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A Systematic Review and Meta-analysis of Gamified Affective Sexual Health Interventions in Schools

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Abstract

Introduction Adolescent sexual education targets risk reduction in STIs, pregnancies, and gender inequality. Inadequacies in traditional methods drive exploration of innovative approaches. This systematic review aims to synthesise, compare, and evaluate gamified affective sexual health interventions for adolescents within the school.

Methods A systematic literature review was conducted across five databases from March 2022, with an update in December 2023, including PubMed, Scopus, PsycINFO, WOS, and EMBASE. Experimental studies of gamified interventions in school-based affective sexual health for adolescents aged 10–19 years were included. Methodological quality was assessed using the Quality Assessment Tool for Quantitative Studies by the Effective Public Health Practice Project. The selected articles were conducted primarily in the USA, encompassing 13 randomised controlled trials, two quasi-experimental studies, and one clinical trial. A subsequent meta-analysis was conducted using the random-effects model to calculate combined effect sizes and 95% confidence intervals (CI).

Results Interventions yielded positive short and long-term impacts, improving attitudes, knowledge, and behaviours, and delaying sexual initiation. Studies revealed a statistically significant effect in follow-ups of less than six months, with 81% of outcomes showing positive impacts on delaying the initiation of any sexual activity and 50% on contraceptive use, knowledge, and improved attitudes. In follow-ups exceeding six months, a consistently positive and significant effect was maintained, ranging between 19% and 62.5%, for the delay in sexual initiation, contraceptive use, knowledge, and attitudes. The results from the meta-analysis indicate that gamified interventions are effective in delaying sexual initiation among adolescents, achieving an 15% reduction in the probability of initiating sexual relationships.

Conclusions To enhance affective sexual health, a recommended methodological framework standardizes the design of universal interventions, enabling comprehensive effectiveness analysis. Emphasizing the encouragement of early initiation of interventions, adopting technological advances to enhance traditional education and address contemporary challenges in adolescent sexual health is highlighted.

Policy Implications Sex education is essential to prevent risky behaviours, unwanted pregnancies, and STIs. This requires effective educational programmes that improve knowledge, skills, attitudes, and behaviours in a standardised way that is accessible to all adolescents.

Keywords Adolescents · Gamification · Game-based Intervention · Sexual behaviour · Sexually transmitted disease · Health education · Sex education

Introduction

Adolescence is characterised by a period of transition marked by significant physical, psychological, emotional, and social changes. The extent and nature of these changes vary according to a multitude of factors, including individual learning, social environment, community, family, beliefs, values, and the education received (Simanjuntak et al., 2023). One of the most pronounced aspects of adolescence is the exploration of one's sexuality. During this stage, when a person's identity and new experiences are created, sexuality, an inherent aspect of human nature, can be perceived and experienced differently based on the information received and the experiences acquired (Temple-Smith et al., 2015).

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A cross-national study conducted by the World Health Organisation (WHO) in Europe and Canada revealed that one in four boys and one in seven girls had started sexual intercourse (SR) at the age of 15. Furthermore, boys were more likely to initiate SR compared to girls. Lastly, condom use showed a decline between 2014 and 2018, with fewer than two-thirds of sexually active adolescents using condoms during the most recent SR (Inchley et al., 2018). In 2019, according to the youth risk behaviour survey, in the USA, 27.4% of high school students reported having SR, with 46% of them not using a condom (Szucs et al., 2022). Sexually transmitted infections (STIs) represent a significant public health problem. In 2020, the WHO (World Health Organization, 2023) estimated that there were 374 million new cases of STIs, including chlamydia (129 million), gonorrhoea (82 million), syphilis (7.1 million), and trichomoniasis (156 million). Furthermore, in 2016, genital herpes infections exceeded 490 million, and 300 million women were infected with human papillomavirus (HPV) (World Health Organization, 2023). In the USA, the incidence of STIs is increasing, and the Centres for Disease Control and Prevention (CDC) (Szucs et al., 2022) estimates that, in 2020, 53% of these cases were among adolescents and young adults aged 15–24 years. There are differences by race/ethnicity, with 32% of cases of chlamydia, gonorrhoea, and syphilis diagnosed in non-Hispanic blacks, and a higher prevalence observed in men who have sex with men. Moreover, according to 2018 surveillance data from the European Union/European Economic Area (EU/EEA) (Andreasen et al., 2021), chlamydia is the most frequently reported STI in Europe (406,406 cases, a notification rate of 146 per 100,000 population), followed by gonorrhoea (100,673 cases, 26 per 100,000 population), and syphilis (33,927 cases, 7 per 100,000 population). In 2021, 16,624 new HIV diagnoses were reported in 29 countries in Europe, with young people aged 15–24 years representing 10% of these diagnoses (Ecdc & Who, 2022). Finally, in 2019, the report "Adding It Up" revealed that adolescents aged 15–19 years who lived in 132 lower-middle socioeconomic countries experienced 21 million pregnancies annually, approximately half of which were unintended. One of the reasons for intended or not pregnancies is the lack of knowledge of obtaining and using contraceptive methods correctly, as well as difficult access to them (Sully et al., 2020).

This review focuses on sexual health education. According to the WHO (World Health Organization, n.d.-b), sexuality is *"…a state of physical, emotional, mental, and social well-being in relation to sexuality; it is not merely the absence of disease, dysfunction, or infirmity. Sexual health requires a positive and respectful approach to sexuality and sexual relationships, as well as the possibility of having pleasant and safe sexual experiences, free from coercion, discrimination, and violence. To achieve and maintain sexual health, the sexual rights of all people must be respected, protected, and fulfilled."* Therefore, it is essential to achieve comprehensive sexual education as a teaching and learning process that goes beyond imparting knowledge about reproduction, human anatomy or physiology, STIs, and pregnancy, but taking into account cognitive, emotional, physical, and social aspects of sexuality based on a curriculum to provide knowledge and tools that allow adolescents to make safe and informed decisions about their sexuality based on empowerment, values, and beliefs rooted in gender equality and human rights (UNESCO et al., 2021). However, despite the traditional education offered in schools, often conditioned by the curricula imposed by different governments, there is a growing prevalence of STIs and unintended pregnancies among young people (Leung et al., 2019). Traditional education provided has not been able to prevent STIs and unwanted pregnancies among the youngest (Haruna et al., 2018).

Gamification in education involves the incorporation of elements of game design into the educational context to improve the teaching and learning process. It is perceived as a motivating didactic strategy in the teaching–learning process (Dicheva et al., 2015). On the contrary, serious games are those specifically designed for educational purpose. Game-based learning, on the other hand, involves the use of existing games adapted for instructional use (de Monterrey, 2016). In the review conducted by Dicheva et al. (2015), no established classification for the elements of the game to be used in gamified interventions was found, given the range of possibilities. However, the most used elements of the game include mechanics, dynamics, components, aesthetics, and emotions. Mechanics refers to those rules, context, boundaries, objectives, environment, and interactions that remain constant throughout the game. Dynamics are based on the player's behaviour during the gameplay. The components consist of points or badges that players can earn. Lastly, instead of aesthetics, the component of emotions will be the result of mechanics and dynamics — in short, how players react to the game, be it amusement, disappointment, amazement, etc. (Wiklund & Wakerius, 2016).

This educational approach improves learning by increasing motivation, cooperation, and participation, as students strive to achieve set objectives, create challenges for themselves or compete against opponents, and enjoy the learning process (Chen et al., 2020; Chu et al., 2015; Fiellin et al., 2017). Gamification can also promote self-knowledge, improve knowledge retention, create a secure learning environment, and provide feedback to students through the game. It also contributes to changes in behaviour and the improvement of skills that contribute to healthy decisions (Huang et al., 2020; Kim & Castelli, 2021).

An important aspect to highlight is the confidentiality, which enables play and free expression of opinions, fostering

trust with adolescents, particularly in environments where the topic of sexuality is considered taboo. Therefore, the use of gamification can serve as an engaging and motivating educational tool for sexual health education (Haruna et al., 2018).

The objective of this systematic review is to review, synthesise, and evaluate existing research on gamification and serious games-based sexual education interventions to improve adolescents' knowledge, attitudes, intention, and behaviours and how they have been implemented. This could be useful in generating effective interventions on sexuality in schools. The review question was as follows: Are gamification interventions effective in preventing risky sexual behaviours and improving knowledge in adolescents?

Method

The systematic review was conducted based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) standardised reporting guidelines (Page et al., 2021). This systematic review has been registered on PROSPERO under ID: CRD42022318541.

