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SYSTEMATIC REVIEW

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Innovation and implementation determinants of HIV testing and linkage-to-care in the U.S.: a systematic review

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Abstract

Objective To identify innovation and implementation determinants of HIV testing, diagnosis, and linkage-to-care in the U.S.

Data sources and study setting Between November 2020 and January 2022, a broad search strategy was employed in three literature databases: Ovid MEDLINE, PsycINFO, and Web of Science.

Study design A systematic review guided by the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) statement.

Data collection/extraction methods A team of master's and Ph.D.-level researchers screened eligible studies against the inclusion criteria and extracted the data using COVIDENCE software in pairs with consensus performed by a senior member of the team. Barriers and facilitators were extracted and analyzed according to the Consolidated Framework for Implementation Research (CFIR). Frequency of determinants across studies was mapped according to CFIR, valence, study design, delivery setting, unit of analysis, population of interest, region of the U.S., and year.

Results We identified 1,739 implementation and innovation determinants from 186 articles. Most determinants were for HIV testing rather than linkage-to-care. Most determinants were identified in the inner setting and individuals domains of CFIR, with the fewest identified in the process and innovations domains. Determinants of providers were only slightly more frequently identified than determinants of recipients. However, determinants of organizations and systems were rarely identified.

Conclusion This review provides a synthesis of innovation and implementation determinants of HIV testing and linkage-to-care using the most-cited implementation science (IS) framework, CFIR. This synthesis enables the larger field of HIV science to utilize IS in efforts to end the HIV epidemic and positions IS to consider the application of IS frameworks to fields like HIV.

Keywords HIV/AIDS, HIV testing, HIV linkage to care, Implementation science, Determinants of implementation, Systematic review, CFIR

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Contributions to the literature

- This review provides new insights into multilevel implementation determinants for the HIV testing and linkage-to-care intervention process in U.S.-based delivery systems.
- The results indicate a need to focus more on implementation determinants that underlie inequities in new HIV infection and preventive HIV services experienced by CDC-defined priority populations.
- Our findings suggest that future research should focus on determinants of objective implementation outcomes (e.g., adoption, reach, sustainment) given the existing literature on antecedent and pre-implementation outcomes (e.g., acceptability).

Background

Although primary prevention is a critical element for ending the HIV epidemic, with the discovery that viral suppression by HIV treatment eliminates onward transmission, testing and treatment remain a key element of HIV elimination strategies [1]. Further, testing is the gateway to interventions along the HIV care cascade [2, 3], with linkage to HIV care, PrEP care, or behavioral intervention pathways depending on test results. Despite significant reductions in HIV incidence in the U.S. over the past four decades, thanks to timely diagnosis and access to treatment, there are still approximately 158,500 individuals unaware of their HIV status [4, 5]. Furthermore, at least 16% of new infections are transmitted by individuals who are unaware of their own status, with modeled estimates ranging from 16.1% to 64.8% [3, 6, 7]. At the height of the HIV/AIDS epidemic in the 1980's, HIV tests required a wait of six to twelve weeks post-infection in order to detect the virus [8]. Today, positive test results can be provided as early as two weeks post-infection, depending on the type of test conducted. Rapid point-of-care tests, such as finger-prick and oral swab tests, can detect HIV antibodies within twenty to thirty minutes [9]. Regular testing enables swift diagnosis of new HIV infections [10]. Further, early diagnosis of new HIV infection is critical to rapid initiation of antiretroviral therapy (ART) [11]. Rapid initiation of ART is associated with higher rates of retention in care and has been found to increase rates of viral suppression and shorten the amount of time from ART initiation to viral suppression [12, 13]. When an individual has achieved viral suppression, the risk of HIV transmission eliminated [14].

Despite advances in prevention and care rapidity, disparities in testing and linkage-to-care (LTC; i.e., connecting an individual to ART if their HIV test is reactive) across race/ethnicity, sex/gender, and geography remain. In response to the ongoing epidemic, the U.S. Department of Health and Human Services launched the Ending the HIV Epidemic in the U.S. by 2030 initiative [15]. This multisectoral initiative includes the goal of reducing new HIV infections in the U.S. by 75% by 2025 and by 90% by 2030. It also aims to advance health equity through attention to CDC-designated priority populations in high-priority jurisdictions (Fig. 1). These priority populations include men who have sex with gay, bisexual, and other men who have sex with men (GBMSM; in particular, Black, Latino, and American Indian/Alaska Native men), cisgender Black women, transgender women, youth aged 13–24 years, and people who inject drugs [16].

To meet the bold goals of the national *Ending the HIV Epidemic* initiative will require the use of implementation science (IS), as mass scale up and adaptation of existing interventions is needed in well-established sites (e.g., clinics, hospital systems, community-based organizations, churches and more across the country) already providing such care, as well as in those that are not yet utilized or optimized for this purpose [17, 18]. Unique strategies and interventions will need to be developed and/or tailored to priority populations. Further, the pace of learning and implementing lessons must be incredibly rapid to meet 2030 goals. Without rapid translation of research into real-world settings, this will not be possible [17].

As implementation scientists have detailed, innovations are not implemented in isolation from interpersonal, social, political, and economic factors [19–22]. For example, the criminalization of HIV [23], HIV stigma [24, 25], racism [26–28], and homophobia [28] have each impeded uptake of testing and ability to be linked to care for patients. These disparities are also evident among different priority populations. For example, research has shown Black immigrant men tend to test later than Black men born in the U.S. and thus be diagnosed at later stages of HIV infection [29]. Black men who have sex with men (MSM) have comparable HIV lifetime testing rates to white MSM, [30] but Black MSM have been found to have lower rates of linkage-to-care than any other racial/ethnic grouping of MSM [31]. Individuals living in urban and suburban areas are more likely to be tested for HIV than individuals in rural areas [32]. Transgender women and transgender men also have lower rates of HIV testing than other at-risk populations, like cisgender MSM, [33].

