

SYSTEMATIC REVIEW OPEN ACCESS

Efficacy of Digital Health Interventions Used for Adolescent's Sexual Health: An Umbrella Review

Sanam Borji-Navan¹  | Nahid Maleki²  | Afsaneh Keramat³ 

¹Student Research Committee, School of Nursing and Midwifery, Shahrood University of Medical Sciences, Shahrood, Iran | ²Department of Midwifery, School of Nursing and Midwifery, Shahrood University of Medical Sciences, Shahrood, Iran | ³Center for Health Related Social and Behavioral Sciences Research, Shahrood University of Medical Sciences, Shahrood, Iran

Correspondence: Afsaneh Keramat (keramat1@yahoo.com)

Received: 19 July 2024 | **Revised:** 20 October 2024 | **Accepted:** 7 November 2024

Keywords: adolescent | digital health interventions | E-Health | sexual health | umbrella review

ABSTRACT

Background and Aims: Adolescents face many barriers and challenges associated with sexual and reproductive health (SRH). These barriers can include limited access to youth-friendly healthcare services, lack of information, and stigma. Digital health interventions has the capability to enhance clinical management. This study was performed to investigate the efficacy of digital health interventions used for adolescent's sexual health.

Methods: This Umbrella Review has reviewed the search engines and databases of PubMed, Web of Science, Scopus, Cochrane Library, Google Scholar in English with the keywords organized into three broad categories: Sexual health and related issues, digital health interventions, and Adolescent, until December 3, 2023. The final analysis was based on a review of 23 full-text articles.

Results: The findings of the study clearly demonstrate the effectiveness of digital health interventions in enhancing sexual health outcomes among adolescents. The review identified several significant fields where digital health interventions have been effective, including promoting safer sexual practices, improving sexual health knowledge, and Minimizing high-risk sexual behaviors among adolescents. The assessment also emphasized the potential of digital health interventions to reach a wide audience, particularly those who may not have access to traditional healthcare services.

Conclusion: The findings of this research suggest that digital health interventions can be an effective way to promote safer sexual practices, improve sexual health knowledge, and reduce risky sexual behavior among adolescents. The quality of the evidence, however, varied across the studies assessed, highlighting the need for further rigorous study to demonstrate the efficacy of these interventions.

Trial Registration: PROSPERO CRD42023488296; https://www.crd.york.ac.uk/prospero/display_record.php?ID=CRD42023488296.

1 | Introduction

Adolescence is a period marked by puberty and sexual maturation. During this time, young people experience significant changes in their physical, social, and emotional well-being [1]. Sexual health promotion and education programs must

prioritize adolescents [2, 3]. This is particularly salient given the considerable global adolescent population of 1.3 billion [4] and the disproportionate burden of adverse sexual health outcomes they experience [5]. For instance, in 2021, 19% of new HIV diagnoses were among individuals aged 13 to 24, while 53% of the new sexually transmitted infections reported in 2020

This is an open access article under the terms of the [Creative Commons Attribution-NonCommercial-NoDerivs](https://creativecommons.org/licenses/by-nc-nd/4.0/) License, which permits use and distribution in any medium, provided the original work is properly cited, the use is non-commercial and no modifications or adaptations are made.

© 2024 The Authors. *Health Science Reports* published by Wiley Periodicals LLC.

occurred among those aged 15 to 24. Furthermore, adolescent pregnancies remain a significant concern, with approximately 143,500 births to mothers aged 15 to 19 in 2022 [6].

These alarming statistics underscore the urgent need for effective strategies to improve adolescent sexual health. Traditional approaches to sexual health education and service delivery often face significant barriers, such as stigma, confidentiality concerns, and limited access to youth-friendly services [7]. To overcome these obstacles and ensure adolescents have access to the information and care they need, healthcare providers and educators have increasingly turned to digital solutions. Digital health interventions hold particular promise in this domain, offering unique advantages in addressing the specific needs and challenges faced by adolescents in the realm of sexual health. For instance, online platforms can provide accessibility, privacy and anonymity, tailored content, interactivity, and engagement [8].

In light of these challenges, innovative approaches, such as digital health interventions, have emerged as promising avenues to enhance access to sexual health information and support for young people. Digital health interventions can facilitate confidential consultations, provide access to specialists, and offer tailored support to adolescents who may face barriers to accessing traditional healthcare settings. For example, online platforms can provide adolescents with accurate information about contraception and safe sex practices, potentially reducing unintended pregnancies and sexually transmitted infections [9].

However, access to comprehensive and reliable sexual health information and support remains a significant challenge, hindering adolescents' well-being and health outcomes [10–12]. Online platforms have emerged as potential solutions to address these barriers by providing convenient and youth-friendly education, counseling, and support [9, 13].

To rigorously evaluate the effectiveness of these digital health interventions, a comprehensive synthesis of the existing evidence is essential. This umbrella review aims to systematically identify, appraise, and synthesize findings from existing reviews examining the impact of digital health interventions on a wide range of adolescent sexual health outcomes, including but not limited to, sexual health knowledge, attitudes, and behaviors. By examining the impact of these interventions on diverse outcomes, this review aims to provide a comprehensive understanding of their potential to improve adolescent sexual health. Despite the growing body of individual studies and reviews on this topic, a clear and comprehensive picture of the overall effectiveness of these interventions across different types of interventions, health outcomes, and adolescent populations is still lacking. Previous research in this area has been limited in scope. For instance, while one umbrella review [14] focused specifically on gender-based violence in middle and low-income countries, it neglected the unique challenges and opportunities presented in high-income contexts, where digital access and utilization patterns may differ significantly. Additionally, its restricted search strategy, encompassing only 2010–2020 and the PubMed database, may have missed relevant evidence published in other databases or earlier time periods. Similarly, another literature review [15] had a limited database search and

a time constraint starting from 2008, potentially overlooking valuable insights from earlier research. Furthermore, its primary focus on sexually transmitted infections failed to capture the broader range of sexual health outcomes that can be impacted by digital health interventions.