Eligibility Criteria

To be considered for inclusion in this review, studies had to meet specific criteria.

Design

Studies were required to be experimental studies, which included randomised controlled trials (RCTs), controlled trials, and quasi-experimental trials. Additionally, the research articles had to involve adolescents in the age range of 10 to 19 years, who received gamification-based interventions within a school setting and were assessed for their efficacy. There were no restrictions on language and year of publication. On the other hand, we excluded position papers, editorial letters, viewpoints, or review protocols, as well as articles that did not pertain to the topic under investigation or those involving participants with disabilities requiring specific treatments.

Population

The target population should be adolescents 10–19 years of age, as established by the WHO as the stage of adolescence (World Health Organization, n.d.-a).

Intervention

The main intervention should be sex education gamification interventions using techniques such as serious games, escape rooms, virtual reality, board games, and applications such as ClassDojo, Socrative, Kahoot!, ClassCraft, and Moodle. Interventions could be online or face-to-face.

Outcomes

As primary outcomes, we will include behaviours (delayed initiation of any type of sex and use of contraceptives). As secondary outcomes, we review knowledge, attitudes, and intentions or self-efficacy in preventing sexual risk behaviours in adolescents.

Search Strategy and Information Sources

The following five databases were peer reviewed on March 2022, and the search was finally updated on December 2023: PubMed, Scopus, PsycINFO, WOS, and EMBASE. References were also retrieved from all articles selected for review. The search strategy was developed following the PICO structure. To select the key words, an initial search was carried out in different review documents of similar subject matter to obtain a better overview of the topic to be addressed. Subsequently, a specialised thesaurus was consulted (Mesh and PsycINFO thesaurus). Finally, a specialised librarian was consulted. (Adolescen* OR student* OR teen* OR "school age" OR minor*) AND (gamification OR "serious gam*" OR "Game-based learning" OR "Game-based intervention*" OR game* OR "video game*" OR "gamified instruction" OR "games-based" OR "digital game*") AND ("sexual behavior*" OR "sexual health" OR "STD" OR "sexually transmitted disease*" OR "sexual and reproductive health" OR "HIV" OR "pregnancy, unwanted" OR "sex offence*") AND (intervention* OR "sex education" OR "health education" OR program* OR prevention OR "health promotion").

Selection Process

The articles selected from the five databases were reviewed by two independent reviewers (AS and AA) after exclusion of duplicates by examining the titles and abstracts of the studies. Independent reviewers (AS and AA) examined the full text of the selected studies. Discrepancies were resolved by discussion and, if necessary, reviewed by a third reviewer (ML). Subsequently, new full-text articles were re-reviewed by independent reviewers (AS and AA).

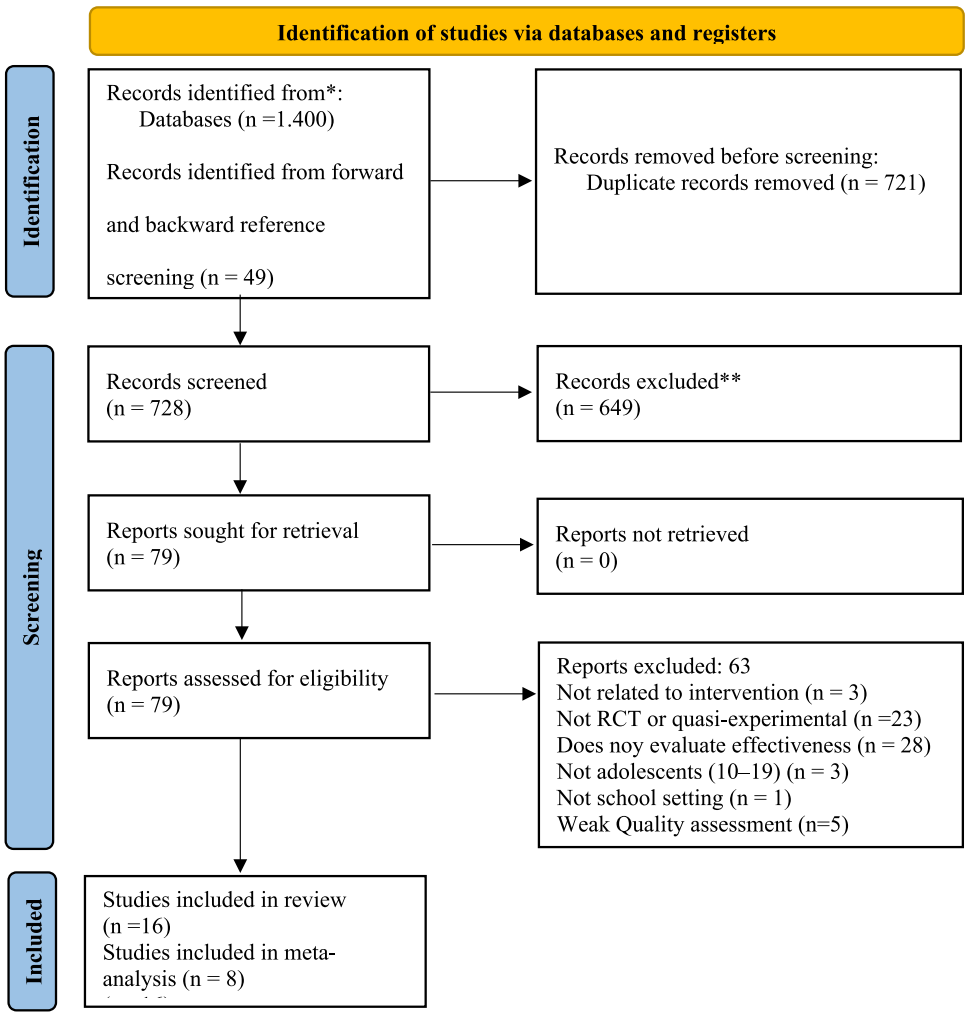

Fig. 1 Flowchart for the selection of articles for the systematic review

The data extraction procedure is represented by a PRISMA flow chart in Fig. 1.

Data Collection Process and Analysis

Data extraction was conducted by two of the study authors (AS and AA) using a custom-made form within a Google spreadsheet, following consensus among the team members. The tables were organised based on projects, as several articles pertained to the same project. Table 1 provides the characteristics of the study, including details about the study design, country, population, sample size, follow-up duration, included outcomes, and main effects of the intervention (only those with $p < 0.05$). Cohen's d was calculated when possible, considering 0.2 low, 0.5 moderate, and 0.8 large effects as a measure of effect size. On the other hand, when offered in the results, the odds ratio was used to see the probability of occurrence, considering 1.50 low, 3.50 moderate, and 9.00 large effects. Table 2 provides a concise summary of the positive or negative effects of interventions on primary outcomes (SR and contraceptive use) and secondary outcomes (knowledge and attitudes) in two distinct timeframes: less than six months and more than six months. Any data that were not explicitly described in the source material were categorised as "not described". Table 3 shows the characteristics of the intervention; objective; context (population, place of implementation, and school year); facilitators; explanation of the intervention; material and resources used; conceptual framework; number, frequency, and duration of the sessions; and content of the activities.

Study Risk of Bias Assessment

The methodological quality of the included studies was evaluated using the Quality Assessment Tool for Quantitative Studies developed by Effective Public Healthcare Panacea Project. (2022) as it is a quality tool to perform systematic reviews as it can be adapted to different types of designs. The quality assessment items were selection bias, study design, confounders, blinding, data collection methods, and withdrawal/dropout. It was evaluated by two independent reviewers (AS and AA), and discrepancies were resolved by

