The effectiveness of digital sexual health interventions for young adults: a systematic literature review (2010–2020)

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ABSTRACT

There has been a proliferation of digital sexual health interventions targeting adolescents; however, limited evaluative reviews have compared the effectiveness of multiple digital tools for sexual health literacy and behaviour change. This study conducted a systematic literature review, screened 9,881 records, and analysed 61 studies. Findings suggest that websites and mobile phones dominate digital sexual health interventions, with a majority effectively delivering cognitive (e.g., awareness and attitudes about sexual and reproductive health) and behavioural outcomes (e.g., abstinence and use of contraception). The most popular sexual health promotion mechanisms were interactive websites, text messaging and phone calls, and online education programs, followed by mobile applications—fewer studies in this review utilised social media, games, and multi-media. Previous reviews focused on single outcome measures (e.g., STI testing) to assess interventions' effectiveness. The current review moves beyond single outcome measures to cover a wider range of behavioural and non-behavioural sexual health issues and contexts covered in the literature. Four main categories were analysed as outcomes: cognitive perceptions, promoting sexual health-related behaviours, promoting sexual health-related products and services, and impact (viral load). Seventy-nine per cent of interventions focused on preventive sexual health behaviours and products (e.g., condoms) and services (e.g., HIV testing). Overall, 75% of studies effectively changed sexual health behaviour and cognitive perceptions. However, the digital-only tools did not vary from the blended formats, in influence outcomes, even after categorising them into behavioural or non-behavioural outcomes. Compared to previous systematic reviews, more studies from the last decade used rigorous research design in the form of randomised controlled trials, non-randomised control trials, and quasi-experiments and lasted longer.

LAY SUMMARY

Sexual health literacy among adolescents is essential to avert unwanted pregnancies or abortions and sexually transmitted diseases. Culturally sensitive and age-appropriate interventions are required to educate youth about safe sex practices and increase their self-efficacy and accessibility to health products and services. Meta-analytical and systematic literature reviews have identified limitations in traditional interventions that rely heavily on classroom-based activities and lectures to educate adolescents about safe sex. In recent years, digital tools have proved productive; however, limited evaluative reviews have compared the effectiveness of multiple digital technologies (such as smartphones, web-based programs, social media, games, and multi-media) used within sexual health interventions. This systematic review assessed 9,881 articles and synthesised 61 experimental studies on adolescent sexual behaviour conducted in the last decade

to identify tools that positively influence cognitive and safe-sex behaviour among youth. Interactive websites, mobile technology, and online education programs were popular promotional tools, but very few studies utilised multi-media alongside games and social media. Findings from this review could facilitate future research and practice in adolescent sexual health.

Keywords: systematic literature review, sexual health interventions, young adults, digital technology, blended learning, effectiveness, behaviour change

Introduction

Adolescents represent one-sixth of the global population (WHO, 2020). This group undergoes a transition from childhood to adulthood, facing unique health challenges. Most adolescent mortality and morbidity are caused by risk-related behaviour, such as sexual intercourse without contraceptives or unprotected intercourse or activities with multiple partners which can result in the contraction of sexually transmitted infections (STI) and unwanted pregnancy (WHO, 2020). Each year about 333 million young adults are diagnosed with an STI worldwide (Dehne & Riedner, 2020). Furthermore, the World Health Organisation (WHO) reported that one million girls under the age of 15 years and 12 million under 19 years give birth, signalling a severe risk of unintended pregnancies (WHO, 2020). To overcome such challenges and improve health and wellbeing, adolescents require protection from harm and support to make independent and reliable decisions. WHO and the United Nations International Children's Emergency Fund (UNICEF) encourage evidence-based sexual health interventions to increase knowledge around sexual health and promote safe sex practices.

One of the main barriers young adults face in seeking sexual health is their inability to gain accurate and trustworthy sexual health information and services. This is due to restrictive policies, teachers', and parents' reluctance to openly discuss sexual health issues, parental control, limited income, and lack of confidentiality (WHO, 2020). Some of these barriers have been overcome recently by the advent of digital media. Program designers in the past decade (Salam et al., 2016) have turned their attention to digital and computer-based sexual health interventions where access is unrestricted, the cost to the user is low, and confidentiality is ensured. To deliver sexual health-related information to young adults, such interventions usually employ websites (e.g., Brady et al., 2015), mobile applications (e.g., Jeong et al., 2017), social media platforms (e.g., Fisser, 2013), text messaging (e.g., Rana et al., 2015), and video games (e.g., Christensen et al., 2013).

Literature indicates that digital sexual health interventions deliver several advantages. First, it can reach at-risk or marginalised populations without compromising their privacy and safety. It also increases cost-effectiveness and efficiency for service providers with limited budgets for facilitator training and materials (Brayboy et al., 2018; DeSmet et al., 2015). Second, interactive computer-based interventions increase user engagement and deliver prompt feedback (Shafii et al., 2019; Wayal et al., 2014), are less threatening to patients, and provide greater anonymity to users than face-to-face modes (Marsch et al., 2015). Third, in countries where sexual issues are taboo (Dehghani et al., 2019; Marsch et al., 2015), web-based strategies are highly relevant in providing user anonymity and widespread dissemination of sexual health information to youth at low costs. Not surprisingly, digital interventions deliver information (for instance, about contraceptives and STIs more effectively than face-to-face interventions (DeSmet et al., 2015).

The aims of this systematic review study are threefold. First, to build on previous reviews (Salam et al., 2016) and reflect the current trends and practices of the safe sexual health promotion sector

when digitising interventions. As the past few years experienced an exponential increase in adolescents' access and use of digital and social media and the expansion of platforms where interactions occur between young adults, peers, and health services, an update of previous reviews is paramount. Second, this review analyses current digital sexual health interventions' effectiveness and presents insights into effective digital interventions in the sexual health field. There is no recent systematic review that looks beyond specific digital interventions (e.g., serious games: DeSmet et al., 2015), scope (Salam et al., 2016), age (e.g., 13-24: Guse et al., 2012), and sexual health outcomes (e.g., STI screening: Daher et al., 2017) to understand the effectiveness of digital sexual health interventions. Third, this review compares the digital-only interventions with those that combine digital and non-digital tools. An integrated model of digital and classroom-based or face-to-face interventions (also known as blended learning) is gaining popularity (Coyle et al., 2019). However, limited rigorous evaluative reviews have assessed such sexual-health interventions (Decker et al., 2020). These insights will highlight the strengths and weaknesses of contemporary digital interventions and provide opportunities for future interventions.

Method

The systematic literature review followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher et al., 2009). Following PRISMA protocols, this review sought to identify studies that evaluated technology-based sexual health programs published in peer-reviewed journal articles to answer three research questions:

RQ1: What insights can we draw from the past ten years of digital sexual health interventions targeting young adults?
RQ2: What contributes to effective digital sexual-health interventions for young adults?
RQ3: Do non-digital features enhance program delivery?

Literature and Database Search

A two-step search process was used for this review. In step one, index terms (i.e., thesaurus and subject headings) were adapted to suit different databases. A search of Web of Science, Pubmed, and Scopus was undertaken to analyse text words in the title, abstract, and keywords. Following this analysis, the final keywords related to technology-based sexual health were selected, and the search strategy was developed. In the second step, a comprehensive electronic search was performed in eight electronic bibliographic databases, including Web of Science, Scopus, CINAHL Complete, Cochrane, Embase, ProQuest Central, Medline, and PsycINFO. Each database was searched by combining terms from each of four conceptual categories: digital (computer*, digital media, social media, Internet, technology, video gam*, gaming, games, cell* phone*, mobile, smartphone, electronic* mail, e-mail, e-mail, hypermedia, web, website*, blog*, weblog*, software*, text messag*, SMS, short messag* service, MMS); sexuality education or sexual health (sexual behavio*, sex behavio*, sex* education, sexual knowledge, sexually transmitted disease*, sexually transmitted infection*, HIV, condom*, contraception, safe sex,

unsafe sex, unprotected sex, protected sex, sexual abstinence, unplanned pregnancy, unwanted pregnancy, sexual activit*, sexual health, family planning); adolescent (adolescen*, teen*, young adult*, youth); and intervention (intervention*, campaign*, program*, trial*, experiment*, school-based, community health*, initiative*, education*, promot*, prevent*). The keywords were customised to each database-specific indexing term (e.g., MeSH in PubMed). The search was conducted during the second two weeks of August 2020.

