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Predictors of Colorectal Cancer Screening and Screening Modalities among Patients seen at Federally Qualified Health Centers Funded by the United States Health Resources and Services Administration

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ABSTRACT

Introduction: Federally qualified health centers provide primary care services to millions of low-income patients in the United States who face challenges accessing colorectal cancer (CRC) screening. We aimed to understand how patient-level factors influence CRC screening participation and screening modality choice in this setting.
Methods: We examined data from the 2022 Health Center Patient Survey, 2021 Uniform Data System, and Area Health Resource File. We performed generalized multilevel logistic regression and multinomial regression to measure associations between our independent variables and receipt of any CRC screening and of screening modalities.
Results: Among 1584 patients ages 50–75, most (56 %) reported having CRC screening, including 33 % with endoscopic screening only, 16 % with stool-based screening only, and 7 % with multiple modalities. Selected factors associated with any CRC screening included having five or more health center visits in the past year (aOR = 1.66, 95 %CI = 1.07–2.56), being insured (Medicaid aOR = 2.25, 95 %CI = 1.44–3.54; other insurance aOR = 2.69, 95 %CI = 1.51–4.82), living within 30 minutes of the health center (aOR = 1.93, 95 %CI = 1.15–3.25), having multiple comorbidities (aOR = 1.72, 95 %CI = 1.13–2.63), using telehealth (aOR = 1.52, 95 %CI = 1.02–2.27), and having a flu shot last year (aOR = 1.77, 95 %CI = 1.29–2.45). We observed that patients who are non-Hispanic Black (aOR = 3.52, 95 %CI = 1.28–9.68) and who do not speak English well or at all (aOR = 5.54, 95 %CI = 1.64–18.75) reported having multiple modalities.
Conclusion: Federally qualified health center patients reported endoscopic CRC screening more commonly than stool-based screening, and barriers to access such as distance to the health center and English proficiency were impactful. Increasing CRC screening in low-income populations requires improving access and promoting opportunities for less invasive screening.

1. Introduction

Colorectal cancer (CRC) remains the second leading cause of cancer-related deaths in the United States despite multiple screening modalities that are effective for early detection and prevention of disease. CRC screening uptake is lowest among non-White, uninsured, and low-income individuals, and many of these groups also suffer from the highest rates of CRC-related morbidity and mortality (McLeod et al.,

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2022; Carethers, 2021). Every year, roughly 1400 federally qualified health centers (FQHCs) are funded by the Health Resources and Services Administration (HRSA), a branch of the United States Department of Health and Human Services, to provide primary care services to over 30 million underserved individuals in the United States (Health Center Program Uniform Data System (UDS) Data Overview, 2024). National CRC screening rates in these health centers improved between 2016 (39.9 %) and 2022 (42.8 %), though improvement has slowed in recent years due to a variety of poorly understood factors (Colorectal Cancer Screening Rates Reach 44.1% In FQHCs In 2018, 2019; Huguet et al., 2022).

The Cancer Moonshot is an initiative created by the Biden Administration aimed to decrease cancer mortality in the United States by 50 % over the next 25 years by increasing prevention and early detection of cancer and by decreasing disparities (Singer, 2022). Considering that the majority (90 %) of the HRSA-funded health center patient population is below 200 % of the Federal Poverty Level (FPL), 63 % are racial/ethnic minorities, and 48 % are Medicaid beneficiaries, improving CRC screening uptake among this population will be important in achieving the goals outlined by the Cancer Moonshot (Colorectal Cancer Screening Rates Reach 44.1% In FQHCs In 2018, 2019; Huguet et al., 2022).

Several studies have identified barriers and facilitators to overall CRC screening participation at the level of the health center (Brown et al., 2015; Centra and Fogg, 2023; Lin et al., 2017). However, few have examined national patient-level data in FQHCs to determine the impact of social determinants on screening uptake, and even fewer have examined the impact of social determinants on choice of screening modality, largely due to scarcity of such data in this setting (Lin et al., 2017; Robertson et al., 2023). Choice of CRC screening modality is important for several reasons. First, most health centers are not able to offer screening colonoscopy on site and, thus, must refer patients to specialists outside their health system if such screening is desired (Centra and Fogg, 2023). As a result, many health centers offer non-invasive stool-based screening tests (e.g., fecal immunochemical test, FIT) that can be performed at home (Domingo and Braun, 2017). Second, if a non-invasive screening test is abnormal, health centers face several patient, provider, and health system challenges obtaining the required follow-up colonoscopy (Robertson et al., 2023). In this study we used recent Health Center Patient Survey (HCPS) data to (1) describe overall CRC screening rates and screening modalities as self-reported by health center patients and (2) determine the association between patient, provider, health center, and contextual factors with receipt of any CRC screening and by screening modality. We hypothesized that individual-level barriers and facilitators to CRC screening participation and specifically to the use of endoscopic (versus non-invasive) screening among patients seen in HRSA-funded health centers as self-reported in the HCPS will differ from barriers and facilitators to overall CRC screening participation previously described at the health center-level (Zhao et al., 2024; Aaronson et al., 2024).

