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Social determinants of health and U.S. cancer screening interventions: a systematic review

Ariella R. Korn, PhD, MPH^{1,2,*}, Callie Walsh-Bailey, MPH³, Margarita Correa-Mendez, PhD, MPH¹, Peter DeNero, PhD, MPH⁴, Meagan Pilar, PhD, MPH⁵, Brittney Sandler, MLIS⁶, Ross C. Brownson, PhD^{3,7}, Karen M. Emmons, PhD⁸, April Y. Oh, PhD, MPH⁹

¹Cancer Prevention Fellowship Program, Implementation Science Team, Division of Cancer Control and Population Sciences, National Cancer Institute, Rockville, MD

²Behavioral and Policy Sciences Department, RAND Corporation, Boston, MA

³Prevention Research Center, Brown School at Washington University in St. Louis, St. Louis, MO

⁴College of Medicine, University of Arkansas for Medical Sciences, Little Rock, AR

⁵Division of Infectious Diseases, Washington University School of Medicine, St. Louis, MO

⁶Bernard Becker Medical Library, Washington University School of Medicine, St. Louis, MO

⁷Department of Surgery, Division of Public Health Sciences, and Alvin J. Siteman Cancer Center, Washington University School of Medicine, Washington University in St. Louis, St. Louis, MO

⁸Department of Social and Behavioral Sciences, Harvard T.H. Chan School of Public Health, Boston, MA

⁹Implementation Science Team, Division of Cancer Control and Population Sciences, National Cancer Institute, Rockville, MD

Abstract

Background: There remains a need to synthesize linkages between social determinants of health (SDOH) and cancer screening to reduce persistent inequities contributing to the U.S. cancer burden. We conducted a systematic review of U.S.-based breast, cervical, colorectal, and lung cancer screening intervention studies to summarize how SDOH have been considered in interventions and relationships between SDOH and screening.

Methods: We searched five databases for peer-reviewed research articles published in English between 2010–2021. We used Covidence to screen articles and extracted data using a standardized template. Data items included study and intervention characteristics, SDOH intervention components and measures, and screening outcomes. We summarized findings using descriptive statistics and narratives.

*Correspondence to: Ariella R. Korn, PhD, MPH, RAND Corporation, 20 Park Plaza, 9th floor, Boston, MA 02116, USA (akorn@rand.org; phone: 617-338-2059 x8908).

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Results: The review included 144 studies among diverse population groups. SDOH interventions increased screening rates overall by a median of 8.4 percentage points (interquartile interval=1.8–18.8). Most interventions aimed to increase community demand (90.3%) and access (84.0%) to screening. SDOH interventions related to health care access and quality were most prevalent (227 unique intervention components). Other SDOH, including educational, social/community, environmental, and economic factors, were less common (90, 52, 21, and 0 intervention components, respectively). Studies including analyses of health policy, access to care, and lower costs yielded the largest proportions of favorable associations with screening outcomes. SDOH were predominantly measured at the individual-level.

Conclusions: This review describes how SDOH have been considered in the design and evaluation of cancer screening interventions and effect sizes for SDOH interventions. Findings may guide future intervention and implementation research aiming to reduce U.S. screening inequities.

Keywords

social determinants of health; cancer screening; early detection of cancer; health equity; implementation science; United States

INTRODUCTION

Despite efforts to promote evidence-based cancer screening in the U.S., inequities persist in screening uptake and cancer burden amongst marginalized racial and ethnic groups, rural populations, and socioeconomically disadvantaged groups.^{1,2} Addressing inequities in cancer screening requires targeted public health efforts to improve the implementation, uptake, and sustained delivery of the evidence-based cancer screening recommendations.^{3–5}

The influence of interrelated and overlapping social determinants of health (SDOH) on outcomes observed across the cancer prevention and control continuum has been broadly recognized.^{1,6–8} Addressing the SDOH that contribute to health inequities is a key focus of the U.S. Healthy People 2030 agenda, which provides a framework for considering SDOH across five domains: Economic Stability; Education Access/Quality; Health Care Access/Quality; Neighborhood/Built Environment; and Social/Community Context.⁹ In addition to an increased focus on SDOH, Healthy People 2030 prioritizes evidence-based cancer screening for breast, cervical, colorectal, and lung cancers to reduce cancer deaths.¹⁰

Significant research efforts have focused on developing strategies to promote evidence-based cancer screening across different settings and populations, but few analyses have examined cancer screening interventions with an explicit SDOH focus. A systematic review published in 2020 analyzed 30 economic evaluations of screening interventions, concluding that intervening on SDOH to improve breast, cervical, and colorectal cancer screening appears to be cost-effective, can improve outcomes, and reduce the disproportionate cancer burden experienced by marginalized populations in the U.S.¹¹ The economic evidence captured in this 2020 review adds to the recognition that reducing cancer screening inequities requires focused action around SDOH.⁶ However, there remains a need to further synthesize the

literature examining linkages between SDOH and cancer screening to identify evidence-based interventions that adequately consider SDOH.¹²

We conducted a systematic review of research articles that describe U.S. intervention studies on breast, cervical, colorectal, and/or lung cancer screening with a focus on at least one SDOH within the five domains defined by Healthy People 2030.⁹ Our research aims were to: (a) identify and summarize how SDOH have been considered in the implementation of cancer screening interventions in the U.S.; (b) summarize intervention findings on the relationships between SDOH and breast, cervical, colorectal, and lung cancer screening; and (c) summarize research gaps and propose opportunities for how SDOH can inform the development of implementation strategies to advance equity in cancer screening.

METHODS

This systematic review follows the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines¹³ and is registered with the International Prospective Register of Systematic Reviews (PROSPERO; #CRD42021276582). The PRISMA checklist is available in Supplementary File 1. Our review methods are reported in detail in a previously published protocol.¹⁴

Information Sources and Search Strategy

We collaborated with a research librarian and experts in cancer control research to develop the search strategy.¹⁴ Search strings included terms for cancer site, screening test, SDOH, and U.S. Search strategies included limiters, with some variation by database: English language; publication years 2010–2021; human studies; adult studies; U.S. studies; journal articles or review articles (the latter to facilitate reference hand searching). We performed systematic literature searches in July 2021 in five databases: Ovid Medline (US National Library of Medicine); Embase (Elsevier); CINAHL (Cumulative Index to Nursing and Allied Health Literature) Plus (Ebscohost); Web of Science: Core Collection (Clarivate Analytics); and Cochrane Library: Database of Systematic Reviews (Wiley & Sons). The research librarian used EndNote reference management software (version 20) for management and automated deduplication of records.