This study addresses these gaps by conducting a comprehensive and methodologically rigorous umbrella review to determine the efficacy of digital health interventions for adolescent sexual health across diverse contexts and outcomes, providing a more definitive answer to the question of whether these interventions are effective in improving adolescent sexual health.

The findings of this review will be of considerable interest to policymakers, healthcare providers, researchers, and other stakeholders invested in improving adolescent sexual health outcomes globally.

2 | Materials and Methods

2.1 | Protocol and Registration

While a formal protocol document was not developed for this umbrella review, the study was prospectively registered on PROSPERO, an international database of systematic reviews, under the registration number CRD42023488296 before commencing the literature search. The PROSPERO registration includes details of our planned methodology, including the research question, eligibility criteria, search strategy, and planned methods for data extraction and synthesis. Ethical approval and informed consent details are provided in the Declarations section. The PRISMA guidelines were followed throughout the development and reporting of this review [16].

2.2 | Research Question

We used the PICOS framework [17] to establish the eligibility criteria for study selection as follows (Supporting Information S1: Table S1):

- Population: Adolescents.
- Intervention: Digital health interventions for adolescent sexual health.
- Comparison: No interventions or usual care.
- Outcome: Sexual health outcomes, including but not limited to, sexual health knowledge, attitudes, and behaviors.
- Study design: Systematic review, meta-analysis papers.

Studies were excluded if:

- Paper was a randomized controlled trials, cohort studies, commentary, gray literature, meeting or conference paper.
- Other types of reviews, such as scoping reviews and rapid reviews.
- Duplicate articles.

In this study, we defined “adolescents” as young people aged 10–24 years [18]. Sexual health outcomes were measured using a variety of methods, including self-report questionnaires, behavioral assessments, and clinical data (e.g., STI testing rates).

We limited our search to systematic reviews and meta-analyses to focus on studies that provide a rigorous and comprehensive synthesis of the evidence. While other types of reviews, such as scoping reviews or rapid reviews, may provide valuable insights, they often have different objectives and may not employ the same level of methodological rigor as systematic reviews and meta-analyses.

2.3 | Search Strategy

A comprehensive search of the search engines and databases of PubMed, Web of Science, Scopus, Cochrane Library, Google Scholar was conducted in English until December 3, 2023. We did not impose any date restrictions on our search to ensure that we captured all relevant reviews, including those that may provide historical context or foundational knowledge of the development and evaluation of digital health interventions. While the final execution of the search was conducted by a single author (SB), the entire process of designing and refining the search strategy was a collaborative effort involving three authors (SB, NM, and AK). This collaborative approach helped to minimize the risk of bias and ensure the comprehensiveness of the search. Two additional authors (NM and AK) reviewed the search terms, which were organized into three broad categories: Sexual health and related issues, digital health interventions, and adolescent. Based on the study's goal and inclusion criteria, appropriate keywords were assigned to each concept. Our search strategy aimed to be both sensitive and comprehensive. We achieved this by combining user-defined keywords with controlled vocabulary terms (e.g., MeSH in PubMed) and free-text method. This approach allowed us to capture a broad range of relevant studies, regardless of the specific terminology used in the articles. The search strategy was developed by connecting keywords within each concept using the “OR” Boolean operator and linking concepts using the “AND” operator. The search method was customized for each database according to its specific guidelines.

To expand the search, we performed forward and backward citation tracking on the references within the selected reviews. A comprehensive search strategy for all databases is accessible in the supplementary file (Supporting Information S1: Table S2).

2.4 | Data Selection and Extraction

After conducting a systematic search, the retrieved literature was transferred to EndNote Ver.21. After removing the duplicates, two independent reviewers (SB and NM) screened titles and abstracts for eligibility. Each study was deemed either relevant or irrelevant. If both reviewers regarded an article as irrelevant, it was excluded. Each reviewer independently

evaluated the entire texts of the remaining articles, and the final qualifying research were identified and included. Discrepancies were resolved by a third reviewer (AK). The PRISMA flow diagram documented the article selection process (Figure 1).

SB and NM extracted information from the chosen studies, employing a standardized data extraction form developed by the reviewers, including author names, review design, number of studies and covered years, intervention specifics, population, comparison, and outcomes. AK independently verified the extracted data for accuracy. Any discrepancies in data extraction were resolved through discussion between SB and NM, with AK acting as an arbiter if necessary. The critical attributes of the studies are contrasted and tabulated. The studies' primary outcomes and populations were too diverse to combine their data. Instead, the results of each study were organized according to their evaluation goals. A qualitative synthesis was conducted, focusing on identifying key themes and patterns across the included reviews. We considered factors such as the consistency of findings across multiple reviews, the methodological quality of the reviews, and the strength of evidence supporting the findings when evaluating the robustness of the evidence. Where findings were inconsistent or contradictory, we employed narrative synthesis techniques to explore and explain the discrepancies. This involved examining the characteristics of the studies (e.g., population, intervention, context) that may have contributed to the different findings, and considering alternative explanations for the observed inconsistencies.

The authors ensured that all intellectual property rights were respected throughout the research process. Researchers adhered to predefined inclusion criteria during article screening, preventing bias in study selection.

2.5 | Methodological Quality Assessment

Two reviewers (SB and AK) independently assessed review quality using AMSTAR2 [19], A validated 16-item tool for assessing systematic review quality. Each item within AMSTAR2 received a rating of “yes,” “partial yes,” or “no.” The overall AMSTAR2 score is calculated by adding up the scores for all 16 items. A higher score indicates a better quality review.