A previous review by Tso et al. of quantitative analyses of interventions to enhance LTC across the world identified staff education, staff shortages, confidentiality concerns, and transportation as barriers to LTC for people living with or impacted by HIV [34]. Fear, stigma, misinformation, and social support were also identified as necessary determinants to target. Bagchi

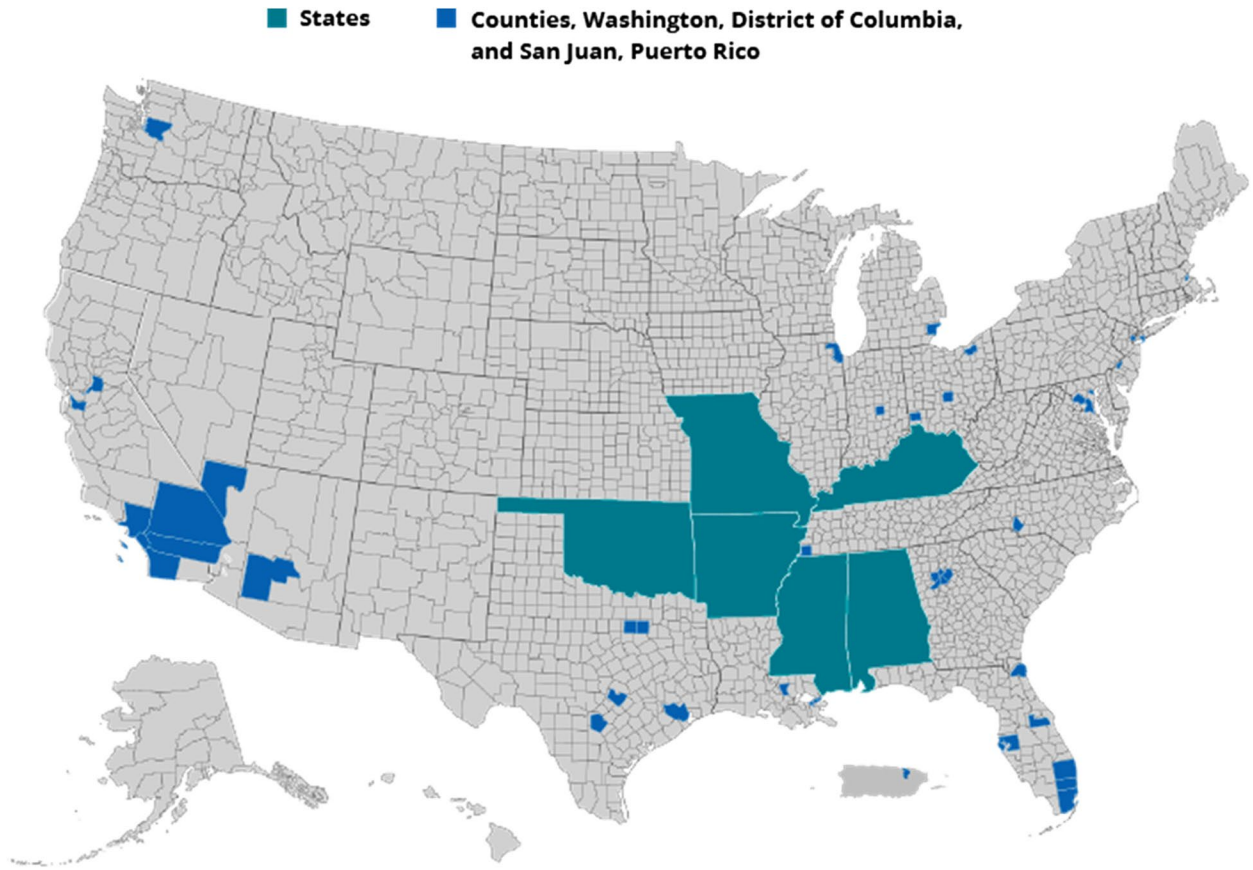

Fig. 1 EHE Priority Jurisdictions. Credit: CDC 2023 (https://www.cdc.gov/ehe/php/jurisdictions-plans/index.html)

and Davi's review of clinician-focused determinants to routine HIV testing pointed to the wealth of studies that have identified "intrapersonal" barriers and facilitators, including education, self-efficacy, and stigma [35]. However, policy level barriers (i.e., reimbursement, laws, and policies) and structural factors (i.e., administrative support) also impeded clinicians' capacity to implement routine testing. Although previous systematic reviews have examined barriers to HIV testing and/or LTC globally [34], specific to particular roles, such as clinicians, [35], or specific to particular populations, such as migrants [36], people 50 years of age and older [37], Asian Americans [38], or Latino MSM [39], or in the case of an ongoing review, specific to particular types of testing [40], no systematic review has identified implementation determinants of HIV testing and LTC for all populations, types of testing, and types of linkage in the U.S., to the best of our knowledge.

To fill this gap, we sought to systematically review the literature for innovation and implementation determinants of HIV testing and/or linkage-to-care to (a) describe the scale and type of research that has thus far been conducted, (b) identify areas of needed research, and (c) contribute to a growing, publicly available dashboard of determinants of implementation for HIV-related interventions for researchers and practitioners alike [41].

Method

Retrieval strategies

The full search strategy is detailed in Supplemental File 1 and was also reported in Merle et al. (2022) [42]. Between November 2020 and January 2022, a broad search strategy was conducted to capture implementation-related studies along the HIV prevention and care continuum. The protocol for this search is registered with the International Prospective Register of Systematic Reviews (PROSPERO ID: CRD42021233089). A clinical informaticist (author C.G.) searched Ovid MEDLINE [1946—January 19, 2021], PsycINFO (EBSCOhost) [2000–2021], and Web of Science (Clarivate Analytics) [2007–2021] for peer-reviewed articles published in English. Supplemental File 2 Presents the

Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) diagram of the process.

Screening and eligibility criteria

To identify articles focused on HIV testing/diagnosing and linkage to care, we conducted a multi-phase screening process. Full screening, extraction, and coding processes and training are described in detail in Supplemental File 3. First, a semiautomated computerized exclusion procedure using text mining and natural language processing[43–45] excluded articles that did not fit the following inclusion criteria: (a) were conducted in the U.S. (b) were related to HIV/AIDS, (c) were related to HIV/AIDS testing, diagnosing, or linkage to care, (d) were focused on outcomes related to dissemination and implementation (i.e., test/evaluate/explore implementation determinants or strategies), (e) conducted original, empirical research, and (f) were behavioral studies (i.e., were not basic science focused related to studying efficacy or effectiveness of particular HIV tests rather than focused on implementation or behavior change). Elsewhere, we have published results of systematic reviews of determinants and strategies for pre-exposure prophylaxis (PrEP), and we have additional reviews of determinants of HIV treatment and implementation strategies for HIV testing, linkage to care, and HIV treatment in process [46–50]. After computerized exclusions, a group of six master's and doctorate level researchers screened 878 titles and abstracts against inclusion and exclusion criteria using Covidence software [51]. We excluded articles if they did not meet inclusion criteria or were conducting basic science research; protocol articles; opinion, perspective, or commentary pieces; studies about research recruitment; or studies solely focused on comorbidities among people with HIV. Two screeners reviewed each record, and discrepancies were reconciled by team members experienced in IS (authors JLM, DL, and JDS). Full-text review of the 429 remaining articles yielded 186 articles for data extraction and coding.