2. Methods

2.1. Data and sample

We used the 2022 Health Center Patient Survey (HCPS), which was sponsored by the HRSA Bureau of Primary Health Care and produced nationally representative data on HRSA-funded health center patients (2022 Health Center Patient Survey Data File User's Manual, 2024). This survey aimed to increase participation of patients identifying as Asian, American Indian/Alaska Native, Native Hawaiian and other Pacific Islander, and those 65 years and over. The HCPS employs a three-stage (health center organization, health center site, patient) sampling design. Eligible patients were individuals who received services in the last year in-person or through telehealth and were interviewed at their second visit. The survey was offered in English, Spanish, Chinese, Tagalog, and Vietnamese. More information about the survey design and sampling strategy can be found in the 2022 HCPS data manual (2022 Health Center Patient Survey Data File User's Manual, 2024). A total of 4414 health center patients were interviewed from January 2021 to March 2022 across 102 unique health centers, with a response rate of 85 %. We merged data from the 2021 Uniform Data System (UDS), an administrative dataset containing health center-level information and electronic clinical quality measures (eCQM) reported annually to HRSA, to incorporate relevant health center organizational data, including staffing and services delivered.

We used the Area Health Resource File (AHRF) to capture relevant contextual factors in the county in which a health center was located. We merged AHRF using the Federal Information Process Standard codes associated with the five-digit ZIP code of the residence of each health center patient. If a health center had service sites in multiple counties, we selected the county where the largest share of patients lived based on UDS data.

We restricted our HCPS sample to adults aged 50–75 years who were eligible for CRC screening throughout the study period and without a personal history of CRC (self-reported). We also excluded patients who received a diagnostic colonoscopy or sigmoidoscopy for symptoms, diagnosis or follow-up of a medical condition. We further excluded respondents with incomplete data on one or more variables of interest. Included respondents were significantly more likely to be non-Hispanic White, and less likely to be Hispanic, or Asian, Pacific Islander, American Indian/Alaskan Native or "other" than both the excluded respondents and the overall HCPS sample. Included respondents were also significantly more likely to be aged $\geq$60, to have "other" insurance, to be employed, to have two or more comorbidities, and to have received a flu shot than overall HCPS respondents. We attribute these differences to the advanced age required to qualify for CRC screening. The characteristics of included HCPS respondents were not significantly different from 2021 UDS health center patient population characteristics (Health Center Program Uniform Data System (UDS) Data Overview, 2024). Our study was exempt from IRB review due to our use of publicly available data.

2.2. Dependent variables

Our dependent variables of interest were 1) any CRC screening (any modality) versus none and 2) specific screening modality used versus none. We first constructed variables for guideline-concordant CRC screening that were consistent with the A grade United States Preventive Service Task Force (USPSTF) recommendation at the time of initial survey collection to screen all adults aged 50–75 years for colorectal cancer (US Preventive Services Task Force et al., 2021). The guidelines included colonoscopy in the past 10 years, sigmoidoscopy in the past five years or 10 years with annual stool-based testing, or a stool-based test in the past year. We then created mutually exclusive categories including (1) endoscopic screening (colonoscopy or sigmoidoscopy) only, (2) stool-based screening only, and (3) multiple modalities. If a patient received more than one modality of screening in the same screening interval (e.g., colonoscopy and stool-based; sigmoidoscopy and stool-based; colonoscopy and sigmoidoscopy; or colonoscopy, sigmoidoscopy, and stool-based), we categorized these as two or more screening modalities. We did not create a separate category for sigmoidoscopy because only 12 patients reported this screening modality.

2.3. Independent variables

We modified the Andersen health care utilization model to include patient-level, health center-level, provider-level, and contextual factors in our analyses (**Fig. 1**) (Anderson, 1973).