Eligibility Criteria

Inclusion criteria.—Eligible studies were English language original research articles published in a peer-review journal between 2010–2021 (Table 1). We selected the 2010 start date to align with the launch of Healthy People 2020 and the passage of the Patient Protection and Affordable Care Act. In alignment with Healthy People 2030 cancer prevention objectives, we included breast, cervical, colorectal, and/or lung cancer screening studies among adults aged 18+ years.¹⁰ Studies must have been conducted in the U.S. Eligible outcomes included behavioral precursors to cancer screening (e.g., knowledge, attitudes, awareness, beliefs) or screening behaviors (e.g., receipt of screening, screening rates) at the patient, provider, organizational, or population levels. Studies also needed to include at least one SDOH factor as an intervention component or target (e.g., SDOH informed the design of a screening intervention, an intervention sought to address a

SDOH), or as part of analysis (e.g., association between SDOH variable and screening). We used SDOH constructs within the Healthy People 2030 domains, which are informed by established frameworks and definitions from Healthy People,⁹ the Kaiser Family Foundation,¹⁵ the National Institutes of Health PhenX Toolkit,¹⁶ relevant literature,¹¹ and expert input.

In the overall review, we included any empirical study design, including intervention, observational, or descriptive studies. For this paper, we report findings on the intervention studies. These include randomized and non-randomized intervention studies (e.g., randomized controlled trials, quasi-experimental, natural experiments, implementation studies, single-arm pre-post studies, program evaluation). Findings from observational studies will be reported elsewhere.

Exclusion criteria.—We excluded studies published pre-2010 and those not available in English. We did not include studies conducted only outside of the U.S. or multinational studies inclusive of the U.S. that did not report country-specific findings. We excluded non-empirical (e.g., editorials, commentaries) papers, conference abstracts, grey literature, and other non-peer reviewed sources. We did not include reviews or meta-analyses, though we conducted hand-searches of references from relevant reviews to determine if they contained any studies eligible for our review. We also “forward searched” protocol papers for eligible articles reporting study outcomes but did not include methodological or protocol papers. Studies were ineligible if they pertained only to primary prevention (e.g., tobacco control, diet, human papillomavirus vaccination), genetic testing, follow-up to abnormal cancer screening results, or cancer diagnosis, treatment, or survivorship. We excluded studies that included SDOH only as demographic or control variables.

Selection of Evidence Sources

We used Covidence, a collaborative web-based platform for managing and streamlining systematic reviews, for screening and data extraction.¹⁷ The screening team piloted and refined procedures prior to each review phase. For title/abstract screening, we conducted pilot screening with four rounds of 20 records. Following satisfactory interrater reliability (Fleiss' kappa=0.76), we used a single-coder approach to screen abstracts for eligibility. The screening team conducted regular evaluations for interrater reliability throughout title/abstract screening.

Full-text screening utilized a dual-independent approach, where each article was screened by two reviewers blinded to the other's decision. If an article did not satisfy all inclusion criteria, screeners applied the first pertinent exclusion code. Screening pairs met to discuss disagreements; a third coder was consulted, as needed, to achieve consensus. We hand searched references of excluded review articles and forward searched relevant protocols to locate potentially eligible records. Upon completing full-text screening, two coders (ARK, CWB) conducted a validation check to ensure all articles met inclusion criteria and to group records by study design (intervention; observational-qualitative; observational-quantitative).

Data Extraction and Quality Assessment

We created a standardized data extraction template in Covidence (see Supplementary File 2 for a PDF version), informed by previous literature, published frameworks, and team-generated items. We extracted bibliometric data and coded for study design. We also extracted information on target population characteristics, informed by NIH-designated U.S. health disparity populations and previous reviews.¹⁸ Cancer screening information included organ sites, screening tests or modalities, and pre-post changes in primary screening outcome(s). Extracted intervention information included delivery settings, approaches to improve screening informed by the Community Guide,^{5,19} and activities to integrate social care from the National Academies of Sciences, Engineering, and Medicine Social Care Report's "5A Framework".²⁰ *Awareness* activities identified social risks and assets (e.g., screening for insurance status or health literacy); *adjustment* activities altered care to accommodate social barriers (e.g., translation services or telehealth); *assistance* activities connected patients with social care resources (e.g., transportation vouchers); *alignment* activities connected with social care assets in the community (e.g., strengthening partnerships between health care institutions and food assistance programs); and *advocacy* activities included efforts by health systems to influence and invest in community social care resources (e.g., working with insurance companies to lower screening costs).

Additionally, we extracted information on SDOH constructs included in the intervention design, measures, and data sources. We coded for analyses between SDOH variables and screening outcomes and extracted information summarizing relationships between SDOH and screening outcomes as applicable. We applied Mixed Methods Appraisal Tool (MMAT), which contains fixed-response items by study design to assess study quality.²¹

If multiple included records pertained to a single study, we grouped these records for extraction. We applied a dual non-independent approach in which primary coders conducted extraction and secondary coders reviewed the extraction for accuracy and completeness. If the primary and secondary coders disagreed, the pair met to discuss, consulting a third reviewer as needed.

Results Synthesis

We generated descriptive statistics (e.g., frequencies) for closed-ended extraction items. We synthesized open-ended items by coding responses (e.g., organizing SDOH variables by Healthy People 2030 domains; coding intervention components by the Community Guide approaches to increase screening and the "5A Framework") and generated summaries with tables, figures, and narratives.