Selection Criteria and Study Screening

Articles retrieved from the database search were stored in EndNote v.X9.2. Duplicate studies, pre-2010 articles, and publications in the non-English language were excluded from the Endnote library by the first author. The remaining articles were then randomly assigned to four independent reviewers. Each reviewer screened the title and abstracts of studies to exclude irrelevant articles. When it was difficult to determine an article's relevance based on its abstract, the full paper was retrieved and examined by two reviewers independently to decide its eligibility.

The following inclusion criteria were applied during full-text screening:

1. A specific time parameter (2010 – 2020) was selected for this systematic review to study trends in digital sexual-health-education interventions' adoption and efficacy. Articles that were dated outside this period were excluded from the study.
2. Empirical studies that focused on sexual health promotion/education. Articles were excluded if they presented only qualitative findings. Clinical studies that discussed clinical procedures were excluded from this study
3. Included a digital intervention. Digital interventions, sometimes referred to as eHealth interventions, are programs that utilise information technology to promote, prevent, or maintain healthy behaviour (Montanaro et al., 2015). Articles were excluded if they did not integrate digital technology such as smartphones, computers, tablets, multi-media, and social media.
4. Targeted at young people. The World Health Organization (2020b) describes *young people* as aged 10 – 24. *Adolescents* refer to individuals aged 10-19, while *youth are* represented by the 15-24 age group (WHO, 2020b). Studies were excluded when it became apparent that none of the participants fit this criterion.

Intercoder reliability was calculated between two reviewers independently assessing a specific quota of full texts. For each group comprising of two reviewers, the Cohen's Kappa score revealed a high agreement level: Group 1 (author 1 and 5; n=23) = 0.86; Group 2 (author 1 and 2; n=30) = 0.88; Group 3 (author 2 and 3; n=19) = 0.75; and Group 4 (author 3 and 5; n=8) = 0.7). Disagreements between investigators were resolved through rigorous discussions.

Search Outcomes

The details of the procedures involved in the article selection process are outlined in Figure 1.

Figure 1 about here

The authors identified 16,826 records through the database search. After removing articles pre-dated 2010 (n=3,486) and duplicate records (n=3,459), a total of 9,881 unique records were identified. We applied the inclusion criteria (which is mentioned in the previous section) to screen the title and abstracts of 9,881 articles. At this stage, the authors identified additional duplicate records (n=79), non-English articles (n=21), non-Journal articles (n=460), non-sexual-health articles (n=490), and irrelevant articles (n=8768) that were outside the inclusion criteria. This resulted in 220 eligible records. We screened the full text of 220 articles to determine further eligibility. One-hundred and fifty-nine (n=159) records were removed because they were non-behaviour-focused, non-empirical, qualitative, non-intervention or non-adolescent focused. No further articles were identified through backward and forward searching—the final set comprised 61 eligible studies with an experimental design.

Data Extraction and Analysis

A meta-analysis was not possible in this study due to the heterogeneity of the tested interventions and study populations and the diversity in outcomes metrics. Not all studies reported precise effect sizes and odds ratios, thus, limiting our analysis to a qualitative description of outcomes reported by 61 studies. The authors used a piloted matrix to extract data from the included articles to assess study characteristics and evidence synthesis. Extracted data consisted of the first author's surname, year of publication, stated purpose of the study, theories informing intervention design, study setting, study design, participant characteristics, sample size, data collection methods, primary variable(s) of interest, descriptions of the interventions, features of effective interventions, description of outcomes, and study limitations. Authors analysed extracted data based on location, sample size, age, target audience, intervention details, duration, digital and non-digital components, behavioural focus, behavioural outcomes, and effectiveness.

Results

In total, 61 studies representing 59 unique interventions qualified for inclusion. Tables 1 and 2 provide information about the interventions, duration, target audience, sample size, outcomes, and intervention effectiveness. Table 3 provides a summary of the outcomes.

Table 1 about here

Table 2 about here

Table 3 about here

Description of Included Studies

More than half of the studies were from the United States (n=32), followed by the UK, Australia, and Nigeria, with three studies from each country (e.g., Bailey et al., 2013; Gold et al., 2011; John et al., 2016). Mexico, Sweden, and South Africa contributed two studies each (e.g., Hacking et al., 2019; Gottvall et al., 2010; Doubova et al., 2017). Only one study was found for Argentina (Stankievich et al., 2018), Chile (Villegas et al., 2015), Colombia (Chong et al., 2020), Ghana, Hong Kong (Chu et al., 2015), Iran (Dehghani et al., 2016), Netherlands (Mevissen et al., 2011), Portugal (Carvalho et al., 2016), Senegal (Massey et al., 2009), South Korea (Jeong et al., 2017), Spain (Ballester-Arnal et al., 2015), Tajikistan (McCarthy et al., 2020), Tanzania (Haruna et al., 2018) and Uganda (Linnemayr et al., 2017). Most interventions (n=38) targeted young adults aged 15-24 years and adolescents aged 10-19 years (n=22), while only one intervention, though targeted at youth, had unspecified age. Few studies were gender specific. For instance, twelve studies targeted young female adults; seven studies were designed for males, while forty-two studies were generic.

Digital Tools Used

Our review suggests that websites and mobile phones dominate digital sexual health interventions, with a majority effectively delivering cognitive and behavioural outcomes. The behaviours were either promoted directly (e.g., abstinence) or in a tangible form (e.g., condoms). The most popular mechanisms for sexual health promotion were interactive websites (n=16), text messaging and phone calls (n=16), and online education programs (n=12), followed by mobile applications (apps) (n=7). Fewer studies in our review utilised social media (n=2), games (n=5), and multi-media (n=3). Social media and multi-media-based interventions used platforms such as Facebook, TV, radio, videos, and digital storytelling to promote sexual health among adolescents.

i) Websites and online education programs

Sixteen studies in this review employed websites. A higher proportion of website-based interventions were found to improve sexual health outcomes in adolescents, evidenced by an increase in knowledge (Danielson et al., 2016; Doubova et al., 2017), access to sexual health services (Mortimer et al., 2015; Brown et al., 2016), increase in STI prevention practices (Doubova et al. 2017; Horvath et al. 2017; Lustria et al. 2016; Massey et al. 2009; Mevissen et al. 2011; Mortimer et al. 2015; Ballester-Arnal et al. 2015; Spielberg et al. 2014), reduction in risky sexual

behaviours (Villegas et al., 2015), increase in condom use efficacy (Starling et al., 2014), and increase in ART adherence (Naar-King et al., 2013).

Twelve studies in this review used online education programs to disseminate information about safe sex and STI risk reduction (e.g., Chong et al., 2020; Kaufman et al., 2018; Klein et al., 2017; Marsch et al., 2015; Scull et al., 2018). The findings from this category produced mixed results. While some studies (n=8) found online programs to be effective in increasing knowledge, four studies (n=4) found contradicting results (e.g., Castillo-Arcos et al., 2016; Klein et al., 2017; Peskin et al., 2019; Shafii et al., 2019). For example, two computer-delivered interventions by Carvalho et al. (2016) positively influenced condom use amongst adolescents; however, internet-based sessions cited by Castillo-Arcos et al. (2016), Chong et al. (2020), and Shafii et al. (2019) were unsuccessful in delivering behavioural outcomes. On the other hand, online programs that targeted STI prevention, such as Marsch et al. (2015) and Kaufman et al. (2018), recorded positive results.

ii) Mobile Applications

Seven studies employed mobile applications, and the majority were found to be effective in increasing sexual health knowledge (Brayboy et al., 2017; Dehghani et al., 2016; Mesheriakova et al., 2017), STI prevention (Jeong et al., 2017), pregnancy prevention (Manlove et al., 2020), and condom use (Jones et al., 2013). Two studies reported insignificant results (Brayboy et al., 2017; Nielsen et al., 2019). Given the sensitivity surrounding open discussions on sexual health, it is not surprising that users value privacy, security, and credibility. Online statistics show that in 2020, almost 50% of people worldwide reported opening an app more than ten times a day, and millennials over 50 times a day (Iqbal, 2020). This indicates the popularity and favourability of mobile applications among adolescents.

iii) Text messaging and Phone Calls

A high proportion of studies (n=16) in this review engaged with adolescents via text messages and phone calls. Eleven studies delivered positive outcomes in terms of influencing HIV knowledge and perceptions (Gold et al., 2011; Merrill et al., 2018), increasing condom use and HIV testing (Yao et al., 2018), increasing ART and PrEP adherence (Belzer et al., 2014; Hacking et al., 2019; Liu et al., 2019; Stankievich et al., 2018), increasing Chlyamadia testing (McCarthy et al., 2016), and enhancing self-care among HIV+ adolescents (John et al., 2016). Five studies found text messaging to be ineffective in increasing the use of contraception (Gold et al., 2011; Juzang et al., 2011; Lim et al., 2012; McCarthy et al., 2016; Ybarra et al., 2018), increasing ART adherence among HIV-positive adolescents (Linnemayr et al., 2017), and rising sexual and reproductive health knowledge (Rokicki et al., 2017; Ybarra et al., 2018). Conflicting results are evident in the literature regarding SMS effectiveness. For example, while Belzer et al. (2014) found text messaging to increase ART adherence among HIV-positive adolescents, Linnemayr et al. (2017)

found the tool ineffective. Similarly, when targeting HIV knowledge and prevention, Merrill et al. (2018) found text messaging useful, while Juzang et al. (2011) did not.