Table 1 Characteristics of studies included

Intervention and project	Study characteristics: Design; Country; Population; Sample & follow-up; Outcomes	Main effects	Risk of bias
Computer- and Internet-based intervention Roberto et al. (Roberto et al., 2007a, 2007b)	Quasi-experimental research. EG & CG. USA; 9 schools. Pre-test at baseline and post-test at the end of the intervention: 550 (EG), 337 (CG). Retention rate: 51% and 73% of the participants. Mean age (SD): EG 14.49 (0.63), CG 14.37 (0.58). EG 54.9%♀, 45.1%♂; CG 51.9%♀, 48.1%♂ Outcomes: Knowledge, Condom self-efficacy Attitude toward waiting, Condom negotiation, Situational self-efficacy, Refusal self-efficacy, Susceptibility (pregnancy), Susceptibility (STDs), Susceptibility (HIV), Severity (pregnancy)	A two-way mixed-model repeated-measures analysis of variance with condition (experimental/control) as an independent group factor and time (pre-test/post-test) as a within-subjects factor revealed the program's effects on various factors. These effects were observed in knowledge (EG Mean = 4.29, CG Mean = 4.10, (d = 0.1279, $p < 0.05$, 95% CI (−0.0078, 0.26)), condom self-efficacy (EG Mean = 4.25, CG Mean = 4.23, d = 0.1878, $p < 0.01$, 95% CI (0.05, 0.32)), attitudes towards waiting to have sex (EG Mean = 3.42, CG Mean = 3.35, (d = 0.1124, $p = 0.05$, 95% CI (−0.02, 0.248)) and perceived increased susceptibility on HIV (EG Mean = 1.82, CG Mean = 1.63, d = 0.1647, $p < 0.02$, 95% CI (0.0289, 0.30))	Strong
Computer- and Internet-based intervention **Roberto et al.** (Roberto et al., 2007a, 2007b)	RCT. EG & CG. USA; 10º grader; 2 schools. Pretest and post-test (approximately 10 weeks after the intervention finished): 139 (EG), 187 (CG). Retention rate: not described. Mean age (SD): EG 15.50 (0.63), CG 15.68 (0.73). EG 55.1%♀, 44.9%♂, CG 58.3%♀, 41.7%♂ Outcomes: knowledge, condom self-efficacy, attitude toward waiting, condom negotiation, situational self-efficacy, refusal self-efficacy, susceptibility (pregnancy), susceptibility (STDs), susceptibility (HIV), severity (pregnancy). Number partners in the last 4 months, initiation of sexual activity and condom use in the last intercourse (the two latter between those that were sexually active)	A two-way mixed-model repeated-measures analysis of variance with condition (experimental/control) as an independent groups factor and time (pre-test/post-test) as a within-subjects factor revealed the program's effects on various factors. These effects were observed in knowledge (EG Mean = 7.96, CG Mean = 6.60, d = 0.6195%, $p < 0.001$, CI (0.39, –0.83)), condom negotiation (EG Mean = 4.44, CG Mean = 3.98, d = 0.24, $p < 0.05$, 95% CI (0.02, –0.46)), attitudes towards waiting to have sex (EG Mean = 3.71, CG Mean = 3.44, d = 0.19, $p < 0.05$, 95%CI (−0.03–0.41)), situational self-efficacy (EG Mean = 4.05, CG Mean = 3.64, d = 0.23, $p < 0.05$, 95% CI (0.006–0.45)) and susceptibility (EG Mean = 1.63, CG Mean = 1.86, d = 0.20, $p < 0.01$, 95% CI (−0.02–0.42)) Logistic regression was used to assess the impact of the intervention on the initiation of sexual activity using only individuals who were not already sexually active at Time 1 (231 subjects [74.4% EG; 72.9% CG]), with a main effect for condition ($p < 0.01$, 33 (18%) In the control group, 33 (18%) students initiated sexual activity between the pretest and the post-test, while in the experimental group, 10 (8%) students did so, resulting in an odds ratio (OR) of 2.93	Strong
Computer- and Internet-based intervention **Roberto et al.**(Roberto et al., 2008)	RCT. EG & CG. USA; 10º grader; 2 schools. Pretest and post-test (3 weeks after the intervention/12 weeks from pretest): 147 (EG), 191 (CG). Retention rate: not described. Mean age (SD): EG 15.25 (0.54), (CG) 15.23 (0.56). EG 56,7%♀ 43,3%♂, CG 45,9%♀, 54,1%♂ Outcomes: knowledge, susceptibility, condom efficacy, condom negotiation, situational efficacy, refusal efficacy, attitude toward waiting	A mixed-model two-way repeated-measures ANOVA, with treatment condition (experimental/control) as an independent groups factor, and time (pre-test/post-test) as a within-subjects factor showed the effect of the intervention on several outcomes. Specifically, the intervention led to higher levels of knowledge (EG Mean = 8.47, CG Mean = 6.35, d = 0.90, $p < 0.001$, 95% CI (0.67–1.13)), greater condom negotiation (EG Mean = 4.40, CG Mean = 4.00, d = 0.19, $p < 0.05$, 95% CI (–0.02–0.41)), greater condom efficacy (EG Mean = 4.21, CG Mean = 4.08, d = 0.20, $p < 0.05$, 95% CI (−0.02–0.41)) and more favourable attitudes toward waiting to have sex (EG Mean = 3.81, CG Mean = 3.48, d = 0.21, $p < 0.05$, 95% CI (−0.01–0.43)) compared to the control school	Strong

Table 1 (continued)