Scores on the higher end of the spectrum [11–16] signify a review conducted with robust methodological practices. Conversely, scores falling within the moderate range [7–10] suggest the review adheres to some, but not all, established methodological principles. Low scores (0–6) warrant caution regarding the review's methodological foundation, potentially compromising the trustworthiness of its conclusions.

Disagreements were resolved through consensus. As this is an umbrella review, individual study quality was not assessed.

The AMSTAR2 scores were used to assess the methodological quality of the included reviews and to inform the interpretation of their findings. Reviews with lower AMSTAR2 scores were considered to have a higher risk of bias, and their findings were interpreted with caution. While we did not exclude any reviews based solely on their AMSTAR2 score, we did discuss the

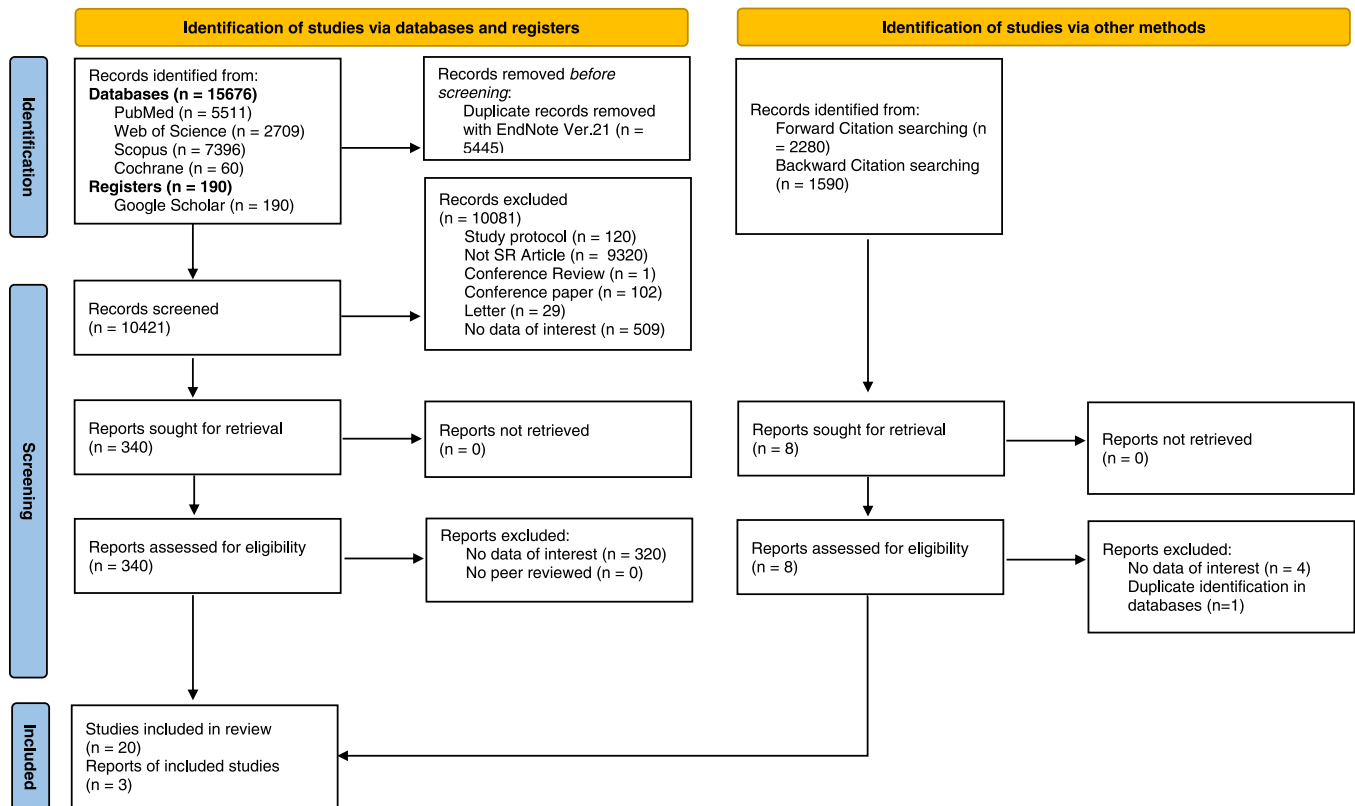


FIGURE 1 | PRISMA flowchart. SR= Systematic review.

potential impact of methodological limitations on the reliability of the findings in the Discussion section.

3 | Results

3.1 | Search Results

In line with PRISMA recommendations, Figure 1 presents a flowchart detailing the study identification and selection procedures for the umbrella review. A comprehensive search identified 15,676 potential studies. Following deduplication procedures, 10,421 studies remained. Based on title and abstract assessment, 10,081 studies were excluded due to exclusion criteria. The majority of these exclusions ($n = 9320$) were due to the studies not being systematic reviews, which was a primary inclusion criterion for this umbrella review. Other reasons for exclusion included studies that were protocols ($n = 120$), conference papers ($n = 102$), letters ($n = 29$), or did not report data relevant to our research question ($n = 509$).

A rigorous full-text review was conducted on the remaining 340 studies. Ultimately, 320 studies were excluded due to non-compliance with the established study design criteria. A total of 20 studies met the inclusion criteria. To achieve a more exhaustive review, we conducted forward and backward citation searches, yielding an additional 3870 studies (2280 forward, 1590 backward). This supplementary search strategy yielded an additional three studies for inclusion. Following a comprehensive evaluation process, A total of 23 studies met the inclusion criteria for the umbrella review.

An analysis of publication years revealed a dispersion across several years, with a notable concentration in 2021 ($n = 6$). The specific distribution is as follows: 2023 ($n = 1$), 2022 ($n = 3$), 2021 ($n = 6$), 2020 ($n = 3$), 2019 ($n = 1$), 2018 ($n = 2$), 2017 ($n = 1$), 2016 ($n = 1$), 2014 ($n = 3$), 2013 ($n = 1$), 2012 ($n = 1$). This distribution highlights a growing body of research published in 2021, suggesting an increasing focus on this area of investigation.