The popularity of text messaging as a clinic-based tool to communicate with HIV+ youth and young adults is evident in this review. In general, text messaging dominates interventions in sexual health education of adolescents and youth, with one in every four interventions using text messaging and phone calls. This can be attributed to the effective results such tools yield and the favourability and usability among adolescents. Text messaging is also preferred for its ease of implementation for large groups and different contexts, making it a highly usable and attractive intervention platform. Over 35% of 13-17-year-olds rated texting their number one communication method (Marketing Charts, 2018). Text messages were also found to serve multiple sexual health issues. For example, Rokicki et al. (2017) found messages to reduce unwanted pregnancies effectively. In a different context, Stankievich et al. (2018) found text messaging to increase adherence to ART medications and decrease HIV Viral Load (VL). Hence, text messaging is an attractive mechanism for health practitioners for its applicability across diverse sexual health issues.

iv) Social Media

Fewer studies (n=2) in this review utilised social media channels for sexual health promotion. Interventions that disseminated STI prevention messages via Facebook page and encouraged ART adherence through Facebook-based support groups produced mixed outcomes, confirming previous review findings by Guse et al. (2012). In our review, Dulli et al.'s (2020) study found that social-media interventions only affect HIV knowledge and do not influence ART adherence behaviour. On the other hand, Bull et al. (2012) found the Facebook page to influence condom perceptions and use effectively, but the intervention was conducted for a short term. Bull et al. (2012) argue that social media could be a useful tool to reach a large number of youth audiences. However, the impact of that reach is limited as this age group is not known to engage with health organisations on Facebook.

v) Games

Interactive games, on the other hand, were employed scarcely in the identified studies (n=5). Three game-based interventions produced positive results; two did not (e.g., Christensen et al., 2013; Fiellin et al., 2017). Game-based learning proved efficacious in influencing knowledge and attitudes towards sex (Chu et al., 2015; Haruna et al., 2018), reducing shame and decreasing risky sexual behaviours (Christensen et al., 2013), and increasing ART knowledge and adherence among HIV+ youth (Whitely et al., 2018). Games were ineffective in delaying sexual initiation (Fiellin et al., 2017). In 2019, 34.5 billion games were accessed, downloaded, and played by online users (Iqbal, 2020). In 2020, the most common web-based applications were gaming applications, highlighting its popularity amongst millennials (Deshdeep, 2020). Sexual health educators and

health practitioners are slowly catching on to the gaming world; however, applications remain limited in numbers.

vi) Multi-media

Limited studies in our review adopted multi-media tools. All three studies that employed multi-media tools generated positive results. Different types of mass media were used, including radio and television (Solorio et al., 2016; Sznitman et al., 2011). The limited number of studies in this category can be attributed to the availability of more interactive tools that offer a two-way communication approach (e.g., text messaging and applications). Although the number of people who have access to TV and radio worldwide has increased, the daily usage rates have declined, indicating that such platforms have limited reach (Richter, 2020). Adolescents are still watching TV but in a different way. Statistics show that young audiences are likelier to use streaming services such as Netflix and Amazon Prime Video than traditional TV (Richter, 2020). This presents an opportunity for sexual health educators to utilise new platforms targeting young adults (e.g., TV shows on Netflix that discuss sexual health problems).

Combination of Digital and Non-digital Tools

Twenty-one out of sixty-one studies used blended mode (digital and non-digital tools) to deliver sexual health interventions to adolescents. Fifteen of these studies reported effectiveness in achieving their outcomes. Studies adopting digital-only tools reflected a higher effectiveness ratio than the blended tool interventions, both cognitive and behavioural outcomes, but the statistical difference was not significant. Mobile-based interventions incorporated traditional features such as clinical visits (Linnemayr et al., 2017), face-to-face interactions with health professionals (Belzer et al., 2014), PrEP, and sexual reproductive health education by a health educator or a nurse (Jeong et al., 2017; Liu et al., 2019; Rockicki et al., 2017), and a free hotline number to gain additional information about reproductive health from health professionals (Rokicki et al., 2017). Four out of six studies were effective.

Web-based interventions (e.g., websites and online education programs) were supplemented by classroom-based discussions and role-plays (Ballester-Arnal et al., 2015; Gottvall et al., 2010), print-based information materials and contraceptives (Gottvall et al., 2010), at-home STD testing by collecting specimen and mailing to the lab for analysis (Lustria et al., 2016), and STI treatment at a pharmacy or at a clinic (Spielberg et al., 2014). Online education programs were also supplemented by face-to-face classroom-based information sessions, presentations, and role-plays (Castillo-Arcos et al., 2016; Kaufman et al., 2018; Klein et al., 2017; Markham et al., 2020; Rohrbach et al., 2019) and parent-child homework activities (Peskin et al., 2019). Seven out of 11 studies were effective.

Interventions that used social media (such as Facebook-based support groups) also provided in-person support (Dulli et al., 2020). Only one intervention combined both mobile and electronic

technology with traditional communication tools. Solorio et al. (2016) used social media outreach, a website, a reminder system via text messaging, radio advertisements, print materials, and a toll-free hotline number to encourage HIV testing among the target audience.

Intervention Outcomes

From the 61 studies representing 59 digital sexual health interventions, 61 outcomes were assessed. We categorised the outcomes into four groups (1) cognitive perceptions assessing likability of stimuli, creating awareness, and influencing attitudes, (2) promotion of preventative sexual health behaviours, (3) promotion of products and services, and (4) impact. Forty-five studies evaluated cognitive perceptions, 28 interventions evaluated preventive sexual health behaviours, 34 studies evaluated the uptake of sexual health products (e.g., condoms) and services (e.g., HIV testing), and four studies reported an impact measure (viral load). Forty-five studies attempted to enhance cognitive perception; 91% of the results were effective, while among 28 studies promoting sexual health behaviours, 60.7% were effective. Promoting products and services was effective in 64.7% of the 34 studies. All four studies reported achieving impact successfully.

Twenty-one interventions targeted STI/HIV prevention, including screening/testing and increasing knowledge, attitudes, and intentions towards preventative behaviour. Furthermore, condom use was a primary outcome of eight studies and is often considered STI/HIV preventive behaviour. This predominant focus on STIs and HIV is unsurprising as they are major global health issues, with approximately one million people acquiring STIs daily (World Health Organization, 2020). We have observed that digital sexual health prevention interventions focus heavily on STI and HIV prevention efforts and ignore other aspects of sexual health-related issues such as sexuality, consensual sex, intimate partner violence, and substance abuse, implying a gap exists in terms of comprehensive sexual health interventions for adolescents and young adults.

Duration

The mean duration of 61 studies was 25 weeks (SD=40.11), with a median of 13 weeks, ranging from one day to 5 years. One could interpret 25 weeks as a sufficiently long duration of an intervention to achieve intermediate outcomes such as knowledge and attitudes. Duration length was not related to intervention effectiveness (χ^2 (9, N=57) = 16.76, p = 0.05). In terms of digital tools, shorter and longer duration interventions utilise a higher proportion of web and online tools and mobile tools, respectively.

Discussion

RQ1: What Insights can be Drawn from the Last ten years of Digital Interventions?

