Preventive Medicine Reports 35 (2023) 102353

Contents lists available at ScienceDirect

Preventive Medicine Reports

journal homepage: www.elsevier.com/locate/pmedr

Barriers and facilitators of colorectal cancer screening using the 5As framework: A systematic review of US studies

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ARTICLE INFO

Keywords:
Colorectal cancer screening
Screening barriers
Screening facilitators
Cancer prevention
Screening disparities

ABSTRACT

Despite clear evidence that regular screening reduces colorectal cancer (CRC) mortality and the availability of multiple effective screening options, CRC screening continues to be underutilized in the US.

A systematic literature search of four databases – Ovid, Medline, EBSCHOhost, and Web of Science – was conducted to identify US studies published after 2017 that reported on barriers and facilitators to CRC screening adherence. Articles were extracted to categorize relevant CRC screening barriers or facilitators that were assessed against CRC screening outcomes using the 5As dimensions: Access, Affordability, Acceptance, Awareness, Activation.

Sixty-one studies were included. Fifty determinants of screening within the 5As framework and two additional dimensions including Sociodemographics and Health Status were identified. The Sociodemographics, Access, and Affordability dimensions had the greatest number of studies included. The most common factor in the Access dimension was contact with healthcare systems, within the Affordability dimension was insurance, within the Awareness dimension was knowledge CRC screening, within the Acceptance dimension was health beliefs, within the Activation dimension was prompts and reminders, within the Sociodemographics dimension was race/ethnicity, and among the Health Status dimension was chronic disease history. Among all studies, contact with healthcare systems, insurance, race/ethnicity, age, and education were the most common factors identified.

CRC screening barriers and facilitators were identified across individual, clinical, and sociocontextual levels. Interventions that consider multilevel strategies will most effectively increase CRC screening adherence.

1. Background

Colorectal cancer remains the third leading cause of cancer death for US adults (American Cancer Society, 2023). While incidence has declined in adults over 50, it has risen 1–2% yearly with an estimated 10.5% of new cases occurring in younger adults (American Cancer Society. Cancer Facts Figures, 2023; Siegel et al., 2017). African American and American Indian/Alaska Native (AI/AN) adults have the highest rates of colorectal cancer incidence (41.7 per 100,000; 48.6 per 100,000, respectively) and mortality (17.6 per 100,000; 18.6 per 100,000, respectively) compared to White adults (incidence: 35.7 per 100,000; mortality: 13.1 per 100,000) (Siegel, 2023). Additionally, over the past decades, high socioeconomic status (SES) areas and non-Hispanic White populations saw a sharper decline in CRC mortality compared to low SES areas and all other racial/ethnic groups (Wang et al., 2012; Clouston et al., 2017; Robbins et al., 2012).

CRC screening reduces associated incidence and mortality (Kaminski et al., 2020; Libby et al., 2012; Zorzi et al., 2015). The US Preventive Services Task Force (USPSTF) and the American Cancer Society (ACS) recommend screening for CRC starting at age 45 and continuing until age 75 among average-risk adults (Davidson et al., 2021; Wolf et al., 2018). Recommended screening options include annual fecal immunochemical test/guaiac-based fecal occult blood test (FIT/gFOBT), multitarget stool DNA (mt-sDNA) assay every 1–3 years, computed tomography colonography (CTC) or flexible sigmoidoscopy every five years, and screening colonoscopy every ten years (Davidson et al., 2021; Wolf et al., 2018). Apart from integrated healthcare systems, CRC screening among average-risk adults occurs largely opportunistically, with

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https://doi.org/10.1016/j.pmedr.2023.102353
Received 6 March 2023; Received in revised form 20 June 2023; Accepted 28 July 2023
Available online 29 July 2023

patients either self-referring or receiving recommendations for screening from healthcare providers during unrelated healthcare visits (Levin et al., 2011; Schreuders et al., 2015).

Despite evidence that regular screening reduces CRC mortality, CRC screening remains underutilized in the US. Approximately 30% of screening-eligible adults in the US were not up-to-date with CRC screening in 2020 (Richardson et al., 2022). Additionally, lower screening rates have been observed among racial/ethnic minorities and lower SES groups experiencing higher CRC mortality (White et al., 2017; May et al., 2017; Gellad and Provenzale, 2010; Doubeni et al., 2019; Steele, 2013; Finney Rutten et al., 2004; Davis et al., 2017; Koblinski et al., 2018; Lansdorp-Vogelaar, et al., 2012; Jackson, 2016; Warren Andersen et al., 2019).

No previous review of CRC screening barriers and facilitators has adopted a framework to systematically categorize multi-level factors that are influential to CRC screening adherence. An updated understanding of the barriers and facilitators to screening is needed to guide intervention development. Therefore, we aim to operationalize the 5As taxonomy developed by Thomson et al., (2016) as a framework to organize our review of barriers and facilitators to CRC screening adherence utilizing the dimensions of Access, Affordability, Awareness, Acceptance, and Activation (Table 1) (Thomson et al., 2016). The 5As taxonomy was developed to understand barriers to vaccine uptake, and offers a multilevel lens to understanding factors that impact behavior at the individual level as well as the contextual level. Extending upon Thomson et al., we also explore how factors pertaining to sociodemographics might further build on this framework to address disparities (Fig. 1a).

2. Methods

2.1. Databases used, search strategies, and selection criteria

This literature search was conducted in consultation with a librarian reference expert who implemented an electronic literature search. The following databases were utilized: Ovid, Medline (Embase, EBM Reviews Cochrane), EBSCHOhost (CINAHL), and Web of Science (Science Citation Index Expanded, Emerging Sources Citation Index). Using key terms such as "colorectal cancer screening" and "barriers", we identified observational and interventional studies published between Jan 2017 and Jan 2022 (see Appendix A for specific search terms). A total of 1659 abstracts were screened against inclusion and exclusion criteria within the Covidence Review platform, and 1364 studies were deemed irrelevant. The inclusion criteria included: data collection after January 2017, English publication, US populations, reported on barriers or facilitators to CRC screening or intentions to screen. The time frame of 2017 – 2022 was selected to prioritize the most recent literature, and to capture studies that were conducted after screening guidelines changed in 2016. Articles were excluded if they were published prior to 2017, data collection was before 2017, non-English publication, did not include barriers or facilitators to CRC screening or intentions to screen, or focused on non-US populations. Reviews, editorial materials, article proceedings, pilot studies, validation studies, study protocols, cost effective studies, simulation studies, qualitative studies, and trend studies were also excluded. Additionally, articles were excluded if they focused on high CRC-risk populations, cancer patients, cancer survivors, follow-up testing, and screening among adults older than age 75. One additional study was added to the assessment apart from the database search. A total of 292 full-text studies were assessed for eligibility. Each full-text article was assessed against inclusion/exclusion criteria by two reviewers to reach a consensus. If there was a discrepancy, a third reviewer made the final decision on inclusion. A total of 61 articles were selected for inclusion. The majority of excluded articles were not included due to study design criteria (see Fig. 2).

Table 1
Definitions of 5As taxonomy adapted for colorectal cancer screening.

Dimension	Definition
Access	the ability of individuals to obtain or receive recommended screening
Affordability	The ability of individuals to afford recommended screening
Awareness	The degree to which individuals have knowledge of the availability and need for screening, as well as relevant recommendations, risks, and benefits of screening
Acceptance	The extent to which individuals accept, question, or refuse screening
Activation	The degree to which individuals are encouraged, reminded, or otherwise incentivized to participate in screening

2.2. Content analysis

Two reviewers extracted each article for study characteristics and content relevant to the 5As dimensions within the Covidence Review platform. The first reviewer categorized each CRC screening barrier or facilitator that was tested for an association with CRC screening. An evidence statement was provided for each categorization. Additional CRC screening factors were categorized as "other" if they did not fit under the 5As. With further review, two new categories relevant to CRC screening emerged and were added: Health Status and Sociodemographics. Additionally, each CRC screening factor was assigned to root causes within the 5As. To capture multilevel influence, these root causes were also categorized as individual-, clinical-, and sociocontextual-level factors. A second reviewer repeated this same process independent of the first reviewer, and discrepancies were resolved by a third reviewer.

3. Results

Article characteristics are summarized in Table 2. Most articles were cross-sectional survey studies (42); 6 were randomized controlled trials, 4 were non-randomized experimental studies, 6 retrospective /cohort studies, 2 retrospective cross-sectional studies and 1 cohort study. The characteristics of the populations represented in the 61 studies included a range of ages (18 – 80 yo), diverse race/ethnicities (e.g.: Asian-American, Asian immigrant, African-American, African immigrant, American Indian/Alaskan Native, Pacific Islander, Latino-American, Latino immigrant, Arab-American adults) (Xiao et al., 2020; Cassel, 2017; Wu and Raghunathan, 2020; Winkler et al., 2022; Wang et al., 2021; Viramontes, 2020; Rogers, 2021; Redwood, 2019; Nakajima et al., 2021; Lee et al., 2019; Lee et al., 2021; Gonzalez et al., 2020; Drolet and Lucas, 2022; Boutsicaris et al., 2021; Ayash et al., 2020; Haverkamp et al., 2020) as well as economic and geographical diversity. The sample size (N) ranged from 70 to 18,488,421, and 44 of the studies focused on adults 50 yo and older (72%). Most studies reported on screening utilizing colonoscopy (67%) or a stool test (mt-sDNA, FIT-DNA, gFOBT, FIT) (75%), and some studies reported on sigmoidoscopy (43%). A limited number of studies reported on intentions to screen (10%).

For each study, all correlates of adherence at every level were summarized. Table 3 summarizes the dimensions and root causes of the factors associated with CRC screening adherence examined in the studies. The majority of the studies reported on the Sociodemographics dimension (n = 36 studies, 59%), followed by Affordability (n = 30 studies, 49%) and Access (n = 30 studies, 49%). A total of 50 root causes of CRC screening were identified for the 61 studies. Most factors were categorized within the Sociodemographics (20%) and Acceptance (26%) dimensions. Health beliefs were identified as the root cause with the greatest number of articles (n = 12 studies) within the Acceptance dimension, while age had the greatest number of articles (n = 27 studies) within the Sociodemographics dimension. Significant facilitators and barriers are reported by dimension in Table 4.

