

Behavioral determinants and effectiveness of digital interventions for STI/HIV prevention: an overview of systematic reviews

Giuliano Duarte-Anselmi, Susana Sanduvete-Chaves, Salvador Chacón-Moscoso,
Daniel López-Arenas

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Table of Contents

Original Manuscript..... 5

Supplementary Files..... 34

 Multimedia Appendixes 35

 Multimedia Appendix 1..... 35



Behavioral determinants and effectiveness of digital interventions for STI/HIV prevention: an overview of systematic reviews

Giuliano Duarte-Anselmi^{1, 2*}; Susana Sanduvete-Chaves^{3*}; Salvador Chacón-Moscoso^{3, 4*}; Daniel López-Arenas^{3*}

¹ Facultad de Psicología Universitat de Barcelona Barcelona ES

² Facultad de Ciencias Médicas Universidad de Santiago de Chile Santiago CL

³ Universidad de Sevilla Sevilla ES

⁴ Universidad Autónoma de Chile Santiago CL

*these authors contributed equally

Corresponding Author:

Susana Sanduvete-Chaves

Universidad de Sevilla

Facultad de Psicología. Dpto. de Psicología Experimental.

Campus Ramón y Cajal. C/ Camilo José Cela, s/n

Sevilla

ES

Abstract

Background: Health risk behaviors are significant contributors to morbidity, premature mortality, and rising healthcare costs. Traditional interventions to change health behaviors often yield modest effects and have limited scalability. To enhance health outcomes, innovative approaches using smart technologies are being implemented to create personalized digital behavior change interventions. Unsafe sex, along with low physical activity, smoking, and alcohol consumption, is linked to over half of premature deaths. Daily, over 1 million people globally contract sexually transmitted infections (STIs), including HIV, result in high personal, social, and economic costs globally.

Objective: This overview aims to synthesize evidence on the effectiveness of digital behavior change interventions for preventing STIs/HIV, considering the possible influence of variables such as the intervention content or its application mode.

Methods: A literature search until August 31, 2024, was performed in four electronic databases for this Overview: Cochrane Database of Systematic Reviews (CDSR), MEDLINE via PubMed, Epistemonikos, and PsycINFO. No language restrictions were imposed. Data were included and extracted from all systematic reviews on digital behavior change interventions used in the prevention of sexually transmitted infections STIs/HIV, and that their use can prevent STIs and/or reduce risky sexual behavior. Two reviewers independently screened the identified articles and extracted data related to the study characteristics and behavior change techniques, mechanism of action and intervention types using standardized classifications whenever available. The AMSTAR-2 tool was used to evaluate the methodological quality of the included studies.

Results: 3,218 identified records, 19 systematic reviews met inclusion criteria, encompassing 428 primary studies and 117,010 participants. Most reviews focused on mobile-based interventions, text messaging (SMS), and web-based platforms. The most effective BCTs included Goal Setting, Feedback on Behavior, and Prompts/Cues, particularly in increasing STI/HIV testing and service uptake. However, evidence for sustained condom use and reductions in STI/HIV acquisition remained inconsistent. While high-income countries dominated the literature, significant gaps persist in low- and middle-income settings. Only three reviews explicitly reported using BCTs or TDF frameworks.

Conclusions: Digital interventions, particularly SMS and mobile applications, effectively promote HIV prevention behaviors, yet their impact on long-term adherence and biological outcomes remains uncertain. Future research should prioritize low-resource settings, explore AI-based interventions, and enhance the systematic application of BCTs to optimize effectiveness. Addressing gender-disaggregated data gaps and ensuring equitable intervention access will be essential for maximizing public health impact. Clinical Trial: Registered in PROSPERO (CRD42023485887) https://www.crd.york.ac.uk/prospero/display_record.php?RecordID=485887

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Original Manuscript

Behavioral Determinants and Effectiveness of Digital Interventions for STI/HIV Prevention: An Overview of Systematic Reviews

Abstract

Background:

Health risk behaviors are significant contributors to morbidity, premature mortality, and rising healthcare costs. Traditional interventions to modify health behaviors often yield modest effects and have limited scalability. To enhance health outcomes, innovative approaches using smart technologies are being implemented to create personalized digital behavior change interventions. Unsafe sex, along with physical inactivity, smoking, and drinking, is linked to over half of premature deaths. Across the globe, over one million people contract a sexually transmitted infection (STI) each day, including HIV, resulting in enormous personal, social, and economic costs.

Objective: This overview aims to synthesize evidence on the effectiveness of digital behavior change interventions for preventing STIs/HIV, considering the possible influence of variables such as the intervention content or its application method.

Methods: A literature search was performed in four electronic databases of all publications released up to August 31, 2024: the Cochrane Database of Systematic Reviews, MEDLINE, Epistemonikos, and PsycINFO. No language restrictions were imposed. Data were included and extracted from all systematic reviews on digital behavior change interventions used to prevent STIs/HIV and/or reduce risky sexual behavior. Two reviewers independently screened the identified articles and extracted data related to the study characteristics and behavior change techniques (BCTs), the mechanism of action, and the intervention characteristics, using standardized classifications whenever available. The AMSTAR-2 tool was used to evaluate the methodological quality of the included studies.

Results: The search yielded 3,218 records, with 19 systematic reviews encompassing 428 primary studies and 117,010 participants that met the inclusion criteria. Most reviews focused on mobile-based interventions, text messaging (SMS), and web-based platforms. The most effective BCTs included Goal Setting, Feedback on Behavior, and Prompts/Cues, particularly with the goal of increasing STI/HIV testing and service uptake. However, evidence for sustained condom use and reductions in STI/HIV acquisition remained inconsistent. While high-income countries were predominant in the literature, significant gaps persist in low- and middle-income settings. Only three reviews explicitly reported using BCTs or the theoretical domains framework.

Conclusions: Digital interventions, particularly SMS and mobile applications, effectively promote HIV prevention behaviors, yet their impact on long-term adherence and biological outcomes remains uncertain. Future research should prioritize healthcare settings with limited resources, explore AI-based interventions, and enhance the systematic application of BCTs to optimize effectiveness. Addressing gender-disaggregated data gaps and ensuring equitable intervention access will be essential for maximizing public health impact.

Trial registration: Registered in PROSPERO ([CRD42023485887](https://www.crd.york.ac.uk/PROSPERO/view/CRD42023485887))
<https://www.crd.york.ac.uk/PROSPERO/view/CRD42023485887>

Keywords: behavioral change, behavioral design, sexually transmitted diseases, HIV, digital

behavior change intervention

Introduction

Unsafe sexual practices, along with behaviors such as physical inactivity, smoking, and drinking, are major contributors to global morbidity and premature mortality, accounting for over half of such cases worldwide [1,2]. Among young people, these practices significantly increase the risk of sexually transmitted infections (STIs) including syphilis, gonorrhea, chlamydia, and HIV, as well as HPV-related cancers [3,4]. A recent report by the WHO highlights an alarming decrease in condom use among adolescents in Europe, leading to higher rates of unprotected sex and, consequently, an increased risk of STIs, particularly among adolescents from low-income families [5]. HIV/AIDS remains a leading cause of death globally, particularly in individuals aged 15 to 49, with over one million people contracting an STI daily and nearly 39 million people living with HIV [6,7].

Given the scale of these challenges, effective prevention strategies must emphasize sociocultural and behavioral changes, such as increasing awareness, reducing stigma, and promoting safe sex practices like consistent condom use and regular STD/HIV testing [8–10]. Widespread access to the Internet and mobile phones presents a unique opportunity to leverage digital interventions as private and effective methods for addressing sexual health, especially in regions with varying levels of literacy [10–12].

Digital behavior change interventions (DBCI), which provide tailored and interactive feedback, offer significant advantages over traditional methods. These interventions are scalable, cost-effective, and adaptive, allowing personalized delivery based on individual needs and leveraging technologies like passive sensing [13–15]. However, information alone is insufficient to drive behavior change: integrating behavior change techniques (BCTs) to these digital platforms is essential for achieving meaningful health outcomes [16,17].

Considering the quantity of systematic reviews that evaluate a range of digital interventions for STI/HIV prevention, an overview of these reviews allows for the synthesis and comparison of evidence from multiple systematic reviews rather than focusing on a single set of primary studies. This approach provides a broader understanding of the effectiveness of these interventions, identifying patterns, strengths, and gaps in the current knowledge. Additionally, by aggregating findings across several reviews, this overview can offer more robust and generalizable recommendations for future digital health interventions, thereby enhancing their practical application in diverse contexts [18,19].

Despite their potential, many digital health interventions lack detailed descriptions of the BCTs they employ, hindering replication and practical application [20,21]. Identifying the most effective BCTs, especially those that successfully promote safe sex and reduce STI/HIV transmission, is crucial for public health initiatives [22–25].

This overview aims to synthesize current evidence on the use of BCTs in digital interventions to prevent STI and HIV. By analyzing the implementation and specific impacts of these techniques, this research seeks to enhance the design of evidence-based digital interventions, ultimately contributing to more effective public health strategies.

Methods

Study Design

This study is an overview of systematic reviews and adheres to the Cochrane Handbook for Systematic Reviews of Interventions [19] and the PRIOR (Preferred Reporting Items for Overviews of Reviews) statement [26]. The PRIOR checklist is reported in Supplementary Material Appendix 1 and the Sex and Gender Equity in Research (SAGER) guidelines [27], in Supplementary Material Appendix 2.

Protocol and Registration

The protocol for this overview was prospectively registered in PROSPERO ([CRD42023485887](https://www.crd42023485887)) on December 5, 2023 (Supplementary Material Appendix 3), and published in our protocol [28]. The overview of systematic reviews followed this predefined protocol but also incorporated the SAGER guidelines. In drafting this overview, we adhered to the Cochrane Handbook for Systematic Reviews of Interventions and the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) guidelines [29]. The full protocol can be downloaded from the [Open Science Framework](#) (OSF) [30,31].