To the authors' knowledge, the last comprehensive systematic review of adolescent-based sexual and reproductive health interventions was conducted by Salam et al. (2016), identified gaps in the comparability of results and suggested using more rigorous study designs and longer-term follow-

ups, and the need for equitable outcomes. This current evaluative review synthesised empirical studies published between 2010 to 2020, out of which half (n=30) were published in the last three years (2017 to 2020). The majority of the studies that we reviewed used rigorous research design in the form of randomised controlled trials (n=40), non-randomised control trials (n=13), and quasi-experiments (n=6), indicating an increase in the volume of high-standard scientific studies in the area of adolescent sexual health. Another notable characteristic of the pool of studies within our systematic review was intervention length, which averaged 25 weeks. Interventions conducted for a longer period allow practitioners to evaluate sustained behavioural outcomes, as recommended by previous systematic reviews (e.g., Salam et al., 2016).

RQ2: Intervention Effectiveness of Digital Tools

Overall, 75% of studies found digital interventions to yield an effective change in sexual health perceptions and behaviour. Web and online interventions contributed to the highest number of effective interventions (50%), followed by mobile text and phone calls (23.9%), mobile apps (10.9%) and social media, multi-media, and games (15.7%). Twenty-five per cent found digital tools to be ineffective. Mobile interventions contributed to the highest percentage of ineffective interventions (46.67%), followed by web and online (33%) and social media, multi-media, and games (20%). A chi-square test of independence showed an insignificant association between the employed digital tools and the effectiveness of the interventions χ^2 (6, N = 61) = 4.02, p = 0.67. These findings highlight the need to analyse other factors that may significantly affect intervention effectiveness (e.g., study design, segmentation, theory base).

RQ3: Effectiveness of Digital-Only Interventions versus Blended-mode (a combination of digital and non-digital tools)

Fifteen interventions that used the blended approach produced positive results in influencing knowledge, self-efficacy, perceptions, and safe sex behaviour, while six blended interventions failed to deliver. On the other hand, 31 digital-only interventions were effective, and nine were not. While a higher proportion of digital-only studies were effective than the blended ones, this difference was not statistically significant (χ^2 (3, N = 61) = 1.04, p = 0.79). This finding is consistent with previous reviews on blended learning for sexual health education, indicating mixed results (Coyle et al., 2019; Decker et al., 2020). More research is required to ascertain whether digital technologies can reinforce traditional sexual health advocacy and behaviour change promotion methods among young adults (Decker et al., 2020).

Limitations & Future Research

Several important limitations apply to the current study. Firstly, the study is limited by the search parameters and search terms. For example, the review only includes studies that empirically test the effectiveness of digital sexual health interventions through quantitative analysis that have been published in peer-reviewed English literature. Hence, studies that evaluate qualitatively (e.g., focus

groups) or solely non-digital interventions (e.g., classroom-based) or published in non-English and non-peer-reviewed studies were excluded. A specific limitation arises from the parameters of the current review where qualitative studies are excluded. Qualitative studies can advance understanding of effectiveness through in-depth interviews and focus groups with sexual health practitioners and youth groups. Future systematic reviews may include other data collection methods (e.g., interviews) and additional data collection strategies or studies that evaluate interventions for other age groups (e.g., children) to widen the understanding of sexual health interventions. Second, due to the heterogeneity of the tested interventions, study populations, and reporting of results, a meta-analysis was not possible; this study could only provide a qualitative description of outcomes. Only a limited number of the included studies provided clear effect sizes and odds ratios, limiting comparing of intervention effectiveness. Third, while the current review provides insights into digital sexual health interventions' effectiveness on a variety of sexual health outcomes, analysis of specific digital tools' effectiveness (e.g., apps) on specific targeted behaviours (e.g., condom use) was not conducted, warranting the need for future research to understand the efficacy of each digital tool.

Fourthly, even though our study explored how different media interact with each other to influence audience behaviour, an in-depth understanding is required of the various persuasion techniques and transmedia employed by the interventions. The current study did not highlight these points as they were beyond the study scope. Future research should analyse both these aspects and provide new insights to improve the effectiveness of digital sexual health interventions.

Similarly, analysis of specific target audiences (e.g., Hispanic youth) and their acceptance and receptiveness of specific digital interventions may yield interesting findings for practitioners in specific cultures and communities. Finally, a comparison with other approaches (e.g., face to face lectures) was not possible by focusing on digital interventions. Future research can benefit from comparing digital interventions to traditional approaches to recommend the best approach practitioners should utilise.

Future research should examine digital sexual health interventions for adolescents by comparing the behaviour change effectiveness of single outcome interventions (e.g., condom use) with holistic interventions (as recommended by the World Health Organization (2020)) that additionally promote the prevention of violence, enhance understanding of sexuality, increase STI knowledge, and promote risk minimising behaviours. This review also noted the absence of studies reporting on Return of Investment (ROI). While a study of sexual health intervention effectiveness is critical to understanding the power of digital strategies, so is efficiency (Schäferhoff et al., n.d.); as funding agencies increasingly require reporting of ROI, future research should measure and report this metric.

As a limited number of digital sexual health interventions employed games, multi-media, and social media platforms, we could not conclude their ability to deliver effective behaviour change. Social media is yet fully utilised and implemented as a sexual health education tool, and future research should mainly analyse their efficacy. This confirms previous systematic review findings, where social media interventions were limited in numbers (Guse, 2012). This is surprising, given that over half of the world's population uses social media, especially the youth audience (Chaffey, 2020). In 2018, 70% of youth aged 13-17 reported using social media more than once daily. Furthermore, game-based interventions are gaining steady interest in other public health areas (e.g., alcohol; Rodriguez et al., 2014). They are less utilised in interventions targeting sexual health education (DeSmet et al., 2015).

Future systematic literature reviews should evaluate interventions based on social marketing benchmarks. Past systematic literature reviews have employed Andreasen's (2002), and National Social Marketing Centre's (2020) benchmarks to assess the extent of the presence of social marketing benchmarks in a variety of behaviour change interventions (for example, the review of nutrition interventions by Carins et al. (2014) and physical activity interventions by Fujihira et al. (2015). However, such a study is lacking in digital sexual education interventions. To highlight a few benchmarks, limited systematic reviews have explored the effects of customising digital interventions for adolescents and whether program efficacy increases through a co-design approach. Previous studies, such as Xia et al. (2016), have revealed a positive association between the presence of benchmarks and the intervention's success in promoting physical activity. A similar association test will help identify critical benchmarks that influence safe sex behaviours among adolescents and guide future practices.

Conclusion

The current review aimed to extend the understanding of digital sexual health intervention effectiveness when delivered to adolescents. Furthermore, we aimed to highlight the trends, opportunities, and limitations of the past ten years of research in the area. Our review supports digital interventions to improve adolescents' sexual health in concordance with existing reviews. There is a need to test digital interventions beyond websites, mobile applications, and text messaging to understand the effectiveness of video games, social media, and multi-media interventions in achieving positive sexual health outcomes. Our findings indicate that most digital sexual health interventions aimed at adolescents focus on one or complementary behavioural outcomes (e.g., HIV prevention and contraception use) with limited attention to a holistic sexual health education that includes a broad range of topics.

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Table 1: Intervention Design (n=61 studies; 59 interventions)