3.2 | Methodological Quality of Systematic Reviews

Supporting Information S1: Table S3 details the findings of the AMSTAR 2 appraisal for each systematic review. AMSTAR 2 identified mostly moderate [16] and high [5] quality systematic reviews out of 23 assessed, with only a small number [2] rated low.

While we did not formally weight the findings of the reviews based on their AMSTAR 2 scores, we did consider the methodological quality of each review when interpreting its findings and drawing conclusions. For example, we placed greater emphasis on findings from high-quality, such as those by Berendes et al. [20], Martin et al. [21], Saragih et al. [22], Meherali et al. [23], Widman et al. [9], to moderate-quality reviews, such as those by Feroz et al. [24], Wadham et al. [25], Guse et al. [26], Jones et al. [27], Inhae and Jiwon [28], Sousa et al. [29], Onukwugha et al. [30], L'Engle et al. [31], Ilskens et al. [32], Gilbey et al. [33], Gaidhane et al. [34], Fevriasanty et al. [35], Dunne et al. [15], Badawy and Kuhns [36], Gustina [37], Park & Calamaro [38],

which demonstrated robust methodologies. Conversely, we interpreted findings from lower-quality reviews, such as those by Sewak et al. [8] and Chávez et al. [39], with more caution due to potential methodological limitations.

Several methodological weaknesses were commonly observed across the included reviews. Many reviews did not adequately address the potential impact of risk of bias in individual studies on the results of the review (AMSTAR 2 item 13). Furthermore, several reviews did not provide a satisfactory explanation for, and discussion of, any heterogeneity observed in the results (AMSTAR 2 item 14). Finally, a number of reviews did not adequately assess the potential for publication bias (AMSTAR 2 item 15). These limitations highlight areas for improvement in the conduct and reporting of systematic reviews in this field.

3.3 | Characteristics of Included Studies

Supporting Information S1: Table S4 outlines the key features of the selected studies. Among the 23 included studies, four employed meta-analysis for data synthesis [9, 20, 22, 28], whereas the remaining 19 did not [8, 15, 21, 23–27, 29–39]. Systematic reviews were conducted over an 11-year period, from 2012 to 2023. The review studies consisted of 22 in English and 1 in Indonesian [37].

3.4 | Online Sexual Health Interventions for Adolescents

The included systematic reviews and meta-analyses ($n = 23$) evaluated a variety of digital interventions for promoting adolescent sexual health, including text messaging [15, 23, 25, 27, 30, 31, 36], smartphone applications [30, 36], social media [15, 27, 35, 38], websites [23, 25], and games [32].

These interventions targeted populations aged 10–24 years across multiple countries and settings.

As detailed in Supporting Information S1: Table S4, the majority of the studies were conducted in high-income countries, particularly in North America, Europe, and Australia. However, a few studies were also conducted in low- and middle-income countries (LMICs), such as Kenya, Ghana, South Africa, Uganda, Tanzania, India, and China. The outcomes assessed were sexual health knowledge [15, 25–28], attitudes [26, 28, 35], behaviors [8, 15, 20, 25–27, 35–37], STI/HIV testing and prevention [15, 20, 25, 27, 39], sexual and reproductive healthcare access [8, 24, 30].

Text messaging interventions showed negligible effects on condom use (SMD 0.02, 95% confidence interval [CI] -0.09 to 0.14 , 9 trials), but increased STI/HIV testing (OR 1.83, 95% CI 1.41–2.36, 7 trials), particularly when the control group did not already receive active text messaging (OR 1.00, 95% CI: 0.68–1.47, two trials) [20]. But mHealth interventions improved the use of contraception (OR 1.21; 95% CI: 1.02–1.43, $I^2 = 20.7\%$; $p = 0.234$) [28]. Smartphone app messages boosted STI/HIV testing among adolescents (RR 1.40, 95% CI: 1.22–1.60,

subgroup analysis, 2 trials) [20]. A meta-analysis of mHealth interventions revealed no statistically significant impact on pregnancy occurrence (OR 0.80, 95% CI: 0.61–1.05, $I^2 = 0.0\%$, $p = 0.950$) [28].

Web-based interventions [23, 25], social media [15, 27, 35, 38], and serious games [32] effectively increased sexual health knowledge and improved psychosocial outcomes like condom self-efficacy. Condom self-efficacy refers to an individual's belief and confidence in their ability to use condoms correctly every time they have sexual intercourse [26, 40]. However, conclusions about changes in sexual behaviors remain challenging due to methodological differences across studies. These differences include variations in study design, outcome measures, and follow-up periods. Such variations make it difficult to directly compare the effectiveness of different interventions and draw definitive conclusions about their impact on sexual behaviors.

Giving teenage girls in developing countries mobile phones, health apps, and online tools improved their access to health-care, information, and educational resources, effectively empowering them [23]. Media literacy education and social networks were valuable platforms for promoting positive health behaviors and comprehensive sexual health education among adolescents [37]. Overall, new digital media offer enormous potential to engage and assist adolescents with their sexual health [8, 25, 26].

The included reviews emphasized a range of obstacles to the widespread use of digital sexual health interventions, such as technological literacy, network accessibility, language barriers, provider bias, stigma, and privacy/confidentiality issues [24]. Studies conducted in African countries (e.g., Kenya, Ghana, South Africa, Uganda, and Tanzania) suggest that limited access to technology and Internet can be a significant barrier to the use of online sexual health interventions [24, 30]. The study by Meherali [23], which was conducted in LMICs, indicates that limited digital literacy can be a barrier to the use of internet-based interventions. Several studies suggest that cultural and social norms can influence the acceptability and effectiveness of digital interventions for different demographic groups. For example, the study by Gilbey [33] shows that digital interventions for LGBTIQ+ groups can face specific challenges, such as lack of tailored content addressing their unique needs and concerns, fear of discrimination or stigma when seeking information online, and difficulty finding relevant and reliable information. However, some studies found that the outcomes of technology-based interventions were consistent even when considering demographic factors such as age and gender, geographical location, intervention frequency, level of interactivity, or program customization [9].