Patient and Public Involvement

Neither patients nor the public were involved in designing or conducting this study. Therefore, no ethical approval was required for this overview. The analyzed data were open access.

Eligibility Criteria

The eligibility criteria were reported in detail in our protocol [28]. The inclusion criteria for this overview were based on the PICOS (population, intervention, comparison, outcome, study type) framework (Table 1):

Table 1. Eligibility criteria for elements of a comprehensive search strategy.

Element	Inclusion and exclusion criteria
Population	Included: Systematic reviews that have evaluated the effect of digital behavior change interventions in any population and that have described behavior change techniques, mechanisms of action, or any behavioral model or framework that takes into account how the digital intervention influences the behavior change used to reduce the risk or prevent the transmission of sexually transmitted infections, including HIV. Excluded: Studies that did not focus on prevention or that focused on treatment and adherence to antiretroviral therapy (ART) and self-care of people living with HIV were excluded, as the focus of the question research is risk reduction and prevention of STIs/HIV.
Intervention	Included: Systematic reviews that evaluated digital and mobile health behavior change interventions focusing on modifying unsafe sexual behaviors or preventing sexually transmitted infections/HIV, i.e. interventions carried out using a digital or mobile platform as a direct interface with the participants. Excluded: Studies that did not report the use of digital intervention, i.e., did not incorporate digital technology such as smartphones, computers, tablets, multimedia, and social networks.
Comparator	As this was an overview of systematic reviews, a comparator or control group was not an inclusion criterion for this study. However, given our interest in effectiveness of interventions and BCTs, we included reviews where evidence from primary

	experimental studies with an appropriate comparator was available
Outcome	Included: During the selection process, we do not consider concrete results as an inclusion criterion. All studies that assessed short- or long-term behavior change concerning the following primary outcomes were included: reduction in risky sexual behaviors, such as condom use (last sexual encounter, frequency, consistency) and increased STI testing; and prevention (vaccination against HPV and hepatitis A and B, and HIV pre-exposure prophylaxis). As secondary outcomes, the use of behavior change theories or techniques was analyzed, using standardized classifications if available, such as the taxonomy of behavior change techniques. Excluded: any study that did not include a primary and/or secondary outcome.
Study design	Included: systematic reviews only* Excluded: Studies other than systematic reviews (for example, primary studies, commentary articles, and conferences) were excluded.

Note: *All systematic reviews (SRs) were included, operationally defined as any secondary research that included only primary clinical studies, with an explicit search strategy in at least two databases [19,32].

Information Sources

In this overview, a comprehensive search strategy was employed, leveraging multiple key sources. Primary searches were conducted on the leading international databases MEDLINE (via PubMed), the Cochrane Database of Systematic Reviews (CDSR), Epistemonikos, and PsycINFO. To enhance the scope of our search, we conducted supplementary searches to identify any studies potentially overlooked by the primary search strategy or absent from the indexed databases. These supplementary efforts included:

- meticulous manual reviews of the references cited in the included studies.
- examination of related systematic reviews that shared at least one study with the reviews included in our study.
- additional records identified through various websites (n = 7), organizations (n = 1), citation searching (n = 274), references provided by authors (n = 1), and consultations with experts (n = 28) (Figure 1).

Each source was rigorously scrutinized, with the date of the last search or consultation carefully documented to ensure the currency and relevance of the findings. Detailed methodologies and search strategies are available in Supplementary Material Appendix 4.

Search Strategy

The electronic search strategy (Supplementary Material Appendix 5-6) was developed and conducted under the supervision of an experienced librarian. The first author performed the electronic search from the databases' inception up to August 31, 2024, without any restrictions. Additionally, we manually searched the bibliographies of relevant reviews and the articles initially retrieved. Letters were also sent to authors and experts identified in the included and excluded studies during the screening stage, to identify additional eligible studies. The eligibility criteria are listed in Table 1.

Study Selection Process

Following deduplication and a pilot test of the inclusion and exclusion criteria, two independent reviewers screened all titles, abstracts, and full text articles for eligibility without knowledge of each other's decisions. Records from electronic and bibliographic searches were stored and full text screening was conducted using Collaboratron™ by Epistemonikos [33]. Differences between the two reviewers were resolved through discussion, and a third reviewer was consulted when necessary. The list of studies excluded after the full text review, along with reasons for exclusions, is detailed in

Supplementary Material Appendix 7.

We reached out to 28 authors (up to three email attempts) to request additional information, particularly on gray literature such as conference presentations and reports (see the list of experts in the Contacting Experts section of Supplementary Material Appendix 4).

The inter-rater reliability was assessed using Cohen's kappa coefficient [34]. Two independent reviewers evaluated the full texts (Supplementary Material Appendix 8).

Data Collection Process

We developed a data extraction tool in Microsoft Excel to obtain various study data recommended by Cochrane [35,36]. The data extracted from the systematic reviews selected for the study was tested and calibrated by the team (Supplementary Material Appendix 9). For this purpose, one author created the spreadsheet and then extracted the data from one systematic review. Subsequently, two authors independently extracted data from three systematic reviews, and all authors provided feedback on whether the data elements were complete and the extracted data were unambiguous. Once a consensus was reached through discussion, one author created a data extraction manual for the spreadsheet, which can be found in Supplementary Material Appendix 10.

Data Items

Data items included systematic review characteristics, PICOS criteria, and variables related to digital behavior change intervention (Textbox 1).

Textbox 1. Data items in this overview of systematic reviews.

Data items:

Bibliographic Information (author, year of publication, title, aim of the SR).

Population Characteristics:

participants (total number of participants included in the studies)

population age

specific population (men who have sex with men, LGTBIQ+ individuals, people with a diagnosis of STD without HIV, people with HIV)

Study Characteristics:

total number of studies included in the review

number of randomized controlled trials included

type of Studies (only RCTs, only non-RCTs -including experimental non-randomized and observational studies-, both RCTs and non-RCTs)

year of the most recent study included

period or specific date range of the literature search

country or geographic location of the studies

Intervention Details:

target population

target behavior

explicit mention or extraction of theoretical frameworks used.

behavioral outcomes (condom use, frequency of unprotected sexual intercourse, number of sexual partners, STD/HIV testing, uptake of medical male circumcision, HIV counseling, vaccination)

cognitive outcomes (self-efficacy, STD/HIV-related knowledge, attitudes towards condom use, pre-exposure prophylaxis awareness)

biological outcomes (HIV or STI acquisition)

Intervention Acceptability and Feasibility:

acceptability: participants' acceptance of the intervention

practicability: ease of implementation in the real world

effectiveness: achievement of the intervention objectives
affordability: cost-effectiveness of the intervention
spill-over effects: unintended consequences
equity: impact on health equity

Technology and Delivery Methods (mobile devices, desktop computers, digital billboards, wearable accessories, digital objects, projection/holograms)
mode of delivery of digital contents (audio calls/messages, video calls/messages, text/instant messages, emails, audio broadcasts/podcasts, websites/computer programs/apps, eBooks, virtual or augmented reality, artificial intelligence -e.g. use of AI-based chatbots to promote safe sex or other sexual behaviors)

Other Characteristics:

number of primary studies included and overlap, tools used to assess the risk of bias in primary studies, whether a meta-analysis was conducted, and certainty of evidence (GRADE)

Quality Appraisal of the Systematic Reviews

We performed critical appraisals of systematic reviews using AMSTAR-2 [37], as outlined in our published protocol [28]. AMSTAR-2 consists of 16 items that assess the thoroughness of various aspects of a systematic review, such as the preparation process, literature search, study selection, data extraction, and analysis, as well as potential biases (e.g., risk of bias, publication bias, or funding sources). Based on the type and number of weaknesses identified (i.e., unmet items), the reviews were assigned a confidence rating: high, moderate, low, or critically low.

Two authors independently assessed all systematic reviews using a spreadsheet (Microsoft Excel 2010) and reached consensus through discussion (Supplementary Material Appendix 11).

Overlap in Primary Studies Included in Reviews

To ensure the accuracy of the primary study outcome data and avoid overlap, we checked whether the included systematic reviews shared overlapping primary studies. This was done by creating a citation matrix and calculating the overall corrected covered area (CCA) using GROOVE (Graphical Representation of Overlap for Overviews) [38]. The GROOVE tool provides a method for interpreting the extent of overlap, where a CCA of 0% to 5% indicates a slight overlap, 6% to 10% a moderate overlap, 11% to 15% a high overlap, and greater than 15% a very high overlap in primary studies cited in multiple systematic reviews.

Data Synthesis Methods

A written description was done on the results of each systematic review on digital interventions for the prevention of sexually transmitted infections (STIs) and HIV, and a table detailed the characteristics and outcomes of each review. The extracted data were synthesized using a predefined and team-approved template, identifying common themes and mapping them according to the stated objectives (Supplementary Material Appendix 9).

Subgroup analyses were done to evaluate various factors, including the aim of the systematic review, the target population, behavioral outcomes, cognitive outcomes, biological outcomes, and the type of digital content and intervention. The mode of delivery (MoD) framework by Marques et al. (2021) [39] was used to categorize interventions into types such as text/instant messages, video calls/messages, websites/computer programs/apps, emails, video games, audio broadcasts/podcasts, e-books, and virtual or augmented reality.

The effectiveness of digital interventions for STI/HIV prevention was assessed based on systematic reviews that explicitly described the use of BCTs or the Theoretical Domains Framework (TDF).

Subsequently, the impact of BCTs on each specific outcome was analyzed following the approach of Michie et al. [40,41], allowing for the identification of the most effective techniques. Findings were synthesized into structured tables to visualize the impact of digital interventions across behavioral, cognitive, and biological domains.

Finally, a five-level classification system was applied: “▼” indicated strong evidence of a negative effect; “O,” mixed or null evidence; “O–” and “O+,” a negative or positive effect with limited evidence; and “▲,” strong evidence of a positive effect. This system aims to provide clear guidance on which BCTs are most effective in digital interventions for STI/HIV prevention. The BCTs were coded according to the Behavior Change Technique Taxonomy version 1 (BCTTv1) [21,42], in studies that reported interventions using TDF, while the original descriptions were retained for studies that explicitly reported BCTs. This methodological approach ensured that conclusions were systematic, evidence-based, and aligned with established behavior change frameworks.