Author(s)	Country	Age of target audience	Characteristics of target audience	Program Name	Treatment details	Non-digital components
Mobile Phone (calls or SMS)						
1. Belzer et al. (2014)	USA	15-24 years	Youth living with HIV (YLH)	None	Daily phone calls (Monday to Friday) to remind participants to take medication.	Face-to-face interaction with Adherence Facilitator at baseline.
2. Bull et al. (2017)	USA	Unspecified	-	*Youth all engaged (YAE!)*	Between 5-7, automated messages were sent weekly, of which 40% were bidirectional.	None
3. Gold et al. (2011)	Australia	16-29 years	-	*S^5 project*	Text messages about 'sex' on a fortnightly basis, with an 'opt out' option.	None
4. Hacking et al. (2019)	South Africa	15-25 years	-	*Virtual Mentors Program*	The virtual mentor interacted with the mentee via a mobile interface (SMS text messaging, call, or WhatsApp messenger).	HIV-positive individuals had the option to join a youth-adherence club.
5. John et al. (2016)	Nigeria	15-24 years	YLH	None	Weekly voice calls, short text messages/multi-media messages (SMS/MMS), and WhatsApp messages (depending on user preference).	None
6. Juzang et al. (2011)	USA	16-20 years	~~African-American~~African American	None	Three text messages per week for 12 weeks about HIV prevention (i.e., condom use and reduction in the number of sexual partners). One quiz was sent per week.	None
7. Lim et al. (2012)	Australia	16-29 years	None	None	SMS messages about STIs every 3-4 weeks while e-mails sent less than monthly. E-mails contained messages about safe sex or STI topic and had links to sexual health websites.	None
8. Linnemayr et al. (2017)	Uganda	15-22 years	YLH	None	Intervention 1: For the 1-way group, the message was, "We hope you are feeling well today." Intervention 2: For the 2-way group, the message was, 'We hope you are feeling well today. Reply 1 if well, 2 if unwell."	Clinical visits once every 1-3 months
9. Liu et al. (2019)	USA	18-29 years	Young men who have sex with men (YMSM)	*PrEPmate*	Reminders for clinic visits via phone calls, while the SMS-based adherence support component included weekly "check-in" messages asking participants how PrEP was going and daily pill-taking reminder messages. A password-protected website ~~which~~ provided information about PrEP, videos and testimonials of peers taking PrEP, and an online support forum.	PrEP education, adherence, and risk-reduction counselling conducted by a health educator.
10. McCarthy et al. (2016)	UK	16-24 years	None	*Safetxt*	Short text messages designed to reduce STIs in young people by promoting condom use, disclosing infection status to partners, and encouraging STI testing before unprotected sex with a new partner.	None

Author(s)	Country	Age of target audience	Characteristics of target audience	Program Name	Treatment details	Non-digital components
11. McCarthy et al. (2018)	Tajikistan	16-24 years	None	None	Mobile app and intervention messages.	None
12. Merrill et al. (2018)	South Africa	11-16 years	Adolescent girls	*SKILLZ Street*	Two-way short-messaging-service (SMS) campaign to link program participants with health services. A supplementary service data (USSD) line, called "Coach Tumi", was created to reinforce messages delivered in the curriculum and provide information on how to access local health services.	2-hour sessions scheduled at school grounds after school hours twice-a-week for ~~5~~ five weeks. During the session, participants would discuss ~~about~~ life skills activities and sexual reproductive health with their coach.
13. Rockicki et al. (2017)	Ghana	14-24 years	Female students	None	Unidirectional Intervention: One text message per week about reproductive health. Interactive Intervention: One multi-choice quiz question via text message each week, which they could respond to free of charge.	A free public hotline number and lecture (30-45mins) about reproductive health delivered by a nurse at a 3-month~~s~~ follow-up.
14. Stankievich et al. (2018)	Argentina	<25 years	HIV-positive individuals	None	Text messages inquiring about the status of the patient and medication-related issues, twice a month. Participants were also contacted via social networks such as WhatsApp, Facebook, and e-mail.	None
15. Yao et al. (2018)	USA	15-24 years	American Indian and Alaska Native youth	*Texting 4 Sexual Health*	Text messages about condom use and STI/HIV testing~~,~~ twice a week for 12 weeks. The study involved ~~a total of 97 SMS delivered over 9 months, inclusive of~~97 SMS delivered over 9 months, including 32 intervention messages and 12 survey questions sent out three times (36 messages in total).	None
16. Ybarra et al. (2018)	USA	14-18 years	Sexual minority adolescent males	*Guy2Guy*	Multiple daily messages for 5 weeks with a 1-week booster delivered six weeks after the 5-week period ended. Additional interactive components included 'Text Buddy"~~,~~ and "G2Genie" (an on-demand tool containing pre-programmed advice on various topics).	None
Mobile Applications						
17. Brayboy et al. (2017)	USA	12-17 years	Teenage girls	*Girl Talk*	A smartphone application (iPhone compatible) containing comprehensive sexual health information. Notifications were sent every 72 hours to encourage the use of the application.	None
18. Dehghani et al. (2016)	Iran	18-25 years	Female students	None	A mobile application ~~that~~ containinged information about high-risk sexual behaviours and STDs, safe sex methods, condom use training, and the skills of 'saying no'.	None
19. Jeong et al. (2017)	South Korea	18+ years	None	None	A smartphone application ~~that~~ containinged information about STI risks, STI knowledge, STI prevention skills, STI coping skills, and links to STI-related websites. Cartoon clips were used to discuss STI	A traditional face-to-face lecture that lasted 50 minutes and a 30-minutes self-study ~~to examine~~examined the contents of

Author(s)	Country	Age of target audience	Characteristics of target audience	Program Name	Treatment details	Non-digital components
					information. Weekly reminders via text messages were sent to participants.	the educational booklet or mobile application.
20. Manlove et al. (2020)	USA	18-20 years	Black and Latinx women	*Pulse*	Regular text messages with program content and reminders to view the app. *Pulse* contained 6 interactive sections centred on sexual and reproductive health and 16 core activities featuring informational videos, appointment reminders, and a clinic locator feature.	None
21. Mesheriakova et al. (2017)	USA	12-18 years	Adolescent females	*Health-E-You*	An iPad-based application that presented audio and visual components in an interactive format. Video vignettes were incorporated into the app featuring young women discussing their experiences with contraception. A truth-vs-myth game was used to assess participants' knowledge about sexual health.	Clinic visit
22. Nielsen et al. (2019)	Sweden	18-23 years	None	MOSEXY trial	A smartphone app~~, called 'Skyddslaget', which~~ called 'Skyddslaget' contained youth-friendly 'safe-sex and STI' information. The app included weekly games and quizzes ~~related to~~about safe sex, condom usage, and STIs. There were also personal stories related to sexual risk-taking narrated by peers.	~~Routine standard of care at the YHCs, including testing and treatment services,~~The routine standard of care at the YHCs includes testing and treatment services and access to contraceptives and counselling services.
23. Jones et al. (2013)	USA	18-29 years	African American women	*Love, Sex, and Choices (LSC)*	Weekly e-mails with a link to soap opera videos about reducing HIV risk behaviour. Participants had to answer three content-related questions before proceeding to the next video episode.	None
Web- and online-based						
24. Bailey et al. (2013)	UK	18-20 years	None	*Sexunzipped Trial*	An interactive intervention website featuring information about safe sex, relationships, and sexual pleasure. An automated e-mail was sent at 6 ~~weeks~~ and 9 weeks to encourage user engagement. The website ~~which~~ contained quizzes and activities that provided tailored feedback.	Urine sample kit by post at 3 months for genital chlamydia testing. The kit contained instructions, a urine sample container, and a prepaid envelope addressed to the laboratory.
25. Ballester-Arnal et al. (2015)	Spain	18-25 years	None	*Unisexsida*	Intervention 1: An educator discussed ~~about~~ HIV/AIDS without illustrative tools. In the website group, participants had access to HIV/AIDS information on the customised website. Intervention 2: Three different motivational techniques were adopted: 1) in the attitudinal discussion group, the educator facilitated a debate about HIV/AIDS; 2) the second technique involved an HIV seropositive individual who explained his experiences with HIV	• Face~~-~~to-face interactions an educator and a HIV-seropositive individual. • In-person~~-~~role-~~plays~~ on dealing with risky sexual situations.

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Author(s)	Country	Age of target audience	Characteristics of target audience	Program Name	Treatment details	Non-digital components
					infection and the best methods to prevent HIV infection; ~~and~~ 3) the third technique used fear-inducing images and video messages about the impact of HIV. Intervention 3: This intervention included a role-play on how to deal with risky sexual situations and communicative skills for negotiating condom use.	
26. Brown et al. (2016)	UK	13-19 years	None	*Respect yourself (RY)*	A website and web- app (both ~~optimized~~ optimised for viewing on a smartphone or tablet computer).	None
27. Danielson et al. (2013)	USA	14-18 years	~~African-American~~African American female adolescents	*Sistas Informing Healing Living Empowering (SiHLEWeb) program*	An interactive website ~~that~~ incorporated videos, quizzes, and demonstrations designed to enhance ethnic and gender pride, HIV prevention, and assertive communication skills. ~~Weekly reminders via e-mail, phone call, or text message were sent by study coordinator~~The study coordinator sent weekly reminders via e-mail, phone call, or text message.	None
28. Doubova et al. (2017)	Mexico	14-15 years	None	None	Four educational sessions on the website for four weeks. Educational content included dating, courtship, sexual relationships, gender- roles, partner abuse, STIs, early pregnancy, self-esteem, safe sex, use of male and female condoms, and examples for condom negotiation. Two comic avatars (a teenage boy and a girl) were used to present the information through an informal dialogue about their experiences and those of their friends.	Six 30-mins class discussions were conducted after the intervention~~,~~ for ~~3~~ three months~~,~~ to encourage participants to examine educational sessions and answer their questions.
29. Gottvall et al. (2010)	Sweden	15-25 years	None	None	A classroom lesson, an intervention website, and an informational folder. The project's website included quizzes about HPV.	• A 1-hour lesson about HPV and preventive methods delivered by a registered nurse • Folder containing condoms and information about HPV and its prevention
30. Horvath et al. (2017)	USA	15-24 years	Gay, Bisexual, and men-who-have-sex with men (MSM)	*Get Connected!*	The intervention website employed tailored algorithms based on participants' key characteristics (e.g., age, race/ethnicity, relationship status, sexual identity) to tailor imagery and intervention content. Educational content focused on HIV/STI~~s~~ transmission and care~~,~~ and HIV/STI test locator.	None
31. Lustria et al. (2016)	USA	Mean age: 20 years	None	*RU@Risk*	A tailored Web-based intervention designed to promote STD testing among young adults. Participants received unique combinations of messages, testimonials, feedback, and images based on their pre-test responses and individual health information needs.	STD testing in a clinic setting or at-home testing (collecting specimens and mailing them to the lab for analysis)