3.1. Sociodemographics (n = 36 studies)

Sociodemographics were the most frequently reported correlates of

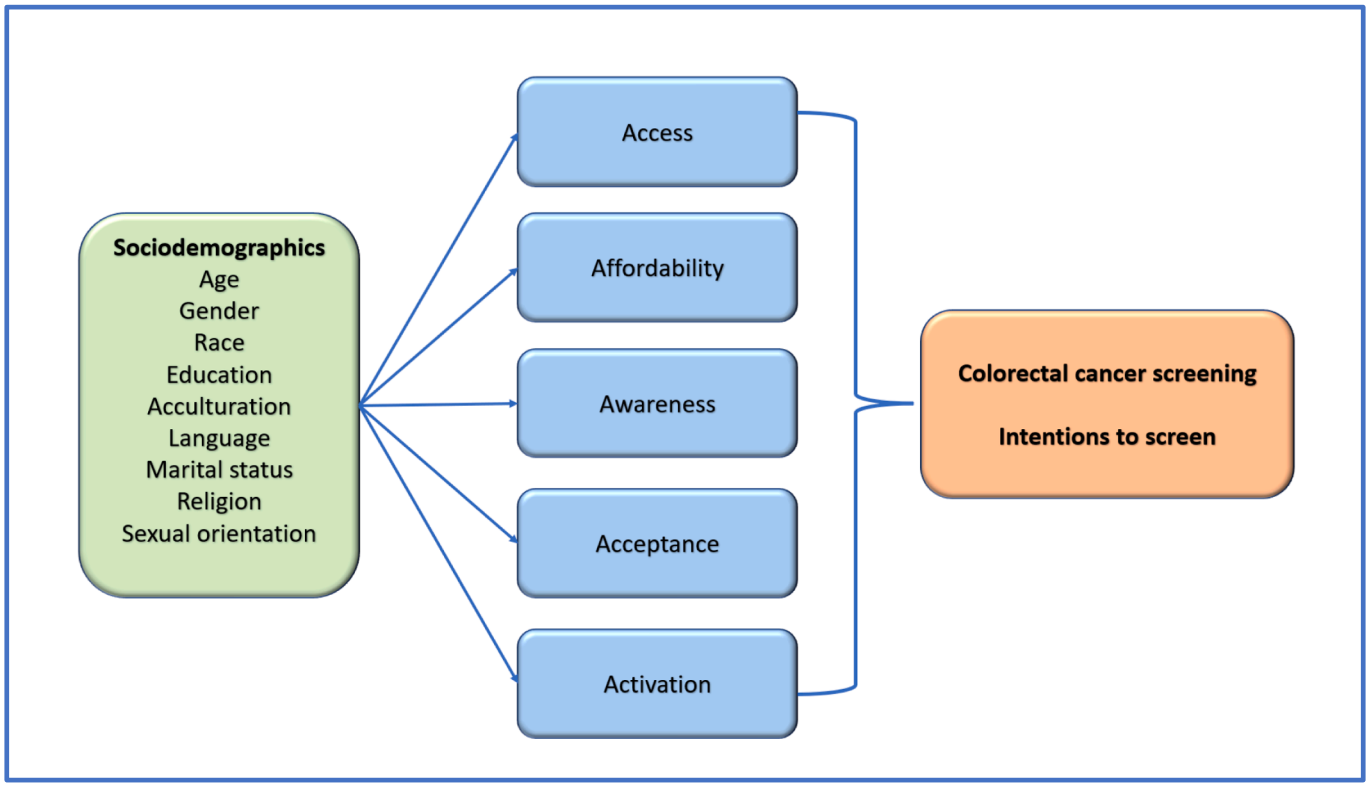

Fig. 1a. 5As framework including sociodemographics.

CRC screening adherence. Within the Sociodemographics dimension, 13 root causes were identified: gender/gender identity, age, race/ethnicity, education, religion/spirituality, sexual orientation, marital status, language, acculturation/time in US, and employment. There were 19 studies that examined the relationship between sex/gender and CRC screening adherence, and of these, 3 studies found that female gender significantly facilitated adherence (Viramontes, 2020; Zhan et al., 2021; McDaniel et al., 2019). Increasing age was found to be significantly associated with adherence for 20 out of 27 studies (McDaniel et al., 2019; Zhu, 2021; Moreno et al., 2019; Rogers, 2021; Williams, et al., 2018; Shete, 2021; Liu et al., 2020; Lee et al., 2019; Kurani et al., 2020; Guo et al., 2021; Camacho-Rivera et al., 2019; Benavidez et al., 2021; Zhan et al., 2021; Viramontes, 2020; Samuel et al., 2021; O'Neil et al., 2021; Mayhand et al., 2021; Elangovan et al., 2021; Charkhchi et al., 2019; Harper et al., 2021). The association between adherence and race/ethnicity was reported for 28 studies. There were several studies that reported that being a minority was a significant facilitator to adherence (Mayhand et al., 2021; Camacho-Rivera et al., 2019; Daniel et al., 2021; Benavidez et al., 2021; Zhan et al., 2021; McDaniel et al., 2019; Charkhchi et al., 2019; Harper et al., 2021), while some studies reported decreased adherence for racial/ethnic minorities, specifically with reduced adherence among African American and AI/AN adults (Kurani et al., 2020; Elangovan et al., 2021; O'Neil et al., 2021; Zhan et al., 2021; McDaniel et al., 2019; Camacho-Rivera et al., 2019; Benavidez et al., 2021; Harper et al., 2021). Additionally, in a study examining Asian immigrant adherence, Korean participants reported significantly higher CRC screening compared to Vietnamese participants (Xiao et al., 2020). Higher education was linked with significant adherence in 9 out of the 24 studies that examined education (Viramontes, 2020; Boutsicaris et al., 2021; Ayash et al., 2020; McDaniel et al., 2019; Guo et al., 2021; Benavidez et al., 2021; Charkhchi et al., 2019; Charkhchi et al., 2020,; Gray, 2021). One study examined the impact of spiritual beliefs on CRC screening using the Spiritual Health Locus of Control scale among Arab American adults, and found that participants with increased spiritual beliefs were significantly less likely to have completed CRC screening (Ayash et al., 2020). One study found that sexual orientation did not impact adherence (Charkhchi et al., 2019). Three out of twelve studies found that being married was significantly associated with CRC screening adherence (McDaniel et al., 2019; Charkhchi et al., 2019; Charkhchi et al., 2020), while in contrast, two studies found that those who were not partnered had higher adherence (Rogers, 2021; Kasting et al., 2021). Gonzalez et al., found that having a physician that spoke both English and Spanish played a significant role in facilitating CRC screening adherence (Gonzalez et al., 2020), and Elangovan et al., reported that non-English speakers had increased adherence compared to their English-speaking counterparts (Elangovan et al., 2021). Acculturation and longer time within the US were found to be facilitators of CRC screening adherence (Lee et al., 2019; Gonzalez et al., 2020). Finally, 15 studies assessed the relationship between employment and adherence, and, of these 15, four found that retirement was a significant factor in CRC screening adherence (Viramontes, 2020; Shete, 2021; Benavidez et al., 2021; Charkhchi et al., 2019; Kasting et al., 2021), and one found that retirement was associated with decreased screening adherence (Benavidez et al., 2021).

3.2. *Access (n = 30 studies)*

There were 7 root causes identified within the Access dimension: rurality, neighborhood (SES), convenience of access, mailed FIT kits, contact with healthcare systems, place of birth, and racism. Rurality was significantly associated with a decreased likelihood of adherence in 7 of 13 studies (McDaniel et al., 2019; Shete, 2021; Kurani et al., 2020; Charkhchi et al., 2019; Charkhchi et al., 2020; Benavidez et al., 2021; Moreno et al., 2020). Mayhand et al., (2020) found that low neighborhood SES was associated with low adherence using data linked to the US Census American Community Survey to measure neighborhood stability, language skills, household isolation, household income, crowding, transportation, multiple index of concentration at the extreme measures, and Yost deprivation index (Mayhand et al., 2021). Wolbert et al., (2021) found that the more convenient a location for screening was, the

Table 2
Study characteristics and assigned dimensions.