The Sex and Gender Equity in Research (SAGER) [27] guidelines were utilized to ensure the consideration of sex and gender variables during the data extraction. These guidelines aim to prevent bias and improve the relevance and validity of findings by promoting the clear distinction between “sex” (biological differences) and “gender” (social and cultural factors), and its purpose is for these distinctions to be accurately reflected in study design, data analysis, and results reporting (Supplementary Material Appendix 2 and 12).

Results

From the 3,218 records identified (2,935 from electronic databases and 283 from bibliographic sources), 122 full-text articles were assessed for eligibility. Of these, 103 were excluded, leading to the inclusion of 19 systematic reviews in this overview [43–61] (Figure 1). The inter-rater reliability for full-text screening was robust (Kappa = 0.88). Additional studies were identified through supplementary methods, including website searches, citation searching, and expert consultations, ensuring a comprehensive review (Supplementary Material Appendix 4).

Figure 1. Flow diagram of study selection based on PRIOR (Preferred Reporting Items for Overviews of Reviews) guideline.

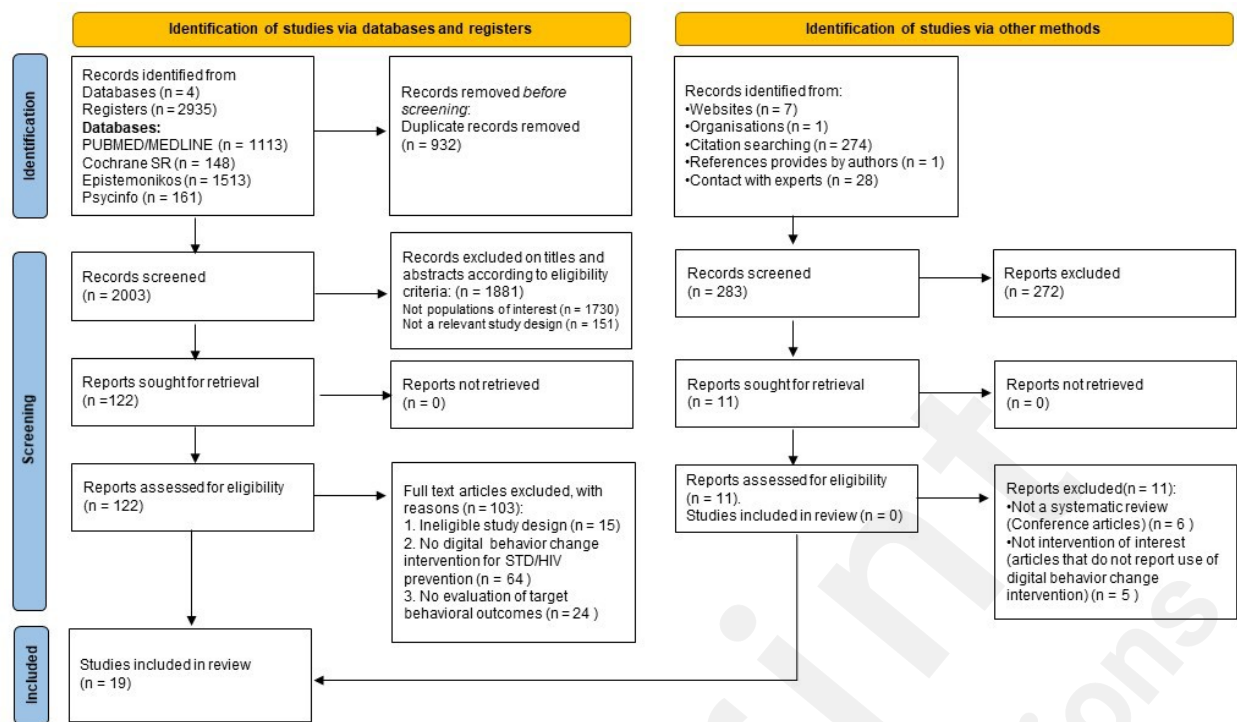


Figure 1. PRISMA 2020 flow diagram from Effectiveness of digital interventions for STI/HIV prevention: an overview of systematic reviews using Behavior Change Techniques

Characteristics of Systematic Reviews

The 19 systematic reviews included in the overview were published between 2014 and 2024, and covered 428 primary studies, including 335 randomized controlled trials (RCTs). Of these reviews, six focused exclusively on RCTs, two on non-RCTs, and 11 included both study types. These reviews encompassed 117,010 participants, with individual studies ranging from 4,669 to 27,704 participants. The targeted populations included adolescents (n = 12), youth (n = 17), adults (n = 14), men who have sex with men (MSM) (n = 12), LGBTQ+ individuals (n = 9), and people diagnosed with STDs other than HIV (n = 10) (Supplementary Material Appendix 13, 14a and 14b).

Most studies were conducted in high-income countries such as the United States and Portugal (n = 204), with a smaller number in upper-middle-income countries (n = 22) like Chile or lower-middle-income countries (n = 17) like China, South Africa, India, and Kenya. Income level here is based on the World Bank classifications [62] (Supplementary Material Appendix 13).

All data are reported, and the detailed characteristics of the individual systematic reviews are presented in Supplementary Material Appendix 13. The synthesis of study characteristics in all 19 systematic reviews is shown in Table 2.

Sex and Gender Equity in Research (SAGER) Application

The SAGER guidelines revealed that most studies did not include sex- or gender-disaggregated data, and significant gender differences were generally not reported. Only one study, Kamitani et al. (2024) [50], mentioned transgender participants, but without a detailed analysis (Supplementary Material Appendix 12)

Table 2. Main characteristics of Systematic Reviews (SRs).

Table 2. Characteristics of systematic reviews (n = 19**)	Results
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Systematic review design	Number of studies included	428*
	Participants (total)	117,010
	Range of years of the studies included	(2014-2024)
	Place (country -geographic location)	High-income countries (n = 204). Upper-middle-income countries (n = 22) Lower-middle-income countries (n = 17)
	Only RCT	6 (19**)
	Only non-RCT (includes non-randomized experimental and observational studies)	2 (19)
	RCT and non-RCT	11 (19)
	Total RCTs	335 (428*)
Population type	Adolescents (population age=or 10 to 19)	12 (19)
	Youth (20 to 29)	17 (19)
	Adults (>29)	14 (19)
	Men who have sex with men	12 (19)
	LGBTBIQ+ individuals	9 (19)
	People diagnosed with an STD (without HIV)	10 (19)
Intervention characteristics	Target of behavior (prevention of STI/HIV)	15 (19)
	Target behavior (safe sex)	14 (19)
	Target behavior (STI/HIV testing)	14 (19)
	Target behavior (treatment-related, i.e., attend the appointment or getting treatment for an STI)	10 (19)
	Environment: schools	9 (19)
	Environment: universities (where it was implemented)	3 (19)
	Environment: health centers (where it was implemented)	10 (19)
	Explicit framework of theoretical domains of behavior change from the studies included in the SR	10 (19)
	Description of behavior change techniques according to BCTTv1	2 (19)
Behavioral outcomes	Description according to Theoretical Domains Framework (TDF)	1 (19)
	Condom use (internal or external)	14 (19)
	Frequency in unprotected sexual intercourse	11 (19)
	Number of sexual partners	6 (19)
	STD/HIV testing	15 (19)
	Uptake of medical male circumcision	4 (19)
	HIV counseling	6 (19)
Cognitive outcomes (mediators of prevention)	Get vaccinated against (VPH- HEP A y B)	5 (19)
	Self-efficacy	12 (19)
	STD/HIV related knowledge	11 (19)
	Attitudes towards condom use	8 (19)
Biological outcomes	PrEP (pre-exposure prophylaxis) awareness	4 (19)
	HIV or STI acquisition	8 (19)
Technology delivered	Mobile device	19 (19)
	Desktop computer	11 (19)
	Digital billboard	0(19)
	Wearable (clothing/accessory)	0 (19)
	Digital object	0 (19)
	Projection/hologram	0 (19)

Digital content type	Audio call/message	10 (19)
	Video call/ message	14 (19)
	Text/instant message	18 (19)
	Email	9 (19)
	Video Game	6 (19)
	Audio broadcast/podcast	1 (19)
	Website/computer /program/app	18 (19)
	eBook	1 (19)
	Virtual or augmented reality	2 (19)
Other descriptions	Artificial intelligence–based chatbots for promoting safe sex or other sexual behaviors	0 (19)
Meta-analysis and certainty of evidence	Meta-analysis	7 (19)
	Certainty of Evidence (GRADE)	4 (19)
APEASE (Acceptability, Practicability, Effectiveness, Affordability, Spill- over effects, and Equity)	Acceptability	6 (19)
	Practicability	0 (19)
	Effectiveness	19 (19)
	Affordability	0 (19)
	Spill-over effects	0 (19)
	Equity	0 (19)

* Total number of primary studies included in the systematic reviews of this overview.

** Total number of systematic reviews included in this overview.

Characteristics of the Interventions

The digital interventions included in this review addressed STI/HIV prevention, diagnosis, and treatment, as well as the promotion of safe sexual behaviors. Most interventions focused on STI/HIV prevention (78.9%) and the promotion of safe sexual behaviors (73.7%), while a similar number targeted STI/HIV diagnosis (73.7%). Additionally, 10 interventions (52.6%) incorporated strategies to enhance treatment adherence, such as attending medical appointments or completing syphilis treatment (Table 2 and Supplementary Material Appendix 15a).

The research study settings varied, with health centers being the most common (52.6%), followed by schools (47.4%), while universities (15.8%) were the least frequent. Regarding the use of theoretical frameworks, 10 interventions (52.6%) applied a behavior change framework, yet only two interventions (10.5%) explicitly described techniques based on the Behavior Change Techniques Taxonomy version 1 (BCTTv1), and just one (5.3%) employed the TDF (Supplementary Material Appendix 15a).