Extraction and coding

Data extraction was conducted in Covidence [51] following four broad categories: (a) study-level variables (author and journal name, year published), (b) sample-level variables (setting, participants, CDC priority population), (c) study design and independent variables, and (d) measurement, data collection method, and dependent variables. In the next phase, studies that were classified as measuring innovation (e.g., affecting recipient uptake or adherence) or implementation (e.g., affecting system or provider-level delivery of an innovation) determinants [52] were qualitatively coded using MAXQDA [53]. Although CFIR 2.0 is intended for implementation determinants, we chose to additionally identify innovation determinants, as both ultimately impact effectiveness of an innovation. The lead authors (az and JLM) iteratively developed the codebook and expanded the CFIR 2.0 version [54]. The codebook further includes structural oppression, added into the *outer setting*. Structural oppression is defined as "the totality of societal structures and policies that create and maintain inequities by unequally distributing access to opportunities and societal resources" [55]. Although CFIR 2.0 includes the constructs local attitudes (or social values and beliefs related to engagement with the intervention) and local conditions (or economic, environmental, political, and other material conditions related to intervention delivery), it does not explicitly identify structural oppression. CFIR is, instead, neutral to systems like racism, sexism, and heterosexism [56], which have been found to impact delivery and engagement with HIV interventions [57, 58]. Within the *inner setting,* staffing was added (e.g., staff do not have enough time; more staff are needed). Finally, within the *individuals* domain, characteristics not associated with behavior were added to include identification of race, gender, sexual orientation, relationship status, and other demographic level factors as associated with increased/decreased uptake or delivery. Additional codes include the valence of the determinant (i.e., barrier or facilitator); the measurement method (i.e., qualitative or quantitative); the type of outcome the determinant influences (i.e., implementation outcomes at the provider or system level or innovation outcomes at the recipient or patient level) [52]; and the HIV-related innovation the determinant effects (i.e., testing, linkage to care, PrEP, treatment). We categorized HIV-related innovation into subcategories. For testing, these subcategories included: (a) reflexive testing (i.e., testing given to anyone (sometimes called universal testing) that is triggered by a protocol to recommend testing based on risk assessments), (b) rapid testing (i.e., an HIV test that provides results the same day, generally within 10–45 min), (c) confirmatory testing (i.e., testing performed after a preliminary test to confirm an HIV diagnosis), and (d) home testing (i.e., testing performed at home by oneself, generally a rapid HIV test). LTC subcategories included: (a) general linkage (i.e., linkage to HIV prevention or treatment services performed without a set time frame) and (b) rapid linkage (i.e., linkage to HIV prevention or treatment services performed within 7 days of an HIV diagnosis). Our full codebook with operational definitions is presented in Supplemental File 3.

A coding team, comprising four PhD-level researchers familiar with the CFIR 2.0, coded each extracted determinant to a construct from the framework, differentiating

between implementation and innovation targets [54]. Coding challenges were flagged for group discussion and reconciliation. MAXQDA training involved 10 sessions, and inter-coder agreement was conducted until reliability across all coding pairs surpassed 80% agreement. Ongoing training sessions occurred biweekly to for continued reliability checks and calibration, with final agreement surpassing 90% agreement.

Data analysis and synthesis

All data was exported into Microsoft Excel. We tabulated the number of discrete determinants and articles by adapted CFIR 2.0 constructs. Using data from Covidence extraction, we stratified determinants by the adapted CFIR 2.0, common delivery settings (e.g., HIV, infectious disease, and LGBT specialty care, hereafter "HIV specialty clinics;" substance use treatment facility, emergency department, labor department) and CDC priority target populations. Studies that included multiple settings or target populations were included in counts for all relevant categories.

Results

We identified $N=1{,}739$ determinants from the 186 articles included in the review (Supplemental File 4) [59–239]. Determinants were most frequently identified in the years 2011, 2015, and 2018 (Fig. 2). The ratio of barriers to facilitators was nearly even ($N=817$ and $N=801$, respectively). More determinants were identified of HIV testing ($N=1511$, 86.9%) than LTC ($N=276$, 15.9%; Table 1), with $N=50$ (2.9%) determinants of both testing and LTC. Regarding type of test, most examined rapid testing ($N=787$; 45.2%), followed by reflexive testing ($N=335$; 19.3%), confirmatory testing ($N=92$; 5.3%), and other types of testing (e.g., home testing; $N=114$; 6.6%).

Slightly more determinants were identified using quantitative methods ($N=891$; 53.5%) than qualitative methods ($N=758$; 45.5%), with a small proportion identified with mixed methods ($N=18$; 1.1%). LTC determinants were primarily focused on standard rather than rapid linkage (13.5% and 2.4% of all determinants respectively). Most determinants were identified from observational study designs ($N=1205$; 69.3%; e.g., interviews, focus groups, and surveys only identifying determinants), followed by within-site designs ($N=473$; 27.2%; e.g., interrupted time-series), between-site designs ($N=26$; 1.5%; e.g., "head-to-head" comparisons of two strategies between two sites), within- and between-site designs ($N=23$; 1.3%; e.g., stepped-wedge trials), and simulation studies ($N=12$; 0.69%).

Regarding regional breakdowns, most determinants were identified from studies conducted in the Northeast