Author (year)	Study design	Population (N)	Factors Examined	Factors Identified for Significant Adherence*	Dimension
Cohort studies					
Green 2020	Cohort study	Aged 50–75 yo (3,386)	Mailed FIT kits, clinical prompts and reminders	↑Mailed FIT kits, ↑clinical prompts and reminders	Access, Activation
Cross sectional surveys					
Allen 2021	Cross sectional survey	Aged 50–75 yo (205)	Perceived risk, cancer cognitions, worry about environmental exposure		Awareness, Acceptance
Ayash 2020	Cross sectional survey	Arab Americans aged 50—75 yo (100)	Gender, religion/spiritual health locus of control, preferred language, education, household income, employment status, health insurance, provider's gender, trust in doctor, provider's race, provider recommendation	↑Insurance, ↑provider recommendation, ↓higher spiritual affinity (SHLC)	Access, Affordability, Acceptance, Sociodemographics
Benavidez 2021	Cross sectional survey	Women aged 65 – 75 yo (109,940)	Age, education, race/ethnicity, income, insurance, rurality, employment, medical cost	↑Age, ↑education, ↑Black, ↓Hispanic, ↓Rurality, ↓low income, ↓retired, ↑insurance, ↓medical cost	Access, Affordability, Sociodemographics
Camacho-Rivera 2019	Cross sectional survey	Aged 18 yo and older (783)	Gender, age, race/ethnicity, health insurance, education, employment, income, cancer history, smartphone	↑Smartphone use, ↑non-Hispanic Black, ↑age, ↑cancer history	Awareness, Sociodemographics
Cassel 2020	Cross sectional survey	Pacific Islanders aged 18 years and older (1,010)	Ethnicity		Sociodemographics
Charkhchi 2019	Cross sectional survey	Aged 18 yo and older (400,000)	Age, race, education, marital status, employment, income, healthcare access hardship, rurality, insurance, gender identity, sexual orientation, history of chronic disease, personal doctor access/PCP, recent checkup	↑Age ↓Rurality, ↑Income, ↑Insurance, ↑history of chronic disease, ↑other minority race, ↑education, ↑married, ↑retired, ↑had personal doctor, ↑recent checkup	Access, Affordability, Sociodemographics, history of chronic disease
Charkhchi 2020	Cross sectional survey	Women aged 50–80 yo (128,287)	Age, race, education, marital status, insurance, employment, income, health access hardship due to cost, rurality, personal doctor access/ PCP, recent checkup, history of chronic disease (BMI), smoking status	↑Education, ↑married, ↑insured, ↓higher income, ↓health access hardship due to cost, ↑Had personal doctor, ↑recent checkup, ↑Hx of chronic disease, ↓rurality, ↓smoker	Access, affordability, Sociodemographics, health status
Daniel 2021	Cross sectional survey	aged 50–80 years old (855)	Race, rurality	↑racial ethnic minority	Access, Sociodemographics
Drolet 2021	Cross sectional survey	African Americans aged 50–75 yo (457)	Attitudes, norms, perceived behavior control	↑Attitudes, ↑norms, ↑perceived behavioral control	Acceptance
Gonzalez 2020	Cross sectional survey	Self-identified Hispanic, aged 50 yo and older (70)	Age, gender, marital status, formal education level, preferred language, place of birth, physician language/ recommendation, time in US, residence status, perceived state of health, acculturation, fatalism	↑Bilingual physician, ↑physician recommendation, ↑Longer time in US	Acceptance, Sociodemographics, Health status
Gray 2021	Cross sectional survey	aged 50—75 yo (164)	Age, sex, race, education, health insurance, knowledge of CRCS, healthcare provider influence, colonoscopy perception (efficacy/ safety)	↑colonoscopy perception (efficacy/ safety), ↑education	Awareness, Acceptance, Sociodemographics
Guo 2021	Cross sectional survey	Aged 18 yo and older (895)	Age, sex, race/ethnicity, education, income, rurality, current smoking, insurance, cancer fatalistic beliefs	↑Age, ↑Education, ↑Income, ↑Cancer fatalistic beliefs	Affordability, Acceptance, Sociodemographics
Harper 2021	Cross sectional survey	Women aged 50—65 yo (394)	Cancer fatalism, physician Communication/shared decision making, age, race/ethnicity	↓Cancer fatalism, ↑physician communication, ↑Black, ↓MENA, ↑age	Acceptance, Sociodemographics
Kasting 2021	Cross sectional survey	aged 18—75 yo (970)	Material, psychosocial and behavioral financial hardship, education, employment, insurance, age, sex, race/ethnicity, US born, marital status, rurality, general health, usual place for healthcare,	↓Material, psychosocial and behavioral financial hardship, ↓married/partnered, ↑retirement	Affordability, Sociodemographics

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Table 2 (*continued*)

Author (year)	Study design	Population (N)	Factors Examined	Factors Identified for Significant Adherence*	Dimension
			cancer history		
Kranz 2020	Cross sectional survey	CHC medical directors (215)	Integrated community health centers, workplace communication policies	↑Integrated community health centers, ↑workplace communication policies	Access, Activation
Lee 2019	Cross sectional survey	Thai immigrants living in Southern California aged 50 – 75 yo (121)	Regular checkups, self-efficacy, age, acculturation, education, spousal encouragement, language, family member diagnosed with cancer, health beliefs	↑Regular checkups, ↑self-efficacy, ↑age, ↑acculturation	Access, Acceptance, Sociodemographics, Health Status
Lee 2021	Cross sectional survey	Korean Americans aged 18 yo and older (377)	Income, insurance, health literacy, education		Affordability, Awareness, Sociodemographics
Liu 2020	Cross sectional survey	Aged 45 – 74 yo (1035)	Income, insurance, information seeking, information scanning, age, race, gender, education, marital status, family history	↑Income, ↑insurance, ↑information seeking, ↑information scanning, ↑age, ↑family history	Affordability, Awareness, Sociodemographics, Health Status
Mayhand 2021	Cross sectional survey	Diverse, underserved, and socioeconomically disadvantaged population of Philadelphia, Aged 50–75 yo (526)	Routine check-ups, quality of healthcare, neighborhood SES, social support, clinical center income, cancer knowledge, race/ethnicity, sex, age, home ownership, perceived discrimination	↑Routine check-ups, ↑high quality of healthcare, ↓low neighborhood SES, ↑home ownership, ↑racial/ethnic minority, ↑age	Access, Affordability, Sociodemographics
McDaniel 2019	Cross sectional survey	Aged 18 yo and older US Armed Forces service members and veterans (63,919)	Rurality, income, insurance, education, comorbidity, age, sex, race/ethnicity, marital status, employment	↓Rurality, ↑income, ↑insurance, ↑education, ↑comorbidity, ↑age, ↑married, ↓male, ↑Black, ↓American Indian, ↑AAPI	Access, Affordability, Sociodemographics, Health status
Miller-Wilson 2021	Cross sectional survey	Aged 65–85 yo (368,494)	Provider type, age, sex, race, employment, education, income, rurality		Access, Affordability, Sociodemographics
Moreno 2019	Cross sectional survey	Aged 50–76 yo (239)	Sex, race/ethnicity, age, modality	↑Age, ↑Modality	Acceptance, Sociodemographics
Moss 2021	Cross sectional survey	Women aged 50–75 yo (100)	Healthcare trust, cancer fatalism, social cohesion, travel time to doctor's office, number of barriers to screening		Access, Acceptance
Moss 2022	Cross sectional survey	Women aged 45–65 yo (474)	Rurality, segregation, insurance, income, education, cancer beliefs, cost of screening.		Access, Acceptance
Nakajima 2021	Cross sectional survey	Men born in East Africa aged 45–75 yo who live in Minnesota (107)	Screening attitudes/ cancer stigma, health literacy, perceived susceptibility, trust in health care system, stress exposure, emotional support, spirituality, sleep, pain, sweet beverage consumption, tobacco use, alcohol use	↑Higher perceived susceptibility, ↑lower stress	Awareness, Acceptance, Health Status
Redwood 2019	Cross sectional survey	Alaskan Native people aged 40–75 yo (1616)	Access to doctor, private space, cost, time, CRC knowledge, provider recommendation, modality features, perceived effectiveness, embarrassment, discomfort		Access, Affordability, Awareness, Acceptance
Rockson 2020	Cross sectional survey	Aged 18 yo and older (136)	Doctor recommendation		Acceptance
Rogers 2021	Cross sectional survey	NH Black men, aged 45 to 75 yo (319)	Knowledge, masculinity barriers to medical care, beliefs and values about CRC screening, social support for CRC screening, age, marital status, education, barriers to CRC screening	↑Knowledge, ↑higher masculinity barriers, ↑social support for CRC screening, ↑age, ↑unmarried,	Awareness, Acceptance, Sociodemographics
Santiago-Rodriguez 2020	Cross sectional survey	aged 50–75 yo (376)	Socioeconomic indicators (education, employment, household income)		Affordability, Sociodemographics
Shah 2021	Cross sectional survey	Aged 18 yo and older (1561)	Income, knowledge, race, education, history of cancer, smoking status, housing status	↑History of cancer, ↑knowledge of cancer prevention	Affordability, Awareness, Sociodemographics
Shete 2021	Cross sectional survey	Women aged 50 to 75 yo (2897)	Rurality, income, insurance, employment, cost of doctor visit, financial security, age, race/	↓Rurality, ↑higher income, ↑insurance, ↑retired, ↑ no concern about cost of doctor visit, ↑age	Access, Affordability, Acceptance, Sociodemographics

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Table 2 (*continued*)