In terms of behavioral outcomes, condom use was assessed in 14 studies (73.7%), while STI/HIV testing was reported in 15 studies (78.9%). Other relevant outcomes included the frequency of unprotected sexual intercourse (57.9%), the number of sexual partners (31.6%), and vaccination against HPV or hepatitis (26.3%). Finally, the most analyzed cognitive outcomes were self-efficacy (63.2%), STI/HIV-related knowledge (57.9%), and attitudes toward condom use (42.1%), whereas PrEP awareness was examined in only four studies (21.1%) (Supplementary Material Appendix 15b and 15c).

Modes of Delivery (MoD)

According to the MoD classification by Marques et al. [39], most interventions were delivered via mobile devices ($n = 19$) and desktop computers ($n = 11$), with text/instant messaging being the most common digital content type ($n = 18$). Other content types included video calls/messages ($n = 14$),

emails (n = 9), and video games (n = 6). Notably, no studies utilized emerging delivery methods such as digital billboards, wearable accessories, digital objects, or projection/holograms (Table 2; Supplementary Material Appendix 15d).

Theoretical Frameworks and Behavior Change Techniques (BCTs)

Of the 19 systematic reviews analyzed, 10 (53%) incorporated behavioral theories, with the IMB model (21.6%), health belief model, and social cognitive theory being the most common. However, nine studies (47%) lacked any theoretical framework, reflecting inconsistent application of behavior change science. Notably, only 3 of the 10 theory-based reviews explicitly reported the use of BCTs or TDF [43,45,46] (Table 3, Supplementary Material Appendix 15e).

Table 3. Overview of theory application, Behavior Change Techniques (BCT), and Theoretical Domains Framework (TDF) in interventions.

Author and year	Behavior change framework used	Framework/ Theory description (if was reported)	BCT description	TDF description
Bailey 2021	Yes	The included studies reported using personalized feedback based on user knowledge, motivation, and behavioral skills. Other interventions included interactive texts, virtual peer discussions, decision-making scenarios, and social support visualization.	Not reported	Yes
Berendes 2021	No	Not specified.	Not reported	Not reported
Burns 2016	Yes	Theory of Planned Behavior, Precaution Adoption Process Model, social cognitive theory, Information-Motivation-Behavioral Skills model of AIDS risk behavior change.	Yes	Not reported
Clarke 2022	Yes	Based on IMB model of adherence and social action theory.	Yes	Not reported
Conserve 2017	No	Not specified	Not reported	Not reported
Iliskens 2022	No	Not specified	Not reported	Not reported
Jones 2014	No	Not specified	Not reported	Not reported
Kamitani 2024	No	Not specified	Not reported	Not reported
Khuwaja 2022	No	Not specified	Not reported	Not reported
Knight 2017	Yes	Social cognitive theory, Health Belief Model, Integrated Behavioral Model, Information-Motivation-Behavioral Skills model.	Not reported	Not reported
Manby 2022	No	Not specified	Not reported	Not reported
Nguyen 2019	Yes	Information-Motivation-Behavioral Skills (IMB) model, social cognitive theory, Stages of Change, Health Belief Model, Sexual Health Model, social support theory.	Not reported	Not reported
Ou 2023	Yes	Information-Motivation-Behavioral Skills model, PRECEDE-PROCEED model, Health Belief Model, Theory of Planned Behavior, social cognitive theory, Theory of Reasoned Action.	Not reported	Not reported
Palmer 2020	Yes	Social support theory, Information-Motivation-Behavioral Skills model, social cognitive theory.	Not reported	Not reported
Saragih 2021	No	Telehealth interventions were based on self-efficacy theory and behavioral skills development.	Not reported	Not reported
Schnall 2014	Yes	Information-Motivation-Behavioral Skills (IMB) model, Health Belief Model, Stages of Change, social learning theory, social cognition and developmental theory, Sexual Health Model.	Not reported	Not reported
Sewak 2023	No	Not specified.	Not reported	Not reported

Veronese 2020	Yes	Self-determination theory principles and integrated behavioral model, Health Belief Model, social learning theory, Information-Motivation-Behavioral Skills model, natural helping, empowerment education, social cognitive theory, integrative model of behavior change, diffusions of innovation theory, social normative theory.	Not reported	Not reported
Xin 2020	Yes	Information-Motivation-behavioral skills (IMB) model. The intervention effects on unprotected anal intercourse (UAI) and HIV testing appeared to be comparable regardless of whether any theory was used.	Not reported	Not reported

Note. This table summarizes the use of behavior change frameworks in the included studies. “Behavior change framework used” indicates whether a theoretical framework was explicitly mentioned. “Framework/Theory Description provides” details only if reported by the authors. “BCTs (BCTTv1) Description” outlines the behavior change techniques used, categorized according to the Behavior Change Technique Taxonomy v1 (BCTTv1). “TDF Description” links these techniques to the domains of the Theoretical Domains Framework (TDF).

Effectiveness and Implementation of Behavior Change Techniques in Digital Interventions for STI/HIV Prevention

Digital behavior change interventions for STI/HIV prevention have incorporated various BCTs; however, their explicit classification using standardized frameworks such as the BCTTv1 or TDF remains limited. Among the studies analyzed, Burns et al. (2016) [45] and Clarke et al. (2022) [46] reported interventions explicitly coded using BCTTv1, whereas Bailey et al. (2021) [43] utilized domains associated with TDF to describe behavioral determinants (Table 4).

Twenty-two BCTs were reported. The most frequently employed in these interventions included goal setting (1.1), feedback on behavior (2.2), and the use of prompts/cues (7.1), commonly delivered through mobile applications, text messaging (SMS), and online modules. Other approaches included commitment strategies (1.9), biofeedback (2.6), social support (3.1, 3.2), and providing information about health consequences (5.1). These techniques targeted key behavioral determinants such as knowledge, behavioral regulation, social influence, and reinforcement strategies, aiming to enhance self-efficacy, motivation, and risk awareness (Table 4).

Table 4 summarizes behavioral determinants, commonly used BCTs, and intervention effectiveness, while Table 5 synthesizes the impact of specific BCTs across behavioral, cognitive, and biological outcomes. Findings were drawn from three systematic reviews (Bailey et al., 2021 [43]; Burns et al., 2016 [45]; Clarke et al., 2022 [46]) and assessed using AMSTAR-2 for methodological quality. Additionally, this section describes how BCTs were implemented in digital interventions, including SMS-based strategies, mobile applications, and online platforms.

Behavioral Outcomes

Condom Use (Bailey et al., 2021; Burns et al., 2016)

Digital interventions showed mixed effectiveness. Bailey et al. (2021) [43] found a significant increase in condom use (OR = 1.28, 95% CI 1.04–1.57, ▲ evidence), supporting the role of Goal Setting (1.1), Commitment (1.9), and Feedback (2.2). Conversely, Burns et al. (2016) [43], reported no significant effect (RR = 0.87, 95% CI 0.62–1.24, O evidence), suggesting that effectiveness varied by population and intervention design.

- Mobile Applications for Risk Awareness (Bailey et al., 2021) [43]: Digital interventions focusing on Health Consequences (5.1) significantly improved HIV-related knowledge (SMD = 0.56, 95% CI 0.33–0.80), reinforcing the role of interactive digital tools in promoting

condom use behaviors.

Sexual Health Services Uptake (Burns et al., 2016)

Mixed results (O+ to ▲) were found regarding the effectiveness of Goal Setting (1.1) and Feedback (2.2) in increasing engagement with sexual health services. SMS reminders significantly increased clinic attendance (RR 0.86, 95% CI 0.74–1.00) and chlamydia re-testing rates (RR 4.5, 95% CI 1.05–19.22) [45]. SMS reminders providing health-related information (5.1) and material incentives (10.1) were effective in some cases, particularly for STI retesting, though results varied across populations.

- SMS Feedback & Goal Setting (Burns et al., 2016) [45]: Participants received weekly SMS messages inquiring about risky sexual behaviors, followed by feedback and goal-setting prompts to encourage health service utilization.

STI/HIV Testing (Burns et al., 2016; Clarke et al., 2022)

Evidence from Burns et al. (2016) [45] was mixed (O to ▲), with Feedback (2.2) and Prompts/Cues (7.1) being somewhat effective in encouraging STI testing. Clarke et al. (2022) [46] found that personalized SMS reminders significantly improved STI re-testing rates (56% vs. 33%, $p < 0.01$). However, Material Incentives (10.1) yielded mixed effects (O), as financial rewards increased short-term attendance but did not sustain engagement.

- Personalized SMS Reminders & Incentives (Clarke et al., 2022) [46]: Tailored SMS messages encouraged STI retesting, with financial incentives increasing attendance (29.17% in the incentive group vs. 0% in the control group).

Cognitive Outcomes

HIV-related Knowledge (Bailey et al., 2021):

Digital interventions incorporating Information about Health Consequences (5.1) and Biofeedback (2.6) significantly improved HIV-related knowledge (SMD = 0.56, 95% CI 0.33–0.80, ▲ evidence). These interventions relied on mobile applications to enhance risk awareness through educational modules and interactive tools [43].

HIV Prevention Self-Efficacy (Bailey et al., 2021)

Strong evidence (▲) supported Goal Setting (1.1), Commitment (1.9), and Feedback (2.2) in improving self-efficacy for HIV prevention. Self-monitoring and digital education modules were key to reinforcing behavior change[43].

HIV Prevention Intentions & Attitudes toward Condom Use (Bailey et al., 2021)

For both outcomes, evidence was weaker (O+ to O), indicating that Goal Setting (1.1) and Feedback (2.2) may contribute to positive attitudes toward condom use, but their long-term impact remains uncertain (SMD = 0.16, 95% CI 0.06–0.26). Health Consequences (5.1) showed inconsistent effects, suggesting that behavior change may require additional reinforcement. [43].