2.3.1. Patient-level factors

Patient-level factors included race/ethnicity categorized as: non-

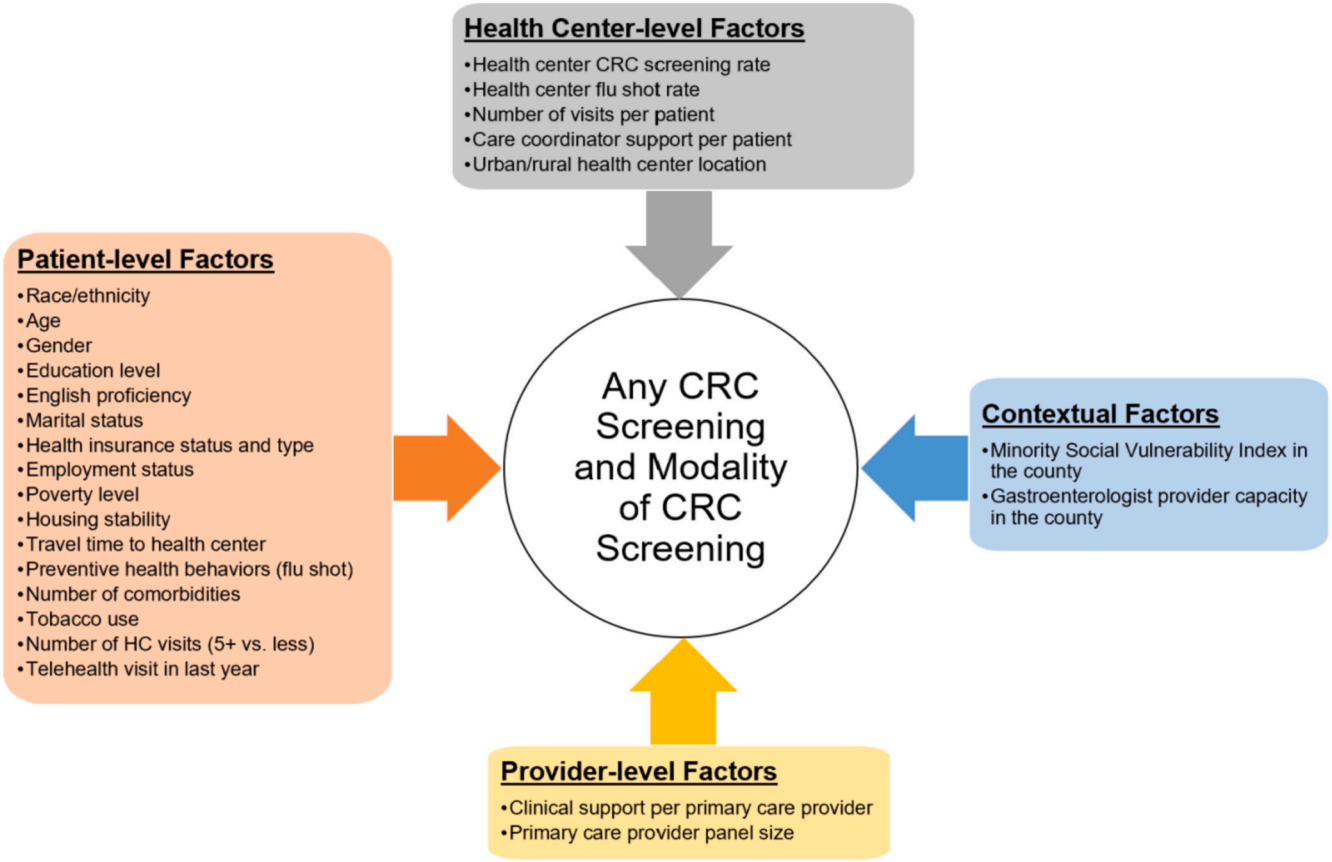

Fig. 1. Conceptual model of factors associated with colorectal cancer screening uptake at federally qualified health centers funded by the United States Health Resources and Services Administration.
Abbreviations: CRC, colorectal cancer; HC, health center.
Notes: Poverty Level is calculated by the United States Department of Health and Human Services and is based on household size and income. Minority Social Vulnerability Index is determined by combining various demographic and socioeconomic factors from the United States Census data and is an established measure level of socioeconomic disadvantage (Flanagan et al., 2018).

Hispanic White, non-Hispanic Black/African American, Hispanic/Latino, and other. We combined Hispanic and non-Hispanic American Indian or Alaska Native, Asian, Native Hawaiian or other Pacific Islander, and other races as "other" due to the small sample size of each group. Additional characteristics included ages 60–75 (vs. 50–59), female (vs. male), greater than high school education (vs. high school or less), speaks English not well or not at all (vs. native English speaker, very well, or well), married or partnered (vs. not married or single), Medicaid or other insurance (vs. uninsured), employed (vs. unemployed or not in the labor force), family income greater or equal to 100 % FPL (vs. less), and living within 30 minutes travel time to the health center (vs. longer). We used travel time to reflect transportation challenges that are known barriers to CRC screening (Lee et al., 2023). We included comorbidities as having two or more of the following health conditions (vs. less): cardiovascular disease, asthma, diabetes, hypertension, any cancer (except CRC), hepatitis B, and overweight or obesity (Amersi et al., 2005). Measures of health service utilization in the past year included frequent health center visits (five or more vs. fewer) and any telehealth visits (vs. none). We measured receipt of flu shot in the past year (vs. not) as a proxy for patient propensity to participate in preventive health care (Nielson et al., 2019).

2.3.2. Health center-level, provider-level, and contextual factors

Health center factors obtained from the UDS included health center-level CRC screening (eCQM) rates (Electronic Clinical Quality Measures Basics, 2024), ratio of enabling services staff per 1000 patients as a proxy for health center capacity to coordinate receipt of endoscopic procedures, and urban versus rural location given the unique challenges of rural health centers.

Provider-level factors included the ratio of clinical support personnel (certified nurse midwives, nurses, other medical personnel) per primary care provider (PCP; family physicians, general practitioners, internists, pediatricians, nurse practitioners, physician assistants) in the health center because these staff can promote CRC screening. We included the ratio of patients per PCP as a proxy for PCP workload.

We included county-level Minority Health Social Vulnerability Index (SVI) to measure level of socioeconomic disadvantage (Flanagan et al., 2018). We also included the ratio of gastroenterologists per 10,000 persons in each county to estimate the availability of providers capable of performing endoscopic screening.

For all health center-level, provider-level, and contextual-level continuous variables, we created low, medium, and high tertiles based on each variable's distribution and then dichotomized them to be able to compare those at the highest tertile with medium and low tertiles.