Author (year)	Study design	Population (N)	Factors Examined	Factors Identified for Significant Adherence*	Dimension
			ethnicity, education, health beliefs, marital status, smoking status		
Viramontes 2020	Cross sectional survey	2016 BRFSS participants self-identified as "Hispanic, Latino/a, or Spanish origin" aged 50–75 years (12,395)	Age, sex, language, marital status, education, employment, income, insurance, access to health care provider, health status	↑Age, ↑female sex, ↑education, ↑retired, ↑income, ↑insurance, ↑access to health care provider, ↑poor health status	Access, Affordability, Sociodemographics, Health Status
Voiss 2020	Cross sectional survey	noninstitutionalized US population, women aged 45 – 85 yo (26,742)	Complementary medicine practitioner consultations	↑Complementary medicine practitioner consultations	Access
Watanabe-Galloway 2021	Cross sectional survey	Primary care clinics in Nebraska (262)	Rurality, insurance/payment type, type of clinic, clinic participation in performance based payment	↑Insurance, ↑performance-based payment	Access, Affordability
Whitaker 2020	Cross sectional survey	Aged 50–74 yo (3183)	Educational intervention	↑Knowledge	Awareness
Williams 2018	Cross sectional survey	Homeless population aged 21 yo and older (201)	Income, age, gender, race/ethnicity, obesity, health status, physical activity, smoking	↑Age, ↑obesity	Affordability, Sociodemographics, Health Status
Wolbert 2021	Cross sectional survey	18 yo and older (713)	Having a PCP, recent doctor visit, convenience of access/location of screening, time/financial cost, knowledge, health beliefs about screening, attitudes, doctor recommendation, family history	↑Having a PCP, ↑recent doctor visit,↑convenience of access/location of screening, ↓time/financial cost, ↑knowledge, ↑doctor recommendation, ↑positive health beliefs about screening, ↑positive attitudes about screening, ↑family history	Access, Affordability, Awareness, Acceptance, Health Status
Wu 2020	Cross sectional survey	Aged 20 yo and older, self-identification as Bengali (166)	Years lived in the US, English fluency, education, employment, insurance	↑Increased years lived in the US	Affordability, Sociodemographics
Xiao 2020	Cross sectional survey	Asian immigrants, 18 years or older (223)	Ethnicity	Ethnicity	Sociodemographics
Ylitalo 2019	Cross sectional survey	aged 50–75 years old (208)	Sex, age, race/ethnicity, insurance, chronic disease history (BMI), smoking status	↓Current smoker	Affordability, Sociodemographics, Health Status
Zhu 2021	Cross sectional survey	Aged 40–75 yo (1062)	Recent routine checkup, income, insurance, employment, doctor recommendation, knowledge, age, race, education, cancer history, chronic disease history (BMI)	↑Recent routine checkup, ↑higher income, ↑insurance, ↑doctor recommendation, ↑age, ↑obesity	Access, Affordability, Acceptance, Sociodemographics, Health Status
Zhu 2021	Cross sectional survey	aged 50–75 years old (1595)	Lack of knowledge, lack of provider recommendation, suboptimal access/lack of PCP, psychosocial barriers	↓Lack of knowledge, ↓lack of provider recommendation, ↓suboptimal access/lack of PCP, ↓psychosocial barriers	Access, Awareness, Acceptance
Retrospective studies					
Elangovan 2021	Retrospective cross sectional study	Aged 50 yo and older (13, 427)	Age, sex, race/ethnicity, preferred language, income, insurance, chronic disease history (BMI), smoking status,provider specialty, Charlson comorbidity index (CCI)	↑Age, ↓Non-Hispanic Black, ↑other non-Hispanic minorities, ↑non-English language, ↓Medicaid/commercial insurance, ↓Current smoker,↓High CCI score, provider specialty (↑internal med)	Affordability, Acceptance, Health Status, Sociodemographics
Ioannou 2021	Retrospective cohort study	aged 50–75 years old (460)	Screening modality options	↑Screening modality options	Acceptance
Kurani 2020	Retrospective cross sectional study	All persons empaneled to a Mayo Clinic or Mayo Clinic Health System primary care practice, aged 50 – 75 yo (78,302)	Rurality, area deprivation index, age, race, Charlson Comorbidity Index	↓Rurality, ↓high area deprivation index, ↑age, race, ↑high Charlson Comorbidity Index	Access, Affordability
Moreno 2020	Retrospective cohort study	Commercially insured individuals aged 18—64 yo (18,488,421)	Urban/rurality	↓Rurality	Access
O'Neil 2021	Retrospective cohort study	Aged 18 yo and older (1329)	Insurance, past screening behaviors, family history, age, sex, marital status, race, employment, smoking/drug use, chronic comorbid conditions (COPD), chronic disease	↑insurance, ↑past screening behaviors, ↑age, ↓racial/ethnic minority, ↓smoking/drug use, ↓chronic comorbid conditions (COPD), ↓greater gap time and	Access, Affordability, Sociodemographics, Health Status

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Table 2 (*continued*)

Author (year)	Study design	Population (N)	Factors Examined	Factors Identified for Significant Adherence*	Dimension
			history (BMI), gap time and procedure time, referring physician type	procedure time	
Samuel 2021	Retrospective cohort study	Aged 50 – 75 years old (2428)	Provider years of training, employment, insurance, past health behaviors, age, race/ethnicity, education, marital status, health status	↑past health behaviors, ↑age	Access, Affordability, Acceptance, Sociodemographics, Health Status
Shepherd 2021	Retrospective cohort study	Employees of the Metropolitan Nashville Public Schools (MNPS) aged 50 yo and over (840)	office vs. population prompts and reminders outreach	↑office prompts and reminders outreach	Activation
Zhan 2021	Retrospective cohort study	Older than 49 yo from a large federally qualified health center (FQHC) system (13,079)	Race/ethnicity, age, sex, insurance, primary care visits, spatial access	↓Racial/ethnicity minority, ↑age, ↑female sex, ↑insurance (medical access program), ↑high primary care visits, ↑closer spatial access	Access, Affordability, Sociodemographics
Experimental studies					
Boutsicaris 2021	Non-randomized experimental study	Aged 50–74 yo (85)	Age, gender, race, education, insurance, screening history, family history, CRC education intervention, knowledge		Awareness
Friedman 2019	Non-randomized experimental study	African-Americans, all ages (110)	Knowledge of CRC	↑Knowledge of CRC	Awareness
Wang 2021	Non-randomized experimental study	Chinese Americans living in Texas aged 50–75 yo (344)	Attitudes toward CRCS, perceived benefits of CRCS, self-efficacy of CRCS, perceived barriers to CRCS	↑Positive attitudes toward CRCS, ↑perceived benefits of CRCS, ↑ self-efficacy of CRCS, ↑ decrease in perceived barriers to CRCS	Acceptance
Winkler 2022	Non-randomized experimental study	Aged 50–75 yo (698)	Patient navigation intervention, prompts/reminders	↑CRCS knowledge, ↑prompts/ reminders	Awareness, Activation
Green 2019	Randomized controlled trial	Aged 50–75 yo (838)	Financial incentives, self-efficacy	↑financial incentives	Acceptance, Activation
Haverkamp 2020	Randomized controlled trial	American Indian/Alaska Native Americans, aged 50 – 75 yo (1288)	FIT kits, prompts and reminders	↑FIT kits	Access
Hirko 2020	Randomized controlled trial	aged 50–75 yo (7,812)	FIT kits, CRCs knowledge, beliefs, trust, efficacy, prompts and reminders	↑FIT kits, ↑CRCs knowledge, ↑beliefs, ↑trust, ↑efficacy, ↑prompts and reminders	Access, Awareness, Acceptance, Activation
Lieberman 2021	Randomized controlled trial	Aged 50–74 yo within a large safety-net health network (7711)	Financial incentives, prompts/ reminders	↑Financial incentives, ↑prompts/ reminders	Activation
Mehta 2019	Randomized controlled trial	Aged 50–74 yo (438)	Sequential modality choice		Acceptance
Mehta 2020	Randomized controlled trial	Aged 50 – 74 yo, socioeconomically underserved population in Southwest Philadelphia (281)	FIT kit, CRCs knowledge, text messaging prompt		Access, Awareness, Activation

*Factors that showed significant increase in adherence are indicated with ↑, whereas factors showing a decrease in adherence are indicated with ↓.

more likely participants would get screened (Wolbert et al., 2021). Zhan et al. (2021) reported that shorter distance to primary care facilities, measured as spatial access, was positively associated with screening adherence (Zhan et al., 2021). Convenience of access was also measured as a scheduling factor, and more convenience in timing significantly increased adherence (O'Neil et al., 2021). Green et al., (2020) reported that participants were more likely to adhere when they received FIT kits in the mail among Medicaid and Medicare enrollees from federally qualified health centers (Green et al., 2020). In a randomized controlled trial among AI/ANs, Haverkamp et al. (2020) also showed that mailed FIT kits was significantly associated with increased adherence (Haverkamp et al., 2020). Having access to a primary care physician, primary care visits, usual place of healthcare, integrated community health centers, type of clinic, quality of healthcare and provider type were categorized under contact with healthcare system. Individuals who reported receiving excellent or very good quality of healthcare having a higher odds of adherence compared to those who rated their care as good or fair/poor (Mayhand et al., 2021). Five studies found that having a primary care physician increased the likelihood of screening adherence (Viramontes, 2020; Redwood, 2019; Charkhchi et al., 2020,; Wolbert et al., 2021; Zhu, 2021), and one study showed that provider type made a difference in screening, with internal medicine physicians having a greater impact on adherence compared to other specialities, such as family medicine (Elangovan et al., 2021). O'Neil et al. (2021) also reported that adherence varied across physician type referrals, with gastroenterologist referrals resulting in higher screening adherence

Table 3
Dimensions and root causes of colorectal cancer screening.