- Mobile Applications for Risk Awareness (Bailey et al., 2021): Digital interventions focusing on HIV prevention knowledge were designed to improve risk awareness and motivation,

though long-term behavior adoption remained a challenge.

Biological Outcomes

STI/HIV Acquisition (Bailey et al., 2021)

Weak positive evidence (O+ to O) was assigned to Goal Setting (1.1), Commitment (1.9), and Feedback (2.2), with ▲ (strong evidence) for Health Consequences (5.1). Despite improvements in knowledge and behavioral determinants, these interventions did not significantly reduce STI/HIV acquisition rates (OR = 1.48, 95% CI 0.96–2.28, $p > 0.05$) [43].

- Chlamydia re-testing: SMS reminders increased re-testing (RR 4.5, 95% CI 1.05–19.22)
- HIV testing uptake: No SMS significant improved effect knowledge (RR 0.94, 95% CI 0.81–1.09)
- Sexual health knowledge: SMS SMS improved knowledge (RR 1.75, 95% CI 1.11–2.77)
- Condom use: No significant changes (RR 0.87, 95% CI 0.62–1.24)
Moderate No critical flaws
More than one non-critical weakness (no information on funding sources, publication bias reported but not discussed)
Clarke 2022 [46]
Systematic review
Searches:
1 January 2000 to 1 September 2021.
Publications:
2011-2018
Digital interventions including SMS (text messages), social media, and app-based messaging
13 studies (RCTs=5 Non RCTs before-after =8)
Population: Adolescents, youth, adults, MSM, LGTBQI+. Total: Not reported
Increasing attendance at scheduled sexual health appointments
Behavioral interventions increased attendance at scheduled sexual health appointments. Text messages were the most frequently used MoD. Some interventions were effective, while others had mixed results.
Beliefs about consequences, environmental context and resources, emotion, reinforcement, social influence, optimism.
credible source (9.1), prompts/cues (7.1), social support (3.2), social reward (10.4), self-incentive (10.5), restructuring of the environment (12.1, 12.2), focus on past success (15.3), vicarious consequences (16.3).
Some interventions significantly increased attendance (p < 0.05), while others had mixed results
Critically **Low**
More than one critical flaw (no justification for excluding individual studies, no consideration of bias when interpreting results)
More than one non-critical weakness (study selection not done in duplicate, no information on funding sources)
Note: STI = sexually transmitted infection; HIV = human immunodeficiency virus; BCT = behavior change technique; RCT = randomized controlled trial; SMS = short message service; MoD = mode of delivery; LGTBQI+ = lesbian, gay, bisexual, transgender, queer, intersex, and other identities; MSM = men who have sex with men; SMD = standardized mean difference; OR = odds ratio; CI = confidence interval; AMSTAR-2 = a measurement tool to assess systematic reviews; IDI = interactive digital intervention. Statistical significance is considered at p<0.05. The BCT numbers (e.g., 1.1, 3.2, 10.4, etc.) were reported according to the Behavior Change Techniques Taxonomy version 1 (BCTTv1).

Table 5. Summary of the effectiveness of behavior change techniques in digital interventions for STI/HIV prevention.X

X	Author	AMSTAR-2 Rating	1.1 Goal setting (behavior)	1.9 Commitment	2.2 Feedback on behavior	2.6 Biofeedback	4.2 Information about antecedents	4.3 Re-attribution	5.1 Information about health consequences	5.2 Salience consequences	7.1 Prompts/Cues	9.1 Credible source	10.1 Material incentive (behavior)	10.4 Social reward	10.5 Self-Incentive	11.2 Reduce negative emotions
Overall Effect			▲		▲		▲		O		▲	O	▲	O	O	O
Behavioral Outcome																
Condom Use	Bailey 2021	🟢	▲	▲	▲		▲	▲	▲							
	Burns 2016	🟡	O						O		O					
Sexual Health Services Uptake	Burns 2016	🟡	O+		▲				▲		▲		▲			
STI/HIV Testing	Burns 2016	🟡	O	O+	▲				▲		▲		O			
	Clarke 2022	🔴							O		▲	O	O	O+	O+	O+
Cognitive Outcome																
HIV Knowledge	Bailey 2021	🟢	▲	▲	▲	▲			▲							
HIV Prevention Self-Efficacy	Bailey 2021	🟢	▲	▲	▲				▲							
HIV Prevention Intentions	Bailey 2021	🟢	O+	O+	O+				O							
Attitudes Toward Condom Use	Bailey 2021	🟢	O+	O+	O+				O	▲						
Biological Outcome																
STI/HIV Acquisition	Bailey 2021	🟢	O+	O+	O				▲							

AMSTAR-2 quality ratings are indicated by colored circles as follows:

🟢 = High 🟡 = Moderate 🟠 = Low 🔴 = Critical Low

Classification of effectiveness from current systematic reviews and meta-analyses: ▲ = Positive effect of BCT based on good evidence such as subgroup or regression analyses. O+ = Positive effect of BCT based on low evidence such as frequency of individual BCTs within effective interventions. O = Mixed evidence or no effect. O- = Negative effect of BCT based on low level of evidence such as frequency of individual BCTs within effective interventions. ▼ = Negative effect of BCT based on good evidence such as subgroup or regression analyses.

Quality Appraisal of the Systematic Reviews

Overall, confidence in the results was high in 21.1% (4/19) of the systematic reviews, moderate in 15.8% (3/19), low in 15.8% (3/19), and critically low in 47.4% (9/19). The most common weaknesses identified were the absence of reported funding sources for primary studies (18/19, 95%), the lack of a full list of excluded studies (10/19, 53%), and the omission of a review protocol (8/19, 42%) (Table 6 and Supplementary Material Appendix 16).

Table 6. Critical assessment outcomes based on the AMSTAR-2 (a critical appraisal tool for systematic reviews).

X ^{Author-Year/} Criteria	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Rating Overall Confidence in the results of the review
Bailey 2021	YES	YES	YES	YES	YES	YES	YES	YES	YES	NO	YES	YES	YES	YES	YES	YES	High
Berendes 2021	YES	YES	YES	YES	YES	YES	YES	YES	YES	NO	YES	YES	YES	YES	YES	YES	High
Burns 2016	YES	YES	YES	YES	YES	YES	YES	NO	YES	NO	NO META-ANALYSIS	NO META-ANALYSIS	YES	YES	NO META-ANALYSIS	YES	Moderate
Clarke 2022	YES	YES	YES	YES	NO	YES	NO	YES	PARTIAL YES	NO	NO META-ANALYSIS	NO META-ANALYSIS	NO	YES	NO META-ANALYSIS	YES	Critically low
Conserve 2017	NO	PARTIAL YES	YES	YES	YES	YES	NO	YES	YES	NO	NO META-ANALYSIS	NO META-ANALYSIS	YES	NO	NO META-ANALYSIS	YES	Low
Ilskens 2022	YES	NO	YES	PARTIAL YES	NO	YES	NO	YES	NO	NO	NO META-ANALYSIS	NO META-ANALYSIS	NO	YES	NO META-ANALYSIS	NO	Critically low
Jones 2014	YES	NO	YES	YES	NO	NO	NO	YES	NO	NO	NO META-ANALYSIS	NO META-ANALYSIS	NO	NO	NO	NO	Critically low
Kamitani 2024	NO	NO	YES	YES	YES	YES	NO	YES	NO	NO	NO META-ANALYSIS	NO META-ANALYSIS	NO	NO	NO META-ANALYSIS	YES	Critically low
Khuwaja 2022	YES	NO	YES	NO	NO	NO	NO	YES	NO	NO	NO META-ANALYSIS	NO META-ANALYSIS	NO	NO	NO META-ANALYSIS	NO	Critically low
Knight 2017	YES	YES	YES	YES	NO	YES	YES	YES	YES	NO	NO META-ANALYSIS	NO META-ANALYSIS	YES	YES	NO META-ANALYSIS	YES	Moderate
Manby 2022	YES	YES	YES	YES	YES	YES	NO	YES	YES	NO	YES	YES	YES	YES	YES	YES	High
Nguyen 2019	YES	NO	YES	YES	YES	YES	NO	PARTIAL YES	YES	NO	NO META-ANALYSIS	NO META-ANALYSIS	YES	NO	NO META-ANALYSIS	YES	Critically low
Ou 2023	NO	PARTIAL YES	YES	YES	YES	YES	NO	YES	YES	NO	NO META-ANALYSIS	NO META-ANALYSIS	NO	NO	NO META-ANALYSIS	NO	Critically low
Palmer 2020	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	High
Saragih 2021	YES	YES	YES	PARTIAL YES	YES	YES	NO	YES	YES	NO	YES	YES	YES	YES	YES	YES	Low
Schnall 2014	NO	NO	YES	PARTIAL YES	YES	YES	PARTIAL YES	PARTIAL YES	PARTIAL YES	NO	NO META-ANALYSIS	NO META-ANALYSIS	NO	NO	NO	NO	Critically low
Sewak 2023	YES	NO	YES	YES	YES	YES	PARTIAL YES	PARTIAL YES	NO	NO	NO META-ANALYSIS	NO META-ANALYSIS	NO	NO	NO META-ANALYSIS	YES	Critically low
Veronese 2020	NO	PARTIAL YES	YES	YES	NO	NO	PARTIAL YES	YES	YES	NO	YES	YES	YES	YES	YES	YES	Moderate
Xin 2020	YES	NO	YES	YES	YES	NO	PARTIAL YES	YES	PARTIAL YES	NO	YES	YES	YES	YES	YES	YES	Low
Rating overall confidence in the results of the review	High	Up to one non-critical weakness: the systematic review provides an accurate and comprehensive summary of the results of the available studies that address the topic of interest.															
	Moderate	More than one non-critical weakness*: the systematic review has more than one weakness but no critical flaws. It may provide an accurate summary of the results of the available studies included in the review.															
	Low	One critical flaw with or without non-critical weaknesses: the review has a critical flaw and may not provide an accurate, comprehensive summary of the available studies that address the topic of interest.															
	Critically low	More than one critical flaw with or without non-critical weaknesses: the review has more than one critical flaw and should not be relied on to provide an accurate, comprehensive summary of the available studies.															
		*Multiple non-critical weaknesses may diminish confidence in the review, and it may be appropriate to move the overall appraisal down from moderate to low confidence.															