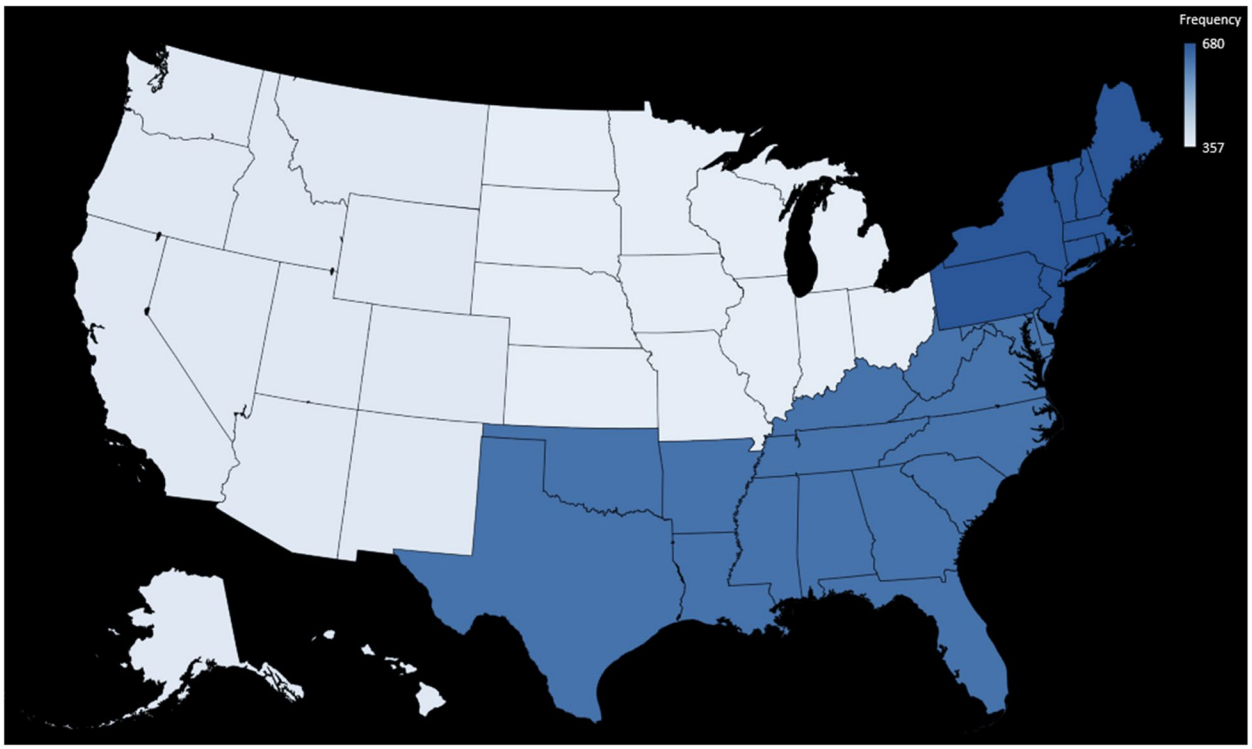

Fig. 2 Heat map of determinants identified by region of the U.S

Table 1 Proportion of determinants by innovation, study design, unit of analysis, and delivery setting[a]

	Proportion of determinants (n)
Innovation	
Testing	**86.9% (1511)**
–Reflexive testing	19.26% (335)
–Rapid testing	45.23% (786)
–Confirmatory testing	5.29% (92)
–Home testing	1.15% (20)
–Other	5.41% (94)
Linkage	**15.87% (276)**
–Standard linkage	13.45% (234)
–Rapid linkage	2.42% (42)
Unit of analysis	
Patients	50.89% (885)
Providers	55.26% (961)
Higher-Level (Policy)	14.2% (247)
Delivery setting	
Bathhouse	1.61% (28)
Community based organization	14.38% (250)
Church	2.36% (41)
Community health center	17.31% (301)
Dental clinic	2.07% (36)
Emergency department	26.8% (466)
Health department	7.02% (122)
Hospital system	32.66% (568)
Labor unit / OBGYN	9.78% (17)
Non-specialized private clinic	23.86% (415)
Other (e.g., mental health clinics, churches, universities, tuberculosis clinics)	13.17% (229)
Pharmacy	2.13% (37)
Prison/Jail	1.84% (32)
Specialized HIV clinic	10.12% (176)
Substance use treatment facility	4.95% (86)
Veterans affairs (VA) sites	3.11% (54)

[a] Numbers are not mutually exclusive

(*N*=680; 39.1%) and the South (*N*=628; 36.1%), with the fewest identified in the nation of Puerto Rico (*N*=8; 0.5%; Fig. 3). Most were determinants at the provider level (*N*=961; 55.3%), with *N*=885 determinants at the patient level (50.9%), and *N*=247 at a higher-level (e.g., at the organizational or society level; 14.2%).

CFIR constructs and domains

Table 2 presents the proportion of implementation determinants and innovation determinants by CFIR construct and domain. Most determinants were implementation determinants (*N*=1,100; 63.3%). Regarding domain, the most studied implementation determinants were within the *inner setting* (*N*=427; 38.8%), followed by *individuals* (*N*=275; 25%), *outer setting* (*N*=167; 15.2%), *process* (*N*=152; 13.8%), and *innovation* (*N*=79; 7.2%). Among all implementation determinants, the most frequent constructs were *structural characteristics of organizations* (*N*=102; 9.3%), *characteristics of innovation recipients not associated with behavior* (e.g., race, gender; *N*=72; 6.6%), *motivation of innovation deliverers* and *motivation of innovation recipients (N*=48 each; 4.5%*); work infrastructure* (*N*=48; 4.4%), and *staffing* (*N*=49; 4.5%). Nearly all innovation determinants were within the *individuals* domain (*N*=602; 94.2%), and among these, the most frequent constructs for were *characteristics of innovation recipients not associated with behavior* (*N*=308; 48.2%), and *motivation of innovation recipients* (*N*=182; 28.5%).

CFIR domain by HIV innovation (i.e., HIV testing or LTC)

In studies examining HIV testing, nearly half of determinants were identified within the *individuals* domain (*N*=786; 52%; examples of determinants included in Table 2). The fewest testing determinants were identified within the *innovations* domain (*N*=76; 5%). Studies of LTC mirrored the same pattern—characteristics of *individuals* accounted for 36.4% of identified determinants (*N*=101), while characteristics of *innovations* accounted for just 4.6% *(N*=13; see Table 3).

CFIR domain by study method

Quantitative methods were most frequently used to identify determinants within the *individuals* domain (*N*=636; 36.57%) and the *inner setting* (*N*=182; 10.47%). Quantitative methods were least frequently used to identify determinants within the *innovations* domain (*N*=35; 2%) and *process* domain (*N*=20; 1.2%). Quantitative methods included analysis of administrative data and documents (*N*=100; 5.8% of all determinants), electronic health record data (*N*=465; 26.7%), survey data (*N*=741; 42.6%), and surveillance data (*N*=166; 9.6%), as well as simulation studies (*N*=12; 0.5%). Qualitative methods were most frequently used to identify determinants within the *inner setting* (*N*=241; 13.86%) and *individuals* (*N*=240; 13.8%) domains. Qualitative methods were least frequently used to identify determinants within the *outer setting* domain (*N*=104; 6%) and *innovations* domain (*N*=52; 3.2%). Qualitative methods included analysis of focus group data (*N*=139; 8% of all determinants), interview data (*N*=813; 46.8%), and observational data (*N*=83; 4.8%).