Dimension Number of Articles *(%)	Root Cause	Number of Articles	Reference(s)
Access 30 (49%)			
Individual level	**Place of birth/US born**	2	(Gonzalez et al., 2020; Kasting et al., 2021)
Clinical level	**Contact with healthcare systems**	20	(Viramontes, 2020; Redwood, 2019; Lee et al., 2019; Ayash et al., 2020; Zhan et al., 2021; Zhu, 2021; Samuel et al., 2021; O'Neil et al., 2021; Mayhand et al., 2021; Elangovan et al., 2021; Charkhchi et al., 2019; Charkhchi et al., 2020,; Kasting et al., 2021; Wolbert et al., 2021; Zhu, 2021; Voiss et al., 2020; Kranz et al., 2020; Watanabe-Galloway et al., 2022; Miller-Wilson et al., 2021; Moss, 2021)
	Convenience of access	3	(Zhan et al., 2021; O'Neil et al., 2021; Wolbert et al., 2021)
	Mailed/Access to FIT kit	4	(Haverkamp et al., 2020; Green et al., 2020; Hirko et al., 2020; Mehta, 2020)
Sociocontextual level	**Rurality**	13	(McDaniel et al., 2019; Shete, 2021; Kurani et al., 2020; Guo et al., 2021; Benavidez et al., 2021; Charkhchi et al., 2019; Daniel et al., 2021; Charkhchi et al., 2020; Kasting et al., 2021; Moreno et al., 2020; Moss et al., 2022; Watanabe-Galloway et al., 2022; Miller-Wilson et al., 2021)
	Neighborhood SES	1	(Mayhand et al., 2021)
	Racism	1	(Moss et al., 2022)
Affordability 30 (49%)			
Individual level	**Time costs**	2	(Redwood, 2019; Wolbert et al., 2021)
	Income	18	(Viramontes, 2020; Lee et al., 2021; Ayash et al., 2020; McDaniel et al., 2019; Zhu, 2021; Williams, et al., 2018; Shete, 2021; Liu et al., 2020; Guo et al., 2021; Benavidez et al., 2021; Mayhand et al., 2021; Elangovan et al., 2021; Charkhchi et al., 2019; Charkhchi et al., 2020; Moss et al., 2022; Shah et al., 2022; Miller-Wilson et al., 2021; Santiago-Rodriguez, 2020)
	Insurance	21	(Wu and Raghunathan, 2020; Viramontes, 2020; Lee et al., 2021; Ayash et al., 2020; Zhan et al., 2021; McDaniel et al., 2019; Zhu, 2021; Shete, 2021; Liu et al., 2020; Guo et al., 2021; Camacho-Rivera et al., 2019; Benavidez et al., 2021; Samuel et al., 2021; O'Neil et al., 2021; Elangovan et al., 2021; Charkhchi et al., 2019; Charkhchi et al., 2020; Gray, 2021; Moss et al., 2022; Watanabe-Galloway et al., 2022; Ylitalo et al., 2019)
	Financial hardship	6	(Redwood, 2019; Shete, 2021; Charkhchi et al., 2019; Charkhchi et al., 2020; Kasting et al., 2021; Wolbert et al., 2021; Moss et al., 2022)
	Home ownership/ status	3	(Redwood, 2019; Mayhand et al., 2021; Shah et al., 2022)
Sociocontextual level	**Area deprivation index**	1	(Kurani et al., 2020)
Awareness 17 (28%)			
Individual level	**Knowledge of CRCs and recommendations**	15	(Winkler et al., 2022; Rogers, 2021; Redwood, 2019; Boutsicaris et al., 2021; Zhu, 2021; Mayhand et al., 2021; Gray, 2021; Wolbert et al., 2021; Zhu, 2021; Whitaker, 2020; Shah et al., 2022; Friedman, 2019; Hirko et al., 2020; Mehta, 2020; Allen et al., 2022)
	Consideration of CRCs	1	(Liu et al., 2020)
	Health literacy	2	(Nakajima et al., 2021; Lee et al., 2021)
	Health technology exposure	1	(Camacho-Rivera et al., 2019)
Sociocontextual level	**Availability of information**	1	(Liu et al., 2020)
Acceptance 26 (43%)			
Individual level	**Screening perceived efficacy/safety**	2	(Redwood, 2019; Gray, 2021)
	Screening modality	4	(Redwood, 2019; Moreno et al., 2019; Ioannou et al., 2021; Mehta, 2019)
	Attitudes	4	(Nakajima et al., 2021; Wang et al., 2021; Redwood, 2019; Drolet and Lucas, 2022; Wolbert et al., 2021)
	Vulnerability to risk	2	(Nakajima et al., 2021; Allen et al., 2022)
	Health beliefs (fatalism)	14	(Wang et al., 2021; Rogers, 2021; Nakajima et al., 2021; Lee et al., 2019; Gonzalez et al., 2020; Shete, 2021; Guo et al., 2021; Harper et al.,

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Table 3 (*continued*)

Dimension Number of Articles *(%)	Root Cause	Number of Articles	Reference(s)
			2021; Wolbert et al., 2021; Moss et al., 2022; Hirko et al., 2020; Mehta, 2020; Moss, 2021; Allen et al., 2022)
	Normative beliefs	1	(Rogers, 2021; Drolet and Lucas, 2022)
	Perceived behavioral control	1	(Drolet and Lucas, 2022)
	Self-efficacy	4	(Wang et al., 2021; Lee et al., 2019; Hirko et al., 2020; Green et al., 2019)
	Trust	4	(Nakajima et al., 2021; Ayash et al., 2020; Hirko et al., 2020; Mehta, 2020; Moss, 2021)
	Psychosocial barriers	3	(Zhu, 2021; Rogers, 2021; Redwood, 2019)
Clinical level	**Healthcare worker influence/doctor recommendation**	9	(Redwood, 2019; Gonzalez et al., 2020; Ayash et al., 2020; Zhu, 2021; Harper et al., 2021; Gray, 2021; Wolbert et al., 2021; Zhu, 2021; Rockson et al., 2020)
Sociocontextual level	**Peer influence**	1	(Lee et al., 2019)
	Social cohesion/ social support	4	(Rogers, 2021; Nakajima et al., 2021; Mayhand et al., 2021; Moss, 2021)
Activation 8 (13%)			
Clinical level	**Prompts & reminders**	6	(Winkler et al., 2022; Gray, 2021; Green et al., 2020; Hirko et al., 2020; Lieberman et al., 2021; Shepherd, et al., 2021; Mehta, 2020)
	Workplace policies	1	(Kranz et al., 2020)
	Financial incentives (motivational)	3	(Lieberman et al., 2021; Mehta, 2020; Green et al., 2019)
Sociodemographics 36 (59%)			
Individual level	**Race/ethnicity**	28	(Xiao et al., 2020; Cassel, 2017; Boutsicaris et al., 2021; Zhan et al., 2021; McDaniel et al., 2019; Zhu, 2021; Moreno et al., 2019; Williams, et al., 2018; Shete, 2021; Liu et al., 2020; Kurani et al., 2020; Guo et al., 2021; Camacho-Rivera et al., 2019; Benavidez et al., 2021; Samuel et al., 2021; O'Neil et al., 2021; Mayhand et al., 2021; Elangovan et al., 2021; Charkhchi et al., 2019; Harper et al., 2021; Daniel et al., 2021; Charkhchi et al., 2020; Gray, 2021; Kasting et al., 2021; Shah et al., 2022;

Table 3 (*continued*)

Dimension Number of Articles *(%)	Root Cause	Number of Articles	Reference(s)
			Ylitalo et al., 2019; Miller-Wilson et al., 2021)
	Age	27	(Xiao et al., 2020; Viramontes, 2020; Rogers, 2021; Lee et al., 2019; Gonzalez et al., 2020; Boutsicaris et al., 2021; Zhan et al., 2021; McDaniel et al., 2019; Zhu, 2021; Moreno et al., 2019; Williams, et al., 2018; Shete, 2021; Liu et al., 2020; Kurani et al., 2020; Guo et al., 2021; Camacho-Rivera et al., 2019; Benavidez et al., 2021; Samuel et al., 2021; O'Neil et al., 2021; Mayhand et al., 2021; Elangovan et al., 2021; Charkhchi et al., 2019; Charkhchi et al., 2020; Gray, 2021; Kasting et al., 2021; Ylitalo et al., 2019; Miller-Wilson et al., 2021)
	Gender/Gender Identity	19	(Viramontes, 2020; Gonzalez et al., 2020; Boutsicaris et al., 2021; Ayash et al., 2020; Zhan et al., 2021; McDaniel et al., 2019; Moreno et al., 2019; Williams, et al., 2018; Liu et al., 2020; Guo et al., 2021; Camacho-Rivera et al., 2019; O'Neil et al., 2021; Mayhand et al., 2021; Elangovan et al., 2021; Charkhchi et al., 2019; Gray, 2021; Kasting et al., 2021; Ylitalo et al., 2019; Miller-Wilson et al., 2021)
	Education	24	(Wu and Raghunathan, 2020; Viramontes, 2020; Rogers, 2021; Lee et al., 2019; Lee et al., 2021; Gonzalez et al., 2020; Boutsicaris et al., 2021; Ayash et al., 2020; McDaniel et al., 2019; Zhu, 2021; Shete, 2021; Liu et al., 2020; Guo et al., 2021; Camacho-Rivera et al., 2019; Benavidez et al., 2021; Samuel et al., 2021; Charkhchi et al., 2019; Charkhchi et al., 2020; Gray, 2021; Kasting et al., 2021; Moss et al., 2022; Shah et al., 2022; Miller-Wilson et al., 2021; Santiago-Rodriguez, 2020)

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Table 3 (*continued*)

Dimension Number of Articles *(%)	Root Cause	Number of Articles	Reference(s)
	Religion/Spirituality	2	(Nakajima et al., 2021; Ayash et al., 2020)
	Sexual orientation	1	(Charkhchi et al., 2019)
	Marital status	12	(Viramontes, 2020; Rogers, 2021; Gonzalez et al., 2020; McDaniel et al., 2019; Shete, 2021; Liu et al., 2020; Samuel et al., 2021; O'Neil et al., 2021; Charkhchi et al., 2019; Charkhchi et al., 2020; Kasting et al., 2021; Voiss et al., 2020)
	Language	5	(Wu and Raghunathan, 2020; Lee et al., 2019; Gonzalez et al., 2020; Ayash et al., 2020; Elangovan et al., 2021)
	Acculturation/Time in US	3	(Wu and Raghunathan, 2020; Lee et al., 2019; Gonzalez et al., 2020)
	Employment	15	(Wu and Raghunathan, 2020; Viramontes, 2020; Ayash et al., 2020; McDaniel et al., 2019; Zhu, 2021; Shete, 2021; Camacho-Rivera et al., 2019; Benavidez et al., 2021; Samuel et al., 2021; O'Neil et al., 2021; Charkhchi et al., 2019; Charkhchi et al., 2020; Kasting et al., 2021; Miller-Wilson et al., 2021; Santiago-Rodriguez, 2020)
Health status 22(36%)			
Individual level	**General health**	6	(Viramontes, 2020; Nakajima et al., 2021; Gonzalez et al., 2020; Williams, et al., 2018; Samuel et al., 2021; Kasting et al., 2021; Wolbert et al., 2021)
	Chronic disease history	12	(McDaniel et al., 2019; Zhu, 2021; Williams, et al., 2018; Kurani et al., 2020; Camacho-Rivera et al., 2019; O'Neil et al., 2021; Elangovan et al., 2021; Charkhchi et al., 2019; Charkhchi et al., 2020; Kasting et al., 2021; Shah et al., 2022; Ylitalo et al., 2019)
	Alcohol/tobacco use	9	(Nakajima et al., 2021; Williams, et al., 2018; Shete, 2021; Guo et al., 2021; O'Neil et al., 2021; Elangovan et al., 2021; Charkhchi et al., 2020; Shah et al., 2022; Ylitalo et al., 2019)
	Family history of cancer	5	(Lee et al., 2019; Boutsicaris et al., 2021; Liu et al., 2020; O'Neil et al., 2021; Wolbert et al., 2021)
	Stress exposure	1	(Nakajima et al., 2021)
	Past screening/ behaviors	4	(Nakajima et al., 2021; Williams, et al., 2018; Samuel et al., 2021; O'Neil et al., 2021)

Table 4
Facilitators and barriers by dimension.