Intervention and project	Study characteristics: Design; Country; Population; Sample & follow-up; Outcomes	Main effects	Risk of bias
It's Your Game: Keep It Real (IYG) **Tortolero et al.** (Tortolero et al., 2010)	RCT. EG & CG. Texas; 12 schools: 7th, 8th and 9th grade. Pretest at baseline and post-test at 24 months of follow up: 349 (EG), 558 (CG). Retention rate: 7th grade 83%, 8th grade 68%. Mean Age (SD): 13.0 (0.54). 59.1%♀, 40.9%♂ Outcomes: **Psychosocial:** General Beliefs, Perceived Friends' Beliefs, Perceived Friends' Sexual Behaviour, Self-Efficacy, Knowledge, Exposure to Risky Situations, STI Signs and Symptoms, Intentions **Reported Sexual Behaviours:** Ever had sex, Sex in past 3 months, Oral sex (Ever had oral sex, Oral sex in past 3 months), Vaginal sex (Ever had vaginal sex, Vaginal sex in past 3 months, Condom at last vaginal sex, Unprotected vaginal sex past 3 months, Unprotected vaginal sex with ≥ 1 partners past 3 months), Anal sex (Ever had anal sex, Anal sex in past 3 months, Unprotected anal sex last 3 months)	A multivariate analysis controlling for confounding factors revealed significant program effects on sexual behaviour. By the 9th month follow-up EG had a lower likelihood of initiating sex compared to CG (CG 29.9%, EG 23.4%, ARR 1.29, (95% 1.02, CI 1.64)), and this effect was particularly significant for Hispanic participants (CG 27.8%, EG 17.4%, ARR 1.64, (95% 1.09, CI 2.47)) and females (CG 26.1%, EG 18.5%, ARR 1.42, 95% (CI 1.01, 2.01)) with $p<0.05$. For the different types of sex, an effect was observed in oral sex in general (GC 17.6%, EG 10.0%, ARR 1.76, 95% CI (1.21, 2.56), $p<0.01$), in African Americans (GC 17.7%, EG 9.5%, ARR 1.84, 95% CI (1.04, 3.25), $p<0.05$) and females (GC 12.8%, EG 5.5%, ARR 2.14, 95% CI (1.12, 4.09), $p<0.05$). For vaginal sex an effect was observed in Hispanics (GC 24.1%, EG 4.8%, ARR 1.67, 95% CI (1.06, 2.62), $p<0.05$), and for anal sex in general (GC 9.9%, EG 3.7%, ARR 2.67, 95% CI (1.45, 4.94), $p<0.01$), in African American race (GC 11.9%, EG 3.3%, ARR 3.12, 95% CI (1.21, 8.06), $p<0.05$), males (GC 16.3%, EG 7.5%, ARR 2.31, 95% CI (1.13, 4.72), $p<0.05$), and females (GC 5.8%, EG 1.5%, ARR 3.90, 95% CI (1.16, 13.13), $p<0.05$). And the effect in the last 3 months for sexual intercourse was significant for the variable number of times had sex in the last 3 months: 2 or more vs. 1 in vaginal sex (ARR 1.30, (95% 1.02, CI 1.66)) with $p<0.05$. An effect on the beliefs about abstinence until marriage was found at 8th grade (EG Mean = 2.78 (SD 0.70), GC Mean = 2.63 (SD = 0.74), ADM = 0.17, d = 0.2083, $p<0.01$ and 9th grade (EG Mean = 2.75 (SD 0.69), GC Mean = 2.65 (SD = 0.73), ADM = 0.12, d = 0.1408, $p<0.01$), perceived friends' beliefs about waiting to have sex at 8th grade (EG Mean = 2.47 (SD 0.71), GC Mean = 2.35 (SD = 0.69), ADM = 0.17, d = 0.1714, $p<0.01$), perceived friend's sexual behavior at 9th grade (EG Mean = 1.77 (SD 0.74), GC Mean = 1.83 (SD = 0.69), ADM = −0.09, d = −0.0839, $p<0.01$), self-efficacy to refuse sex at 8th grade (EG Mean = 3.07 (SD 0.85), GC Mean = 2.97 (SD = 0.86), ADM = 0.11, d = 0.117, $p<0.01$), condom knowledge at 8th grade (EG Mean = 2.58 (SD 0.71), GC Mean = 2.04 (SD = 1.01), ADM = 0.53, d = 0.6186, $p<0.01$) and 9th grade (EG Mean = 2.41 (SD 0.79), GC Mean = 2.25 (SD = 0.95), ADM = 0.16, d = 0,1831 $p<0.01$), perceived friends' beliefs about condom at 9th grade (EG Mean = 3.32 (SD 0.64), GC Mean = 3.21(SD 0.68), ADM = 0.12, d = 0.1666, $p<0.01$), self-efficacy to use condoms 8th grade (EG Mean = 2.51 (SD 0.39), GC Mean = 2.37(SD 0.44), ADM = 0.12, d = 0.1202, $p<0.01$), exposure to risky situations at 8th grade (EG Mean = 0.75 (SD 0.65), GC Mean = 0.82 (SD = 0.6 9), ADM = −0.10, d = −0.1044, $p<0.05$) and 9th grade (EG Mean = 0.86 (SD 0.86), GC Mean = 0.96 (SD = 0.91), ADM = −0.12, d = −0.113, $p<0.05$), STI signs/sx knowledge at 8th grade (EG Mean = 0.83 (SD 0.24), GC Mean = 0.78 (SD = 0.26), ADM = 0.10, d = 0.1998, $p<0.01$) and 9th grade (EG Mean = 0.82 (SD 0.18), GC Mean = 0.76 (SD = 0.20), ADM = 0.05, d = 0.3154, $p<0.01$), HIV/STI knowledge at 8th grade (EG Mean = 0.82 (SD 0.21), GC Mean = 0.65 (SD = 0.29, ADM = 0.17, d = 0.6715, $p<0.01$) and 9th grade (EG Mean = 0.80 (SD 0.24), GC Mean = 0.70 (SD = 0.29), ADM = 0.10, d = 0.3757, $p<0.01$), reasons not to have sex at 8th grade (EG Mean = 4.87 (SD 2.45), GC Mean = 4.29 (SD = 2.49, ADM = 0.71, d = 0.2348, $p<0.01$), intention oral in next year at 8th grade (EG Mean = 1.97(SD 1.26), GC Mean = 2.14 (SD = 1.24, ADM = −0.24, d = −0.136, $p<0.01$), intention abstinent thru high school at 8th grade (EG Mean = 3.16 (SD 1.44), GC Mean = 2.89 (SD = 1.41, ADM = 0.31, d = 0.1895, $p<0.01$)	Strong
It's Your Game: Keep It Real (IYG) **Markham et al.**(Markham et al., 2012)	RCT. EG1 (RA), EG2 (RR) & CG. USA; 15 middle schools: 7th, 8th, 9th graders; Pre-test at baseline and post-test 16-month-follow-up: 462 (EG1), 359 (EG2) and 435 (CG). Retention rate: 9th: 76,5%. Mean age (SD): 12.6 (0.76). 59.8%♀, 40.2% ♂ Outcomes: Delayed sexual initiation, Number of sexual relations in the last 3 months, unprotected sexual relations, Number of sexual partners in the last 3 months, Number of partners in the last 3 months Psychosocial: STI/HIV knowledge, condoms; Self-efficacy to expect or refuse sex, condom use; Perceived beliefs about friends and sexual relationships; Intention to have sex or not to have sex, condom use, STI testing; Beliefs about condoms; Communication with parents	Multivariate analysis of variance demonstrated efficacy in delaying sexual initiation for the "RA" and "RR" vs. CG groups. In the "EG RA" the Hispanic group was less likely to initiate any sexual activity (AOR 0.40, 95%CI 0.19, 0.86) with $p<0.05$, and there were no significant changes by sex. For oral sex, women were less likely to initiate sex (AOR 0.56, 95% CI (0.32, 0.97)) with $p<0.05$, no change by race. In the case of vaginal sex, Hispanics were less likely to initiate (AOR 0.39, 95% CI (0.18, 0.88)) with $p<0.05$, no changes by sex were observed. In the "EG RR" for any sexual initiation was less likely in general (AOR 0.65, 95% CI (0.54, 0.77)) with $p<0.01$. It showed improvement in African American (AOR 0.38, 95% CI (0.18, 0.79)) with $p<0.05$ and women (AOR 0.43, 95% CI (0.31, 0.60)) with $p<0.01$. For oral sex women were less likely to initiate (AOR 0.44; 95% CI (0.26, 0.75)). For vaginal sex improved overall (AOR 0.64, 95% CI (0.45, 0.93)) with $p<0.05$, in African Americans (AOR 0.32, 95% 0.15, CI 0.67) with $p<0.01$ and women (AOR 0.45, 95% CI (0.30, 0.67)) with $p<0.01$. For the variable unprotected sex at last vaginal intercourse, "RA" and "RR" were less likely to perform (RA: AOR 0.70, 95% CI (0.52, 0.93), $p<0.05$; RR: AOR 0.67, 95% 0.47, CI 0.96, $p<0.05$). To have sex in the next 3 months, were less likely "RR" group for vaginal and anal sex respectively (AOR 0.73, 95% CI (0.53, 1.00), $p<0.05$) (AOR 0.53, 95% CI (0.33, 0.84), $p<0.01$). Having sex without a condom was less likely in RR (AOR 0.59, 95% (CI 0.36, 0.95), $p<0.05$)	Moderate

Table 1 (continued)