To summarize intervention effectiveness by cancer type and SDOH domain, we calculated medians and interquartile intervals (IQIs) of absolute and relative change in screening rates compared to no intervention or usual care.^{5,22} Some studies only reported behavioral precursors (e.g., screening knowledge; n=24 studies) and not screening outcomes and were therefore excluded. Summary measures also excluded single-group studies with baseline screening rates of 0% due to potential bias in the favorable direction (n=22),²² studies without a SDOH intervention component (n=4), and studies with insufficient reporting to

calculate change in screening rates (n=13). For studies with multiple primary outcomes, evidence-based screening modalities, and/or measures, summary calculations were derived from mean effect sizes of the following: screening history and up-to-date adherence (n=4); colorectal cancer screening tests (colonoscopy, sigmoidoscopy, fecal immunochemical test, fecal occult blood test) (n=7); and self-reported and medical record measures (n=2). For studies with two primary follow-up periods, summary measures included outcomes for the longest duration (n=5).

To synthesize evidence across all studies included in the review, we categorized reported associations between SDOH and screening outcomes, including both bivariate and multivariable analyses, by directionality of the relationship (favorable, null, unfavorable). We examined summaries of associations overall and by outcome (screening behavior vs. behavioral precursors to screening). We presented preliminary findings to two expert groups of cancer control researchers and implementation scientists. These discussions generated feedback on our data visualization approach and helped identify gaps in the evidence base, future directions for SDOH-related methods, and potential implications of our findings.

RESULTS

Study Selection

Figure 1 shows the PRISMA flow diagram,¹³ which included all eligible study designs for the parent systematic review project. The database searches yielded 20,406 records. After removing duplicates, 19,095 studies underwent title and abstract screening and then 1,541 full-text studies were assessed for eligibility. A total of 699 studies were included, of which 144 were unique intervention studies included in the current analysis (representing 150 articles).^{23–172}

Study Characteristics

Detailed characteristics of each intervention study are reported in Supplementary Table 1. There were 63 randomized controlled trials (43.8%), 34 pre-post/single arm studies (23.6%), 30 quantitative non-randomized studies (20.8%), 13 post-only/single arm studies (9.0%), and four other designs (2.8%). Interventions most commonly targeted colorectal cancer screening (n=59), followed by breast (n=38), cervical (n=27), and lung (n=2) cancer screening. Eighteen studies targeted multiple organ sites. Primary outcomes mainly focused on individual-level measures, including screening behavior (i.e., screening receipt or rate; n=120), screening knowledge (n=42), intention to screen (n=27), attitudes and beliefs (each n=18), self-efficacy (n=13), awareness (n=8), and other (n=23) outcomes. Three studies assessed a primary outcome at the provider-level, including knowledge or awareness of screening guidelines (n=2) and referrals to screening services (n=1).^{137,161,166}

Table 2 shows the characteristics of the intervention target population group(s). Many studies targeted individuals with Asian (n=29 studies), Black or African American (n=24), or Hispanic/Latino (n=48) racial/ethnic identities. Over half of the interventions included people who spoke a language other than English (n=85). Interventions with specific geographic targets focused on a mix of urban (n=26) and rural (n=18) areas. Interventions

were also aimed towards uninsured individuals (n=21), low-income individuals (n=52), and immigrant and refugee populations (n=35). Approximately half of studies were conducted among female participants only (n=77), whereas only two studies were restricted to male participants only. No interventions targeted minoritized populations based on sexual orientation or gender identity.

Intervention and Implementation Characteristics

Table 3 summarizes the intervention delivery settings (reported in n=139 studies), approaches, and activities. Clinics were the most prevalent intervention setting (n=73). Other common settings included homes, community-based organizations, religious establishments, among others. More interventions were delivered in a single setting (n=93; 66.9%) versus multiple settings (n=46; 33.1%). Most interventions were multicomponent in nature, with 124 studies (86.1%) using more than one approach based on the Community Guide to increase screening.^{5,19} Increasing community demand for screening was the most common approach (n=130) and included targeted individual-level behavior change interventions (e.g., education, client reminders). These interventions were often paired with approaches to increase community access to screening (n=121) (e.g., reducing costs, transportation support, language support). Many studies included aspects of community engagement, partnerships, and outreach during intervention development and delivery (n=82). Fewer studies aimed to increase provider delivery of screening services (n=24) (e.g., provider reminders and incentives).

The most common activities to better integrate social care in the health care sector were in the awareness (e.g., screening for insurance status; n=90 studies), adjustment (e.g., translation services; n=118), and assistance (e.g., transportation vouchers; n=50) “5A Framework” categories (Table 3). Several interventions used awareness, adjustment, and assistance activities together (n=35). Few interventions focused on alignment with other social care assets in the community (e.g., housing programs; n=5)^{68,69,74,130,133} and community-level advocacy efforts (e.g., working with insurance companies to lower screening costs; n=2).^{74,121}

Toward identifying how SDOH can inform the development of implementation strategies to advance equity in cancer screening, we documented the extent to which studies assessed implementation outcomes (informed by the Implementation Outcomes Framework¹⁷³) and were guided by implementation science theories, models, and frameworks. Among the 52 studies that reported implementation outcomes (36.1%), the most common outcomes were acceptability (n=27) and penetration (n=22). Fewer studies assessed fidelity (n=7), cost (n=6), feasibility (n=5), appropriateness (n=4), sustainability (n=3), adoption (n=2), and adaptation (n=1). Only eight studies (5.6%) reported the use of an implementation science theory, model, or framework.^{72,74,91,100,133,143,147,156}

SDOH Intervention and Measurement Characteristics

Figure 2 shows the frequency of SDOH constructs included as intervention components. Table 4 compares the distribution of SDOH intervention components with SDOH measures examined in relation to screening outcomes. Many studies incorporated multiple SDOH in

the intervention design (e.g., cultural and linguistic adaptation of intervention materials), though not all studies explicitly sought to change SDOH in relation to screening outcomes.

Health Care Access/Quality intervention components were most common (227 unique components), though only 97 measures in this SDOH domain were analyzed in relation to screening. For example, while 70 interventions aimed to improve cancer screening affordability or cost, there were only three measures of affordability or cost in the SDOH-screening analyses.^{91,96,168} Measures of health insurance coverage were most common (n=54).

Aiming to improve Education Access/Quality, 90 interventions incorporated components related to language and/or literacy (e.g., translation of study materials, accessible materials for low literacy populations). Education level was most commonly assessed in relation to screening (n=47).