2.4. Statistical methods

We described the study sample and determined any CRC screening (vs. not) and screening modality (vs. not). We compared the independent variables by screening modality using *t*-tests or chi-square tests. We examined the association of independent and dependent variables in generalized multilevel structural equation logistic (any screening) and multinomial regression models (screening modality). The models accounted for clustering of patients within health centers and included a

scaled probability weight to account for the complex survey design of HCPS. We assessed all independent variables for multicollinearity (Stata "COLLIN" command). We calculated predicted probabilities for each independent variable by CRC modality to assess whether the likelihood of a given modality varied by patient, provider, health center, or contextual predictors. We also calculated the CRC screening rate at the health center level to assess if the rate differed for patients of health centers surveyed in the HCPS versus overall rates reported in UDS. We reported probability values at 0.05 or smaller. Since the HCPS was administered during the COVID-19 pandemic, we conducted a sensitivity analysis to test inclusion of a covariate measuring impact by COVID-19 (i.e., testing positive for COVID-19, unable to get care because of COVID-19, or unable to work because of COVID-19). Analyses were conducted using Stata 16.

3. Results

Our sample included 1584 patients ages 50–75 years with complete data. Most study patients were 60 years and over (55 %), female (55 %), non-Hispanic White (51 %), and had a high school education or less (56 %). Also, most had two or more comorbidities (71 %), had some form of health insurance (74 %), and lived within 30 minutes travel time to the health center (90 %) (Table 1). In addition, many were patients of health centers at the highest tertile of performance in CRC screening eCQM rate (39 %), enabling services staff (29 %), clinical support (27 %), and number of patients per PCP (29 %). Many patients lived in counties at highest tertile of SVI (24 %) and with the highest ratio of gastroenterologists per 10,000 persons (36 %).

Of the respondents, 56 % reported having undergone any CRC screening concordant with USPSTF guidelines (Table 1). This included 33 % who reported endoscopic screening only, 16 % with stool-based

Table 1
Characteristics of selected Health Center Patient Survey Respondents aged 50–75 in 2021 and 2022 by Colorectal Cancer Screening Uptake and by Screening Modality.

	Total	No CRC Screening	Any CRC Screening	Endoscopic screening	Stool-based screening	Two or more modalities	*p-value none* vs. *any*	*p-value none* vs. *screening modalities*
Sample	1584	730	854	478	242	134		
Weighted %		44 %	56 %	33 %	16 %	7 %		
Patient factors								
Race/Ethnicity							0.55	0.56
Non-Hispanic White (ref)	51 %	50 %	53 %	52 %	58 %	43 %		
Non-Hispanic Black or African American	21 %	22 %	20 %	21 %	19 %	17 %		
Hispanic/Latino	19 %	21 %	17 %	17 %	18 %	21 %		
Other	9 %	7 %	10 %	11 %	5 %	20 %		
Age ≥ 60 years (ref 50–59)	55 %	44 %	63 %	69 %	53 %	61 %	<0.001	<0.001
Female (ref Male)	55 %	60 %	51 %	55 %	40 %	54 %	0.18	0.13
More than high school education	44 %	43 %	45 %	42 %	46 %	52 %	0.82	0.81
Speaks English not well or not at all	17 %	18 %	17 %	14 %	19 %	22 %	0.70	0.08
Married or domestic partner (ref. unmarried)	48 %	41 %	53 %	55 %	47 %	61 %	0.02	0.07
Insurance							<0.001	<0.001
Uninsured (ref)	27 %	38 %	17 %	14 %	23 %	21 %		
Medicaid	27 %	29 %	25 %	23 %	32 %	22 %		
Other (Private, Medicare, other Public)	47 %	33 %	57 %	64 %	45 %	57 %		
Employed	29 %	32 %	28 %	28 %	23 %	34 %	0.42	0.68
Family income ≥100 % Federal Poverty Level[φ]	43 %	45 %	41 %	37 %	44 %	48 %	0.42	0.54
Lives ≤30 minutes from the health center	90 %	89 %	92 %	89 %	97 %	94 %	0.37	0.11
Has two or more comorbidities	71 %	66 %	75 %	71 %	80 %	81 %	0.10	0.14
Current smoker	25 %	28 %	22 %	21 %	24 %	21 %	0.11	0.38
Five or more visits to the health center last year	23 %	19 %	26 %	28 %	22 %	27 %	0.05	0.29
Had a telehealth visit last year	42 %	34 %	47 %	43 %	55 %	50 %	0.02	0.03
Received a flu shot in the last year	63 %	51 %	73 %	75 %	63 %	83 %	<0.001	<0.001
Health Center factors								
Highest tertile of CRC screening rate	39 %	29 %	47 %	55 %	32 %	45 %	0.00	0.00
Highest tertile of enabling service staff per 1000 patients	29 %	22 %	34 %	31 %	35 %	47 %	0.03	0.10
Rural (vs. urban health center location)	35 %	38 %	33 %	38 %	29 %	20 %	0.51	0.41
Provider factors								
Highest tertile of clinical support per PCP	27 %	30 %	24 %	25 %	24 %	21 %	0.01	0.03
Highest tertile of PCP panel size	29 %	31 %	27 %	26 %	31 %	26 %	0.08	0.24
Contextual (county-level) factors								
Highest tertile of Minority Social Vulnerability Index[τ]	24 %	28 %	21 %	20 %	27 %	17 %	0.27	0.43
Highest tertile of GI providers per 10,000 persons	36 %	30 %	41 %	40 %	46 %	34 %	0.06	0.15

Notes: *p*-values obtained using chi-squared testing.
Abbreviations: CRC, colorectal cancer; PCP, primary care provider; GI, Gastroenterology; Subcategories may sum to more than 100 % due to rounding.
[φ]Federal Poverty Level is calculated by the United States Department of Health and Human Services and is based on household size and income.
[τ]Minority Social Vulnerability Index is determined by combining various demographic and socioeconomic factors from the United States Census data and is an established measure level of socioeconomic disadvantage (Flanagan et al., 2018).

screening only, and 7 % with multiple modalities. The overall self-reported screening rate of 56 % in the weighted HCPS sample differs from the average eCQM screening rate of 42 % for all health centers as reported by the UDS in 2021, which is based on electronic health record (EHR) data.