Author(s)	Country	Age of target audience	Characteristics of target audience	Program Name	Treatment details	Non-digital components
32. Massey et al. (2013)	Senegal	15-21 years	None	None	~~Intervention~~ The intervention was implemented at 3 schools which involved peer-led, school-based clubs that engaged students in raising HIV awareness and testing. Clubs at 3 schools were formed to create a youth-focused space whereby students created original videos, audio (songs), and print messages (journalistic articles) about HIV/AIDS. A contest was held to identify the best content created by club members.	None
33. Mevissen et al. (2011)	Netherlands	18-25 years	None	*Justify your love*	Intervention: A web-based, tailored, relationship-oriented intervention that provided advice about safe sex. The website acted as a virtual STI public clinic involving a virtual consultant that asked questions and provided information in text blocks or balloons. Non-tailored Intervention: A simplified version of the tailored intervention ~~embedded in a similar virtual STI public clinic but lacked the virtual consultant and~~was embedded in a similar virtual STI-public clinic but lacked the virtual consultant, question-answer structure, and tailored feedback.	None
34. Mortimer et al. (2015)	Australia	18-29 years	None	*Healthy.me*	Online access to a personally controlled health management system~~s~~ (PCHMS) which provided evidence-based information about sexual health and STI testing indications and procedures, and an online appointment booking service and forum.	Interactions with a healthcare professional
35. Naar-King et al. (2013)	USA	16-24 years	HIV+ youth	*Motivational Enhancement System for Adherence (MESA)*	Computer-delivered motivational intervention for youth starting ART. The software used realistic interactions with a two-dimensional animated character to mimic person-delivered brief interventions' conversational nature. The program also delivered ~~personalized~~ personalised health feedback, ART information and activities~~,~~ and provided affirmations based on user responses.	Clinic visits
36. Rosser et al. (2010)	USA	>18 years	MSM	*SexPulse*	The *SexPulse* website incorporated video segments, interactive text, and animations focused on safe sex, risk reduction, and long-term sexual health. Interactive modules included a 'hot sex' calculator, virtual gym, online chat simulation, and reflective journal. Participants could also consult the frequently-asked-questions (FAQ) section.	None
37. Spielberg et al. (2014)	USA	18-30 years	Women	None	~~Website.~~ The website contained information about STIs, prevention, testing, and treatment. An eSTI system provided access to both patients and clinical staff. Participants were mailed a vaginal specimen collection kit in a pre-addressed postage-paid return envelope. Notification about results ~~were~~ was sent via text	• Home STI test-kit • STI treatment at a pharmacy or a clinic

Author(s)	Country	Age of target audience	Characteristics of target audience	Program Name	Treatment details	Non-digital components
					message, e-mail, or both to notify them to log onto the website to view their results.	
38. Starling et al. (2014)	USA	14-16 years	None	*Bready4it*	Participants spent 3 hours over ~~a period of~~ 2 days completing an online program (a multi-media interactive website that consisted of 5 units~~,~~ involving simulations and activities).	None
39. Villegas et al. (2015)	Chile	18-24 years	Women	*I-STIPI*	A password-protected I-STIPI website that consisted of 4 online modules. Participants who completed three or more modules received an electronic certificate of completion.	None
Online Education Program						
40. Carvalho et al. (2016)	Portugal	18-25 years	Men	None	Intervention 1: The motivational intervention consisted of screen content that promoted positive outcomes of condom use. Intervention 2: ~~Involved a~~A volitional intervention that used an onscreen page to encourage participants to formulate action plans.	None
41. Castillo-Arcos et al. (2016)	Mexico	14-17 years	None	*Connect: A Program on Responsible Sexuality*	Internet-based sessions designed to reduce sexual risk behaviours and increase resilience to sexual risk. The intervention comprised ~~of~~ eight 1-hour sessions (6 online sessions; 2 face-to-face sessions).	Two face-to-face sessions lasting 1-hour, facilitated by health experts.
42. Chong et al. (2020)	Colombia	14-15 years	None	None	Intervention Classroom: Mandatory internet-based sexual education course. An online tutor monitored students' performance and answered their questions. ~~Spillover~~Spill over classroom Did not receive the treatment but is in the same school as the one that does.	Condom vouchers
43. Kaufman et al. (2018)	USA	10-12 years	American Indians and Alaska Natives	*Circle of Life (mCOL)*	An online multi-media format was used. Each online chapter comprised stories, games, and videos and required 20-25 minutes to complete.	Class-based discussions, instructions, demonstrations, games, and craft activities ~~that~~ require approximately 1 hour.
44. Klein et al. (2017)	USA	19-34 years	Latina and ~~African-American~~African American women	*C-SAFE (Sexual Awareness for Everyone)*	A clinic-based intervention comprising three sessions, each lasting 3-4 hours, delivered via a computer and~~/or~~ mobile device (or tablet) ~~aimed at promoting~~to promote abstinence, mutual monogamy, correct and consistent condom use, STI treatment protocols, and reduction in the number of sex partners.	Presentation, discussions, role-plays, games, and videos were incorporated into the program.
45. Marsch et al. (2015)	USA	12-18 years	None	*Therapeutic Education System (TES)*	The Therapeutic Education System (TES) is an interactive, ~~customizable~~customisable, web-based program containing 26 modules cent~~e~~red on preventing HIV, STIs, hepatitis, and substance-abuse treatment.	None

Author(s)	Country	Age of target audience	Characteristics of target audience	Program Name	Treatment details	Non-digital components
46. Scull et al. (2018)	USA	18-19 years	None	*Media Aware*	The intervention was a 5-lesson, web-based~~,~~ sexual health program accessible on mobile devices that included various interactive features such as quizzes, peer-based videos, popular media examples, and skill practice with real-time feedback.	None
47. Shafii et al. (2019)	USA	14-24 years	None	*e-KISS (electronic KIOSK)*	The interactive computer-based intervention included ~~personalized~~ personalised sexual health feedback from a physical avatar and instructive video modules advocating sexual health.	None
48. Widman et al. (2018)	USA	15 years	Girls	*Health Education and Relationship Training [HEART]*	The program included five modules that could be accessed via a computer, tablet, or smartphone. Each module contained audio and video clips, tips from other adolescents, interactive games and quizzes, infographics, and skill-building exercises with self-feedback given in real-time.	None
49. Markham et al. (2020)	USA	Mean age: 13 years	None	*It's Your Game (IYG)*	**IYG** is a 2-year program encompassing 24 lessons that integrate group-based classroom activities with ~~personalized~~ personalised journaling~~,~~ and computer-based activities. It comprises ~~of~~ 24, and 50-minute lessons-addressing life skills, sexual behaviour, and related psychosocial factors. The program is highly interactive, combining classroom-based activities with individual journaling and tailored computer-based activities.	~~Group~~ Group-based lessons. ~~Classroom lessons are conducted by trained teacher~~Trained teachers conduct classroom lessons.
50. Peskin et al. (2019)	USA	12-13 years	None	*It's Your Game…Keep It Real!*	Twenty-four (24) lessons delivered to ~~students in~~ 7th and ~~8th~~ 8th-grade students by teachers during regular classroom time.	Parent-child homework activities ~~to facilitate dialogue on topics including~~facilitate dialogue on friendship qualities, dating, and sexual ~~beahviour~~behaviour.
51. Rohrbach et al. (2019)	USA	14-15 years	None	*It's Your Game (IYG)…Keep It Real*	IYG comprises ~~of 24 lessons centred on HIV/STI/teen pregnancy prevention that contains tailored computer-based activities~~24 lessons centred on HIV/STI/teen pregnancy prevention that contains tailored computer-based and classroom-based activities.	Classroom-based activities~~,~~ facilitated by teachers~~,~~ include movie acting, role plays, individual journaling, and group discussion.
Social Media						
52. Bull et al. (2012)	USA	18-24 years	African American and Latino	*Just/US*	STI prevention messages delivered via a Facebook page. Youth facilitators updated the page daily with new video~~-~~ links, quizzes, games, and threaded discussions relevant to weekly topics.	None
53. Dulli et al. (2020)	Nigeria	15-24 years	Youth living with HIV (YLHIV)	*SMART Connections*	Facebook-based support group involving daily activities and expert-facilitated discussions.	• Support-group facilitators provided in-person support for HIV+ youth. • Routine clinical care for HIV treatment
Games						