Intervention and project	Study characteristics: Design; Country; Population; Sample & follow-up; Outcomes	Main effects	Risk of bias
It's Your Game: Keep It Real (IYG) **Potter et al.** (Potter et al., 2016)	Controlled clinical trial. EG & CG. Carolina del Sur; 24 schools: 7th, 8th and 9th grade. Pre-test at baseline and post-test at 0 to 6 months after, 12 and 18 months after: 1775 (EG), 1469 (CG). Retention rate: 8th: 86.7% EG and 89.1% CG; 9th: 78.7% EG and 79.7% CG. Mean Age (SD): EG 12.7 (0.5), CG 12.8 (0.5). 8th grade EG 54.5%♀, 45.5%♂, CG 51.4%♀, 48.6%♂, 9th grade EG 54%♀, 46%♂, CG 52.5%♀, 47.5%♂ Outcomes: Behavioural (Initiation of vaginal sex, Had vaginal sex in past 3 months). Psychosocial: general beliefs about waiting to have sex or not having sex, condom knowledge, perceived friends' beliefs about sex and condoms, general knowledge about condoms and STI, perceived self-efficacy about sex and use of condoms, personal limits about communication, intentions to have sex and exposure to risky situations	Multilevel logistic regression analysis demonstrated the program's effect on psychosocial variables in 8th and 9th grade but not on behavioural outcomes. In 8th grade, it was statistically significant for the variables: "number of reasons to not have sex" (d = 0.10, $p < 0.05$, b = 0.32; 95% CI (0.08, 0.56)), "general condom knowledge" (d = 0.33, $p < 0.001$, b 95% CI 13.06 (9.97, 16.15), "general HIV/STI knowledge" (d = 0.28, $p < 0.001$, b 95% CI 9.23 (6.56, 11.89), "knowledge of STI signs and symptoms" (d = 0.11, $p < 0.05$, b 95% CI 3.67 (0.85, 6.49), "obtain and correctly use condoms" (d = 0.21, $p < 0.001$, b 95% CI 0.23 (0.14, 0.32), "know how far I would go sexually and be able to communicate this to partner" (d = 0.22, $p < 0.001$, b 95% CI 0.29 (0.19, 0.40), "I know what I think about condom use and can communicate it to my partner" (d = 0.13, $p < 0.01$, b 95% CI 0.12 (0.04, 0.19). In 9th grade the following variables showed statistically significant effects: "general condom knowledge" (d = 0.11, $p < 0.05$, b 95% CI 5.72 (1.24, 10.20), "general HIV/STI knowledge" (d = 0.12, $p < 0.05$, b 95% CI 4.68 (1.38, 7.98), "obtain and correctly use condoms" (d = 0.16, $p < 0.001$, b 95% CI 0.13 (0.06, 0.19), "know how far I would go sexually and be able to communicate this to partner" (d = 0.15, $p < 0.001$, b 95% CI 0.18 (0.08, 0.28)	Strong
It's Your Game: Keep It Real (IYG) **Rohrbach et al.** (Rohrbach et al., 2019)	Quasi-experimental research. EG & CG. Los Angeles; 10 schools. Pretest at baseline and post-test at 24 months of follow up: Assignment to treatment groups is not described. Retention rate: 86,1%. Mean age (SD): EG 15.0 (0.38), CG 15.1 (0.37). EG 49.1%♀, 50.9%♂; CG 49.5%♀, 50.5%♂ Outcomes: Primary: Lifetime sexual behaviours (Have you ever had any sex? ever had oral sex, ever had vaginal sex, ever had anal sex); Recent sexual behaviours (Sex, Oral sex, Vaginal sex, Anal sex, in the last 3 months); Condom/contraceptive use (Condom use at last vaginal/anal intercourse, Unprotected vaginal/anal intercourse in last 3 months,); Lifetime pre-sexual behaviours (Have you ever been alone on a date? Have you ever had a boyfriend or girlfriend? Ever touched private parts or been touched) Psychosocial: Information; Motivation, Beliefs and Reasons, Perceived friends' acceptability and prevalence of sexual behaviour, Personal acceptability of teen sex); Behavioural skills (Personal limits, Self-efficacy, Quality of friendships); Behavioural skills (Quality of dating relationships, Exposure to risky situations)	Multivariate analysis controlling for confounding found that EG who was significantly less likely to report having had any sex (AOR 0.77, 95% CI 0.66, 0.90, $p < 0.001$), oral sex (AOR 0.81, b 95% CI (0.68, 0.97), $p < 0.05$), and vaginal sex (AOR 0.75, b 95% CI (0.63, 0.89), $p < 0.001$). They were also less likely to report having had sex (AOR 0.77, b 95% CI 0.63 0.95, $p < 0.05$), oral sex (AOR 0.75, b 95% CI (0.59, 0.96), $p < 0.05$), and vaginal sex (AOR 0.73, b 95% CI (0.59, 0.92), $p < 0.01$) in the past 3 months than CG. Additionally, the EG was more likely to report condom use at last anal intercourse (AOR 1.86, b 95% CI (1.07, 3.25), $p < 0.05$), and less likely to report lifetime presexual behaviours, such as being alone on a date (AOR 0.85, b 95% CI (0.75 to 0.95)), $p < 0.01$), having a boyfriend or girlfriend (AOR 0.80, b 95% CI (0.69 to 0.94, $p < 0.01$), and having touched someone's private parts or had their private parts touched (AOR 0.83, b 95% CI (0.73 to 0.94), $p < 0.01$). For the psychosocial variables, statistically significant improvements were obtained for knowledge of condoms (EG M/SD (0.71/0.25); GC M/SD (0.63/0.25), AMD 0.09, 95% CI (0.05, 0.13)), beliefs about the importance of abstinence (EG M/SD (1.97/0.74); GC M/SD (1.85/0.74), AMD 0.11, b 95% (CI 0.06, 0.17)), reasons for not having sex (EG M/SD (4.44/2.36); GC M/SD (4.00/2.37), AMD 0.44, b 95% CI (0.25, 0.63)), Perceived friends' acceptability of teen sex (EG M/SD (1.39/0.61); GC M/SD (1.50/0.60), AMD − 0.11, b 95% CI (− 0.16, − 0.06)), perceived prevalence of friends' sexual behaviour (EG M/SD (1.50/0.80); GC M/SD (1.65/0.76), AMD − 0.15, b 95% CI (− 0.22, − 0.08)), perceived prevalence of teen sexual behaviour (EG M/SD (1.91/0.72); GC M/SD (2.02/0.70), AMD − 0.10, b 95% CI (− 0.17, − 0.04)), personal acceptability of teen sex (EG M/SD (1.22/0.61); GC M/SD (1.30/0.63), AMD − 0.08, b 95% CI (− 0.13, − 0.02)) whit $p < 0.001$. The EG group had better outcomes on personal limits (EG M/SD (2.21/1.05); GC M/SD (2.11/1.05), AMD 0.10, b 95% CI (0.02, 0.18), $p < 0.01$), self-efficacy to refuse sex (EG M/SD (2.18/0.80); GC M/SD (2.13/0.78), AMD 0.05, b 95% CI (− 0.01, 0.11), $p < 0.05$), exposure to risky situations (AOR 0.70; b 95% CI (0.59, 0.82)), and quality of dating relationships (AOR 1.44; b 95% CI (1.16, 1.81))	Moderate
It's Your Game: Keep It Real (IYG) **Peskin et al.**(Peskin et al., 2019)	RCT. EG & CG. Texas: 7th and 8th grade; 10 school. Pre-test at baseline and post-test at 12, 24 follow up: 804 (EG), 739 (CG). Retention rate: 12 months 83%; 24 months 75%. Mean age (SD): 12.99 (0.57). 54.7%♀, 45.3%♂ Outcomes: sexual initiation (vaginal or oral sex; vaginal sex only; oral sex only), other sexual risk behaviours among sexually active youth in the last 3 months (had sex without a condom; Had sex without an effective contraceptive method; Number of times had sex; Number of sexual partners; Number of times used drugs or alcohol before having sex). Used an effective contraceptive method at last intercourse Psychosocial: Knowledge, Normative beliefs, perceived self-efficacy (Refraining from sex, negotiating condom use with a partner, to obtain and correctly use condoms), Personal boundaries, environmental factors, Intentions, Exploratory outcomes (Heard about HPV, heard about HPV shots/vaccines, ever received HPV shots/vaccines, Perception of alcohol use of best friends)	The multilevel regression analysis revealed significant effects on psychosocial outcomes in both 8th and 9th grades for knowledge variables related to sexual health, including: general knowledge about condoms (d = 0.29, $p < 0.001$, d = 0.22, $p < 0.001$ respectively); general knowledge about HIV/STIs (d = 0.28, $p < 0.001$, d = 0.36, $p < 0.001$ respectively); knowledge of signs and symptoms of STIs (d = 0.31, $p < 0.001$, d = 0.015, p 0.007 respectively); Additionally, exploratory outcomes showed significant improvements, including: heard about HPV (AOR = 2.22, $p < 0.001$, AOR = 1.44, p 0.005 respectively); heard about HPV injections/vaccines (AOR = 1.45, p 0.01, AOR = 1.33, p 0.04). However, for the following variables, the significant effects were observed only in 8th grade: normative beliefs: to have waited to have sex as an adult (d = 0.14, p 0.02), how many other teens their age are having sex (d = 0.16, p 0.003), Perceived self-efficacy: negotiating condom use with a partner (d = −0.11, p 0.047), to obtain and correctly use condoms (d = 0,26, $p < 0.001$). Personal limits: knowing how far I would go sexually and being able to communicate this to a partner (d = 0.11, p 0.04). Intentions: having sex in the next year if I have the chance (d = − 0.13, p 0.04, using an effective contraceptive method if having sex in the next year (d = 0.14, p 0.02)	**Strong**

Table 1 (continued)