Comparisons between patient characteristics and any CRC screening showed that patients that were older or partnered; had some form of insurance, telehealth visits, or flu shot; and patients of health centers with highest tertile of performance in CRC screening eCQM rate, enabling services staff, and clinical support per PCP, were more likely to report any CRC screening versus not (Table 1). Comparisons by specific CRC screening modalities revealed significant differences by age, insurance status, telehealth visits, flu shot, and health center performance in CRC screening and clinical support per PCP (Table 1).

The logistic regression model results for likelihood of any screening are displayed in Table 2. This analysis demonstrated that being 60 years or over (aOR = 1.79, 95 %CI = 1.24–2.59), married or partnered (aOR = 1.68, 95 %CI = 1.06–2.67), having five or more visits to a health center in the past year (aOR = 1.66, 95 %CI = 1.07–2.56), being insured (Medicaid aOR = 2.25, 95 %CI = 1.44–3.54, other insurance aOR = 2.69, 95 %CI = 1.51–4.82), living within 30 minutes to the health center (aOR = 1.93, 95 %CI = 1.15–3.25), having multiple comorbidities (aOR = 1.72, 95 %CI = 1.13–2.63), using telehealth (aOR = 1.52, 95 %CI = 1.02–2.27), and having a flu shot (aOR = 1.77, 95 %CI = 1.29–2.45) were associated with increased odds of reporting any screening.

The multinomial logistic regression models estimating the likelihood of receiving endoscopic screening only and of receiving multiple screening modalities compared with no screening demonstrated higher likelihood for non-Hispanic Black or African American patients, (aOR = 1.95, 95 %CI = 1.05–3.60 and aOR = 3.52, 95 %CI = 1.28–9.68), older patients (aOR = 2.31, 95 %CI = 1.50–3.57 and aOR = 2.24, 95 %CI = 1.11–4.54), and those with five or more visits to a health center (aOR = 1.86, 95 %CI = 1.11–3.11 and aOR = 3.08, 95 %CI = 1.51–6.27) or flu shot (aOR = 2.06, 95 %CI = 1.45–2.92 and aOR = 4.97, 95 %CI = 2.09–11.85) in the past year (Table 2). There was also increased likelihood of receiving endoscopic screening among those who were married or partnered (aOR = 1.64, 95 %CI = 1.05–2.58) or had other insurance (aOR = 3.37, 95 %CI = 1.77–6.42). Living within 30 minutes of the health center (aOR = 3.33, 95 %CI = 1.45–7.68), having multiple comorbidities (aOR = 2.38, 95 %CI = 1.20–4.72), and having a telehealth visit (aOR = 1.91, 95 %CI = 1.08–3.38) were associated with reporting stool-based screening. Having Medicaid was positively associated with patient report of endoscopic screening only (aOR = 2.68, 95 %CI = 1.50–4.79), stool-based screening only (aOR = 2.09, 95 %CI = 1.06–4.12, and multiple modalities (aOR = 2.29, 95 %CI = 1.09–4.83).

Additional predictors associated with receiving multiple screening modalities versus no screening included speaking English not well or not at all (aOR = 5.54, 95 %CI = 1.64–18.75), being employed (aOR = 2.12, 95 %CI = 1.11–4.08), and greater enabling services staff (aOR = 2.68, 95 %CI = 1.50–4.79). Highest tertile of clinical support per PCP (aOR = 0.40, 95 %CI = 0.18–0.86) and gastroenterologist capacity (aOR = 0.31,

Table 2
Patient, Provider, Health Center, and Contextual Factors Associated with Receipt of any Colorectal Cancer Screening and with Receipt of Specific Screening Modalities as Self-Reported by Federally Qualified Health Center Patients Ages 50–75 in 2021 and 2022 based on Multilevel Logistic Regression and on Multinomial Regression, respectively.