Research limitations included small sample size, short follow-up, non-probabilistic design, self-reported data, poor retention, limited generalizability, and a lack of meta-analysis in some reviews. While many of the included reviews provided narrative syntheses of the findings, the lack of quantitative synthesis in some reviews limited the ability to draw definitive conclusions about the effectiveness of the interventions. Only a few studies incorporated theoretical frameworks in their intervention design.

4 | Discussion

This review comprehensively explores the effectiveness of digital health interventions in enhancing sexual health outcomes for adolescents. The findings reveal that these interventions are a promising strategy for promoting safer sexual practices, increasing sexual health knowledge, and reducing risky sexual behaviors among adolescents. These results align with previous reviews and meta-analyses on internet-based interventions for adolescent sexual health [20, 21, 24–30, 41].

For instance, Berendes et al. [20] found that a smartphone app delivering tailored sexual health information and support led to a significant increase in STI/HIV testing. Similarly, Wadham et al. [25] reported that a web-based intervention increased knowledge of HIV/STIs and improved attitudes towards condom use. However, Berendes et al. [20] found that a text messaging intervention had negligible effects on sexual risk behaviors. These examples highlight the variability in effectiveness across different types of digital health interventions.

Having the capacity of digital health interventions to reach a vast and diverse audience of adolescents is one of its strengths. This is especially crucial for adolescents who may lack access to traditional healthcare services owing to geographic, financial, or cultural constraints [42]. Digital health interventions can help to address inequities in sexual health outcomes among adolescents by giving online access to evidence-based sexual health information and services [43].

Digital health interventions can be personalized to individual adolescents' needs and preferences. Mobile applications, for example, can be created to deliver tailored feedback and reminders regarding contraception use or STI testing [44]. Online courses and interactive websites can be tailored to adolescents' learning styles and literacy levels [45]. Customizing digital health interventions can enhance their effectiveness and acceptability in promoting sexual health among adolescents [31].

Our findings should be interpreted in light of several limitations. First, the included studies were heterogeneous in terms of their design, populations, and interventions. Due to the heterogeneity of the studies, a meta-analysis was not feasible. This heterogeneity may limit the generalizability of our findings and make it difficult to draw definitive conclusions about the effectiveness of digital health interventions for adolescent sexual health. For example, some studies focused on specific types of interventions (e.g., text messaging, and smartphone apps), while others included a broader range of interventions. Similarly, some studies focused on specific populations (e.g., adolescents in high-income countries), while others included more diverse populations. This heterogeneity makes it difficult to determine which interventions are most effective for which populations. However, the narrative synthesis allowed us to identify key themes and patterns across the studies, providing valuable insights into the factors that may influence intervention effectiveness.

Second, many of the included studies relied on self-reported data, which may be subject to social desirability bias and recall

bias. This may have led to an overestimation of the effectiveness of the interventions. For example, participants may have been more likely to report positive changes in their sexual behavior if they knew they were participating in a study on sexual health. To address this limitation, future research should include more objective measures of sexual health outcomes, such as STI testing rates or unintended pregnancy rates.

Third, the quality of evidence supporting digital health interventions, on the other hand, varied across the research included in this umbrella review. Some interventions were found to be highly beneficial, while others were discovered the evidence for effect is uncertain. This emphasizes the importance of conducting more rigorous evaluations of digital health interventions, such as randomized controlled trials and quasi-experimental methods.

Furthermore, implementing digital health interventions for sexual health among adolescents offers a number of challenges. These concerns include issues of privacy and confidentiality, providing equal access and equity for all adolescents, and engaging and retaining adolescents in interventions [31, 46]. To address these issues, researchers, healthcare practitioners, policymakers, and adolescents themselves will need collaborate together.

While new media offers the potential to enhance efficiencies and broaden coverage, the technology alone does not ensure success. Interventions utilizing new digital media must focus on delivering high-quality, evidence-based content that effectively engages individual participants [25]. Exposure to electronic media can have both beneficial and harmful effects on adolescents [34].

5 | Conclusion

In conclusion, this umbrella review points out the potential of digital health interventions for promoting sexual health among adolescents. Digital interventions, particularly those using text messaging, smartphone applications, websites, and serious games, have shown promise in improving adolescent sexual health knowledge, attitudes, and some behaviors. However, further high-quality research is needed to confirm long-term benefits, particularly on biological outcomes like STI/HIV incidence.

To fully realize the potential of digital health interventions, it is essential to address the challenges that hinder their widespread implementation and effectiveness. To alleviate privacy concerns, developers can adopt strategies such as end-to-end encryption, data anonymization, and clear communication about data usage policies [47–49]. Additionally, involving adolescents in the design and development of interventions can help ensure that their privacy needs are addressed [50]. Also, Strategies to improve access to digital tools could include providing subsidized internet access, distributing devices to those in need, and creating interventions that are accessible on a variety of devices (e.g., smartphones, tablets, computers) [51]. Furthermore, interventions should be designed to be culturally sensitive and accessible to adolescents from diverse backgrounds [52].

To enhance engagement and retention, interventions can incorporate interactive elements, gamification, and personalized feedback. Incorporating peer support and social networking features can help adolescents feel more connected and motivated to use the intervention [53].