Related to Social/Community Context, social support intervention components were most common (n=28). Few studies aimed to intervene on and analyze factors related to trust, social vulnerability, and discrimination.

The Neighborhood/Built Environment domain only included transportation intervention components (n=21); however, just three transportation measures were examined with screening.^{58,65,96}

No interventions aimed to improve participants' Economic Stability. Fifty-seven measures of economic stability (e.g., income, employment) were assessed in relation to cancer screening outcomes, commonly as predictor variables in statistical models.

Fifty studies (34.7%) considered SDOH in the intervention design or delivery but did not analyze a SDOH variable in relation to screening outcomes. For the 94 studies (65.3%) that included such an analysis, SDOH constructs were predominantly assessed at the individual-level (n=88) and measured via patient self-report with surveys (n=77). Ten studies measured SDOH with electronic health records. Few studies assessed SDOH at the family/social support (n=2), provider/team (n=1), organization/practice setting (n=1), local community environment (n=1), state health policy environment (n=4), and national health policy environment (n=1) levels.¹⁷⁴

Changes in Cancer Screening

Eighty-one studies representing 89 intervention arms were included in summary measures of intervention effectiveness on screening rates (Table 5). Across cancer types, SDOH interventions increased screening by a median 8.4 percentage points (IQI=1.8–18.8) when compared to no intervention or usual care. Median absolute increases in screening ranged from 6.1 percentage points for colorectal cancer (IQI=-0.2–14.2; 50 intervention arms), 6.4 percentage points for cervical cancer (IQI=1.3–19.1; 27 intervention arms), 12.3 percentage points for breast cancer (IQI=5.7–26.4; 30 intervention arms), to 20.3 percentage points for lung cancer (range=14.9–25.7; 2 intervention arms) screening interventions.

When examining effectiveness by SDOH domain, Neighborhood/Built Environment interventions (which all included a transportation component) had the greatest increase in overall screening (median=24.5 percentage points (IQR=8.1–45.1); 12 intervention arms). Median absolute increase in screening rates for interventions that considered SDOH factors related to health care, education, and social/community context ranged from 8 to 11 percentage points. Increases in screening were greater for interventions that addressed 3+ SDOH domains (median=21.6 percentage points (IQR=7.9–38.5); 21 intervention arms) than 2 domains (median=8.9 percentage points (IQR=1.8–15.4); 33 intervention arms).

Associations between SDOH Measures and Cancer Screening

Figure 3A–C summarizes associations between measured SDOH constructs and all included screening outcomes (260 associations), screening behavior (226 associations), and behavioral precursors to screening (34 associations), respectively. Favorable associations indicate that the SDOH (e.g., having health insurance) related to better outcomes, whereas unfavorable associations indicate that the SDOH (e.g., higher education level) related to worse outcomes.

Across outcome types, findings for SDOH constructs were mixed, with mostly favorable or null associations. Overall, health policy (e.g., Medicaid expansion, health insurance mandates), access to care (e.g., patient navigation services, seeing a physician within the past year), and lower costs (e.g., no payment for screening) had the highest ratios of favorable versus null and unfavorable associations with screening outcomes (83.3%, 66.7%, and 66.7% favorable associations, respectively; Figure 3A). We observed similar patterns for screening behavior outcomes (Figure 3B). While few in number, favorable associations for social capital/networks and provider linguistic/cultural competency were unique to behavioral precursors to screening (Figure 3C).

Twenty-nine studies examined relationships between language (i.e., language spoken, preference, fluency) and cancer screening. These findings are reported narratively as association directionality could not be readily discerned (e.g., improved screening by Spanish vs. English preference). Most studies (n=17) observed a null association and three studies observed both null and significant findings among multiple analyses or outcomes. Eight studies reported favorable outcomes among participants who preferred or spoke a language other than English, of which seven studies specified that the intervention was provided in the population's preferred language. Conversely, four studies reported favorable outcomes among those with stronger English fluency or preference.

Risk of Bias

Table 6 summarizes the MMAT quality assessment findings.²¹ Quality assessment ratings for individual studies are reported in Supplementary Tables 2–4. Most studies (randomized controlled trials: 62.7%; quantitative non-randomized studies: 93.9%; quantitative descriptive studies: 83.3%) reported on most (3 of 5) MMAT criteria. For randomized controlled trials, common absences included limited randomization information, unclear or uneven distribution of baseline participant characteristics, incomplete outcome data (follow-up data available for <80% of participants), and participant non-adherence

to the assigned intervention (<80% adherence). Many studies did not report blinding, however blinding is not always warranted or feasible in all studies (e.g., for patient-reported outcomes). Limitations of quantitative non-randomized studies included ambiguity of whether participants represented the target population, incomplete outcome data, and lack of details on potential confounding. For quantitative descriptive studies, concerns related to unrepresentative sampling and risk of nonresponse bias.

DISCUSSION

The cancer research community is increasingly recognizing the need to understand and address structural and social determinants of health to advance equity across the cancer control continuum—including cancer screening.^{1,6,8,9,11} This systematic review of 144 breast, cervical, colorectal, and/or lung cancer screening intervention studies in the U.S. contributes to characterizing the evidence base of how a broad range of SDOH have been considered in intervention design, development, and evaluation. We found that SDOH interventions increased screening use overall. Findings help explicate links between SDOH and cancer screening outcomes, which may help activate key scientific actors (i.e., researchers, funders) to further invest in intervention and implementation research aiming to reduce cancer screening inequities among a wide array of population groups.¹²

Intervention Effectiveness

Results from this systematic review indicate the effectiveness of SDOH-oriented interventions on breast, cervical, colorectal, and/or lung cancer screening rates. While health care components were most common, findings suggest greatest effectiveness for interventions considering SDOH in several domain areas. The greatest improvements in screening were among the subset of interventions that addressed transportation to screening appointments among other components^{27,36,41,58,63,112,113,141,142,144,155,163}—an important finding given that transportation is a well-documented barrier to health care access.^{175,176} Despite these results, limitations of the current intervention evidence base and SDOH evaluation approaches are discussed below.