	Any CRC Screening (vs. no screening)		CRC Screening Modality (vs. no screening)					
			Endoscopic screening		Stool-based screening		Two or more modalities	
Sample size	1584		478		242		134	
	aOR	**95 % CI**	**aOR**	**95 % CI**	**aOR**	**95 % CI**	**aOR**	**95 % CI**
Patient factors								
Race/Ethnicity (ref. Non-Hispanic White)								
Non-Hispanic Black or African American	1.78	[0.91,3.48]	1.95*	[1.05,3.60]	1.24	[0.40,3.84]	3.52*	[1.28,9.68]
Hispanic/Latino	0.93	[0.56,1.54]	0.98	[0.58,1.65]	1.03	[0.39,2.75]	0.57	[0.19,1.69]
Other	1.19	[0.67,2.10]	1.08	[0.58,2.04]	1.27	[0.55,2.94]	1.99	[0.46,8.61]
Age ≥ 60 years (ref 50–59)	1.79**	[1.24,2.59]	2.31***	[1.50,3.57]	1.13	[0.68,1.87]	2.24*	[1.11,4.54]
Female (ref. Male)	0.84	[0.52,1.36]	0.96	[0.58,1.58]	0.75	[0.33,1.70]	0.62	[0.32,1.22]
More than high school education	1.14	[0.74,1.77]	1.10	[0.72,1.69]	0.96	[0.50,1.86]	1.70	[0.82,3.53]
Speaks English not well or not at all	1.26	[0.61,2.58]	1.20	[0.57,2.53]	0.82	[0.34,1.97]	5.54**	[1.64,18.75]
Married or domestic partner (ref unmarried)	1.68*	[1.06,2.67]	1.64*	[1.05,2.58]	1.75	[0.93,3.31]	1.87	[0.89,3.94]
Insurance (ref. uninsured)								
Medicaid	2.25***	[1.44,3.54]	2.68***	[1.50,4.79]	2.09*	[1.06,4.12]	2.29*	[1.09,4.83]
Other (Private, Medicare, other Public)	2.69***	[1.51,4.82]	3.37***	[1.77,6.42]	2.07	[0.86,4.95]	2.67	[0.99,7.21]
Employed	1.13	[0.74,1.74]	1.35	[0.84,2.17]	0.65	[0.37,1.12]	2.12*	[1.11,4.08]
Family income ≥100 % Federal Poverty Level[φ]	1.02	[0.65,1.61]	1.13	[0.74,1.72]	0.97	[0.46,2.06]	0.67	[0.36,1.27]
Lives ≤30 minutes from the health center	1.93*	[1.15,3.25]	1.48	[0.82,2.67]	3.33**	[1.45,7.68]	1.43	[0.43,4.73]
Has two or more comorbidities	1.72*	[1.13,2.63]	1.42	[0.94,2.13]	2.38*	[1.20,4.72]	1.84	[0.82,4.14]
Current smoker	0.90	[0.55,1.46]	0.86	[0.51,1.48]	0.74	[0.34,1.58]	1.62	[0.72,3.63]
Five or more visits to the health center last year	1.66*	[1.07,2.56]	1.86*	[1.11,3.11]	1.08	[0.49,2.36]	3.08**	[1.51,6.27]
Had a telehealth visit last year	1.52*	[1.02,2.27]	1.37	[0.94,1.98]	1.91*	[1.08,3.38]	1.49	[0.72,3.09]
Received a flu shot in the last year	1.77***	[1.29,2.45]	2.06***	[1.45,2.92]	0.95	[0.56,1.61]	4.97***	[2.09,11.85]
Health Center factors								
Highest tertile of colorectal cancer screening rate	1.27	[0.78,2.05]	1.42	[0.86,2.35]	0.80	[0.40,1.58]	1.77	[0.84,3.75]
Highest tertile of enabling service staff per 1000 persons	1.19	[0.77,1.86]	1.18	[0.68,2.06]	0.89	[0.51,1.58]	2.68*	[1.14,6.29]
Rural (vs. urban health center location)	1.01	[0.57,1.78]	1.16	[0.56,2.40]	1.03	[0.52,2.04]	0.58	[0.16,2.13]
Provider factors								
Highest tertile of clinical support per PCP	0.70	[0.44,1.11]	0.76	[0.44,1.31]	0.66	[0.33,1.30]	0.40*	[0.18,0.86]
Highest tertile of PCP panel size	0.97	[0.61,1.54]	0.93	[0.53,1.63]	1.04	[0.53,2.04]	0.92	[0.36,2.36]
Contextual (county-level) factors								
Highest tertile of Minority Social Vulnerability Index[τ]	0.92	[0.59,1.43]	0.85	[0.53,1.37]	1.10	[0.56,2.19]	0.68	[0.30,1.51]
Highest tertile of GI providers per 10,000 persons	0.88	[0.51,1.51]	1.01	[0.56,1.82]	1.05	[0.48,2.26]	0.31*	[0.12,0.77]

Notes: Statistically significant at *$p < 0.05$; **$p < 0.01$; ***$p < 0.001$; Abbreviations: CRC, colorectal cancer; PCP, primary care provider; GI, Gastroenterology.
[φ]Federal Poverty Level is calculated by the United States Department of Health and Human Services and is based on household size and income.
[τ]Minority Social Vulnerability Index is determined by combining various demographic and socioeconomic factors from the United States Census data and is an established measure level of socioeconomic disadvantage (Flanagan et al., 2018).

95 %CI = 0.12–0.77) were associated with a lower odds of reporting multiple screening modalities.

Examining the predicted probabilities of all independent variables by CRC screening modality indicated that likelihood of endoscopic screening was always higher than stool-based screening regardless of the patient, provider, health center, or contextual characteristics (**Appendix Table 1**).

Our sensitivity analysis showed that COVID impact was not significantly associated with report of any CRC screening and resulted in no significant changes in relationships of other independent variables with any CRC screening (data not shown). We did not find multicollinearity between the independent variables.