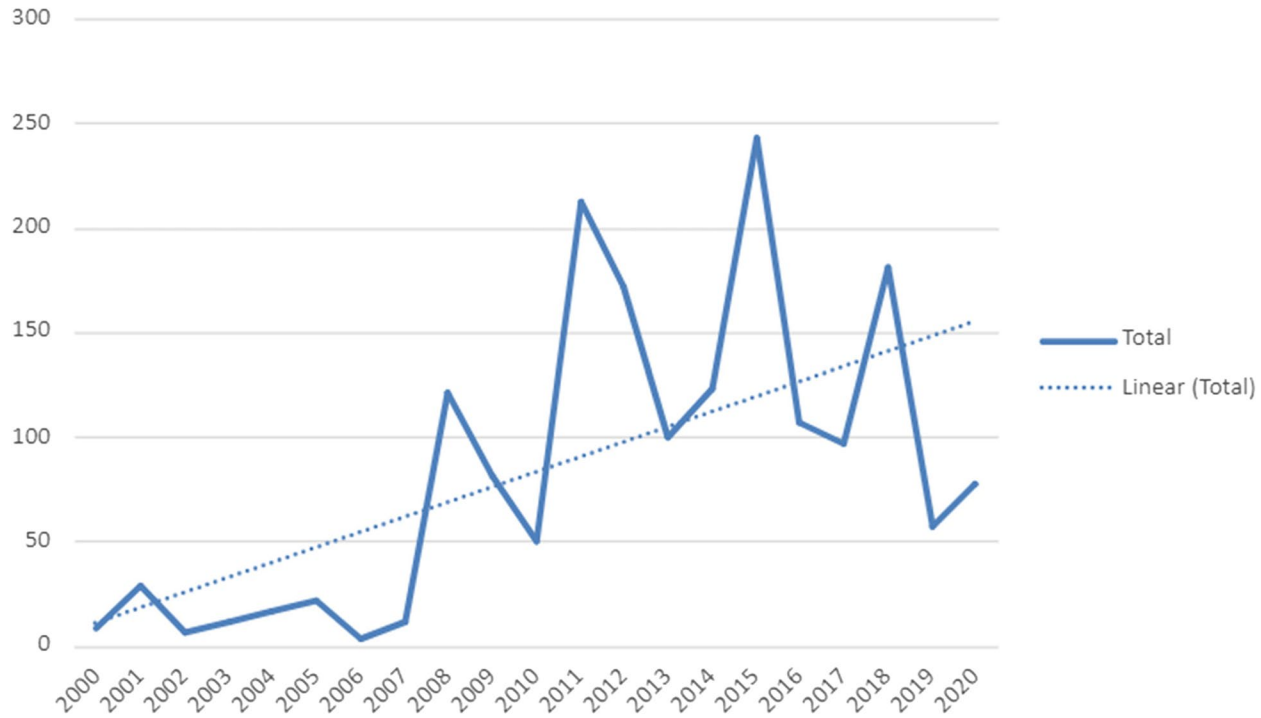

Fig. 3 Frequency of determinants by publication year

Delivery settings

Most frequently, studies were conducted in hospital systems ($N=568$; 32.7%), followed by emergency departments ($N=466$; 26.8%), non-specialized clinics (e.g., primary care; $N=415$; 23.9%), community health centers ($N=301$; 17.3%), and community-based organizations ($N=250$; 14.4%; Table 1). Few were conducted in jails/prisons ($N=32$; 1.8%), bathhouses ($N=28$; 1.6%), dental clinics ($N=36$; 2.1%), pharmacies ($N=37$; 2.1%), or churches ($N=41$; 2.4%). Determinants identified in studies conducted in bathhouses, jails/prisons, via online survey or nationally conducted surveillance, or another location (e.g., churches, tuberculosis clinics) more frequently focused on innovation recipients. Studies conducted in dental clinics, substance use treatment facilities, emergency departments, community-based organizations, and labor units of a hospital were more frequently focused on innovation deliverers. Determinants of higher-level units of analysis (e.g., policy, organizations) were more frequently identified in health departments, community-based organizations, hospital systems, and community health centers.

Implementation outcomes

Determinants were frequently identified in studies assessing more than one implementation outcome; thus, counts and proportions are not mutually exclusive (Table 4). Most determinants were identified in papers assessing penetration ($N=617$; 38.4%), followed by acceptability ($N=391$; 24.3%). Fewest were identified in papers assessing adoption ($N=127$; 7.9%), cost ($N=77$; 4.8%), and sustainability ($N=21$; 1.3%). A small percentage of determinants (7.5%) were identified in papers that assessed knowledge, awareness, stigma, and discontinuation, rather than implementation outcomes, as defined by Proctor et al. [240].

Priority populations

Most papers did not address determinants for CDC priority populations at large ($N=70$; 37%). Only $N=12$ determinants were identified across all studies for transgender populations (0.7% of all determinants; Table 5). In comparison, $N=195$ were identified for cisgender gay, bisexual, and other MSM (GBMSM) (11.2% of all determinants). Most determinants within priority populations were related to testing (between 59.9% and 92.4% of each population's total determinants).

Quantitative methods identified most determinants among all populations but were most used for Latine populations ($N=65$; 86.7% of all Latine determinants) and least commonly used for adolescents ($N=91$; 50.6% of all adolescent determinants). Qualitative methods were most used to identify determinants among

Table 2 Proportion of implementation and innovation determinants identified by CFIR construct and domain

	Construct	Proportion of implementation determinants (n)	Example determinant[a]	Proportion of innovation determinants	Example determinant
Innovations	Innovation Source	0.00% (0)	-	0.00% (0)	-
	Innovation Evidence-Base	0.55% (6)	Lack of definitive evidence for efficacy of particular forms of screening	0.00% (0)	-
	Innovation Relative Advantage	0.91% (10)	Rapid testing as quicker and easier to perform	0.78% (5)	Preference for oral swabs over traditional blood draws
	Innovation Adaptability	0.18% (2)	-	0.00% (0)	-
	Innovation Trialability	0.00% (0)	-	0.00% (0)	-
	Innovation Complexity	1.18% (13)	Rapid testing viewed as easier to implement due to lack of complexity	0.00% (0)	-
	Innovation Design	0.73% (8)	Provider preference for rapid testing	0.31% (2)	-
	Innovation Cost	2.82% (31)	Rapid testing as cost saving	0.78% (5)	Patient concerns over cost of test
	Other Innovation Characteristic	0.82% (9)	Provider stated importance of same-day linkage to care	0.47% (3)	-
	Total	**7.18% (79)**	**-**	**2.35% (15)**	**-**
Outer setting	Critical Incidents	0.00% (0)	-	0.00% (0)	-
	Local Attitudes	2.18% (24)	Providers perceived their colleagues as fearful of HIV stigma deterring patients from their practice	0.47 (3)	-
	Local Conditions	3.55% (39)	No existing list of HIV primary care providers in a region as a barrier to linkage	1.72% (11)	Living in a rural area associated with increased fear of test results
	Partnerships & Connections	1.45% (16)	Lack of consistent contact person in medical care site as barrier to linkage	0.00% (0)	-
	Policies & Laws	4.27% (47)	HIPAA regulations as a barrier to confirming patient attendance post-linkage	0.31% (2)	-
	Financing	2.63% (29)	Increase in CDC HIV prevention funds as a facilitator for HIV testing	0.16% (1)	-
	External Pressure	0.00% (0)	-	0.00% (0)	-
	Societal Pressure	0.09% (1)	-	0.31% (2)	-
	Market Pressure	0.8% (2)	-	0.00% (0)	
	Performance-Measurement Pressure	0.8% (2)	-	0.00% (0)	-
	Systemic/Structural Oppression	0.64% (7)	Toxic stress, health illiteracy, and misinformation as barriers to linking racially minoritized recipients and MSM	0.47% (3)	-
	Total	**15.18% (167)**	**-**	**3.44% (22)**	**-**

Table 2 (continued)