Interventions should address contextual barriers, incorporate behavior change theory, and be tailored to the specific needs and preferences of diverse adolescent populations. To maximize their impact, digital health interventions should be grounded in behavior change theory. These theories offer a framework for understanding the factors that drive behavior and can inform the development of targeted interventions [54]. For example, interventions based on the Information-Motivation-Behavioral Skills (IMB) model ensure users have the necessary information, motivation, and behavioral skills to adopt healthy practices. This could involve providing information about STI risks and condom effectiveness, addressing social norms and self-efficacy, and teaching condom negotiation skills [55–57].

Future research should prioritize longitudinal studies with extended follow-up periods to assess the long-term impact of digital health interventions on sexual health outcomes. This research should also focus on diverse settings and populations, including LMICs and vulnerable groups, and explore the potential of new technologies, such as artificial intelligence and virtual reality. Critically, future interventions should be grounded in theory and tailored to adolescents' specific needs, while carefully addressing ethical considerations related to privacy, confidentiality, and informed consent.

Overall, this research offers evidence supporting the viability and accessibility of digital health interventions for improving sexual health among adolescents. The research in this area is rapidly evolving. The effectiveness of new digital media in modifying adolescent sexual behavior requires further investigation through controlled studies with extended follow-up periods.

Author Contributions

Sanam Borji-Navan: conceptualization, data curation, formal analysis, visualization, writing—original draft, methodology, writing—review and editing, validation, investigation. **Nahid Maleki:** methodology, data curation. **Afsaneh Keramat:** conceptualization, data curation, visualization, methodology, project administration, writing—review and editing, validation, supervision, investigation, formal analysis, writing—original draft.

Acknowledgments

We acknowledge the valuable contributions of the authors whose articles were consulted in the preparation of this review. The authors acknowledge the use of an AI language model for assistance with writing and editing this manuscript. The authors maintained full oversight and responsibility for the final content.

Ethics Statement

Not applicable.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

The data that supports the findings of this study are available in the supplementary material of this article.

Transparency Statement

The lead author Afsaneh Keramat affirms that this manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

Endnote

¹Global Accelerated Action for the Health of Adolescents (AA-HA!): guidance to support country implementation, second edition. Geneva: World Health Organization; 2023. Licence: CC BY-NC-SA 3.0 IGO.

References

1. M.-C. Tsai, Y.-C. L. Wang, and H.-Y. Chan, “Pubertal Progression and Its Relationship to Psychological and Behavioral Outcomes Among Adolescent Boys,” *Development and Psychopathology* 35, no. 4 (2023): 1891–1900.
2. N. F. Mohammed Tohit and M. Haque, “Empowering Futures: Intersecting Comprehensive Sexual Education for Children and Adolescents With Sustainable Development Goals,” *Cureus* 16, no. 7 (2024): e65078.
3. World Health Organization, *Global Accelerated Action for the Health of Adolescents (AA-HA!): Guidance to Support Country Implementation*, 2nd ed. (Geneva: World Health Organization, 2023).
4. United Nations International Children's Emergency Fund Adolescents data.unicef.org: unicef; 2023, <https://data.unicef.org/topic/adolescents/overview/>.
5. R. A. Mahumud, M. A. Rahman, J. Gow, et al., “The Global and Regional Burden of Sexual Behaviors and Food Insecurity and Their Combined Association on the Magnitude of Suicidal Behaviors Among 121,248 Adolescent Girls: An International Observational Study in 67 Low- and Middle-Income and High-Income Countries,” *Journal of Affective Disorders* 298 (2022): 481–491.
6. Centers for Disease Control and Prevention. Sexual Risk Behaviors cdc.gov: Centers for Disease Control and Prevention; 2024, <https://www.cdc.gov/healthyyouth/sexualbehaviors/index.htm>.
7. C. Cassidy, A. Bishop, A. Steenbeek, D. Langille, R. Martin-Misener, and J. Curran, “Barriers and Enablers to Sexual Health Service Use Among University Students: A Qualitative Descriptive Study Using the Theoretical Domains Framework and COM-B Model,” *BMC Health Services Research* 18, no. 1 (2018): 581.
8. A. Sewak, M. Yousef, S. Deshpande, T. Seydel, and N. Hashemi, “The Effectiveness of Digital Sexual Health Interventions for Young Adults: A Systematic Literature Review (2010–2020),” *Health Promotion International* 38, no. 1 (2023): 1–14.
9. L. Widman, J. Nesi, K. Kamke, S. Choukas-Bradley, and J. L. Stewart, “Technology-Based Interventions to Reduce Sexually Transmitted Infections and Unintended Pregnancy Among Youth,” *Journal of Adolescent Health* 62, no. 6 (2018): 651–660.
10. S. P. Patterson, S. Hilton, P. Flowers, and L. M. McDaid, “What Are the Barriers and Challenges Faced by Adolescents When Searching for Sexual Health Information on the Internet? Implications for Policy and Practice from a Qualitative Study,” *Sexually Transmitted Infections* 95, no. 6 (2019): 462–467.