Note: Below is a brief summary of the aspects evaluated in each of the 16 items of the AMSTAR-2 tool, with the critical domains in bold: 1) clear definition of the research question and inclusion criteria (PICO), 2) **protocol registered before starting the review**, 3) justification for included study designs, 4) **adequate literature search strategy**, 5) study selection conducted in duplicate, 6) data extraction conducted in duplicate, 7) **clear justification for excluded studies**, 8) detailed description of included studies, 9) **appropriate assessment of risk of bias in individual studies**, 10) adequate reporting of funding sources, 11) **appropriate use of meta-analytical methods**, 12) assessment of the impact of risk of bias on results, 13) **interpretation of the risk of bias in discussing results**, 14) discussion of heterogeneity in results, 15) **assessment of potential publication bias**, and 16) reporting of conflicts of interest by review authors.

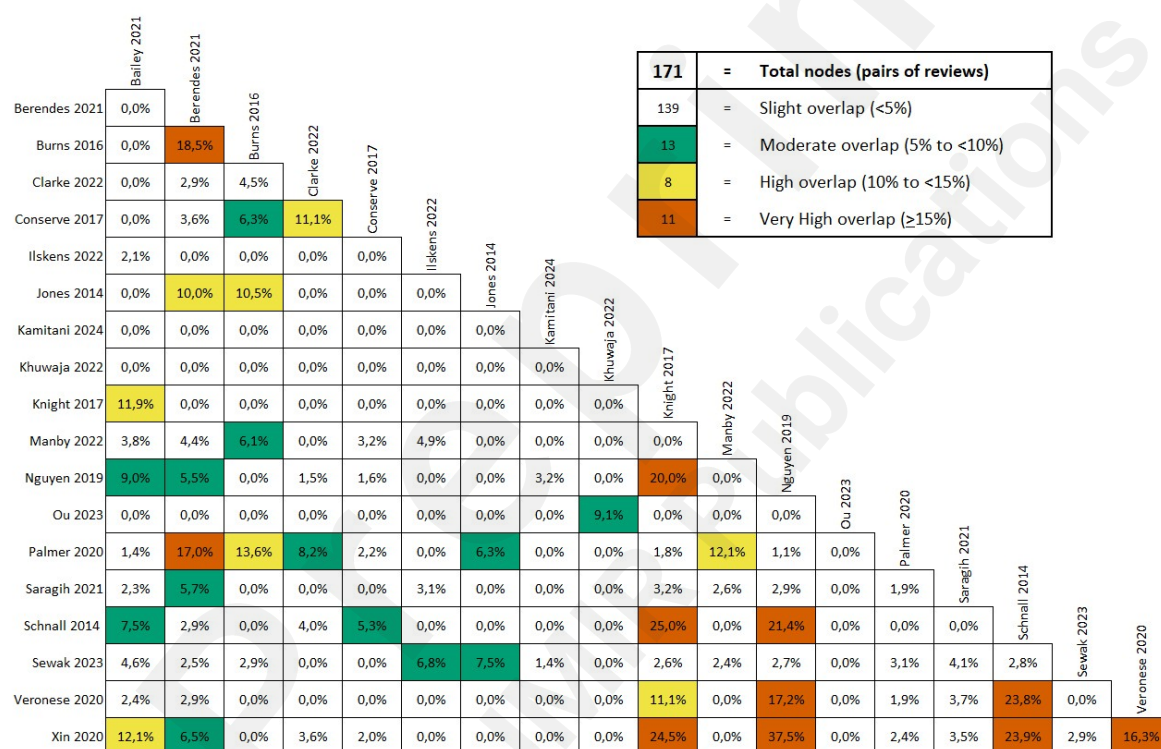
Overlap in Primary Studies Cited in Reviews

The overlap assessment revealed a minimal overlap in the 274 primary studies, most of which were cited only once in the 19 systematic reviews, with a Corrected Covered Area (CCA) of

3.10. Comparisons between pairs of systematic reviews indicated that 81.2% (139 out of 171) had a low overlap (< 5%), 7.6% (13 out of 171) had a moderate overlap (5% to < 10%), 4.7% (8 out of 171) had a high overlap (10% to < 15%), and 6.4% (11 out of 171) had a very high overlap ($\geq 15\%$).

Moreover, the overlap assessment of the three systematic reviews (Bailey et al., 2021 [43]; Burns et al., 2016 [45]; Clarke et al., 2022 [46]) indicated a low overlap (<5%) between pairs of reviews, with only Burns and Clarke showing a slightly higher overlap of 4.5%. These findings are illustrated in Figure 2 and detailed in Supplementary Material Appendix 17 and 18.

Figure 2. Overlap in the primary studies among review pairs based on the GROOVE (Graphical Representation of Overlap for Overviews) tool.



Discussion

Principal Results

This overview synthesizes findings from 19 systematic reviews evaluating digital behavior change interventions (DBCIs) for STI/HIV prevention. The results confirm that mobile-based strategies, particularly SMS reminders and interactive web-based platforms, increase STI/HIV testing and service uptake. Moreover, DBCI are highly suitable for STI/HIV prevention across diverse populations and settings, including schools, higher education institutions, clinics, and online platforms.

The most effective BCTs were categorized under goals and planning (1.1 Goal Setting),

feedback and monitoring (2.2 Feedback on Behavior), and associations (7.1 Prompts/Cues), contributing to positive behavioral and cognitive outcomes. However, heterogeneity in intervention components limited direct comparisons across studies, as many interventions combined multiple BCTs, making it difficult to pinpoint their individual effectiveness.

Methodological quality varied significantly across reviews. The quality of nearly half of the included systematic reviews were rated low or critically low (AMSTAR-2), often due to incomplete reporting, risk of bias, and lack of predefined protocols. These factors may explain inconsistencies in reported intervention effectiveness, particularly in sustaining long-term behavior change and reducing STI/HIV acquisition rates.

While some digital interventions significantly improved condom use (Bailey et al., 2021) [43], others showed no effect (Burns et al., 2016) [45], suggesting that effectiveness varies based on population and intervention design. Similarly, SMS-based reminders improved STI re-testing rates, yet financial incentives had only mixed success in sustaining re-testing behavior.

Furthermore, the overlap assessment revealed that most primary studies were cited only once across systematic reviews, with a low overlap (<5%) in the three reviews used for the synthesis of BCT effectiveness (Bailey et al., 2021 [43]; Burns et al., 2016 [45]; Clarke et al., 2022 [46]). This strengthens the independence of findings, ensuring that the synthesis was not disproportionately influenced by a small subset of highly cited studies.

The review highlights a critical gap in the use of behavioral science frameworks, with only three reviews explicitly coding BCTs using BCTTv1 or TDF. The inconsistent application of behavior change principles may contribute to variations in intervention effectiveness, limiting the ability to optimize future strategies.

Comparison with Prior Work

These findings align with previous meta-analyses indicating that theoretical grounding enhances intervention effectiveness. Studies by Simoni et al. [16], Albarracín et al. [24], and Thomas Craig et al. [17] have emphasized the importance of integrating behavior change models into digital health interventions. However, this overview reveals a continued underutilization of theoretical frameworks, with 47% of systematic reviews failing to reference any behavior change model.

Furthermore, while AI-driven interventions and virtual reality tools are increasingly recognized for their potential in health promotion [17], this review found minimal evidence to support their use in STI/HIV prevention, indicating a major research gap.

Evidence Gaps

Despite the promising findings on digital behavior change interventions (DBCI) for STI/HIV prevention, several key evidence gaps remain.

One major limitation is the lack of research in low- and middle-income countries (LMICs). The vast majority of studies were conducted in high-income settings, such as the United States, Australia, and the United Kingdom. This geographic imbalance limits the generalizability of findings, as digital interventions may function differently in regions with varying healthcare infrastructure, cultural norms, and digital access. Expanding research to

LMICs is crucial to ensuring that digital health strategies are effective and equitable across diverse populations.

Additionally, there is underutilization of artificial intelligence (AI) and emerging digital tools in STI/HIV prevention. While AI-based chatbots and machine learning models have shown promise in other health domains, no interventions in this review leveraged AI-driven approaches. AI-powered digital interventions have the potential to personalize messaging, adapt behavior change strategies in real time, and increase engagement, making them an essential avenue for future research.

Another critical gap is the lack of gender-disaggregated analyses. The application of the Sex and Gender Equity in Research (SAGER) guidelines revealed that most studies failed to account for gender differences, with only one study explicitly mentioning transgender participants [50]. This omission limits the ability to understand how digital interventions differentially affect men, women, and gender-diverse individuals, potentially reinforcing existing health disparities.

To advance the field, future research should prioritize equitable access to digital health interventions by addressing these gaps and integrating standardized BCT coding frameworks. Furthermore, AI-driven tools, chatbots, and virtual environments should be explored as next-generation solutions for tailored STI/HIV prevention strategies. Ensuring gender-sensitive approaches and expanding research in LMICs will be key to maximizing the public health impact of digital interventions.

Strengths and Limitations

This is the first overview of systematic reviews on safer sex interventions to systematically examine intervention content using behavioral theories and behavior change techniques (BCTs). By synthesizing findings across multiple systematic reviews, it provides a structured analysis of how digital interventions apply behavior change principles, filling a key gap in the literature.

However, several limitations should be noted:

- **Limited depth in BCT extraction:** Not all included systematic reviews explicitly coded BCTs using BCTTv1. In cases where BCTs were not directly reported, they were inferred based on reported intervention components and theoretical frameworks, introducing potential limitations in accuracy.
- **Reliance on systematic reviews:** This overview synthesized exclusively systematic reviews, meaning that relevant primary studies not included in these reviews were not analyzed directly.
- **Heterogeneity in intervention designs:** The interventions described in the reviews varied significantly, often combining multiple BCTs, making it difficult to pinpoint the specific contribution of each BCT to intervention effectiveness.