	Construct	Proportion of implementation determinants (n)	Example determinant[a]	Proportion of innovation determinants	Example determinant
Inner setting	Structural Characteristics	9.27% (102)	Teaching hospital Emergency Departments as more likely to offer routine HIV testing that non-teaching hospitals	–	-
	Physical Infrastructure	0.52% (9)	Concerns over space to implement testing in non-HIV specialty clinics	–	-
	Information Technology Infrastructure	1.82% (20)	Use of routine HIV testing electronic clinical reminders as a facilitator	–	-
	Work Infrastructure	4.36% (48)	Need to streamline process of obtaining informed consent and conducting pre- and post-test counseling	–	-
	Relational Connections	1.55% (17)	Co-locating testing and HIV care as a facilitator	–	-
	Communications	0.91% (10)	Difficulties in communicating across agencies or with providers with busy schedules made linkage difficult	–	-
	Culture	0.27% (3)	-	–	-
	Equity-Centeredness	1.00% (11)	Integrating testing into Black churches as a site of empowerment and community-connection	–	-
	Recipient-Centeredness	1.82% (20)	Clinic schedules (e.g., 9am-5 pm) do not always match recipients' needs	–	-
	Deliverer-Centeredness	0.09% (1)	-	–	-
	Learning-Centeredness	0.09% (1)	-	–	-
	Tension for Change	0.45% (5)	Resistance to changing existing process and protocols	–	-
	Compatibility	3.36% (37)	Pre- and post-test counseling perceived as incompatible with workflow in non-HIV specialty clinics	–	-
	Relative Priority	1.09% (12)	Testing for HIV perceived as a lower priority by nurses and staff in emergency departments	–	-
	Incentive Systems	0.27% (3)	-	–	-
	Mission Alignment	0.91% (10)	Perception that HIV testing does not align with mission of emergency department	–	-
	Available Resources	2.00% (22)	Time constraints as a frequently mentioned barrier by nurses and staff to conduct testing	–	-

Table 2 (continued)

	Construct	Proportion of implementation determinants (n)	Example determinant[a]	Proportion of innovation determinants	Example determinant
	Funding	1.45% (16)	Need for funding to support testing and linkage to care	–	-
	Space	0.91% (10)	Limited space to provide confidential testing and counseling as a barrier	–	-
	Materials & Equipment	0.8% (2)	-	–	-
	Staffing	4.45% (49)	Shortage of providers in clinics may lead to long wait times (e.g., multiple weeks)	–	-
	Access to Knowledge & Information	1.73% (19)	Formalized and ongoing training as a facilitator for increasing HIV testing	–	-
	Total	**38.82% (427)**	**-**	**–**	**-**
Individuals	High-Level Leaders	–	-	–	-
	–Capability	0.00% (0)	-	0.00% (0)	-
	–Opportunity	0.00% (0)	-	0.00% (0)	-
	–Motivation	0.45% (5)	27% of emergency department directors in one study believed preventive services should not be offered in emergency departments	0.00% (0)	-
	–Characteristics Not Associated with Behavior	0.00% (0)	-	0.00% (0)	-
	Mid-Level Leaders	–	-	–	-
	–Capability	0.00% (0)	-	0.00% (0)	-
	–Opportunity	0.00% (0)	-	0.00% (0)	-
	–Motivation	0.09% (1)	-	0.00% (0)	-
	–Characteristics Not Associated with Behavior	0.00% (0)	-	0.00% (0)	-
	Opinion Leaders	–	-	–	-
	–Capability	0.00% (0)	-	0.00% (0)	-
	–Opportunity	0.00% (0)	-	0.00% (0)	-
	–Motivation	0.8% (2)	-	0.00% (0)	-
	–Characteristics Not Associated with Behavior	0.09% (1)	-	0.00% (0)	-
	Implementation Facilitators	–	-	–	-
	–Capability	0.00% (0)	-	0.00% (0)	-
	–Opportunity	0.00% (0)	-	0.00% (0)	-
	–Motivation	0.00% (0)	-	0.00% (0)	-

Table 2 (continued)

Construct	Proportion of implementation determinants (n)	Example determinant[a]	Proportion of innovation determinants	Example determinant
–Characteristics Not Associated with Behavior	0.00% (0)	-	0.00% (0)	-
Implementation Leads	–	-	–	-
–Capability	0.00% (0)	-	0.00% (0)	-
–Opportunity	0.00% (0)	-	0.00% (0)	-
–Motivation	0.00% (0)	-	0.00% (0)	-
–Characteristics Not Associated with Behavior	0.00% (0)	-	0.00% (0)	-
Implementation Team Members	–	-	–	-
–Capability	0.00% (0)	-	0.00% (0)	-
–Opportunity	0.00% (0)	-	0.00% (0)	-
–Motivation	0.00% (0)	-	0.00% (0)	-
–Characteristics Not Associated with Behavior	0.00% (0)	-	0.00% (0)	-
Other Implementation Support	–	-	–	-
–Capability	0.09% (1)	-	0.00% (0)	-
–Opportunity	0.00% (0)	-	0.31% (2)	-
–Motivation	0.09% (1)	-	0.16% (1)	-
–Characteristics Not Associated with Behavior	0.00% (0)	-	0.31% (2)	-
Innovation Deliverers	–	-	–	-
–Capability	3.64% (40)	Having a good understanding of appropriate opt-out language	0.47% (3)	-
–Opportunity	1.36% (15)	Lack of time to spend encouraging patients to test	0.47% (3)	-
–Motivation	4.09% (45)	Belief that patient population is at high risk for HIV served as a motivator	0.31% (2)	-
–Characteristics Not Associated with Behavior	1.27% (14)	Female residents as more willing to offer testing than male residents in one study	0.00% (0)	-
Innovation Recipients	–	-	–	-
–Capability	0.73% (8)	Concerns that populations from different countries would have difficulty accessing and understanding HIV counseling and testing	5.01% (32)	Lack of knowledge about HIV or need for HIV testing as a barrier to testing
–Opportunity	2.18% (24)	HIV stigma as a barrier to testing	10.49% (67)	Fears of being judged for testing

Table 2 (continued)

	Construct	Proportion of implementation determinants (n)	Example determinant[a]	Proportion of innovation determinants	Example determinant
	–Motivation	4.18% (46)	Perception that Black MSM do not want to access testing or know their HIV status	28.48% (182)	Lack of perceived risk as a barrier
	–Characteristics Not Associated with Behavior	6.55% (72)	Difficulty linking immigrants and undocumented workers due to fears of losing their visas or deportation	48.20% (308)	HIV testing more frequent as age increases
	Total	**25.00% (275)**	**-**	**94.21% (602)**	**-**
Process	Teaming	8.18% (9)	Nurses in one clinic came together to develop strategies in response to barriers they noticed in their clinics	–	-
	Assessing Needs	–	-	–	-
	–Of Innovation Deliverers	0.8% (2)	-	–	-
	–Of Innovation Recipients	0.8% (2)	-	–	-
	Assessing Context	1.00% (11)	Stated importance of assessing context from the ground level up instead of decisions being made off top-down assessments	–	-
	Planning	0.27% (3)	-	–	-
	Tailoring Strategies	1.36% (15)	Shifting to targeted testing of priority populations	–	-
	Engaging	–	-	–	-
	–Innovation Deliverers	2.36% (26)	Provider-level coaching about HIV testing as a facilitator	–	-
	–Innovation Recipients	2.73% (30)	Providing system navigators, case managers, or peer navigators for recipients to aid in linkage to care	–	-
	Doing	1.73% (7)	Pharmacists desired staggered implementation, beginning in communities with higher HIV prevalence and slowly implementing in more clinics	–	-
	Reflecting & Evaluating	–	-	–	-
	–Implementation	0.64% (22)	Identifying performance metrics, instituting monitoring, and implementing quality improvement activities	–	-
	–Innovation	0.27% (3)	-	–	-
	Adapting	2.00% (22)	Integrating HIV testing into other health initiatives at Black churches to increase reach	–	-
	Total	**13.82% (152)**	**-**	**–**	**-**