SDOH Intervention Characteristics and Gaps

Our findings demonstrate the predominance of cancer screening interventions that considered SDOH at the individual-level (versus organizational, community, or system-wide change), most commonly through interventions aiming to improve patients' access to care, reduce screening costs, and provide language and literacy support. Through the lens of the "5A Framework",²⁰ we observed that few interventions sought to address SDOH beyond the individual-level, with only five studies including activities that aligned or invested in social care integration in health care settings and the community,^{68,69,74,130,133} and two studies that advocated for policies addressing social needs.^{74,121} Much more common were individually-focused interventions that identified patients' social risks (e.g., assessing health literacy) and/or adjusted care to accommodate social risks (e.g., providing educational materials at appropriate health literacy levels). Future interventions may consider expanding the evidence beyond the individual-level to structural, community, and health care system levels.^{6,174,177}

The skewed distribution of SDOH intervention domains (Table 4)—with the Health Care Access/Quality interventions exceeding studies focused on other areas—suggests more attention toward educational, social, environmental, and economic factors is needed. Notable were the absence of interventions addressing structural inequities that drive cancer screening disparities, including discrimination, racism, racial and ethnic segregation, and poverty.^{1,6} Other SDOH not targeted in the interventions included: education; employment; exposure to violence and trauma; food insecurity; housing instability; internet access; and social isolation, among other factors. Similar research gaps are reflected in Mohan and Chattopadhyay’s 2020 systematic review examining the cost-effectiveness of cancer screening interventions that leverage SDOH.¹¹ Interventions were also lacking for minoritized populations based on sexual orientation and gender identity.

SDOH Evaluation Approaches and Gaps

We observed significant discrepancies in SDOH included as intervention components versus what was measured and examined in relation to cancer screening (Table 4). These “intervention-measurement gaps” were prevalent across all SDOH domains. For example, relating to Health Care Access/Quality, only eight studies intervened on health insurance coverage,^{24,32,33,74,75,113,141,142,169} yet 54 studies included health insurance in their analysis—the most assessed predictor of screening outcomes. Additionally, while many studies (n=57) included Economic Stability measures, no interventions sought to improve participants’ economic well-being. This finding reflects potential missed opportunities among populations with more barriers to care, lower socioeconomic status, or experiencing homelessness or housing insecurity. In contrast, other SDOH constructs were more commonly intervened upon than measured (e.g., access to care; affordability or cost; health literacy; language and literacy; social support; transportation).

Additionally, studies rarely examined causal relationships between SDOH and cancer screening outcomes—for example, by testing the effectiveness of transportation assistance alone to improve screening rates. A few studies used natural experiments (e.g., federal funding for family planning clinics¹²⁰ and state insurance mandates³³) paired with national survey data to investigate effects on screening, yet studies that examined associations or treated SDOH variables as moderators of intervention effectiveness were more common. This finding highlights the need for research that seeks to intervene upon SDOH (i.e., reducing or eliminating structural barriers, leveraging positive SDOH) and test intervention effects on screening outcomes. As discussed by Brown and colleagues, building the evidence base of structural interventions requires community engagement, measurement improvements, use of rigorous study designs to investigate mechanisms of change, and careful consideration of unintended consequences.¹⁷⁸

While few in number, most studies that assessed the effects of health policy implementation at the state- or national-level found favorable cancer screening outcomes.^{32,33,75,120,138} For example, Sabik and colleagues observed increases in cervical cancer screening rates among low-income women residing in states that implemented Medicaid expansion relative to women in comparison non-expansion states.¹³⁸ This type of analysis contrasts with the high prevalence of individual-level, self-reported SDOH constructs (e.g., having health

insurance coverage) represented in our synthesis of associations between SDOH and cancer screening outcomes (Figure 3A–C). Measurement and methodologic advances are needed in the SDOH intervention research agenda to better understand multilevel social and structural influences on cancer screening.^{11,179,180}

Strengths and Limitations

Strengths of this systematic review include the breadth of included SDOH domains and constructs, allowing for a holistic examination of the extant cancer screening literature and identification of research gaps. Another strength includes the use of established frameworks to guide data extraction and syntheses, facilitating comparisons across studies.

Several limitations are noted. Our single abstract reviewer approach may have omitted potentially relevant records. However, we carefully piloted and documented our procedures and conducted regular interrater reliability checks to ensure a high rate of agreement. Our methods sought to balance rigor and pragmatism to screen many records. Additionally, there is the potential for publication bias and reporting bias (e.g., for implementation outcomes). Other study limitations include the exclusion of: articles published before 2010; prostate cancer screening studies due to current informed decision-making guidelines;^{3,10} cancer survivorship studies; and studies conducted outside of the U.S. due to country differences in health systems and population characteristics.