Despite these limitations, this review provides valuable insights into effective digital intervention strategies, emphasizing the importance of behavioral frameworks, standardized BCT reporting, and equitable access in future STI/HIV prevention research.

Conclusions

This overview underscores the potential of digital behavior change interventions in promoting safer sexual behaviors, particularly through mobile technologies and SMS-based approaches. Goal Setting, Feedback, and Prompts/Cues emerged as key drivers of engagement and behavior change. However, inconsistencies in theoretical application, variations in effectiveness across populations, and limited evidence for long-term impact highlight the need for more rigorous research.

To optimize future digital interventions, the systematic application of BCT frameworks (BCTTv1, TDF), the expansion into low-resource settings, and the exploration of AI-driven personalized interventions will be essential. Incorporating sex- and gender-disaggregated data and ensuring equitable access will further enhance the global public health impact of digital strategies for STI/HIV prevention.

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Authors' Contributions

The study design and literature search strategy were developed by GD, SSC, and SCM. Articles were located, identified, and evaluated by GD and DL, who also check the data extraction. All authors were responsible for the initial dimension and criteria list. The manuscript was drafted and edited by GD with close revision and feedback from SSC and SCM as well as review and feedback from the other coauthors.

Conflicts of Interest

None declared.

Abbreviations

AI: artificial intelligence

ART: antiretroviral therapy

BCT: behavior change technique

BCTTv1: Behavior Change Technique Taxonomy Version 1

CDSR: Cochrane Database of Systematic Reviews
CCA: corrected covered area
DBCI: digital behavior change intervention
GRADE: Grading of Recommendations, Assessment, Development, and Evaluation
HIV: human immunodeficiency virus
HPV: human papillomavirus
IMB: Information-Motivation-Behavioral Skills model
LGBTQ+: lesbian, gay, bisexual, transgender, queer, and other sexual orientations and gender identities
MoD: Mode of Delivery
MSM: men who have sex with men
OSF: Open Science Framework
PICO: population, intervention, comparison, outcome, study type
PrEP: pre-exposure prophylaxis
RCT: randomized controlled trial
SAGER: Sex and Gender Equity in Research
SR: systematic review
STI: sexually transmitted infection
TDF: Theoretical Domains Framework

References

1. Murray CJL, Aravkin AY, Zheng P, Abbafati C, Abbas KM, Abbasi-Kangevari M, et al. Global burden of 87 risk factors in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. *The Lancet*. 2020;396: 1223–1249. doi:10.1016/S0140-6736(20)30752-2
2. Fishbein M, Triandis HC, Kanfer FH, Becker M, Middlestadt SE, Eichler A, et al. Factors influencing behavior and behavior change. In: *Handbook of health psychology*. Mahwah, NY: Erlbaum; 2001.
3. Tran KB, Lang JJ, Compton K, Xu R, Acheson AR, Henrikson HJ, et al. The global burden of cancer attributable to risk factors, 2010–19: a systematic analysis for the Global Burden of Disease Study 2019. *The Lancet*. 2022;400: 563–591. doi:10.1016/S0140-6736(22)01438-6
4. Zheng Y, Yu Q, Lin Y, Zhou Y, Lan L, Yang S, et al. Global burden and trends of sexually transmitted infections from 1990 to 2019: an observational trend study. *The Lancet Infectious Diseases*. 2022;22: 541–551. doi:10.1016/S1473-3099(21)00448-5
5. World Health Organization. Alarming decline in adolescent condom use, increased risk of sexually transmitted infections and unintended pregnancies, reveals new WHO report. [cited 3 Sep 2024]. Available: <https://www.who.int/europe/news/item/29-08-2024-alarming-decline-in-adolescent-condom-use--increased-risk-of-sexually-transmitted-infections-and-unintended-pregnancies--reveals-new-who-report>
6. World Health Organization. Infecciones de transmisión sexual (ITS). [cited 31 Aug 2024]. Available: [https://www.who.int/es/news-room/fact-sheets/detail/sexually-transmitted-infections-\(stis\)](https://www.who.int/es/news-room/fact-sheets/detail/sexually-transmitted-infections-(stis))
7. Ritchie H, Spooner F, Roser M. Causes of death. In: *Our World in Data* [Internet]. 14

Feb 2018 [cited 30 Nov 2022]. Available: <https://ourworldindata.org/causes-of-death>

8. Michie S, van Stralen MM, West R. The behaviour change wheel: A new method for characterising and designing behaviour change interventions. *Implementation Sci.* 2011;6: 42. doi:10.1186/1748-5908-6-42
9. Johnson BT, Michie S, Snyder LB. Effects of Behavioral Intervention Content on HIV Prevention Outcomes: A Meta-Review of Meta-Analyses. *J Acquir Immune Defic Syndr.* 2014;66: S259–S270. doi:10.1097/QAI.0000000000000235
10. Duarte G, Okan Y, Johnston M, Ortiz L, Villalobos Dintrans P, Armayones M. Introduction to behavioral science and its practical applications in public health. *Medwave.* 2025;25: e3017. doi:10.5867/medwave.2025.01.3017
11. Michie S, Johnston M. Theories and techniques of behaviour change: Developing a cumulative science of behaviour change. *Health Psychology Review.* 2012;6: 1–6. doi:10.1080/17437199.2012.654964
12. CDC. How to Prevent STIs. In: Sexually Transmitted Infections (STIs) [Internet]. 24 Apr 2024 [cited 4 Sep 2024]. Available: <https://www.cdc.gov/sti/prevention/index.html>
13. Hollands GJ, Shemilt I, Marteau TM, Jebb SA, Kelly MP, Nakamura R, et al. Altering micro-environments to change population health behaviour: towards an evidence base for choice architecture interventions. *BMC Public Health.* 2013;13: 1218. doi:10.1186/1471-2458-13-1218
14. Hekler EB, Michie S, Rivera DE, Collins LM, Pavel M, Jimison H, et al. Advancing Models and Theories for Digital Behavior Change Interventions. *Am J Prev Med.* 2016;51: 825–832. doi:10.1016/j.amepre.2016.06.013
15. West R, Michie S. A Guide to Development and Evaluation of Digital Behaviour Change Interventions in Healthcare. Silverback Publishing; 2016.
16. Simoni JM, Ronen K, Aunon FM. Health Behavior Theory to Enhance eHealth Intervention Research in HIV: Rationale and Review. *Current HIV/AIDS reports.* 2018;15: 423–430. doi:10.1007/s11904-018-0418-8
17. Thomas Craig KJ, Morgan LC, Chen C-H, Michie S, Fusco N, Snowdon JL, et al. Systematic review of context-aware digital behavior change interventions to improve health. *Transl Behav Med.* 2020;11: 1037–1048. doi:10.1093/tbm/ibaa099
18. Smith V, Devane D, Begley CM, Clarke M. Methodology in conducting a systematic review of systematic reviews of healthcare interventions. *BMC Medical Research Methodology.* 2011;11: 15. doi:10.1186/1471-2288-11-15
19. Pollock M, Fernandes RM, Becker LA, Pieper D, Hartling L. Chapter V: Overviews of Reviews. In: Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, Welch VA (editors). *Cochrane Handbook for Systematic Reviews of Interventions* version 6.3 (updated February 2022). Cochrane, 2022. In: www.training.cochrane.org/handbook. [Internet]. [cited 4 Dec 2022]. Available: <https://training.cochrane.org/handbook/current/chapter-v>

20. Glasziou P, Meats E, Heneghan C, Shepperd S. What is missing from descriptions of treatment in trials and reviews? *BMJ*. 2008;336: 1472–1474. doi:10.1136/bmj.39590.732037.47
21. Michie S, Richardson M, Johnston M, Abraham C, Francis J, Hardeman W, et al. The Behavior Change Technique Taxonomy (v1) of 93 Hierarchically Clustered Techniques: Building an International Consensus for the Reporting of Behavior Change Interventions. *ann behav med*. 2013;46: 81–95. doi:10.1007/s12160-013-9486-6
22. Cornet VP, Holden RJ. Systematic review of smartphone-based passive sensing for health and wellbeing. *Journal of Biomedical Informatics*. 2018;77: 120–132. doi:10.1016/j.jbi.2017.12.008
23. Armayones Ruiz M, Pinto EL, Figueroa O, Robles N, Prehn DL, Riquelme FV, et al. Barriers and facilitators for safe sex behaviors in students from universidad de Santiago de Chile (USACH) through the COM-B model. *BMC Public Health*. 2023;23: 677. doi:10.1186/s12889-023-15489-y
24. Albarracín D, Fayaz-Farkhad B, Granados Samayoa JA. Determinants of behaviour and their efficacy as targets of behavioural change interventions. *Nat Rev Psychol*. 2024;3: 377–392. doi:10.1038/s44159-024-00305-0
25. Duarte-Anselmi G, Leiva-Pinto E, Vanegas-López J, Thomas-Lange J. Experiences and perceptions on sexuality, risk and STI/HIV prevention campaigns by university students. Designing a digital intervention. *Cien Saude Colet*. 2022;27: 909–920. doi:10.1590/1413-81232022273.05372021
26. Gates M, Gates A, Pieper D, Fernandes RM, Tricco AC, Moher D, et al. Reporting guideline for overviews of reviews of healthcare interventions: development of the PRIOR statement. *BMJ*. 2022;378: e070849. doi:10.1136/bmj-2022-070849
27. Heidari S, Babor TF, De Castro P, Tort S, Curno M. Sex and Gender Equity in Research: rationale for the SAGER guidelines and recommended use. *Research Integrity and Peer Review*. 2016;1: 2. doi:10.1186/s41073-016-0007-6
28. Duarte G, Sanduvete-Chaves S, López-Arenas D, Chacón-Moscoso S. Digital strategies and behavior change techniques for preventing sexually transmitted infections: Protocol for an overview of systematic reviews. *Medwave*. 2025;25: e3020. doi:10.5867/medwave.2025.02.3020
29. Moher D, Liberati A, Tetzlaff J, Altman DG, PRISMA Group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. *BMJ*. 2009;339: b2535. doi:10.1136/bmj.b2535
30. Duarte G, Sanduvete-Chaves S, Chacón-Moscoso S. Specifying the content of digital interventions for prevention of sexually transmitted infections /HIV using the Behaviour Change Technique Taxonomy v1 (BCTTv1): Protocol for an overview of systematic reviews. In: PROSPERO International prospective register of systematic reviews [Internet]. 5 Dec 2023 [cited 18 Jul 2024]. Available: <https://www.crd.york.ac.uk/PROSPERO/view/CRD42023485887>
31. Duarte Anselmi G. Digital behaviour change interventions to prevent sexually