Dimension (number of studies)	Significant Facilitator	Significant Barrier
Sociodemographics (n = 36)	Female gender, older age, higher education, racial/ethnic minority, married, physician language/bilingual physician, acculturation/time in the US, retired	Racial/ethnic minority, greater spiritual affinity, married
Access (n = 30)	Convenience of access: close spatial access/scheduling/location of screening, contact with healthcare system: have PCP, mailed FIT kits, recent routine checkup, high quality of healthcare, complementary medicine practitioner, integrated health centers	Rurality, low neighborhood SES, lack of PCP
Affordability (n = 30)	Insurance, higher income, home ownership	Time costs, financial hardship, high area deprivation, medicaid/commercial insurance
Acceptance (n = 26)	Health beliefs, healthcare provider recommendation, increased trust, self-efficacy, social support, perceived behavior control over screening, high perceived susceptibility, attitudes, norms, psychosocial barriers (higher masculinity beliefs), less invasive screening modality, cancer fatalism	Psychosocial barriers (pain/embarrassment), lack of physician recommendation, cancer fatalism
Health status (n = 22)	Obesity, family history of cancer, lower stress	Chronic disease history: comorbidity, current smoking status, self-reported excellent/good health
Awareness (n = 17)	Increased knowledge, information seeking, information scanning, smart phone use	Lack of knowledge
Activation (n = 8)	Prompts and reminders, workplace communication policies, motivational financial incentives	

compared to primary care physicians (O'Neil et al., 2021). Using data from the 2017 National Health Interview Survey, Voiss et al., (2020) found that receiving health care from complementary medicine practitioners was associated with increased screening adherence (Voiss et al., 2020). One study assessed the effectiveness of integrated community

health centers serving racially/ethnically diverse and economically disadvantaged patients, and found that centers that were more strongly integrated with specialists have higher rates of screening compared with less integrated centers (Kranz et al., 2020). Finally, multiple studies found that regular doctor visits facilitated screening (Lee et al., 2019; Zhan et al., 2021; Zhu, 2021; Mayhand et al., 2021; Charkhchi et al., 2020; Wolbert et al., 2021).There were no significant findings for place of birth in the two studies that assessed birthplace (Gonzalez et al., 2020; Kasting et al., 2021). Segregation, as a form of racism, was reported as not having a significant impact on adherence (Moss et al., 2022).

3.3. Affordability (n = 30)

Insurance, income, time costs, financial hardship, area deprivation index, and home ownership status were identified as root causes within the Affordability dimension. Having insurance had a significant positive impact on adherence in 13 out of 21 articles (Viramontes, 2020; Ayash et al., 2020; Zhan et al., 2021; McDaniel et al., 2019; Zhu, 2021; Shete, 2021; Liu et al., 2020; Benavidez et al., 2021; O'Neil et al., 2021; Elangovan et al., 2021; Charkhchi et al., 2019; Charkhchi et al., 2020,; Watanabe-Galloway et al., 2022). Increasingly higher income was also significantly associated with screening adherence in 9 out of the 18 studies that assessed income (Viramontes, 2020; McDaniel et al., 2019; Zhu, 2021; Shete, 2021; Liu et al., 2020; Guo et al., 2021; Benavidez et al., 2021; Charkhchi et al., 2019; Charkhchi et al., 2020). Wolbert et al., (2021) found that with increased time costs, there was a decrease in adherence (Wolbert et al., 2021), but Redwood et al., (2019) did not find any significant association between time costs and adherence (Redwood, 2019). Financial hardship, measured in terms of material, psychosocial, and behavioral financial hardship, was reported as a barrier to screening adherence (Kasting et al., 2021). Charkhchi et al., (2020) used data from the 2016 Behavioral Risk Factor Surveillance System to show how financial hardship affecting doctor visits was a significant barrier to CRC screening adherence among women (Charkhchi et al., 2020). Additionally, Kurani et al., (2020) reported that adherence was negatively affected by high area deprivation, defined as a composite area-based indicator that captures levels of poverty, education, housing and employment (Kuznar, 2017). Home ownership status was a facilitator in increasing adherence in a diverse, underserved population (Mayhand et al., 2021).

3.4. Awareness (n = 17 studies)

The Awareness dimension was reported i/n 17 studies, and 5 root causes were identified: knowledge of CRC screening, availability of information, consideration of CRC screening, health technology use, and health literacy. Knowledge was the predominant root cause studied, with 15 studies assessing its effect on adherence. Increased knowledge about CRC screening was found to be a significant facilitator to screening in 9 studies (Winkler et al., 2022; Rogers, 2021; Boutsicaris et al., 2021; Wolbert et al., 2021; Zhu, 2021; Whitaker, 2020; Shah et al., 2022; Friedman, 2019; Hirko et al., 2020). In a randomized control study, Hirko et al., (2020) used educational and motivational messaging to increase screening adherence (Hirko et al., 2020). Whitaker et al., (2021) also conducted a culturally tailored behavioral intervention aimed at promoting awareness and knowledge of colorectal cancer in racial/ethnic and rural populations, and found that increased colorectal cancer knowledge increased the likelihood or intentions of cancer screening (Whitaker, 2020). Liu et al., (2020) found that increased adherence was associated with exposure to CRC screening information from any source (eg: online, doctor, friends) and actively seeking out information from any source (Liu et al., 2020). Camacho-Rivera et al., (2019) found a significant increase in adherence with greater exposure to health information technology, such as smartphone use (Camacho-Rivera et al., 2019). Health literacy was found not to be a significant factor in screening adherence in the two studies that reported on literacy (Nakajima et al., 2021; Lee et al., 2021).

3.5. Acceptance (n = 26 studies)

Acceptance accounted for 43% of the 61 studies. The root causes identified for Acceptance were: health beliefs, normative beliefs, trust, self-efficacy, perceived behavioral control, vulnerability to risk, attitudes, psychosocial barriers, screening perceived efficacy, screening modality, healthcare worker influence/doctor recommendations, peer influence, and social cohesion/support. Health beliefs were identified in 14 studies, 5 of which had significant findings for beliefs and screening (Wang et al., 2021; Rogers, 2021; Guo et al., 2021; Wolbert et al., 2021; Hirko et al., 2020). Wolbert et al., (2021) and Hirko et al., (2020) both found that health beliefs facilitated screening (Wolbert et al., 2021; Hirko et al., 2020). An intervention conducted by Hirko et al., (2020) targeted health beliefs using motivational letters which resulted in greater odds of screening compared to those who received usual care mailed letters (Hirko et al., 2020). In an educational intervention aimed at increasing fecal occult blood test (FOBT) uptake among Chinese Americans, an increased belief in the perceived benefits to screening was significantly shown to facilitate adherence (Wang et al., 2021). Cancer fatalism beliefs, defined by Guo et al., (2021) as a belief that everything causes cancer, was reported to be a significant facilitator for CRC screening among women (Guo et al., 2021). Finally, among a sample of 319 Black men, a high level of masculinity beliefs acted as a facilitator for increasing CRC screening (Rogers, 2021).

Increased trust (Hirko et al., 2020), self-efficacy (Wang et al., 2021; Lee et al., 2019; Hirko et al., 2020), perceived behavioral control over screening (Drolet and Lucas, 2022), higher perceived susceptibility/vulnerability to risk of CRC (Nakajima et al., 2021) and attitudes (Wang et al., 2021; Wolbert et al., 2021; Drolet and Lucas, 2022) were all found to be significant facilitators for adherence. Psychosocial barriers such as pain or embarrassment were found to be significant barriers to adherence (Zhu, 2021), whereas psychosocial barriers such as higher masculinity beliefs were found to facilitate adherence (Rogers, 2021). One study found that increased perceived efficacy and safety of screening significantly influenced adherence (Gray, 2021). Screening modality linked to adherence and providing patients with less invasive options was significantly associated with CRC screening (Moreno et al., 2019; Ioannou et al., 2021). Healthcare provider recommendation was found to be a significant facilitator to screening adherence in 7 out of 9 studies (Gonzalez et al., 2020; Ayash et al., 2020; Zhu, 2021; Harper et al., 2021; Gray, 2021; Wolbert et al., 2021; Zhu, 2021). Peer influence, in the form of spousal encouragement, was not found to significantly influence adherence (Lee et al., 2019). Finally, social support was to be a significant facilitators for adherence in one study (Rogers, 2021).

3.6. Activation (n = 8 studies)

Activation had the lowest number of reported studies (13%), and included three root causes: prompts and reminders, motivational financial incentives, and workplace policies. Prompts and reminders was a significant facilitator for screening for several studies (Winkler et al., 2022; Gray, 2021; Green et al., 2020; Hirko et al., 2020; Lieberman et al., 2021; Shepherd, et al., 2021), while insignificant for one study (Mehta, 2020). Lieberman et al., (2021) and Green et al., (2019) found increased adherence to screening with financial incentives, such as monetary incentives or cash with deadlines (Lieberman et al., 2021; Green et al., 2019). Kranz et al., (2020) found that workplace communication policies significantly increased screening adherence (Kranz et al., 2020).