Implications for Implementation Science and Practice

This review included mostly efficacy and effectiveness trials. Approximately a third of studies (36.1%) reported on an implementation outcome—most commonly acceptability and penetration—but overall, the sample lacked implementation studies or hybrid trials in which effectiveness and implementation are investigated together.¹⁸¹ SDOH are often described as part of the broader implementation context (e.g., outer setting health policies^{182,183}), yet to make progress in developing implementation strategies that incorporate SDOH to advance equity in cancer screening, the field must look toward attempting change at the community and systems levels.^{6,12,174,178} Findings from our review—particularly the major emphasis on individual-level intervention approaches and measurement—point toward the need for additional evidence at these broader levels of influence. Partnerships with practitioners, providers, and decisionmakers from across sectors (e.g., health care, social services, government)¹⁸⁴ can help identify the most critical SDOH in their communities and contribute to the development of feasible and impactful implementation strategies to advance cancer screening equity.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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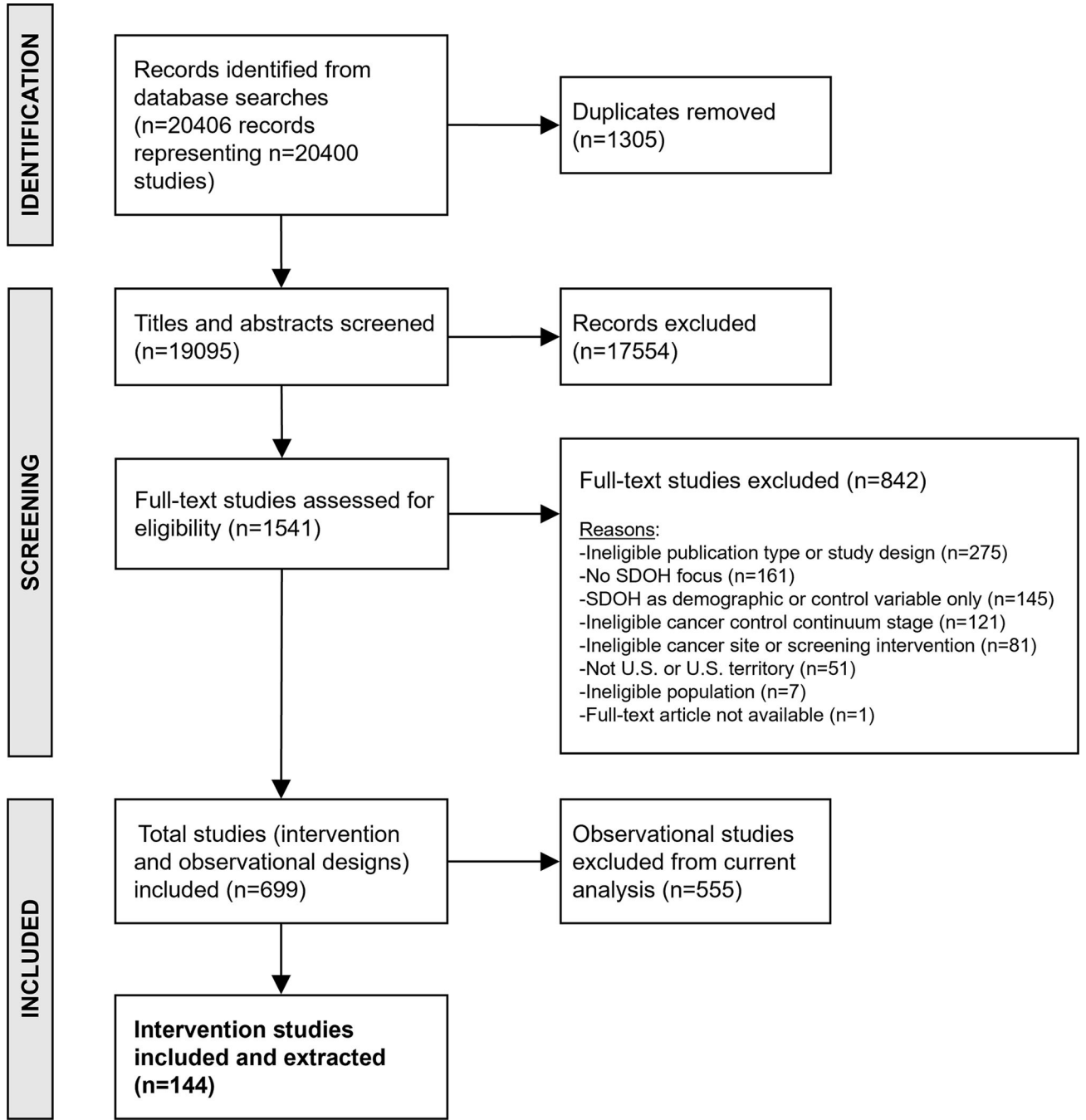


Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram.