[a] Examples provided for constructs with 5 more identified determinants

cisgender GBMSM, adolescents, and transgender populations (46.2%, 43.3%, and 41.7%, respectively).

Innovation determinants were most common across all priority populations, *except* for cisgender GBMSM. Among cisgender GBMSM, implementation determinants included just more than half of all identified determinants ($N=103$; 52.8%). Aside from cisgender GBMSM, implementation determinants were most identified among Black/African American and transgender populations (47.8% and 41.7% respectively). Implementation determinants were least identified among Latine populations ($N=23$; 30.7%). Innovation determinants were most identified among Latine populations, cisgender women, and adolescents (69.3%, 64.2%, and 62.1%, respectively). Innovation determinants were least identified among cisgender GBMSM ($N=92$; 47.2%).

Table 3 Proportion of determinants by CFIR Domain and HIV innovation ($n=1609$)

CFIR domain	Proportion of determinants of testing	Proportion of determinants of linkage-to-care
Characteristics of innovations	5.01% (77)	4.61% (20)
Outer setting	10.34% (159)	15.67% (68)
Inner setting	25.03% (385)	26.50% (115)
Characteristics of individuals	52.02% (800)	36.41% (158)
Process	7.61% (117)	16.82% (73)
Total	**100% (1655)**	**100% (434)**

Discussion

There has been a wealth of research identifying determinants of HIV testing, particularly rapid testing, with much less attending to LTC (especially rapid linkage). We have aimed to detail the scope and scale of research within the field. In doing so, we have noted the breadth of research identifying innovation and implementation determinants in the domains of the inner setting and individuals. To maximize the value of IS to HIV researchers and practitioners, additional research is needed identifying determinants in the outer setting and of innovations. Further, future research should move beyond simply identifying determinants of HIV testing and LTC, aiming instead to identify determinants to target in collaboration with the piloting and trialing of implementation strategies.

Our review also highlights several determinants for future researchers to target in their selection and development of implementation strategies. Within the inner setting, which accounted for nearly 39% of all identified determinants, this includes a lack of funding, staffing, training, and physical capacity for providers to carry out HIV testing in new environments (e.g., emergency departments, dental settings, hospital labor units). Limited staffing, training, unclear referral processes, and limited capacity also impede linkage-to-care across clinics (i.e., when a patient is tested in one location but must receive care elsewhere). Providers must also be trained to navigate patient fear, mistrust, and stigma. More attention should also be paid to process determinants, which often include facilitators of implementation. Within this review, those include training and education for both providers and patients, strengthening cross-agency relationships, tailoring approaches to specific populations, and the use of quality improvement initiatives to scale up and enhance current implementation.

Compared to another systematic review of determinants of HIV pre-exposure prophylaxis (PrEP) conducted by our team [50], implementation researchers have identified more implementation determinants of HIV testing and LTC whereas researchers have identified a greater number of innovation determinants of PrEP. In part, this may be due to the longer use of HIV testing and LTC whereas PrEP only received FDA approval in 2012.

Research identifying determinants of HIV testing and LTC has largely neglected CDC priority populations. Only 12 determinants were identified from projects that included transgender populations, for example. This is despite surveillance data identifying 42.2% of transgender women in seven major U.S. cities as living with HIV [241] and separate research finding transgender women are linked to HIV care at rates lower than cisgender populations [242]. Only 4.31% of all identified determinants were of Latine populations, despite vast disparities in HIV transmission rates, testing, and LTC [243–245]. In comparison, a greater number of determinants of HIV testing and LTC have been identified for Black populations (10.4%), yet that number remains low considering the disparities in HIV incidence, testing and LTC for Black populations, as well [246, 247]. The greater focus on implementation determinants, as opposed to innovation determinants, of testing and LTC may partially explain the lesser attention to CDC-designated priority populations. Although implementation researchers focus on providers, organizations, and systems-level determinants and implementation strategies (i.e., methods, processes, policies, interventions, and organizational changes to overcome barriers to implementation), it is still necessary to better incorporate a health equity approach into implementation

Table 4 Proportion of determinants by CFIR domain and implementation outcome assessed by manuscript author(s) ($n = 1609$)[a]

CFIR domain	Accept-ability	Appropriate-ness	Feasibility	Adoption	Penetration	Cost	Sustainability
Innovations	1.80% (29)	1.18% (19)	1.45% (12)	0.37% (6)	1.99% (32)	1.18% (19)	0.06% (1)
Outer setting	1.50% (24)	1.33% (11)	0.68% (8)	0.19% (3)	3.29% (53)	0.56% (9)	0.06% (1)
Inner setting	7.09% (114)	7.86% (64)	3.12% (50)	1.86% (30)	1.12% (18)	1.24% (20)	0.50% (8)
Individuals	9.94% (160)	8.71% (71)	4.35% (70)	4.79% (77)	19.95% (321)	1.43% (23)	0.56% (9)
Process	3.98% (64)	4.47% (38)	2.05% (33)	0.68% (11)	3.92% (63)	0.37% (6)	0.12% (2)
Total	**24.31% (391)**	**12.62% (203)**	**10.75% (173)**	**7.89% (127)**	**38.35% (617)**	**4.79% (77)**	**1.31% (21)**

[a] $n = 130$ determinants were not associated with an implementation outcome. Counts and proportions are not mutually exclusive

research, which requires identifying barriers and facilitators to implementation within priority populations [56, 248, 249].

Additionally, most determinants were associated with antecedent or pre-implementation outcomes (e.g., acceptability) rather than sustainability, adoption, and cost. Study of (ongoing) implementation determinants is needed, as is further research identifying structural and system-level barriers. Further, it is often the case that the same concept As Damschroder et al. have detailed, many determinants are correlated with implementation outcomes [52, 250]. Finally, identification of determinants beyond emergency departments, hospital systems, and clinics is needed, such as more unique settings (e.g., bathhouses), as well as co-located delivery settings (e.g., pharmacies, dental clinics), will continue to play a key role in HIV testing, LTC, and treatment in the U.S. [59–61].