Intervention and project	Study characteristics: Design; Country; Population; Sample & follow-up; Outcomes	Main effects	Risk of bias
It's Your Game: Keep It Real (IYG)-Tech **Peskin et al.** (Peskin et al., 2015)	RCT. EG & CG. Desing: Texas; 19 schools. Pre-test at baseline and post-test 1-year follow-up: 768 (EG), 606 (CG). Retention rate: 12 months 90%. Mean age (SD): 14.3 (0.59). 59%♀, 41%♂ Outcomes: initiation of sexual activity (any sex, oral sex, vaginal sex, and anal sex). Psychosocial: Beliefs about abstinence, Beliefs about waiting to have sex until marriage, Friends' beliefs about abstinence, Perceptions of friends' behaviour, Reasons against having sex, Refusal self-efficacy, Condom knowledge, Condom beliefs, Condom negotiation self-efficacy, Condom use self-efficacy, Global character, Exposure to risky situations, STI signs/symptoms, STI knowledge, Parental communication, Future orientation, Intentions to engage in oral sex in the next year, Intentions to engage in vaginal sex in the next year, Intentions to engage in anal sex in the next year, Intentions to remain abstinent until end of high school, Intentions to remain abstinent until marriage, Intentions to use a condom in the next 3 months, Personal limits, Perceived norms: most teens wish they waited, Perceived norms: most teens my age having sex	In the multivariate analysis controlling for confounding, the program had a significant effect on various psychosocial variables, including:: beliefs about waiting to have sex until marriage (B = 0.08, SE 0.03, 95% CI (0.01, 0.14), $p < 0.05$), friends' beliefs about abstinence (B = 0.09, SE 0.04, 95% CI (0.01, 0.16), $p < 0.05$), condom knowledge (B = 0.07, SE 0.01, 95% CI (0.05, 0.10), $p < 0.01$), Condom use self-efficacy (B = 0.09, SE 0.03 95% CI (0.02, 0.16), $p < 0.01$), STI knowledge (B = 0.05, SE 0.02 95% CI (0.01, 0.10), $p < 0.05$). Perceived norms: most teens wish they waited (B = 0.09, SE 0.04, 95% CI (0.00, 0.17), $p < 0.05$), most teens my age having sex (B = −0.08, SE 0.04, 95% CI (−0.16, −0.01), $p < 0.05$) A post hoc analysis further examined the association between the level of exposure to the intervention and changes in sexual initiation outcomes. The program was effectiveness for any sex at medium exposure OR = 0.42 ($p < 0.01$) and at full exposure OR = 0.19 ($p < 0.01$), for vaginal sex at medium exposure OR = 0.42 ($p < 0.05$) and full exposure OR = 0.20 ($p < 0.01$) and for oral sex at full exposure OR = 0.14 ($p < 0.05$) vs low exposure. There was significant difference between the high exposure and low exposure groups. No effect on delay of sexual debut or behaviour was found	Strong
PR:EPARe game **Arnab et al.** (Arnab et al., 2013)	RCT. EG & CG. UK; 3 schools. Pretest and post-test (not described): 298 (EG), 207 (CG). Retention rate: not described. Mean age (SD): 13.5 (0.5). 48,91%♀, 50,1%♂, others 0.99% Outcomes: Knowledge and perceived personal relevance of coercion, Positive attitude to say 'no' if you are coerced or others say so, Confidence in communication, Beliefs about coercion and saying no, Knowledge and perceived personal relevance of coercion, Positive attitude to say 'no' if you are coerced or others say so, Confidence in communication, Beliefs about coercion and saying no	Multivariate analysis of variance MANOVA with a 2 (condition: control vs. game) × 2 (time: baseline vs. follow-up) design. There was a significant effect on psychological factors in relation to time (F(3,501) = 2.847, p = 0.037, n2p = 0.017), a significant main effect of condition (F(3,501) = 7.27, p < 0.001, n2p = 0.048), and a significant interaction of time by condition (F(3,501] = 15.306, $p < 0.001$, n2p = 0.084) Specifically, for the factor "confidence to recognize coercion and act to stop," there was a significant main effect of time (F(1,501) = 4.746, p = 0.030, n2p = 0.009) suggesting changes in confidence over time. However, there was no significant time*condition (F [1, 501] = 0.406, p = 0.524, n2p = 0.001). For the factor "knowledge and positive attitudes toward saying no/others saying no," a significant time*condition interaction was observed (F(1,501) = 7.808, p = 0.005, η^2p = 0.015), indicating that the changes in this factor were influenced by the condition (game vs. control). In the case of the factor "understanding of personal risk and consequences for all," the main effect of time approached significance (F(1,501) = 3.35, p = 0.068, n2p = 0.007) suggesting potential changes over time. There was also a significant time*condition interaction (F(1,501) = 27.717, $p < 0.001$, n2p = 0.052) indicating that the impact of the intervention varied between the control and game conditions for this factor	Strong
CyberSenga **Ybarra et al.**(Ybarra et al., 2013, 2015)	RCT. EG & CG. Uganda; 4 secondary schools: 9th, 10th, 11th grades; Pretest and posttest: Pre-test and 3, 6-month-follow-up: 183 (EG), 183 (CG). Retention rate: 3 months: 96% EG, 93% CG; 6 months: 92% EG, 93% CG. Mean age (SD): 16.1 (1.4) 16.1%♀, 83.9%♂ Outcomes: Abstinence, unprotected vaginal sex, Trends for the booster group at six-month follow-up	Adjusted analysis showed that at three-month follow-up, among abstinent youth at baseline, there were more abstinent intervention participants than control participants (EG 88.0% vs. GC 77.3%, AOR = 2.27 95% CI (1.17, 4.39), $p \leq 0.05$). Multilevel analysis fitted to the growth curve performed later in 2015 showed that there were statistically significant changes over time in the individual constructs. Time by condition improved for the predictors HIV prevention-related information (B = 2.63, $p < 0.001$), attitudes toward condom use (B = 0.12, p 0.006), subjective norms for condom use (B = 0.12, p 0.015), behavioural intentions for condom use (B = 0.13, p 0.001). For the predictor time by tired of hearing about STD and HIV/AIDS prevention, improved behavioural intentions for abstinence (B = 0.15, p 0.029). For the predictor time by condition by vaginal sex prior to baseline, it improved subjective norms for condom use (B = 0.12, p 0.053) and behavioral skills for condom use (B = 0.08, p 0.039). In the outcome behavioral skills for condom use, it was significant for the predictor's attitudes toward abstinence (B = 0.05, p 0.012), attitudes toward condom use (B = 0.22, $p < 0.001$), behavioral intentions for abstinence (B = 0.07, p 0.004), behavioral intentions for condom use (B = 0.17, $p < 0.001$). In the outcome behavioral skills for abstinence, it was significant for the predictor's subjective norms for abstinence (B = 0.20, $p < 0.001$) and behavioral intentions for abstinence (B = 0.21, $p < 0.001$)	Strong
PlayForward: Elm City Stories **Fiellin et al.** (Fiellin et al., 2016, 2017)	RCT. EG & CG. USA; 12 after-school, school, and summer community programs. Pre-test before and post-test at 6 weeks and at 3, 6 and 12 months. 166 (EG), 167 (CG). Retention rate: 6 WK 82,7%; 3 months 82,9%; 6 months 78,6%; 12 months 81. 6%. Mean age (SD): 12.9 (1.1). 46.8%♀, 53.2%♂ Outcomes: Delayed initiation of sexual intercourse; attitudes and knowledge	The longitudinal mixed-effect models for secondary outcomes showed the following results. Over a 12-month period, there was a statistically significant effect on sexual health attitudes in EG vs CG (LS mean difference 0.37, 95% CI (0.01, 0.72), p = 0.04). Improvement in sexual health attitudes was observed in boys (LS mean difference 0.67, p = 0.008), but not in girls (LS mean difference 0.06, p = 0.81). In the 11–12 years age group, there was a significant increase in sexual health attitudes (LS mean difference 0.71, 95% CI [0.21, 1.20], p = 0.005). For knowledge, the intervention was effective over 12 months (LS mean difference 1.13, 95% CI [0.64, 1.61], $p < 0.001$). Both girls and boys in the EG demonstrated an increase in sexual health knowledge vs. CG (girls: overall LS mean difference 1.16, 95% CI [0.46, 1.86], p = 0.001; boys: LS mean difference 1.10, 95% CI [0.43, 1.77], p = 0.001). For group (age 11–12 years) and (age 13–14 years) of EG demonstrated an increase in sexual health knowledge vs. CG (younger: LS means difference 1.18, 95% CI [0.50, 1.85], p = 0.001; older: LS means difference 1.08, 95% CI [0.39, 1.78], p = 0.002). During the 12-month follow-up period, there was no significant difference in intentions to delay sexual debut between the two groups (MC mean difference 0.10, 95% CI [−0.23 to 0.43], p = 0.56)	Strong

Table 1 (continued)