3.7. Health status (n = 22 studies)

There were 22 studies that examined factors related to Health Status, including six root causes: general health, chronic disease history, family

history of cancer, past screening behaviors, alcohol or tobacco use, and stress exposure. Viramontes et al., (2020) found that self-reported poor or fair health status was associated with increased screening adherence compared with those who reported excellent or very good health (Viramontes, 2020). Twelve studies examined how chronic disease history affects adherence, and ten of the studies showed a significant association with screening. The majority of the studies reported chronic disease history using the Charlson comorbidity index, cancer history report, or obesity. Chronic disease history was a significant facilitator for screening adherence for nine of these ten studies (McDaniel et al., 2019; Zhu, 2021; Williams, et al., 2018; Kurani et al., 2020; Camacho-Rivera et al., 2019; Elangovan et al., 2021; Charkhchi et al., 2019; Charkhchi et al., 2020,; Shah et al., 2022), while one study reported that chronic comorbid conditions decreased screening adherence (O'Neil et al., 2021). Family history of cancer and past health behaviors, such as screening, were found to be effective facilitators to CRC screening (Liu et al., 2020; Samuel et al., 2021; O'Neil et al., 2021; Wolbert et al., 2021), while current smoking status was reported to be a significant barrier to adherence (O'Neil et al., 2021; Elangovan et al., 2021; Charkhchi et al., 2020,; Ylitalo et al., 2019). Finally, Nakajima et al., (2021) found that reported lower stress significantly increased CRC screening adherence among East African men in the US (Nakajima et al., 2021).

4. Discussion

This review sought to integrate the most up-to-date consensus reported in the literature on barriers and facilitators of CRC screening, guided by the 5As framework with the addition of Sociodemographics and Health status (Fig. 1b). Most studies included in our review assessed individual level factors or clinical level factors as barriers or facilitators, while a few considered sociocontextual factors such as neighborhood SES. Our review is unique because it is limited to current quantitative research, without focus on a specific US demographic.

Much of the current literature on CRC screening included in this review reported on the Sociodemographics, Affordability, and Access dimensions. In particular, for Sociodemographics, screening disparities were described for racial/ethnic minorities and immigrant populations, a consistent finding in other studies (American Cancer Society, 2019; Agrawal et al., 2005; Centers for Disease Control and Prevention, 2023; Samuel, 2009; Puli et al., 2023; Crawford et al., 2016). Low screening among racial/ethnic minority groups, specifically within African American populations, might be linked to factors ranging from individual level characteristics to healthcare system and sociocontextual factors, therefore, multi-level interventions are needed to address these barriers. For example, from an individual level perspective, interventions aimed at increasing CRC screening could target improving patient knowledge and self-efficacy through tailored educational materials, and provide screening modality options, which have been identified as effective strategies in prior studies (Roy et al., 2021; White and Itzkowitz, 2020). To address adherence gaps among racial/ethnic minorities at the clinical level, cultural competency training for healthcare providers might improve patient-physician communication, reduce lack of trust, and address implicit biases, all factors that have been reported to be barriers in colorectal cancer screening within minority communities (Dawadi et al., 2022). Additionally, using prompts and reminder systems via digital platforms, improved patient navigation approaches, and strategies to encourage patients to establish primary care would ultimately increase clinical encounters and screening opportunities (Roy et al., 2021). Improving social support and norms around screening within cultural hubs such as barber/beauty shops and churches may also address some social-contextual barriers, specifically among African American adults (Roy et al., 2021; Mitchell et al., 2013; Coughlin et al., 2006; Fyffe et al., 2008; Shariff-Marco, 2013). Notably, only one study in this review reported on an intervention among AI/ANs despite this population having the highest reported CRC incidence and

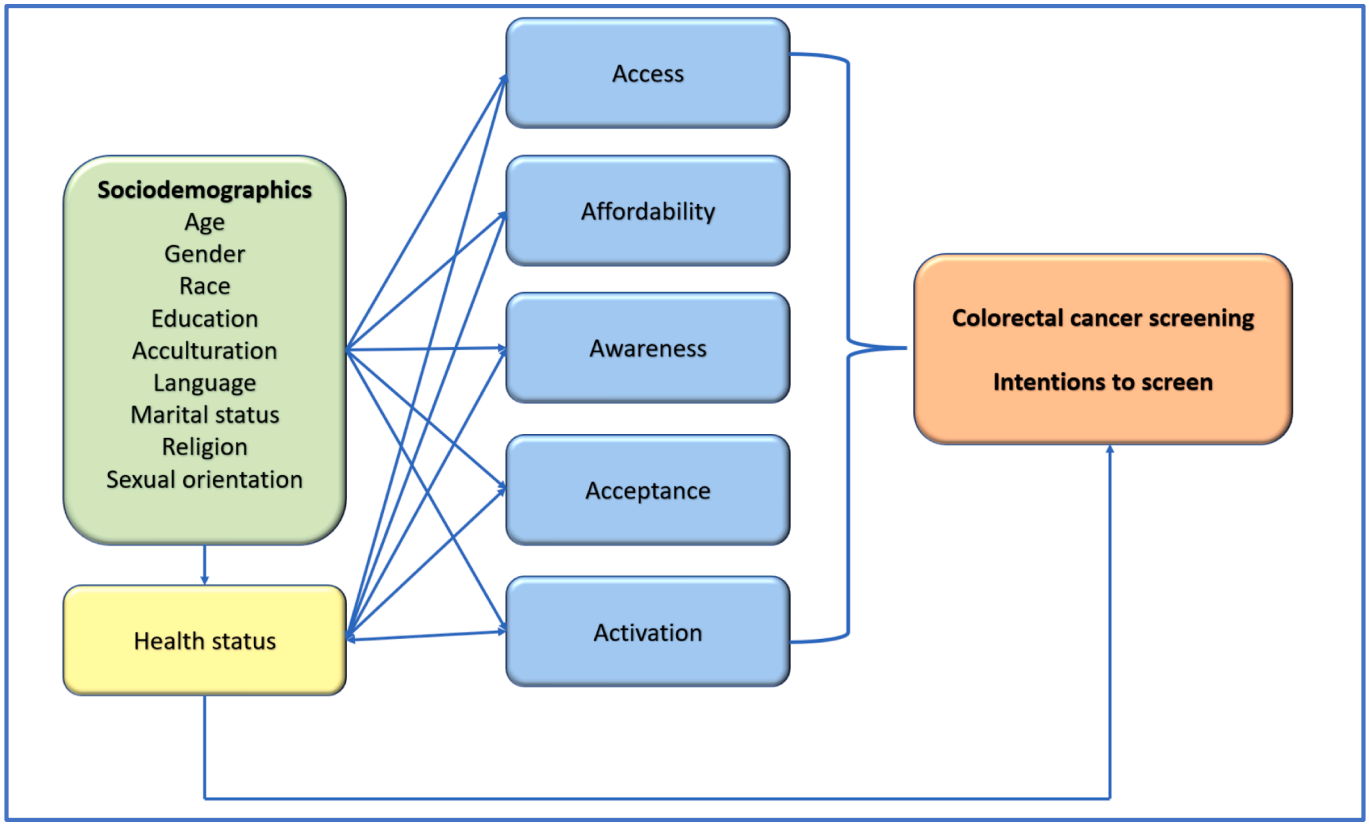

Fig. 1b. 5As framework including sociodemographics and health status.

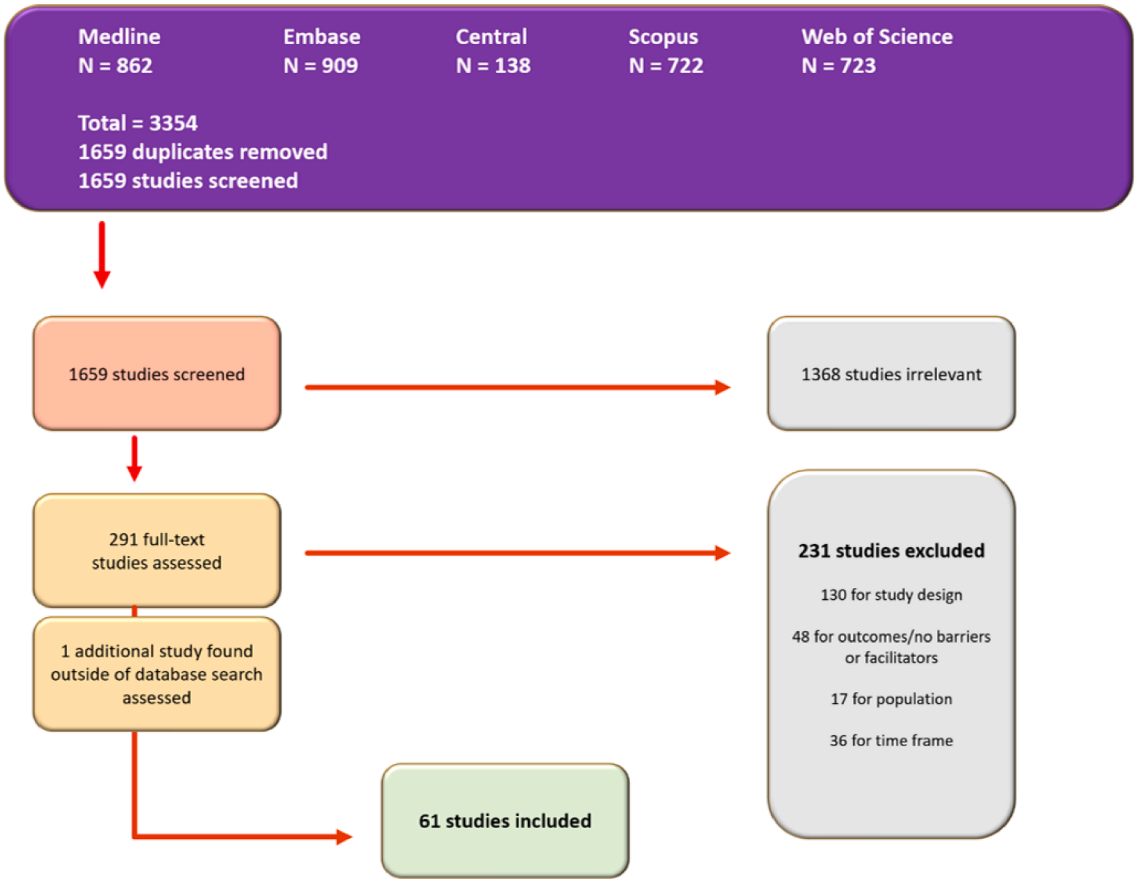

Fig. 2. Selection process for inclusion of studies.

mortality rates (Siegel, 2023); this randomized controlled trial affirmed the importance of providing access to mailed FIT kits, with the increase in screening adherence (Haverkamp et al., 2020).