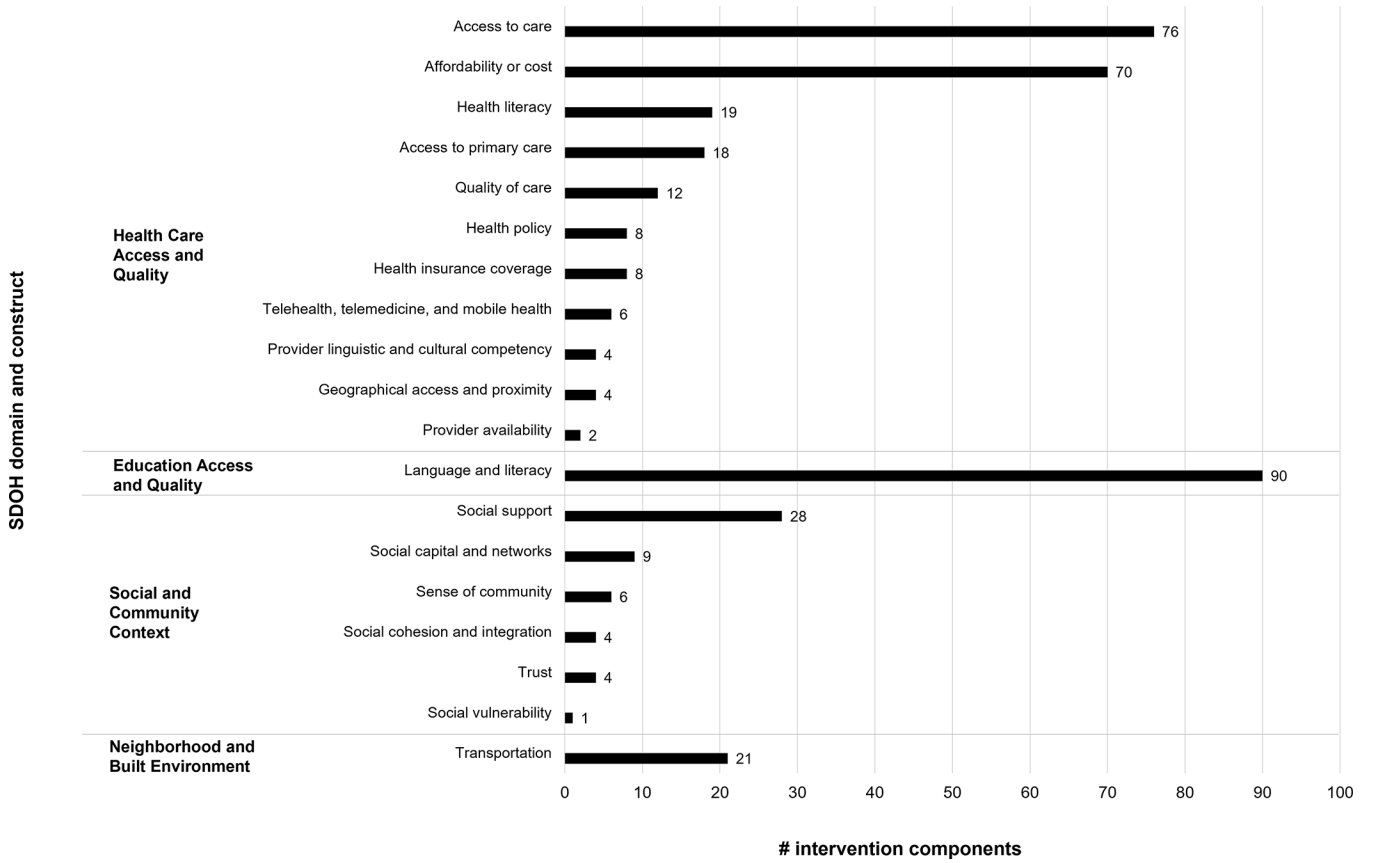


Figure 2. Intervention components grouped by SDOH domain and construct. A component may represent >1 SDOH construct (e.g., state health insurance mandate addresses health insurance coverage and health policy).

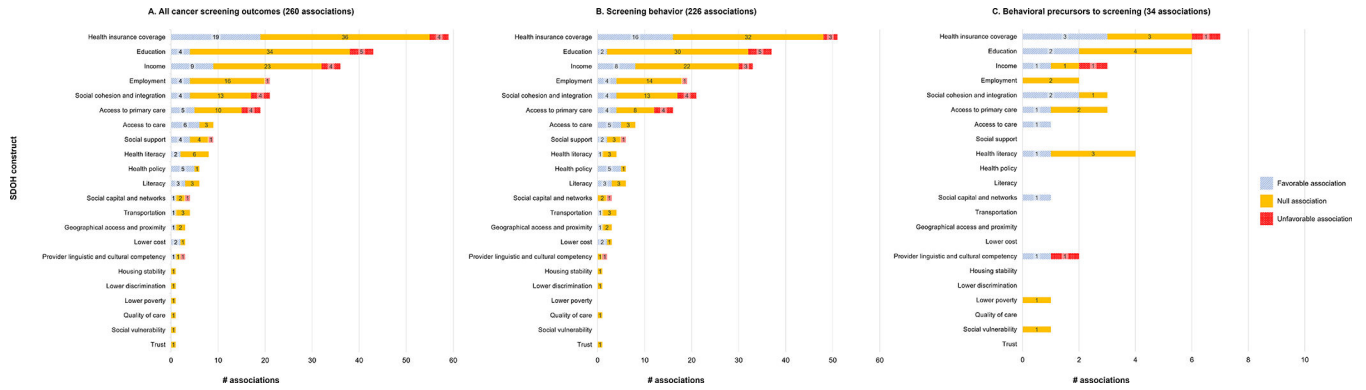


Figure 3A-C. Summary of associations between SDOH and (A) all cancer screening outcomes, (B) screening behavior, and (C) behavioral precursors to screening. Favorable associations (blue) indicate that the SDOH (e.g., having health insurance) was associated with better screening outcomes, whereas unfavorable associations (red) indicate that the SDOH (e.g., having a higher education level) was associated with worse outcomes. Overall, 31 studies reported mixed associations (e.g., favorable and null) for a single SDOH construct due to multiple analyses and/or screening outcomes; each association is reported separately. Two associations were excluded from the summary: a favorable association between a SES index (including poverty, income, income support, education, employment) and screening behavior, and an association with screening behavior that could not discern directionality between categorical health insurance types.

Table 1.

Inclusion and exclusion criteria

	Include	Exclude
Record available	Full text record available	Full text irretrievable
Year published	2010–2021	Before 2010
Language	English	Non-English
Country	U.S. and U.S. territories (American Samoa, Guam, Northern Mariana Islands, Puerto Rico, U.S. Virgin Islands); multinational studies only if U.S. is included and country-level findings reported	Any non-U.S. countries; multinational studies reported in aggregate (no U.S.-specific findings)
Population	Adults aged ≥18y; populations with participants < and >18y (e.g., 16–30y); age group not explicit	Populations <18y
Study design and publication type	Peer-reviewed empirical studies involving primary or secondary data collection and analysis (e.g., experimental studies, quasi-experimental, observational, qualitative) • Intervention studies included randomized controlled trials, non-randomized studies with a comparison group, or single-arm designs ^a	Non-empirical records (e.g., commentaries, debates, editorials, conceptual articles) • Observational quantitative and/or qualitative studies ^a
Cancer control continuum	Cancer screening and early detection	Etiology, primary prevention, diagnosis, treatment, survivorship
Cancer screening type	Reports on screening for breast, cervical, colorectal, and/or lung cancers; reports both eligible and ineligible screening types (e.g., colorectal and prostate)	Does not report on screening for these four cancers
SDOH	Any constructs relevant to 1 Healthy People 2030 domain: Economic Stability; Education Access/Quality; Health Care Access/Quality; Neighborhood/Built Environment; Social/Community Context ⁹	No mention of relevant SDOH; SDOH constructs collected only as demographic or contextual information

^a Additional study design criteria added for intervention-focused reporting.

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Table 2.

Study priority population(s)

Population characteristic	No. studies
Racial/ethnic background(s) ^a	
American Indian or Alaska Native	6
Asian	29
Black or African American	24
Hispanic/Latino	48
Middle Eastern or North African	5
Native Hawaiian or Other Pacific Islander	4
Racial/ethnic group (not specified)	2
Geography(ies)	
Urban	26
Rural	18
Insurance status and healthcare access	
Uninsured	21
Underinsured	12
Medically underserved	2
Socioeconomic status	
Low income	52
Low education attainment	7
Language and literacy	
Language other than English	85
Low literacy	7
Immigration status	
Immigrant	29
Refugee	5
Undocumented immigrant	1
Other population groups	
Farmworker populations	2
Homeless or experiencing housing insecurity	2
D/deaf or hard of hearing	1
Incarcerated or previously incarcerated	1
Sexual and gender minority / LGBT	0
Priority population not specified	14

^aRacial/ethnic background categories were informed by the NIH-designated U.S. health disparity populations.¹⁸ Racial/ethnic background categories are listed in alphabetical order, whereas other categories are listed in descending order based on study count, and when applicable, also alphabetically.