4. Discussion

To our knowledge, this study is the first since 2017 to examine national patient-level data among HRSA-funded health centers to determine the impact of social determinants of health on individuals' likelihood of receiving CRC screening. In addition, prior analyses of HCPS data have not examined uptake of specific CRC screening modalities among HRSA-funded health center patients (Lin et al., 2017). We found that 56 % of patients seen at HRSA-funded health centers self-reported adherence to USPSTF guideline-concordant CRC screening, a rate similar to that reported by patients in the 2014 survey (Lin et al., 2017). We also found that most health center patients reported participation in endoscopic screening only compared to stool-based screening only or multiple screening modalities.

Our finding that 56 % of health center patients self-reported guideline-concordant CRC screening is lower than the rate reported in other national surveys for 2021, including the National Health Interview Survey (59 %) and Behavioral Risk Factor Surveillance System (70 %) and the Healthy People 2030 target of 68 % (Increase the proportion of adults who get screened for colorectal cancer — C-07 - Healthy People 2030, 2024; Data and Progress, 2024). Our lower rate compared to these more nationally representative samples likely reflects additional barriers that HRSA-funded health center patient populations face in accessing preventive health services compared to patients in other health care settings (Huguet et al., 2022; Lin et al., 2017). Exclusion of diagnostic colonoscopies in our analyses may also contribute to our findings as some diagnostic colonoscopies may also include screening; however, screening is intended to detect or prevent CRC among asymptomatic individuals. Our finding that most patients participated in endoscopic screening only may reflect the preference for colonoscopy as the gold standard test despite evidence and USPSTF recommendation that there are several appropriate screening test options (Brown et al., 2015).

Our findings that patients of a higher age, who are married, who are employed, and who have insurance were more likely to complete CRC screening recommendations are consistent with prior research, including a prior study examining 2014 HCPS data (McLeod et al., 2022; Carethers, 2021; Lin et al., 2017). Our finding that non-Hispanic Black/African American individuals were more likely to use multiple screening modalities may reflect concerns for a higher risk of CRC in this group, though is distinct from other studies reporting lower CRC screening participation in this population (McLeod et al., 2022; Carethers, 2021; Augustus and Ellis, 2018). At least one systematic review indicated that Black individuals who participate in CRC screening may undergo additional unnecessary screening (Predmore et al., 2018). Our finding that English proficiency impacted receipt of multiple screening modalities highlights that educational materials containing culturally and linguistically appropriate CRC screening information is critical in diverse patient populations. Our findings among non-Hispanic Black/African American individuals support the use of multi-level strategies, such as culturally-tailored patient navigation or outreach and health education to reduce disparities in CRC screening (Grubbs et al., 2013; Percac-Lima et al., 2009).

We also identified several positive associations between modifiable factors related to patient access to healthcare and CRC screening uptake, including frequent health care visits, receipt of flu shot, and proximity to a health center. These findings are consistent with existing studies and suggest that HRSA-funded health centers might consider coupling CRC screening counseling with provision of other preventive services, such as Flu-FIT programs (Sarfaty et al., 2013; Potter et al., 2013; Miller et al., 2022). Our finding that having a telehealth visit increased the likelihood of receiving stool-based screening only may reflect that patients are more willing to participate in screening if the screening test can be completed at home (Fedewa et al., 2022; Hanna et al., 2022; Nodora et al., 2021; Star et al., 2023). Based on this, efforts to increase the availability of telehealth and of at-home stool-based screening options, particularly in rural areas, may improve CRC screening rates, provided that patients receive appropriate education about these tests (Finney Rutten et al., 2023; Zhu et al., 2024). In addition, the positive associations between living in close proximity to a health center and receipt of any CRC screening and stool-based screening highlight the importance of nesting health centers within neighborhoods to increase access to preventive services, particularly in geographically remote areas (Seymour et al., 2017).

Our finding that patients seen at health centers with the highest proportion of enabling services staff had increased likelihood of receiving multiple screening modalities may indicate that health centers with greater investment in enabling services staff have better capability to coordinate care for different types of CRC screening (Lee et al., 2018). This may reflect referrals by enabling services staff to promote and coordinate the distribution of stool-based screening tests and endoscopic screening by external providers, or the availability of transportation and translation services aimed at increasing access to preventive services (Domingo and Braun, 2017; Lee et al., 2018; Chuang et al., 2019; Green et al., 2014; Coronado et al., 2022). Conversely, the association between greater clinical support and gastroenterologist capacity and lower likelihood of multiple modalities may reflect the influence of improved patient-provider ratios and of increased community education pertaining to screening.