- transmitted infections (STIs) including HIV: Evidence reviews and integrated report on the quantitative and qualitative evidence. 2024 [cited 12 Apr 2024]. Available: <https://osf.io/u9gz7/>
32. Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, Welch VA J. Cochrane Handbook for Systematic Reviews of Interventions. In: version 6.3 (updated February 2022). Cochrane, 2022. [Internet]. [cited 24 Nov 2022]. Available: <https://handbook-5-1.cochrane.org/>
 33. Collaboratron™ [Software]. In: Epistemonikos [Internet]. [cited 6 May 2024]. Available: <https://www.epistemonikos.org/en/documents/647cdbf675135cca583bcfeca7dad0560f80e02>
 34. Viera AJ, Garrett JM. Understanding interobserver agreement: the kappa statistic. *Fam Med*. 2005;37: 360–363.
 35. Cochrane Consumers and Communication La Trobe University, Ryan R, Synnot A, M P, Hill S. Data extraction template. 2018 [cited 25 May 2024]. doi:10.26181/5b57cfd711743
 36. Ryan R, Hill S. Supporting implementation of Cochrane methods in complex communication reviews: resources developed and lessons learned for editorial practice and policy. *Health Research Policy and Systems*. 2019;17: 32. doi:10.1186/s12961-019-0435-0
 37. Shea BJ, Reeves BC, Wells G, Thuku M, Hamel C, Moran J, et al. AMSTAR 2: a critical appraisal tool for systematic reviews that include randomised or non-randomised studies of healthcare interventions, or both. *BMJ*. 2017; j4008. doi:10.1136/bmj.j4008
 38. Bracchiglione J, Meza N, Bangdiwala SI, Niño de Guzmán E, Urrutia G, Bonfill X, et al. Graphical Representation of Overlap for OVERviews: GROOVE tool. *Research Synthesis Methods*. 2022;13: 381–388. doi:10.1002/jrsm.1557
 39. Marques MM, Carey RN, Norris E, Evans F, Finnerty AN, Hastings J, et al. Delivering Behaviour Change Interventions: Development of a Mode of Delivery Ontology. *Wellcome Open Res*. 2021;5: 125. doi:10.12688/wellcomeopenres.15906.2
 40. Michie S, West R, Sheals K, Godinho CA. Evaluating the effectiveness of behavior change techniques in health-related behavior: a scoping review of methods used. *Translational Behavioral Medicine*. 2018;8: 212–224. doi:10.1093/tbm/ibx019
 41. Mair JL, Salamanca-Sanabria A, Augsburg M, Frese BF, Abend S, Jakob R, et al. Effective Behavior Change Techniques in Digital Health Interventions for the Prevention or Management of Noncommunicable Diseases: An Umbrella Review. *Annals of Behavioral Medicine*. 2023;57: 817–835. doi:10.1093/abm/kaad041
 42. Castro O, Fajardo G, Johnston M, Laroze D, Leiva-Pinto E, Figueroa O, et al. Translating the behaviour change technique taxonomy version 1 into Spanish: Methodology and validation. *Wellcome Open Research | Open Access Publishing Platform*. 2024;9: 298. doi:(<https://doi.org/10.12688/wellcomeopenres.21388.1>)

43. Bailey JV, Wayal S, Aicken CRH, Webster R, Mercer CH, Nazareth I, et al. Interactive digital interventions for prevention of sexually transmitted HIV. *AIDS*. 2021;35: 643–653. doi:10.1097/QAD.0000000000002780
44. Berendes S, Gubijev A, McCarthy OL, Palmer MJ, Wilson E, Free C. Sexual health interventions delivered to participants by mobile technology: a systematic review and meta-analysis of randomised controlled trials. *Sexually transmitted infections*. 2021;97: 190–200. doi:10.1136/sextrans-2020-054853
45. Burns K, Keating P, Free C. A systematic review of randomised control trials of sexual health interventions delivered by mobile technologies. *BMC public health*. 2016;16: 778. doi:10.1186/s12889-016-3408-z
46. Clarke R, Heath G, Ross JDC, Farrow C. Increasing attendance at pre-booked sexual health consultations: a systematic review. *Sexual health*. 2022;19: 236–247. doi:10.1071/SH21245
47. Conserve DF, Jennings L, Aguiar C, Shin G, Handler L, Maman S. Systematic review of mobile health behavioural interventions to improve uptake of HIV testing for vulnerable and key populations. *Journal of telemedicine and telecare*. 2017;23: 347–359. doi:10.1177/1357633X16639186
48. Ilskens K, Wrona KJ, Dockweiler C, Fischer F. An Evidence Map on Serious Games in Preventing Sexually Transmitted Infections Among Adolescents: Systematic Review About Outcome Categories Investigated in Primary Studies. *JMIR serious games*. 2022;10: e30526. doi:10.2196/30526
49. Jones K, Eathington P, Baldwin K, Sipsma H. The impact of health education transmitted via social media or text messaging on adolescent and young adult risky sexual behavior: a systematic review of the literature. *Sexually transmitted diseases*. 2014;41: 413–9. doi:10.1097/OLQ.0000000000000146
50. Kamitani E, Peng Y, Hopkins D, Higa DH, Mullins MM. A Community Guide Systematic Review: Digital HIV Pre-Exposure Prophylaxis Interventions. *American Journal of Preventive Medicine*. 2024 [cited 5 May 2024]. doi:10.1016/j.amepre.2024.02.009
51. Khuwaja SS, Peck JL. Increasing HPV Vaccination Rates Using Text Reminders: An Integrative Review of the Literature. *Journal of pediatric health care: official publication of National Association of Pediatric Nurse Associates & Practitioners*. 2022. doi:10.1016/j.pedhc.2022.02.001
52. Knight R, Karamouzian M, Salway T, Gilbert M, Shoveller J. Online interventions to address HIV and other sexually transmitted and blood-borne infections among young gay, bisexual and other men who have sex with men: a systematic review. *Journal of the International AIDS Society*. 2017;20. doi:10.1002/jia2.25017
53. Manby L, Aicken C, Delgrange M, Bailey JV. Effectiveness of eHealth Interventions for HIV Prevention and Management in Sub-Saharan Africa: Systematic Review and Meta-analyses. *AIDS and behavior*. 2022;26: 457–469. doi:10.1007/s10461-021-03402-w
54. Nguyen LH, Tran BX, Rocha LEC, Nguyen HLT, Yang C, Latkin CA, et al. A

- Systematic Review of eHealth Interventions Addressing HIV/STI Prevention Among Men Who Have Sex With Men. *AIDS and behavior*. 2019;23: 2253–2272. doi:10.1007/s10461-019-02626-1
55. Ou L, Chen AC, Amresh A. The Effectiveness of mHealth Interventions Targeting Parents and Youth in Human Papillomavirus Vaccination: Systematic Review. *JMIR pediatrics and parenting*. 2023;6: e47334. doi:10.2196/47334
 56. Palmer MJ, Henschke N, Villanueva G, Maayan N, Bergman H, Glenton C, et al. Targeted client communication via mobile devices for improving sexual and reproductive health. *The Cochrane database of systematic reviews*. 2020;8: CD013680. doi:10.1002/14651858.CD013680
 57. Saragih ID, Imanuel Tonapa S, Porta CM, Lee BO. Effects of telehealth interventions for adolescent sexual health: A systematic review and meta-analysis of randomized controlled studies. *Journal of telemedicine and telecare*. 2021; 1357633X211047762. doi:10.1177/1357633X211047762
 58. Sewak A, Yousef M, Deshpande S, Seydel T, Hashemi N. The effectiveness of digital sexual health interventions for young adults: a systematic literature review (2010-2020). *Health promotion international*. 2023;38. doi:10.1093/heapro/daac104
 59. Veronese V, Ryan KE, Hughes C, Lim MS, Pedrana A, Stoové M. Using Digital Communication Technology to Increase HIV Testing Among Men Who Have Sex With Men and Transgender Women: Systematic Review and Meta-Analysis. *J Med Internet Res*. 2020;22: e14230. doi:10.2196/14230
 60. Schnall R, Travers J, Rojas M, Carballo-Diéguez A. eHealth interventions for HIV prevention in high-risk men who have sex with men: A systematic review. *Journal of Medical Internet Research*. 2014;16. Available: <https://www.epistemonikos.org/en/documents/cd34162fde27d0fea5115d28e8bcc40ea00e2b91>
 61. Xin M, Viswanath K, Li AY, Cao W, Hu Y, Lau JT, et al. The Effectiveness of Electronic Health Interventions for Promoting HIV-Preventive Behaviors Among Men Who Have Sex With Men: Meta-Analysis Based on an Integrative Framework of Design and Implementation Features. *Journal of medical Internet research*. 2020;22: e15977. doi:10.2196/15977
 62. World Bank Country and Lending Groups – World Bank Data Help Desk. [cited 30 May 2024]. Available: <https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups>

Supplementary Files

Multimedia Appendixes

Effectiveness and the content of digital interventions for prevention of sexually transmitted infections /HIV using Behavior Change Technique: an overview of systematic reviews–Multimedia Appendixes.

URL: <http://asset.jmir.pub/assets/da76a90d05627771e0ed67fcc7179024.docx>