In some studies, racial/ethnic minorities were reported to have increased screening adherence. For example, several studies reported that non-Hispanic Black women were more likely to undergo CRC screening compared to non-Hispanic White women (Benavidez et al., 2021; Harper et al., 2021), consistent with previous screening trend reports on non-Hispanic Black women (Hall et al., 2018). These contrasting results reported for racial/ethnic minorities across different studies could be explained by differences in screening modalities. For example, Camacho-Rivera et. al. (2019) found that non-Hispanic Black women were more likely to utilize blood stool kit testing, and concluded that their non-Hispanic White counterparts were more likely to access colonoscopies, leading to decreased need for fecal immunochemical testing (Camacho-Rivera et al., 2019). Additionally, some studies that reported increased adherence among racial/ethnic minorities were often geographically specific (e.g., Michigan, New York, Deep South, Philadelphia) (Camacho-Rivera et al., 2019; Mayhand et al., 2021; Harper et al., 2021; Daniel et al., 2021), suggesting that location may play a role.

Our review also highlighted the importance of language and acculturation on screening adherence. Language barriers and limited English proficiency (LEP) among immigrant populations have previously been linked with decreased screening and healthcare utilization (Lee et al., 2019; Lee et al., 2021; Fiscella et al., 2002; Jacobs et al., 2005). In contrast, acculturation, often measured as the length of time living in the US, has been linked with the adoption of social norms around screening behaviors (Afable-Munsuz et al., 2009; Tang et al., 2001; Maxwell et al., 2000). Language and acculturation capture complex social processes for immigrants, impacting encounters within healthcare systems. For some immigrant populations, cultural barriers and beliefs about cancer screening, such as cancer stigma and fatalism, impact the likelihood of obtaining CRC screening (Jung et al., 2018; Choe, 2003; Lee et al., 2014; Allen et al., 2014; Moreno et al., 2019). To address these barriers, educational interventions aimed at improving screening knowledge, should incorporate these cultural factors using community-based participatory approaches. Our study reported that the overlap in patient and physician language increases adherence, supporting the need for bilingual providers and translation services. Additionally, there are communication barriers for LEP populations that occur even before a patient visit. For example, communication over the phone presents challenges in scheduling an appointment. Translational services could be offered for scheduling either online or over the phone. Additionally, patient navigation, which has been shown to help vulnerable populations utilize complex medical systems (Paskett et al., 2011) might be another clinical-level strategy to increase screening adherence among LEP patients. Given persisting racial/ethnic minority screening disparities, it is critical to develop culturally appropriate interventions in partnership with affected communities to address individual, clinical, and social-contextual level barriers.

Age was another substantial demographic factor examined in 27 studies, with 20 studies reporting that increasing age was a significant facilitator in screening adherence. These results are consistent with national trend data from the Behavioral Risk Factor Surveillance System, which has reported an increase in screening from 65% to 69.7% between 2012 and 2020 in adults aged 50–75 years old (Centers for Disease Control and Prevention, 2012). As age is an important risk factor for colorectal cancer, it is promising to see studies reporting older patient populations receiving CRC screening. The screening adherence is likely due to targeted interventions that focus on older populations (Leach, 2021), and screening guidelines that promote physician

recommendation of CRC screening in older adults (Bénard et al., 2018; Shaukat et al., 2021).

Access and affordability barriers found in this review included: rurality, low neighborhood SES, lack of PCP, time costs, financial hardship, high area deprivation, and Medicaid/commercial insurance. Rurality has previously been found to be associated with low CRC screening adherence (Moreno et al., 2020; Coughlin and Thompson, 2004). This may be explained by underresourced facilities within rural areas (Khaliq et al., 2014; Tailor et al., 2019) and barriers such as high screening cost, lack of insurance coverage, lack of knowledge, and lack of physician recommendation within rural areas (Wang et al., 2019). Additionally, populations residing in rural areas frequently experience lower SES (Shiels et al., 2019). Contextual factors such as neighborhood SES, deprivation, and financial hardship have decreased CRC screening adherence, factors that have been reported to be barriers in previous studies (Mayhand et al., 2021; McDougall, et al., 2018). This is likely due to a limit in the availability of healthcare services and acces to resources to obtain medical care within rural areas (Wang et al., 2019; Pruitt, et al., 2009; Mobley et al., 2010; Stimpson et al., 2012; Shariff-Marco, 2013). To address these barriers and increase uptake in rural areas, clinical interventions could include mailed stool kits (Green et al., 2020; Green et al., 2017) and training physicians how to recommend CRC screening using up-to-date guidelines. Additionally, those who do not have adequate health insurance coverage are less likely to see their PCP or receive healthcare services (Wilkins et al., 2012; Thompson et al., 2005; Tessaro, 2006; Thompson et al., 2005). While the Affordable Care Act has expanded coverage, variation in implementation across states has resulted in decreased penetration within rural areas (Newkirk and Damico, 2014). Programs that assist in enrollment within rural areas could help address this coverage gap. Furthermore, recent expansion of Medicare to cover follow-up screening colonoscopy after a positive stool-based as a preventive service, will reduce out-of-pocket costs, thereby addressing a common barrier to CRC screening.

Additional barriers reported within the Acceptance and Awareness dimensions include lack of cancer screening knowledge and lack of physician recommendation. Cancer screening knowledge and physician recommendation have been reported as significant screening factors in prior studies (Gilbert and Kanarek, 2005; Gimeno Garcia et al., 2014; Hudson et al., 2012).To address knowledge gaps, national programs could be modeled after the "Screen to Save" intervention, which was implemented using culturally tailored messaging resulting in improved cancer screening adherence within at-risk populations (Whitaker, 2020). The significant relationship between physician recommendation and CRC screening adherence reflects trust in physicians as a credible source of health information (Marrie et al., 2013; Hesse et al., 2010; Hesse et al., 2005). To address the lack of physician recommendation barrier, effective patient-centered health communication should be capitalized especially among underserved populations. Additionally, health system interventions including standing orders for CRC screening, reviewing CRC screening status at all patient visits, and EMR point of care prompts may be effective in addressing the barrier of lack of physician recommendation (Nemeth et al., 2009; Ornstein et al., 2010).

For the Activation dimension, prompts and reminders, workplace communication policies, and motivational financial incentives were significant facilitators. Lieberman et al. (2021) found that deadlines and reminders coupled with monetary incentives, increased screening adherence (Lieberman et al., 2021). Imposing deadlines to reduce delayed action has been shown in prior studies (Shu and Gneezy, 2010; Ariely and Wertenbroch, 2002), and could present a cost effective way to increase CRC screening adherence by creating a sense of urgency. At the clinical level, greater integration within community health centers (CHC) promotes communication between specialists, resulting in more referrals and increased screening (Kranz et al., 2020). Communication links within an integrated center can help facilitate the referral process, while allowing rapid information sharing across providers.

Being a current smoker was found to be a significant screening barrier within the Health Status dimension. Numerous studies have reported that smokers have lower screening rates (Tessaro, 2006; Newkirk and Damico, 2014; Gilbert and Kanarek, 2005; Gimeno Garcia et al., 2014), and there is significant evidence that health promoting behaviors, such as eating healthy and exercise, are generally lower in individuals who smoke (Hudson et al., 2012; Marrie et al., 2013; Hesse et al., 2010; Hesse et al., 2005). The social-ecological model has been successfully applied to tobacco control efforts, with multilevel interventions aimed at reducing tobacco behavior through cessation programs, media campaigns that change social norms, and policies that regulate the tobacco industry such as ad bans (Corbett, 2001). Cancer screening interventions could similarly be designed around the social-ecological model to consider not only individual-level factors, but campaigns to change the social norms around screening, specifically targeting populations that smoke. Additionally, Ylitalo et al. (2019) proposed "teachable moments" during clinical encounters with smokers to address multiple lifestyle behaviors, including screening.

5. Strengths and limitations

The findings in this systematic review are limited by several factors. First, we did not differentiate between CRC screening modalities, but instead combined data for all recommended CRC screening modalities. Secondly, because we included heterogenous study designs, we could not quantify the weight of evidence for any particular barrier or facilitator in a *meta*-analysis. Additionally, while we attempted to do a comprehensive literature search for all studies that examined CRC screening barriers and facilitators, it is possible that our search strategy failed to capture all studies, and therefore missed identifying additional barriers and facilitators. We also limited our study to US published data, to reduce variation across contexts. In doing so, we may have missed some global CRC screening factors. Our study methodology was strong in that we had multiple reviewers at every stage of selection and categorization. Furthermore, we were able to identify quantitative studies that examined CRC screening adherence at multiple levels, providing insight for interventions to target both individual factors as well as clinical factors. Finally, we did not exclude any reported barrier or facilitator from our 61 studies, and we were able to expand on the 5As framework to include two additional dimensions.

6. Conclusions

This review offers multilevel strategies to inform clinical and community efforts to improve adoption of CRC screening. Many of the root causes reported in this review are interrelated across dimensions, and future interventions could integrate these relationships. For example, factors such as physician recommendation within the Acceptance dimension and mailed FIT kits within the Access dimension are also factors that impact specific racial/ethnic groups. As CRC screening options and recommendations change, as new screening options emerge, and as the variables that impact CRC screening in the population evolve, it is important to look to the evidence-base to discern key barriers to and facilitators of CRC screening. Our comprehensive summary of barriers and facilitators of CRC screening updates prior reviews, and coincides with new screening recommendations and the addition of emerging CRC screening options.

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.

Data availability

No data were used for the research described in the article.

Acknowledgements

The authors would like to thank Elissa A. Kinzelman-Vesely for her assistance in conducting our database search.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.pmedr.2023.102353.

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