Intervention and project	Study characteristics: Design; Country; Population; Sample & follow-up; Outcomes	Main effects	Risk of bias
The SAFETY Jerlström et al.(Jerlström & Adolfsson, 2020)	RCT. EG & CG. Sweden; 10 school: 8th grade; Pretest 1 week before and post-test 1 week after the intervention: 427 (EG), 399 (CG). Retention rate: 85%. Mean age (SD): 15 years (not described) EG 50%♀, 50%♂; CG 49%♀, 50%♂, 1% Other Outcomes: Knowledge about condom use and STIs protection (chlamydia); Attitudes to condom use; Behaviour about condom use	Effects of the program on knowledge, attitudes and behaviour were found. On the variable knowledge between EG and CG groups "how is your knowledge on condom use?" ($p < 0.001/p < 0.001$), in the difference between pre/post-test, (p = 0.38/ $p < 0.001$), I know where to get condoms between EG and CG groups ($p < 0.001$/p 0.160), in the difference between pre/post-test (p 0.062/$p < 0.001$), I think I have knowledge on how to use protection during intercourse between EG and CG groups ($p < 0.001/p < 0.009$), in the difference between pre/post-test (p 0.037/ < 0.001), I know what chlamydia is between EG and CG groups ($p < 0.001/p < 0.001$), between pre/post-test (p 0.581/$p < 0.001$), I know how chlamydia is transferred between EG and CG groups ($p < 0.001/ < 0.001$), at pre/post-test (p 0.343/$p < 0.001$), I know how to protect against chlamydia between EG and CG groups ($p < 0.001/p < 0.001$), at pre/post-test (p 0.318/$p < 0.001$). The EG improved knowledge after the intervention vs. CG but in the post-test, knowledge improved for both For the variable Attitude, it was statistically significant between EG and CG for the items It is my responsibility to bring condoms ($p < 0.001$/p 0.907) and it is my partner's responsibility to bring condoms ($p < 0.001$/p 0.011). No post-test differences for both groups As for the variable Behaviour, it was statistically significant between EG and CG for the items. In the future I would probably talk to my partner (p < 0.001/p 0.668), In the future I would probably use condoms ($p < 0.001$/p 0.346), If I did not have condoms, I would make sure that we both got pleasure without intercourse ($p < 0.001$/p 0.249). For the variable in future, I would probably talk to my partner was significant in pre/post-test (p 0.450/$p < 0.001$)	Moderate
AIDS Fighter—Health Defense Tang et al. (Tang et al., 2022)	RCT. EG & CG. China; 1 school. Pre-test at baseline And post-test 14 days later: 50 (EG), 46 (CG) Retention rate: 100%. Mean age (SD): EG 16.68 (0.74), CG 16.76 (0.71). EG 58%♀, 42%♂; CG 54.35%♀, 45.65%♂. Outcomes: AIDS knowledge awareness rate (Basic knowledge of AIDS, Knowledge of AIDS prevention, testing, treatment, Prep, and related laws and regulations); Stigma; Positive rate of attitude of high-risk AIDS behaviours	Bivariate analysis effect that the program had on AIDS-related knowledge in EG on AIDS knowledge awareness rate in Overall (EG Pre-test: mean 58.04 (SD 17.55), post-test: mean 70.09 (SD 11.58) $p < 0.001$; CG Pre-test: mean 57.87 (SD 11.80), post-test mean: 57.49 (SD 16.58), p = 0.90, d = 0.8876). Knowledge of AIDS-related laws and regulations (EG pre-test: mean 65.75 (SD 27.87), post-test: mean 82.25 (SD 15.79), $p < 0.001$; CG mean: 73.64 (SD 20.79), p = 0.6280, d = 0.4691)	Moderate

STI, sexually transmitted infections; *HIV*, human immunodeficiency virus; *HPV*, Human papillomavirus; *STD*, sexually transmitted diseases; *AIDS*, acquired immunodeficiency syndrome; *RA*, risk avoidance; *RR*, risk reduction

Table 2 Summary of results

Intervention	Author/s and year	Primary outcome				Secondary outcome			
		Sexual intercourse		Contraceptive use		Knowledge		Attitudes	
		< 6 months	> 6 months	< 6 months	> 6 months	< 6 months	> 6 months	< 6 months	> 6 months
Computer- and Internet-based intervention	(Roberto et al., 2007a, 2007b)	+	ND	+	ND	+	ND	+	ND
	(Roberto et al., 2007a, 2007b)	+	ND	NS	ND	+	ND	+	ND
	(Roberto et al., 2008)	+	ND	NS	ND	+	ND	+	ND
"It's Your Game" (IYG)	(Tortolero et al., 2010)	+	+	+	NS	+	+	ND	ND
	(Markham et al., 2012)	+	+	+	+	+	+	ND	ND
	(Potter et al., 2016)	NS	-	NS	NS	+	+	NS	NS
	(Rohrbach et al., 2019)	+	+	+	NS	NS	+	+	ND
	(Peskin et al., 2019)	+	NS	+	NS	+	+	NS	NS
"It's Your Game (IYG)-Tech"	(Peskin et al., 2015)	NS	NS	+	+	+	+	ND	ND
"PR:EPARe game	(Arnab et al., 2013)	ND	ND	ND	ND	+	+	ND	ND
"Cyber-Senga"	(Ybarra et al., 2013)	+	NS	+	NS	ND	ND	ND	ND
	(Ybarra et al., 2015)	ND	ND	+	+	+	+	+	+
"PlayForward"	(Fiellin et al., 2016, 2017)	NS	NS	ND	ND	+	+	+	+
The SAFETY	(Jerlström & Adolfsson, 2020)	ND	ND	NS	ND	NS	ND	+	ND
AIDS Fighter—Health Defense	(Tang et al., 2022)	ND	ND	NS	ND	+	ND	NS	NS

NS, not significant; *ND*, no data; +, positive significant effects; −, negative significant effects

discussion. In case of disagreement, a third reviewer (ML) was consulted.

Meta-analysis

The analyses were performed using Comprehensive Meta-Analysis version 3.3.070 software (Biostat, Inc.). A weighted mean of the different effects from the studies was obtained using the relative risk (RR) when the outcomes of the studies included in each meta-analysis were measured as dichotomous variables, and the odds ratio (OR) when they were measured as both dichotomous and quantitative variables. A random-effects model (Hedges & Vevea, 1998) was used for the meta-analyses, given the variation in the population studied (e.g., sex and age). When a study included multiple follow-up time points, the latest was used. In longitudinal studies with repeated measures that used correlations referring to the same time point, we selected the first correlation to ensure the independence of comparisons (Higgins & Thomas, 2019). Statistical heterogeneity was assessed using

Table 3 Characteristics of interventions

Project	Objective	Target population; Setting; Course	Facilitators and capacitation	Intervention design; Material and resources; Conceptual framework	Program duration; Number of sessions; sessions duration	Intervention content
Computer- and Internet-based intervention (Roberto, et al., 2007a, 2007b); (Roberto et al., 2007a, 2007b); (Roberto et al., 2008)	improving knowledge, effectiveness and negotiation of condom use, delay of sexual initiation	9th, 10th grade adolescents Rural high schools: Delivered in the school setting	Facilitators and training are not described	Computer-based activities. Printed copy for students without computer or Internet access Conceptual framework: extended parallel process model	7-week program 6 lessons 10 to 15-min lesson	Sensation Seeking and Decision-Making They received explanations of personality traits, how to relate to their risk behaviour, and things they could do to reduce their risk Truth or Myth Identification Risky Behaviour Perception Delaying Tactics Activity: "Best Delaying Tactics Contest." Choose Your Own CD-ROM Adventure: they had a virtual date and made choices that may have put them in a situation where their date wanted to have sex, but they didn't Refusal skill activity: a "Best Rejection Skill Contest." Radio PSA Contest: create a radio public service announcement to prevent pregnancy, STD, and HIV

Table 3 (continued)

Project	Objective	Target population; Setting; Course	Facilitators and capacitation	Intervention design; Material and resources; Conceptual framework	Program duration; Number of sessions; sessions duration	Intervention content
It's Your Game: Keep It Real (IYG) (Tortolero et al., 2010); (Potter et al., 2016)	Delaying sexual initiation	Low-income high school adolescents Rural schools: Conducted during school terms in the fall or spring semester 7° and 8° grades. FU 9° grade	Teachers or staff members 2-day training by IYG researchers	The IYG consists in activities in the classroom with personalized journaling and individual, tailored, computer-based activities and 3 parent–child activities to facilitate dialogue on topics including friendship qualities, dating, and sexual behaviour Conceptual framework: intervention mapping, social cognitive, social influence, and theory of triadic influence	2-year program 12 lessons for 7°, 12 for 8° graders and 6 joint activities for parents and children 45 min per session	**7° grade:** healthy friendships; setting personal boundaries and practicing refusal skills in a general context; information about puberty, reproduction, and STIs; and setting personal boundaries and practicing refusal skills related to sexual behaviours **8° grade:** 7th grade topics plus characteristics of healthy relationships; the importance of HIV, STI and pregnancy testing and skills training regarding condom and contraceptive use. **Parents and children's**: topics such as the qualities of friendship, dating and sexual behaviour
It's Your Game: Keep It Real (IYG) (Markham et al., 2012)	delaying sexual initiation	Adolescents mostly poor urban high schools: Delivered in the school setting 7°, 8° and 9° grades	Facilitators are not described. Were trained for 5 days	The IYG consists in activities in the classroom with personalized journaling and individual, tailored, computer-based activities and 3 parent–child activities to facilitate dialogue on topics including friendship qualities, dating, and sexual behaviour 2 interventions groups: RA, RR Conceptual framework: Intervention Mapping: social cognitive theory, social influence models and the theory of triadic influence	2-years program 12 lessons for 7°, 12 for 8° graders and 6 joint activities for parents and children 50 min per session	**RA**: 4 lessons on beliefs about the benefits of abstinence until marriage and the benefits of marriage and parenting within marriage. 3 lessons on character qualities and their influence on healthy relationships and decision making **RR**: beliefs about the benefits of abstinence until old age, promoting self-respect and responsibility, and activities on knowledge and self-efficacy of condom and contraceptive use