11. M. Janighorban, Z. Boroumandfar, R. Pourkazemi, and F. Mostafavi, "Barriers to Vulnerable Adolescent Girls' Access to Sexual and Reproductive Health," *BMC Public Health* 22, no. 1 (2022): 2212.
12. M. J. Decker, T. V. Atyam, C. G. Zárate, A. M. Bayer, C. Bautista, and M. Saphir, "Adolescents' Perceived Barriers to Accessing Sexual and Reproductive Health Services in California: A Cross-Sectional Survey," *BMC Health Services Research* 21, no. 1 (2021): 1263.
13. E. T. Crehan, A. E. Schwartz, and E. K. Schmidt, "Who Is Delivering Sexual Health Education Content to Young Adults With Intellectual or Developmental Disability?: A Survey of US-Based School-Based Professionals and Parents," *Sexuality and Disability* 41 (2023): 189–200.
14. K.-Y. Huang, M. Kumar, S. Cheng, A. E. Urcuyo, and P. Macharia, "Applying Technology to Promote Sexual and Reproductive Health and Prevent Gender Based Violence for Adolescents in Low and Middle-Income Countries: Digital Health Strategies Synthesis From An Umbrella Review," *BMC Health Services Research* 22, no. 1 (2022): 1373.
15. A. Dunne, J. McIntosh, and D. Mallory, "Adolescents, Sexually Transmitted Infections, and Education Using Social Media: A Review of the Literature," *The Journal for Nurse Practitioners* 10, no. 6 (2014): 401–408.
16. K. Knobloch, U. Yoon, and P. M. Vogt, "Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Statement and Publication Bias," *Journal of Cranio-Maxillofacial Surgery* 39, no. 2 (2011): 91–92.
17. P. Brown, K. Brunnhuber, K. Chalkidou, et al., "How to Formulate Research Recommendations," *BMJ* 333, no. 7572 (2006): 804–806.
18. S. M. Sawyer, P. S. Azzopardi, D. Wickremarathne, and G. C. Patton, "The Age of Adolescence," *The Lancet Child & Adolescent Health* 2, no. 3 (2018): 223–228.
19. B. J. Shea, B. C. Reeves, G. Wells, et al., "AMSTAR 2: A Critical Appraisal Tool for Systematic Reviews That Include Randomised or Non-Randomised Studies of Healthcare Interventions, or Both," *BMJ* 358 (2017): j4008.
20. S. Berendes, A. Gubijev, O. L. McCarthy, M. J. Palmer, E. Wilson, and C. Free, "Sexual Health Interventions Delivered to Participants By Mobile Technology: A Systematic Review and Meta-Analysis of Randomised Controlled Trials," *Sexually Transmitted Infections* 97, no. 3 (2021): 190–200.
21. P. Martin, L. Cousin, S. Gottot, A. Bourmaud, E. de La Rochebrochard, and C. Alberti, "Participatory Interventions for Sexual Health Promotion for Adolescents and Young Adults on the Internet: Systematic Review," *Journal of Medical Internet Research* 22, no. 7 (2020): e15378.
22. I. D. Saragih, S. I. Tonapa, C. M. Porta, and B. O. Lee, "Effects of Telehealth Interventions for Adolescent Sexual Health: A Systematic Review and Meta-Analysis of Randomized Controlled Studies," *Journal of Telemedicine and Telecare* 30, no. 2 (2024): 201–214.
23. S. Meherali, K. A. Rahim, S. Campbell, and Z. S. Lassi, "Does Digital Literacy Empower Adolescent Girls in Low- and Middle-Income Countries: A Systematic Review," *Frontiers in Public Health* 9 (2021): 761394.
24. A. S. Feroz, N. A. Ali, A. Khoja, A. Asad, and S. Saleem, "Using Mobile Phones to Improve Young People Sexual and Reproductive Health in Low and Middle-Income Countries: A Systematic Review to Identify Barriers, Facilitators, and Range of mHealth Solutions," *Reproductive Health* 18, no. 1 (2021): 9.
25. E. Wadham, C. Green, J. Debattista, S. Somerset, and A. Sav, "New Digital Media Interventions for Sexual Health Promotion Among Young People: A Systematic Review," *Sexual Health* 16, no. 2 (2019): 101–123.
26. K. Guse, D. Levine, S. Martins, et al., "Interventions Using New Digital Media to Improve Adolescent Sexual Health: A Systematic Review," *Journal of Adolescent Health* 51, no. 6 (2012): 535–543.
27. K. Jones, P. Eathington, K. Baldwin, and H. Sipsma, "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* 41, no. 7 (2014): 413–419.
28. C. Inhae and K. Jiwon, "Effects of mHealth Intervention on Sexual and Reproductive Health in Emerging Adulthood: A Systematic Review and Meta-Analysis of Randomized Controlled Trials," *International Journal of Nursing Studies* 119 (2021): 103949.
29. D. de Sousa, A. Fogel, J. Azevedo, and P. Padrão, "The Effectiveness of Web-Based Interventions to Promote Health Behaviour Change in Adolescents: A Systematic Review," *Nutrients* 14, no. 6 (2022): 1258.
30. F. I. Onukwugha, L. Smith, D. Kaseje, et al., "The Effectiveness and Characteristics of mHealth Interventions to Increase Adolescent's Use of Sexual and Reproductive Health Services in Sub-Saharan Africa: A Systematic Review," *PLoS One* 17, no. 1 (2022): e0261973.
31. K. L. L'Engle, E. R. Mangone, A. M. Parcesepe, S. Agarwal, and N. B. Ippoliti, "Mobile Phone Interventions for Adolescent Sexual and Reproductive Health: A Systematic Review," *Pediatrics* 138, no. 3 (2016): e20160884.
32. K. Ilskens, K. J. Wrona, C. Dockweiler, and F. Fischer, "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* 10, no. 1 (2022): e30526.
33. D. Gilbey, H. Morgan, A. Lin, and Y. Perry, "Effectiveness, Acceptability, and Feasibility of Digital Health Interventions for LGBTIQ+ Young People: Systematic Review," *Journal of Medical Internet Research* 22, no. 12 (2020): e20158.
34. A. Gaidhane, A. Sinha, M. Khatib, et al., "A Systematic Review on Effect of Electronic Media on Diet, Exercise, and Sexual Activity Among Adolescents," *Indian Journal of Community Medicine* 43, no. 5 (2018): 56.
35. F. I. Fevriasanty, B. Suyanto, O. Soedirham, R. Sugihartati, and A. Ahsan, "Effects of Social Media Exposure on Adolescent Sexual Attitudes and Behavior: A Systematic Review," *International Journal of Public Health Science* 10, no. 2 (2021): 272–280.
36. S. M. Badawy and L. M. Kuhns, "Texting and Mobile Phone App Interventions for Improving Adherence to Preventive Behavior in Adolescents: A Systematic Review," *JMIR mHealth and uHealth* 5, no. 4 (2017): e50.
37. E. Gustina, "Promosi Kesehatan Di Kalangan Remaja Melalui Media: Literatur Review," *Medika Respati: Jurnal Ilmiah Kesehatan* 15, no. 2 (2020): 99–106.
38. B. K. Park and C. Calamaro, "A Systematic Review of Social Networking Sites: Innovative Platforms for Health Research Targeting Adolescents and Young Adults," *Journal of Nursing Scholarship* 45, no. 3 (2013): 256–264.
39. N. R. Chávez, L. S. Shearer, and S. L. Rosenthal, "Use of Digital Media Technology for Primary Prevention of STIs/HIV in Youth," *Journal of Pediatric and Adolescent Gynecology* 27, no. 5 (2014): 244–257.
40. C. M. Markham, R. Shegog, A. D. Leonard, T. C. Bui, and M. E. Paul, "+CLICK: Harnessing Web-Based Training to Reduce Secondary Transmission Among HIV-Positive Youth," *AIDS Care* 21, no. 5 (2009): 622–631.
41. R. Celik and E. K. Toruner, "The Effect of Technology-Based Programmes on Changing Health Behaviours of Adolescents: Systematic Review," *Comprehensive Child and Adolescent Nursing* 43, no. 2 (2020): 92–110.
42. M. L. Ybarra, J. S. Holtrop, T. L. Prescott, M. H. Rahbar, and D. Strong, "Pilot RCT Results of Stop My Smoking USA: A Text Messaging-Based Smoking Cessation Program for Young Adults," *Nicotine & Tobacco Research* 15, no. 8 (2013): 1388–1399.
43. L. M. Brayboy, A. Sepolen, T. Mezoian, et al., "Girl Talk: A Smartphone Application to Teach Sexual Health Education to Adolescent