Although separate innovations, HIV testing and LTC are critically intertwined. HIV testing provides the entry point to linkage to either PrEP for those with nonreactive test results or ART for those with reactive test results. This interconnection of the two innovations results in some shared determinants, such as availability of space, materials, and funding within the inner setting [62, 251], and patient opportunity due to HIV stigma [63, 252]. However, there are differences that emerge in determinants across the two innovations, particularly within the outer setting. Due to the lack of a clinic within all HIV testing sites or a lack of protocol for linkage from one department to another within a larger hospital or clinical system, local conditions (e.g., transportation) and partnerships and connections across clinics play a pivotal role in the ability for patients to be linked from one site to another [64]. Additional attention to outer setting determinants for LTC is thus needed, as only 15% of determinants in this review were identified in the outer setting.

This review not only contributes to literature in IS and HIV but also has implications for implementation practitioners, providers, and clinicians directly working with systems supporting populations at highest risk of HIV. For providers, understanding implementation determinants of HIV testing and LTC, particularly the perspectives of patients synthesized in this study, can catalyze modifications in their own practices to better serve their patients. Implementation practitioners are provided with a wealth of data, synthesized in line with a widely used determinant framework. Uncovering the determinants of HIV testing and LTC in this study may also provide new avenues for practitioners who may not have considered particular determinants across all socio-ecological levels. Indeed, practitioners will need to translate the findings here to be appropriate for their settings and connect these findings to implementation strategies to overcome identified barriers that also leverage facilitators.

The following limitations should be considered. First, this review only included English-language papers. As such, the limited number of papers focused on delivery settings in Puerto Rico, may have resulted, in part due to screening processes that excluded Spanish-language papers. Second, we only searched published, peer-reviewed manuscripts indexed in specific databases. Other studies, including those published in the gray literature, were excluded. Third, coding of innovation determinants was shaped by the current state of the field. Quantitative studies examining barriers and facilitators to HIV testing and linkage-to-care for patients often include demographic factors (e.g., race, ethnicity, gender) as independent variables (or potential causes of an outcome). For this reason, we coded such factors as "characteristics not associated with behavior." Ultimately, researchers should attend to the impact of structural oppression on clinical outcomes [65]. Finally, though we characterized the frequency with which determinants were identified in papers assessing particular implementation outcomes, we did not determine whether determinants were empirically associated with said outcomes.

Table 5 Proportion of determinants by CFIR domain, innovation, and method per priority population

CFIR domain	Adolescents (13–25)	Black/ African American	Cis women	Cis GBMSM[b]	Latino/a/e	Transgender individuals	People who inject drugs
Innovations	3.03% (4)	2.78% (5)	2.99% (4)	2.56% (5)	2.67% (2)	8.33% (1)	1.52% (1)
Outer setting	6.82% (9)	8.89% (16)	4.48% (6)	11.79% (23)	12.00% (9)	0% (0)	3.03% (2)
Inner setting	14.39% (19)	14.44% (26)	7.46% (17)	20.00% (39)	2.67% (2)	0% (0)	19.70% (13)
Individuals	68.93% (91)	63.89% (115)	76.87% (103)	57.43% (112)	82.67% (62)	91.67% (11)	66.67% (44)
Process	6.82% (9)	1.00% (18)	2.99% (4)	8.21% (16)	0% (0)	0% (0)	9.10% (6)
Total	**132**	**180**	**134**	**195**	**75**	**12**	**66**
Proportion of all determinants[a]	**7.59%**	**10.35%**	**7.71%**	**11.21%**	**4.31%**	**0.69%**	**3.80%**
Testing/ Diagnosis[c]	59.85% (79)	83.89% (151)	89.55% (120)	74.36% (145)	76.00% (57)	66.67% (8)	92.42% (61)
Linkage-to-Care	40.15% (53)	16.11% (29)	10.45% (14)	25.64% (50)	24.00% (18)	33.33% (4)	7.58% (5)
Implementation	37.88% (50)	47.78% (86)	35.82% (48)	52.82% (103)	30.67% (23)	41.67% (5)	39.39% (26)
Innovation	62.12% (82)	52.22% (94)	64.18% (86)	47.18% (92)	69.33% (52)	58.33% (7)	60.61% (40)

[a] Numbers are not mutually exclusive as studies sometimes focused on multiple CDC/EHE priority populations. These numbers also do not add up to 100% as a majority of studies did not attend to any CDC/EHE priority population

[b] Gay, bisexual, and other men who have sex with men

[c] Numbers by innovation are not mutually exclusive as studies also assessed linkage and testing

Conclusion

This review provides a necessary synthesis of determinants of HIV testing, diagnosis, and linkage-to-care using the most-cited IS framework, CFIR [66]. This synthesis enables the larger field of HIV science to utilize IS in efforts to end the HIV epidemic. Further, this synthesis positions IS to consider the application of IS frameworks to fields like HIV and highlights the glaring absence of HIV IS literature attending to determinants shaping implementation for Black, Latinx, transgender, and other marginalized communities. Adaptations to CFIR may be needed to reflect the unique conditions in HIV science. More research is also needed in the i*nnovation* and *outer setting* domains. Moreover, precise identification of determinants will aid in the identification and development of implementation strategies. Finally, the findings from this review will be added to an existing dashboard of HIV implementation science literature (hivimpsci.org) to assist researchers in identifying gaps in the literature and practitioners in identifying barriers and facilitators to implementation within their delivery settings, as well as research that has attempted to address those specific determinants.

Abbreviations

AIDS	Acquired Immunodeficiency Syndrome
ART	Antiretroviral therapy
CDC	Centers for Disease Control and Prevention
GBMSM	Gay, bisexual, and other men who have sex with men
HIV	Human Immunodeficiency Virus
IS	Implementation science
LTC	Linkage to care
MSM	Men who have sex with men
PEP	Post-exposure prophylaxis
PrEP	Pre-exposure prophylaxis
PWID	People who use injectable drugs

Supplementary Information

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Supplementary Material 1.

Supplementary Material 2.

Supplementary Material 3.

Supplementary Material 4.

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Author's contributions

Authors JLM, JDS, DHL, and CG developed the search words, and CG carried out the search. Authors az and JLM developed the codebook and led training and quality assurance on coding of determinants. Author az wrote the background, results, and discussion. Author JLM wrote the methods section. Authors AAFLNQ and JPZ contributed significantly to early drafts and revisions of the full manuscript. Authors az, JLM, AAFLNQ, JPZ, MM, JSD, and AMP contributed to coding of determinants. Authors az and JSD contributed to data analysis. All authors, including BM and NB, contributed to full text revisions.

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Availability of data and materials

All articles used for this review and the coding of these articles can be found at https://hivimpsci.northwestern.edu/dashboard/.

Declarations

Ethics approval and consent to participate

Not applicable.

Consent for publication
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Competing interests
The authors declare that they have no competing interests.

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