) | 0 (0) |

| Last Healthcare Visit | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) |
|-----------------------|-------|-------|-------|-------|-------|-------|-------|
| <2 years ago          | 93 (24.5) | 127 (32.5) | 138 (25.4) | 210 (38.5) | 22 (17.3) | 21 (23.5) | 23 (32.5) |
| More than 2 years ago | 4 (28.2) | 1 (4.7) | 7 (31) | 3 (10) | 0 (0) | 1 (5.8) | 0 (0) |

| Self-rated Health | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) |
|-------------------|-------|-------|-------|-------|-------|-------|-------|
| Excellent or very good | 47 (22.4) | 64 (29.2) | 69 (24.9) | 109 (35) | 11 (22.5) | 12 (23.7) | 11 (32.7) |
| Good               | 36 (29.1) | 47 (34.9) | 56 (31.8) | 74 (39.3) | 11 (23) | 8 (22.4) | 8 (25.3) |
| Fair or poor       | 15 (19.7) | 18 (30.5) | 20 (13.4) | 31 (40.1) | 0 (0) | 2 (21.7) | 4 (37.8) |

| Non-CRC Cancer History | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) | N (%) |
|------------------------|-------|-------|-------|-------|-------|-------|-------|
| No                     | 85 (25.9) | 105 (30) | 125 (26.5) | 178 (36.6) | 20 (16.8) | 19 (19.5) | 23 (34.3) |
| Yes                    | 13 (17.1) | 23 (41.1) | 20 (20.2) | 35 (42.2) | 2 (14) | 3 (53.2) | 0 (0) |

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

† Racial/ethnic minorities were combined into one group due to small sample size.
4.1. Limitations

We relied on self-reported data rather than objective measures of CRC screening and provider recommendation, which may contain misreporting due to inaccuracies in participants’ memory or tendency to provide socially desirable responses. Future research may benefit from using electronic health record data to confirm CRC screening and provider recommendation. Additionally, to reduce respondent burden, we limited our study to the three most commonly recommended and commonly used screening options, thus we were unable to capture patient preferences regarding other less widely used CRC screening options including computed tomography colonography and flexible sigmoidoscopy. Future research may benefit from including all recommended screening options to obtain a more comprehensive understanding of barriers to CRC screening. Moreover, we did not quantify the extent to which each barrier may prevent the use of a particular CRC screening option. Future research should consider assessing the relative importance of these barriers to each screening option. Such information would be useful for guiding intervention design in low-resource contexts by pinpointing which barriers should be targeted in the intervention in order to bring maximum improvement to screening completion. The majority (93%) of our survey participants reported private or public health insurance coverage, thus findings of this study may not generalize to uninsured patient populations. Future research with uninsured and underinsured patient samples are needed to understand these populations’ specific needs and barriers related to each screening option. Last, although consistent with the gradual decline in response rate of cross-sectional national surveys, our response rate is low, thus our findings’ generalizability may be impacted by non-response bias (Maitland et al., 2017). However, our sample was selected using rigorous stratification to ensure adequate population representation.

5. Conclusions

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

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CRediT authorship contribution statement

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