Girls,” *Journal of Pediatric and Adolescent Gynecology* 30, no. 1 (2017): 23–28.

44. S. S. Bull, D. K. Levine, S. R. Black, S. J. Schmiege, and J. Santelli, “Social Media-Delivered Sexual Health Intervention,” *American Journal of Preventive Medicine* 43, no. 5 (2012): 467–474.

45. A. DeSmet, D. Van Ryckeghem, S. Compennolle, et al., “A Meta-Analysis of Serious Digital Games for Healthy Lifestyle Promotion,” *Preventive Medicine* 69 (2014): 95–107.

46. K. E. Muessig, E. C. Pike, S. Legrand, and L. B. Hightow-Weidman, “Mobile Phone Applications for the Care and Prevention of HIV and Other Sexually Transmitted Diseases: A Review,” *Journal of Medical Internet Research* 15, no. 1 (2013): e1.

47. F. Schillinger and C. Schindelhauer, “End-to-End Encryption Schemes for Online Social Networks,” *Security, Privacy, and Anonymity in Computation, Communication, and Storage*, eds. W. Guojun, F. Jun, M. Z. A. Bhuiyan, and L. Rongxing (Cham: Springer International Publishing, 2019).

48. A. Zuiderwijk and M. Janssen, “Open Data Policies, Their Implementation and Impact: A Framework for Comparison,” *Government Information Quarterly* 31, no. 1 (2014): 17–29.

49. F. Neves, R. Souza, J. Sousa, M. Bonfim, and V. Garcia, “Data Privacy in the Internet of Things Based on Anonymization: A Review,” *Journal of Computer Security* 31 (2023): 261–291.

50. I. Psaroudakis, F. Quattrone, L. Tavošchi, et al., “Engaging Adolescents in Developing Health Education Interventions: A Multi-disciplinary Pilot Project,” *European Journal of Public Health* 30, no. 4 (2020): 712–714.

51. A. Afzal, S. Khan, S. Daud, Z. Ahmed, and A. Butt, “Addressing the Digital Divide: Access and Use of Technology in Education,” *Journal of Social Sciences Review* 3 (2023): 883–895.

52. S. Martinez and A. Mahoney, “Culturally Sensitive Behavior Intervention Materials: A Tutorial for Practicing Behavior Analysts,” *Behavior Analysis in Practice* 15, no. 2 (2022): 516–540.

53. L. B. Hightow-Weidman, K. J. Horvath, H. Scott, J. Hill-Rorie, and J. A. Bauermeister, “Engaging Youth in mHealth: What Works and How Can We Be Sure?,” *mHealth* 7 (2021): 23.

54. M. Pelly, F. Fatehi, D. Liew, and A. Verdejo-Garcia, “Novel Behaviour Change Frameworks for Digital Health Interventions: A Critical Review,” *Journal of Health Psychology* 28, no. 10 (2023): 970–983.

55. C. Rongkavilit, S. Naar-King, L. M. Kaljee, et al., “Applying the Information-Motivation-Behavioral Skills Model in Medication Adherence Among Thai Youth Living With HIV: A Qualitative Study,” *AIDS Patient Care and STDs* 24, no. 12 (2010): 787–794.

56. C. Y. Osborn and L. E. Egede, “Validation of an Information-Motivation-Behavioral Skills Model of Diabetes Self-Care (Imb-Dsc),” *Patient Education and Counseling* 79, no. 1 (2010): 49–54.

57. E. S. Anderson, D. A. Wagstaff, T. G. Heckman, et al., “Information-Motivation-Behavioral Skills (IMB) Model: Testing Direct and Mediated Treatment Effects on Condom Use Among Women in Low-Income Housing,” *Annals of Behavioral Medicine* 31, no. 1 (2006): 70–79.

Supporting Information

Additional supporting information can be found online in the Supporting Information section.