Table 3.

Intervention characteristics

Intervention characteristic	No. studies
Delivery setting(s)	
Clinical	73
Home	38
Community-based organization	31
Religious establishment	29
Other community setting	21
Policy	6
Mobile screening unit	4
Workplace	2
Other	12
Not specified	5
Approach(es) taken to increase screening ^{5,19}	
Increase community demand	130
Increase community access	121
Community engagement	82
Increase provider delivery of screening services	24
Other	1
“5A Framework” activity(ies) to integrate social care in the health care sector ²⁰	
Awareness	90
Adjustment	118
Assistance	50
Alignment	5
Advocacy	2
Not applicable	12

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Table 4.

SDOH domains and constructs included as intervention components and measured in relation to cancer screening outcome*

SDOH domain and construct ^a	Intervention component ^b	Measured in relation to cancer screening outcome
	No. components or measures	
Health Care Access/Quality	227 total	97 total
Access to care	76	8
Affordability or cost	70	3
Health literacy	19	7
Access to primary care	18	15
Quality of care	12	1
Health insurance coverage	8	54
Health policy	8	5
Telehealth, telemedicine, and mobile health	6	0
Provider linguistic and cultural competency	4	2
Geographical access and proximity	4	2
Provider availability	2	0
Education Access/Quality	90 total	81 total
Language and literacy	90	34
Education	0	47
Social/Community Context	52 total	31 total
Social support	28	6
Social capital and networks	9	3
Sense of community	6	0
Social cohesion and integration	4	19
Trust	4	1
Social vulnerability	1	1
Discrimination ^c	0	1
Neighborhood/Built Environment	21 total	3 total
Transportation	21	3
Economic Stability	0 total	57 total
Housing instability	0	1
Income	0	32
Employment	0	21
Poverty	0	2
Income support	0	1
No SDOH intervention component ^d	6	-
No SDOH measured in relation to screening	-	50

* For detailed information about interventions by cancer site, please see Supplementary Table 1.

Abbreviation: SDOH, social determinants of health.

^aSDOH domains and constructs ordered in descending frequency by intervention components.

^bAn intervention component may represent >1 SDOH construct (e.g., state health insurance mandate addresses health insurance coverage and health policy).

^cCross-cutting across SDOH domains.¹⁵

^dStudies were eligible for inclusion if the analysis considered a SDOH-screening relationship.

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Table 5.

Summary of intervention findings

Cancer screening types and SDOH intervention domains	No. studies	No. intervention arms	Absolute increase (percentage points)	Relative increase (%)
			Median (IQR) ^a	
Overall	81	89	8.4 (1.8, 18.8)	22.2 (1.8, 68.2) ^b
Organ site(s) ^c				
Breast	28	30	12.3 (5.7, 26.4)	36.6 (13.4, 76.8)
Cervical	25	27	6.4 (1.3, 19.1)	26.0 (-0.1, 129.9)
Colorectal	44	50	6.1 (-0.2, 14.2)	11.1 (-0.3, 43.8)
Lung	2	2	20.3 (range: 14.9, 25.7)	106.9 (range: 41.3, 172.5)
2+ organ sites ^d	11	13	4.9 (-0.1, 16.7)	9.0 (-0.6, 82.0)
SDOH domain(s) ^e				
Health Care Access/Quality	66	71	8.4 (1.3, 23.1)	29.7 (1.0, 82.0)
Education Access/Quality	55	62	10.4 (3.6, 23.3)	27.2 (7.9, 76.5)
Social/Community Context	22	23	11.1 (5.0, 23.1)	34.7 (8.1, 52.5)
Neighborhood/Built Environment	11	12	24.5 (8.1, 45.1)	82.0 (20.9, 196.1)
Economic Stability	0	-	-	-
2 SDOH domains	31	33	8.9 (1.8, 15.4)	22.2 (1.9, 53.3)
3+ SDOH domains	19	21	21.6 (7.9, 38.5)	51.3 (10.3, 186.0)

Abbreviation: IQI, interquartile interval; SDOH, social determinants of health.

^aRange used for summary measures with four or fewer data points.

^bFour studies excluded from relative change estimates due to unspecified pre/post screening rates.

^cSummarized across SDOH domains.

^dSummary estimates included effect sizes for each organ site outcome.

^eSummarized across all cancer screening outcomes. Domains are not mutually exclusive.

Table 6.

Summary of quality assessment findings, Mixed Methods Appraisal Tool (MMAT)

Study design	Question	Yes	No	Can't tell
		No. studies		
All	S1. Are there clear research questions?	144	0	0
	S2. Do the collected data allow to address the research questions?	143	1 ^a	0
Quantitative randomized controlled trials ^b	2.1. Is randomization appropriately performed?	32	0	27
	2.2. Are the groups comparable at baseline?	41	10	8
	2.3. Are there complete outcome data?	44	14	1
	2.4. Are outcome assessors blinded to the intervention provided?	5	38 ^c	16
	2.5. Did the participants adhere to the assigned intervention?	50	8	1
Quantitative non-randomized studies ^b	3.1. Are the participants representative of the target population?	53	1	12
	3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?	65	0	1
	3.3. Are there complete outcome data?	51	10	5
	3.4. Are the confounders accounted for in the design and analysis?	43	8	15
	3.5. During the study period, is the intervention administered (or exposure occurred) as intended?	58	1	7
Quantitative descriptive studies	4.1. Is the sampling strategy relevant to address the research question?	16	0	2
	4.2. Is the sample representative of the target population?	12	1	5
	4.3. Are the measurements appropriate?	16	0	2
	4.4. Is the risk of nonresponse bias low?	5	2	11
	4.5. Is the statistical analysis appropriate to answer the research question?	16	0	2

^aPer MMAT guidance, study was not considered for further appraisal.

^bFor the quality appraisal, three secondary analyses from randomized controlled trials were included in the MMAT "quantitative non-randomized studies" category due to aggregation across study arms or inclusion of intervention arm data only.

^cMany studies had patient-reported outcomes; therefore, the outcome assessor (patient) was not blinded to the intervention provided, and this is not necessarily a limitation.