Our study had several limitations. We measured associations rather than causality due to the cross-sectional nature of the HCPS. Additionally, we found that patients' self-reported CRC screening rate was 56 %, which differed from the EHR-based UDS eCQM screening rate of 42 %; this may reflect recall and acquiescence biases wherein patients over-report CRC screening and/or incorrectly report screening modalities (Health Center Program Uniform Data System (UDS) Data Overview, 2024; Dodou and de Winter, 2015; Griffin et al., 2009). The HCPS was conducted during the COVID-19 pandemic, and our measures of use of health care may have been impacted by pandemic restrictions, though we are reassured that our sensitivity analyses demonstrated no associations between COVID and our outcomes of interest. We could not include patients ages 45–49 because the HCPS was developed prior to the 2021 USPSTF recommendation to screen individuals age 45–49 years. The survey only asked about CRC screening procedures for patients 50 or older (2022 Health Center Patient Survey Data File User's Manual, 2024; US Preventive Services Task Force et al., 2021). Additionally because we excluded respondents with missing data, our included study population was skewed towards older and White patients, which may bias these findings, though reassuringly our patient population did not differ significantly from national health center characteristics from 2021 UDS data. Lastly, stool-based testing at health centers is generally limited to FIT, and thus HCPS did not include other less commonly used screening modalities recommended by the USPSTF, such as the high sensitivity fecal occult blood test and the stool FIT-DNA test. Despite these limitations, our study had the unique strength of assessing factors associated with screening modalities from a representative sample of HRSA-funded health center patients who are disproportionally impacted by disparities in access to CRC screening.

In conclusion, this study is the first in many years to characterize

patient-level CRC screening patterns among HRSA-funded health center patients and the first to assess type of screening test performed in this setting. Our findings highlight opportunities for HRSA-funded health centers to increase CRC screening uptake by obtaining access to a variety of stool-based tests, promoting various screening modalities, and by recommending screening via low-cost, non-invasive tests that can be performed at home, particularly via telehealth (Miller et al., 2022; Shaukat and Levin, 2022). Since patient preferences about CRC screening modality may differ, providers have the opportunity to involve patients in shared decision-making to address their preferences and concerns for CRC screening (Miller et al., 2022; Shaukat and Levin, 2022; Zhu et al., 2022).

Data statement

The study's original data are available to the public. You can find this data at the following links: HCPS https://data.hrsa.gov/topics/health-centers/hcps, UDS https://bphc.hrsa.gov/data-reporting, ARF https://data.hrsa.gov/topics/health-workforce/ahrf

CRediT authorship contribution statement

Megan R.M. Aaronson: Writing – original draft, Visualization, Methodology, Investigation, Conceptualization. **Nadereh Pourat:** Writing – review & editing, Supervision, Software, Resources, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Connie Lu:** Methodology, Formal analysis, Data curation. **Jayraan Badiee:** Writing – review & editing, Software, Resources, Methodology, Formal analysis, Data curation. **Helen Yu-Lefler:** Writing – review & editing, Supervision, Resources, Project administration, Methodology, Investigation. **Benjamin Picillo:** Project administration. **Hank Hoang:** Resources, Project administration, Methodology. **Folasade P. May:** Writing – review & editing, Supervision, Resources, Methodology, Investigation, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Appendix

Appendix Table 1
Predicted Probabilities of Colorectal Cancer Screening Modalities by Patient, Health Center, Provider, and Contextual Factors Among Respondents of The Health Center Patient Survey ($n = 1584$).

	Endoscopic screening	Stool-based screening	Two or more modalities
Overall predicted probability	30 %	15 %	7 %
Patient factors			
Race/ethnicity			
Non-Hispanic White (ref)	28 %	14 %	7 %
Non-Hispanic Black or African American	36 %	13 %	13 %
Hispanic/Latino	29 %	15 %	4 %
Other	27 %	16 %	11 %
Age ≥ 60 years (ref 50–59)	36 %**	13 %**	8 %
Female (ref. Male)	31 %	13 %	6 %
More than high school education	30 %	14 %	9 %
Speak English not well or not at all	27 %	10 %	20 %**
Married or domestic partner (ref unmarried)	33 %	17 %	8 %
Insurance			
Uninsured (ref)	19 %	13 %	6 %
Medicaid	31 %	17 %	8 %
Other	36 %	15 %	8 %
Employed	34 %	10 %	10 %*
Family income ≥100 % Federal Poverty Level[φ]	28 %	15 %	9 %
Lives ≤30 minutes from the health center	28 %	7 %	7 %**
Has two or more comorbidities	31 %	17 %	8 %
Current smoker	28 %	12 %	10 %
Five or more visits to the health center last year	36 %	12 %	12 %
Had a telehealth visit last year	31 %	18 %	8 %
Received a flu shot in the last year	34 %**	13 %	10 %***
Health Center factors			
Highest tertile of colorectal cancer screening rate	34 %	12 %	9 %
Highest tertile of enabling service staff per 1000 persons	31 %	13 %	11 %*
Rural (vs. urban health center location)	29 %	15 %	8 %
Provider factors			
Highest tertile of clinical support per PCP	29 %	13 %	5 %
Highest tertile of PCP panel size	29 %	15 %	7 %
Contextual (county-level) factors			
Highest tertile of Minority Social Vulnerability Index[τ]	28 %	16 %	6 %
Highest tertile of GI providers per 10,000 persons	32 %	15 %	4 %*

Notes: Statistically significant at *p<0.05; **p<0.01; ***p<0.001; Abbreviations: CRC, colorectal cancer; PCP, primary care provider; GI, Gastroenterology
[φ]Federal Poverty Level is calculated by the United States Department of Health and Human Services and is based on household size and income.
[τ]Minority Social Vulnerability Index is determined by combining various demographic and socioeconomic factors from the United States Census data and is an established measure level of socioeconomic disadvantage (Flanagan et al., 2018).

Data availability

The authors do not have permission to share data.

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