Author(s)	Country	Age of target audience	Characteristics of target audience	Program Name	Treatment details	Non-digital components
54. Chu et al. (2015)	Hong Kong	12-16 years	None	*Making Smart Choices*	A game application (designed for tablets, Facebook, and the Web) was used for sex education and attitudinal change. The app contains 5 ~~mini-games~~mini games based on different scenarios.	None
55. Christensen et al. (2013)	USA	18-24 years	MSM	*Socially Optimised Learning in Virtual Environments (SOLVE)*	A simulation video game designed to reduce shame and unprotected anal intercourse.	None
56. Haruna et al. (2018)	Tanzania	11-15 years	None	None	Intervention 1: Sexual health education delivered using game-based learning in a computer lab. Participants were asked to view the game story and attempt questions related to each topic. Intervention 2: Sexual health education delivered using gamification in a computer lab. Lessons were delivered in a quiz format.	None
57. Whitely et al. (2018)	USA	14-26 years	Youth living with HIV (YLWH)	*BattleViro*	An iPhone game/app with ~~game-~~game-related text messages (sent bi-weekly) and quizzes.	• Medication monitoring device. • Clinical care visits.
58. Fiellin et al. (2017)	USA	11-14 years	None	*PlayForward*	An experimental role-playing adventure video game focused on sexual health and risky behaviours. Participants were asked to engage in two gaming sessions per week, approximately one hour per session, to improve sexual health outcomes.	None
Multi-media						
59. Ezegbe et al. (2018)	Nigeria	14-15 years	None	*REDStory*	HIV/AIDS videos played during group meetings or at home twice a week. Each participant reflected on lessons learned from the video during group meetings. Homework assignments were incorporated into the course.	Group meetings led by a therapist.
60. Solorio et al. (2016)	USA	18-30 years	Latino MSM	*Tu Amigo Pepe*	- Spanish-language radio public service announcements (PSAs) - Website - Social media outreach (Facebook, Twitter) - Reminder system using mobile - Toll-free hotline - Zip code locator to identify nearby HIV testing sites - Two free HIV testing sites	• Print materials, including 100 posters posted in small grocery stores frequented by Latinos. • Free home-based HIV testing kits
61. Sznitman et al. (2010)	USA	14-17 years	~~African-American~~African American	*iMPPACS*	Television and radio advertisements were delivered, averaging at 3 per month, in two cities randomly selected within each of two regionally matched city pairs with the other cities serving as controls.	• ART treatment • Face-to-face small group counselling

Table 2: Overview of Intervention Outcomes

Study Characteristics				Cognitive Outcomes														Behavioural Outcomes						Product/ Service-based					Impact
Author(s)	Research Design	Duration	Sample size	Knowledge about sexual and reproductive health & services	Knowledge about STI/HIV/HPV	Knowledge about contraceptives and condoms	Attitude towards condom use	STI vulnerability/risk/fear	HIV stigma/shame	Self-esteem	Self-efficacy to use condoms and protect from unwanted	Motivation or intention to engage in preventive	Intention to take STI/HIV test	Belief that sexual health services are important	Belief that participants could access sexual health services	Belief that services can be accessed free of charge	Belief that anyone of any age can access services	Abstinence or Monogamy	Multiple sex partners	Self-reported pregnancy	Unsafe sex	Self-care	Partner or peer communication	ART initiation	ART or PrEP adherence	Condom or contraceptive use	STI test or order test-kit online	Service Uptake (clinic visits)	HIV Viral Load (VL)
Mobile Phone (calls or SMS)																													
1. Belzer et al. (2014)	RCT	24 weeks	37																						***				***
2. Bull et al. (2017)	Cluster RCT	26 weeks	852																							*			
3. Gold et al. (2011)	RCT	4 months	7606	*															*							ns	ns		
4. Hacking et al. (2019)	Mixed	8 weeks	40																					***					***
5. John et al. (2016)	Pre/post	6 months	19									***										***						ns	
6. Juzang et al. (2011)	Intervention*	12 weeks	60	* *														**								ns			
7. Lim et al. (2012)	RCT	12 months	994		**																					ns	**		
8. Linnemayr et al. (2017)	RCT	12 months	332																						ns				
9. Liu et al. (2019)	RCT	36 weeks	121																						*				
10. McCarthy et al. (2016)	Pilot RCT	12 months	200																								ns		
11. McCarthy et al. (2018)	RCT	4 months	640																							ns		ns	

Study Characteristics				Cognitive Outcomes														Behavioural Outcomes						Product/ Service-based					Impact
Author(s)	Research Design	Duration	Sample size	Knowledge about sexual and reproductive health & services	Knowledge about STI/HIV/HPV	Knowledge about contraceptives and condoms	Attitude towards condom use	STI vulnerability/risk/fear	HIV stigma/shame	Self-esteem	Self-efficacy to use condoms and protect from unwanted	Motivation or intention to engage in preventive	Intention to take STI/HIV test	Belief that sexual health services are important	Belief that participants could access sexual health services	Belief that services can be accessed free of charge	Belief that anyone of any age can access services	Abstinence or Monogamy	Multiple sex partners	Self-reported pregnancy	Unsafe sex	Self-care	Partner or peer communication	ART initiation	ART or PrEP adherence	Condom or contraceptive use	STI test or order test-kit online	Service Uptake (clinic visits)	HIV Viral Load (VL)
12. Merrill et al. (2018)	Mixed method	5 weeks	394		*				**	**	**												**						
13. Rockicki et al. (2017)	Cluster RCT	12 weeks	756	Ns																Ns									
14. Stankievich et al. (2018)	Sequential prospective study	32 weeks	25																						***				
15. Yao et al. (2018)	Pre/Post	9 months	408			Ns	**					***														**			
16. Ybarra et al. (2018)	RCT	5 weeks	273		Ns							*						Ns								Ns			
Mobile Applications																													
17. Brayboy et al. (2017)	2-phase prospective study	2 weeks	20	Ns																									
18. Dehghani et al. (2016)	Quasi-experiment	2 weeks	200	*			***																						
19. Jeong et al. (2017)	Non-equivalent control group	5 weeks	88		***			***			***	***																	
20. Manlove et al. (2020)	RCT	6 weeks	1304			***					*										***								

Study Characteristics				Cognitive Outcomes														Behavioural Outcomes						Product/ Service-based					Impact
Author(s)	Research Design	Duration	Sample size	Knowledge about sexual and reproductive health & services	Knowledge about STI/HIV/HPV	Knowledge about contraceptives and condoms	Attitude towards condom use	STI vulnerability/risk/fear	HIV stigma/shame	Self-esteem	Self-efficacy to use condoms and protect from unwanted	Motivation or intention to engage in preventive	Intention to take STI/HIV test	Belief that sexual health services are important	Belief that participants could access sexual health services	Belief that services can be accessed free of charge	Belief that anyone of any age can access services	Abstinence or Monogamy	Multiple sex partners	Self-reported pregnancy	Unsafe sex	Self-care	Partner or peer communication	ART initiation	ART or PrEP adherence	Condom or contraceptive use	STI test or order test-kit online	Service Uptake (clinic visits)	HIV Viral Load (VL)
21. Mesheriakova et al. (2017)	Prospective study	6 months	120	***								***																	
22. Nielsen et al. (2019)	RCT	6 months	433																Ns	Ns						Ns	Ns		
23. Jones et al. (2013)	RCT	3 months																			***								
Web- and Online-based																													
24. Bailey et al. (2013)	RCT	5 months																									**		
25. Ballester-Arnal et al. (2015)	Experiments	1 month	239		***			Ns													**					*			
26. Brown et al. (2016)	Pre/post	6 weeks	148											* *	*	*	* *											*	
27. Danielson et al. (2013)	Mixed method	1 month	41		***					Ns	*												Ns						
28. Doubova et al. (2017)	RCT	4 weeks	456		***		***																						
29. Gottvall et al. (2010)	Mixed method	1 day	274		***		Ns																						
30. Horvath et al. (2017)	RCT	1 month	130		**			**					**																

Study Characteristics				Cognitive Outcomes														Behavioural Outcomes						Product/ Service-based					Impact
Author(s)	Research Design	Duration	Sample size	Knowledge about sexual and reproductive health & services	Knowledge about STI/HIV/HPV	Knowledge about contraceptives and condoms	Attitude towards condom use	STI vulnerability/risk/fear	HIV stigma/shame	Self-esteem	Self-efficacy to use condoms and protect from unwanted	Motivation or intention to engage in preventive	Intention to take STI/HIV test	Belief that sexual health services are important	Belief that participants could access sexual health services	Belief that services can be accessed free of charge	Belief that anyone of any age can access services	Abstinence or Monogamy	Multiple sex partners	Self-reported pregnancy	Unsafe sex	Self-care	Partner or peer communication	ART initiation	ART or PrEP adherence	Condom or contraceptive use	STI test or order test-kit online	Service Uptake (clinic visits)	HIV Viral Load (VL)
31. Lustria et al. (2016)	RCT	Not specified	1065					***					***														**		
32. Massey et al. (2013)	Quasi-experiment	2 years	2176	***				***					**																
33. Mevissen et al. (2011)	RCT	3 months	171				Ns	Ns			Ns	* *	Ns													*	Ns		
34. Mortimer et al. (2015)	Non-blinded parallel-group RCT	5 months	747									*	**														*	**	
35. Naar-King et al. (2013)	RCT	12 weeks	76																						**				**
36. Rosser et al. (2010)	RCT	3 weeks	650																		*								
37. Spielberg et al. (2014)	Intervention	3 months	217					***	**										*		***					*			
38. Starling et al. (2014)	Pre/Post	2 days	173				Ns				***	* *														Ns			
39. Villegas et al. (2015)	Pre/Post	1 month	40		***		*				*										**								
Online Education Program																													
40. Carvalho et al. (2016)	RCT	6 weeks	159									I1: **														I1: *** I2: *			

Study Characteristics				Cognitive Outcomes														Behavioural Outcomes						Product/ Service-based					Impact
Author(s)	Research Design	Duration	Sample size	Knowledge about sexual and reproductive health & services	Knowledge about STI/HIV/HPV	Knowledge about contraceptives and condoms	Attitude towards condom use	STI vulnerability/risk/fear	HIV stigma/shame	Self-esteem	Self-efficacy to use condoms and protect from unwanted	Motivation or intention to engage in preventive	Intention to take STI/HIV test	Belief that sexual health services are important	Belief that participants could access sexual health services	Belief that services can be accessed free of charge	Belief that anyone of any age can access services	Abstinence or Monogamy	Multiple sex partners	Self-reported pregnancy	Unsafe sex	Self-care	Partner or peer communication	ART initiation	ART or PrEP adherence	Condom or contraceptive use	STI test or order test-kit online	Service Uptake (clinic visits)	HIV Viral Load (VL)
41. Castillo-Arcos et al. (2016)	Quasi-experiment	Not specified	193								Ns										Ns								
42. Chong et al. (2020)	RCT	6 months	4599		***	***	*												Ns	Ns	Ns					*			
43. Kaufman et al. (2018)	Cluster RCT	Not specified	167					***			***																		
44. Klein et al. (2017)	RCT	2 years	321		Ns		Ns														Ns		*						
45. Marsch et al. (2015)	RCT	6 weeks	141		***						*	Ns									*					***			
46. Scull et al. (2018)	RCT	8 months	184	* *			*					*									**		*						
47. Shafii et al. (2019)	RCT	3 months	242																Ns	Ns	*					**			
48. Widman et al. (2018)	RCT	6 weeks	222		***		***				***	Ns																	
49. Markham et al. (2020)	Intervention	5 years	4531																				**						
50. Peskin et al. (2019)	RCT	2 years	1543		***	***					***	*							Ns		Ns					Ns			
51. Rohrbach et al. (2019)	Quasi-experiment	2 years	50, 766			***					*										Ns					Ns			

Study Characteristics				Cognitive Outcomes														Behavioural Outcomes						Product/ Service-based					Impact
Author(s)	Research Design	Duration	Sample size	Knowledge about sexual and reproductive health & services	Knowledge about STI/HIV/HPV	Knowledge about contraceptives and condoms	Attitude towards condom use	STI vulnerability/risk/fear	HIV stigma/shame	Self-esteem	Self-efficacy to use condoms and protect from unwanted	Motivation or intention to engage in preventive	Intention to take STI/HIV test	Belief that sexual health services are important	Belief that participants could access sexual health services	Belief that services can be accessed free of charge	Belief that anyone of any age can access services	Abstinence or Monogamy	Multiple sex partners	Self-reported pregnancy	Unsafe sex	Self-care	Partner or peer communication	ART initiation	ART or PrEP adherence	Condom or contraceptive use	STI test or order test-kit online	Service Uptake (clinic visits)	HIV Viral Load (VL)
Social Media																													
52. Bull et al. (2012)	Cluster RCT	2 months	652																		*					*			
53. Dulli et al. (2020)	RCT	22 weeks	349		**				Ns																Ns				
Games																													
54. Chu et al. (2015)	Pre/post	1 hour	1176			***																							
55. Christensen et al. (2013)	RCT	3 months	921						*												Ns								
56. Haruna et al. (2018)	RCT	5 weeks	120	***			***					***																	
57. Whitely et al. (2018)	RCT	16 weeks	61		***																				*				*
58. Fiellin et al. (2017)	RCT	6 weeks	333	***			*														Ns								
Multi-media																													
59. Ezegbe et al. (2018)	RCT	8 weeks	80		***			***																					
60. Solorio et al. (2016)	Interventi on	16 weeks	50				*				* *		**													Ns	**		
61. Sznitman et al. (2010)	RCT	16 months	1657								* *								Ns		**								

Note: ***p≤0.001; **p≤0.01; *p≤0.05; ns= non-significant

Table 3. Summary of Outcomes

		Cognitive Outcomes	Behavioural Outcomes	Products/ Service Outcomes	Impact
		Not effective studies, Effective studies[1]			
Digital Tools	Mobile Text and Phone calls	1,7[2]	2,4	7,7	0,2
		0,0[3]	5,11		
	Mobile apps	1,4	1,2	10	0,0
		1,3	1,2		
	Web- and Online-based	0,13	1,4	1,8	0,1
		0,4	2,10		
	Online Education Programs	2,8	4,5	2,4	0,0
		0,2	3,7		
	Social Media	0,1	0,1	1,1	0,0
		0,0	1,1		
	Games	0,5	2,0	0,1	0,1
		0,2	2,1		
	Multimedia	0,3	1,1	0,1	0,0
		0,1	0,2		
Digital tools versus blended	Digital Only	1,27	6,12	8,14	0,2
		1,8	8,23		
	Combination of digital and non-digital	3,14	5,5	4,8	0,2
		0,4	6,11		
Duration of studies	Short (13 and fewer weeks)	2,24	5,10	3,10	0,2
		1,10	6,15		
	Long (14 and longer weeks)	1,14	5,6	9,11	0,2
		0,1	7,17		

[1] Effective at $p<.05$

[2] All studies that measured this particular outcome and reported a level of effectiveness. The total exceeds 61, as most studies measured more than one outcome.

[3] Studies where this outcome was the most advanced measure (according to the persuasion process, behavioural outcomes are more advanced than cognitive outcomes). Only one outcome (the most advanced one) was assigned to each study. Behaviour, its tangible form (product/service) and impact were considered equally advanced. Thus, the total is equal to 61.