Table 3 (continued)

Project	Objective	Target population; Setting; Course	Facilitators and capacitation	Intervention design; Material and resources; Conceptual framework	Program duration; Number of sessions; sessions duration	Intervention content
It's Your Game: Keep It Real (IYG) (Rohrbach et al., 2019)	delaying sexual initiation	Middle urban school adolescents: conducted during school terms in the fall or spring semester 7º and 8º grades. FU 9º grade	Science health, or physical education teachers 3-day training by IYG researchers	The IYG consists in a 24-lesson curriculum for HIV/STI/teen pregnancy prevention. Offers classroom activities (film acting, role-playing and group discussions) with individual diaries and personalized computer activities Conceptual framework: Social cognitive and social influence theories	2-year program 24 lessons, 18 in 7° and 6 in 8° grades	Not described
It's Your Game: Keep It Real (IYG) (Peskin et al., 2019)	Delay initiation of vaginal or oral sex at 24 months follow-up	9th grade adolescents Urban schools: Delivered in the school setting during Winter–Spring 2013 and 2014 7º and 8º grade. FU 9º grade	Teachers at school 2-day training by IYG researchers	The IYG consists in activities in the classroom with personalized journaling and individual, tailored, computer-based activities and 3 parent–child activities to facilitate dialogue on topics including friendship qualities, dating, and sexual behaviour Conceptual framework: Intervention Mapping	2-year program 12 lessons for 7°, 12 for 8° graders and 3 joint activities for parents and children Minutes per lesson not described	7° and 8° grades not described **Parents and children**: topics such as the qualities of friendship, dating and sexual behaviours

Table 3 (continued)

Project	Objective	Target population; Setting; Course	Facilitators and capacitation	Intervention design; Material and resources; Conceptual framework	Program duration; Number of sessions; sessions duration	Intervention content
It's Your Game: Keep It Real (IYG)-Tech (Peskin et al., 2015)	Efficacy of It's Your Game (IYG)-Tech for delaying sexual initiation in ninth grade	8th grade adolescents Urban schools: Delivered in the school setting 8° and 9° grades	Facilitators and training are not described	It's Your Game (IYG)-Tech is a computer-based, classroom-based sexual health education intervention. Mall-like environment with "storefronts" and "owners". These are guided by two animated narrators, to engage in activities with animated scenarios for skills practice, peer-to-peer videos ("teen chats"), quizzes, handouts, a graffiti wall for personalization and reflection, and virtual role-playing activities Conceptual framework: Intervention Mapping	1-year program Data were collected at the school, and if this was not possible it was done at the student's home, library, or other location 13 lessons 35 to 45 min per lesson	Select their personal rules (or boundaries) about behaviours (sexual and non-sexual) ahead of time, detect signs and situations that might challenge their rules, and protect their rules with refusal skills. Characteristics of healthy and unhealthy friendships and dating relationships; anatomy and reproduction; social, emotional, and physical consequences of sex; communication skills; Internet communication and safety; consequences of teen pregnancy and STIs; condom and contraceptive knowledge and skills; and condom negotiation
PR:EPARe game (Arnab et al., 2013)	Reducing the likelihood of being coercive towards others or allowing others to coerce	High school adolescents (13 or 14 years) School: Delivered in sex education class 9° grade	Teacher, training not described	PR:EPARe is a Game Show, in which they must face a round of questions and answers on coercive situations and go to a role-playing round to decide on the different situations posed through the computer Conceptual framework: Kolb's experiential learning model, 4DF and intervention mapping	Data were collected at the school, 1 lesson 1 h	**Part 1:** Question and Answer: group participation in the correct response to scenarios with possible coercive behaviours **Part 2:** students play a role in two scenarios with the opportunity to be both the coercer and the coerced

Table 3 (continued)

Project	Objective	Target population; Setting; Course	Facilitators and capacitation	Intervention design; Material and resources; Conceptual framework	Program duration; Number of sessions; sessions duration	Intervention content
CyberSenga (Ybarra et al., 2013); (Ybarra et al., 2015)	to prevent HIV	High school adolescents: private schools founded by the church, private Muslim and coeducational school, public coeducational school: Delivered after school hours 8° grade	Township youth guidance centre staff and school nurse: undescribed training	CyberSenga online healthy sexuality program with four different versions so that the content could be tailored according to biological sex and self-reported previous sexual experience with the same concepts Conceptual framework: preventive behaviour model	5-week program A booster module was offered between the three- and six-month FU. 50% of EG were randomly assigned to the booster session and half were not 6 lessons Duration per session not described	1. HIV information 2. Decision making and communication 3. Motivations to be healthy 4. How to use a condom 5. Healthy relationships 6. Review
PlayForward: Elm City Stories (Fiellin et al., 2016); (Fiellin et al., 2017)	to improve sexual health outcomes in adolescents delaying sexual initiation	Adolescents 11 to 14 years old Urban afterschool, school, and summer camp programs: It was carried out during the hours of urban afterschool, school, and summer camp programs	Intensive training of research staff on study methods and procedures	PlayForward: Elm City Stories is a two-dimensional role-playing adventure video game that allows the player to see how their individual decisions are influenced by their social environment. For the CG, 12 video games such as Angry Birds, Dragonbox and Subway Surfer were offered that had no content relevant to the objectives Conceptual framework: theoretical base	6-week program 60 min per lesson twice a week	Me Power: elaborate goals and aspirations to reflect upon Refusal Power: assesses risky situations and decides the best way to refuse Know Power provides knowledge on sex, drugs, and alcohol People Sense: association between the behaviours of their peers and influence on their own behaviours Priority Sense: learning to prioritize behaviours that maximize long-term benefits

Table 3 (continued)

Project	Objective	Target population; Setting; Course	Facilitators and capacitation	Intervention design; Material and resources; Conceptual framework	Program duration; Number of sessions; sessions duration	Intervention content
The SAFETY (Jerlström & Adolfsson, 2020)	Improving knowledge, attitudes, and behaviour on condom use	Adolescents 15 years old (8th grade) School: Delivered in the school setting 8° grade	Teacher. training is not described	The SAFETY intervention consisted of a skit (20 min), a courage exercise (10 min), chlamydia games (10 min), a condom school (10 min), and a replay (30 min) Conceptual framework: not described	1-day program 1 session 80 min	1. Theatre play: portraying young people and problems with condom use 2. Values exercise: dealing with various issues by moving to corners of the classroom 3. Chlamydia games: information on symptoms, protection, how to get tested, treatment and consequences, etc 4. Condom school: practical demonstration of condoms and concepts such as lust, respect and function of genitalia and sexuality 5. Replay: students proposed new endings for the play
AIDS Fighter—Health Defense (Tang et al., 2022)	Improving knowledge, stigma, and attitudes for HIV prevention	High school adolescents Urban school Grade not described	Facilitators and training are not described	Educational game about AIDS, AIDS Fighter—Health Defense. It tells a story that HIV launches an attack on the human body and players must control the heroes to eliminate HIV. They had to earn at least 20 points a day The GC played games, but they had to study the subject on their own Conceptual framework: not described	18-day program Duration per session and place of implementation are not described	Trained to use condoms to refuse dangerous sexual behaviours, avoid drugs to refuse intravenous drug use, avoid alcohol to refuse dangerous sex when drunk, obtain antiviral drugs for PrEP and post-exposure prophylaxis (PEP)

IYG, It's Your Game; *FU*, follow-up; *STD*, sexually transmitted diseases; *HIV*, human immunodeficiency virus; *RA*, risk avoidance; *RR*, risk reduction; *EG*, experimental group; *CG*, control group; *AIDS*, acquired immunodeficiency syndrome; *PrEP*, pre-exposure prophylaxis; *PEP*, post-exposure prophylaxis

the Q (Cochran, 1954) test to evaluate the consistency of results across the different studies, Higgins' inconsistency index (I^2) to estimate whether variability between studies was not due to chance (Higgins et al., 2002), and the prediction interval to analyse total heterogeneity (Borenstein, 2024). To assess publication bias, Egger's test (Egger et al., 1997) was employed to determine funnel plot asymmetry, and the Trim and Fill (Duval & Tweedie, 2000) method was used to estimate the effect size in a scenario without publication bias. Sensitivity analyses were conducted by removing one study at a time (leave-one-out method) to examine the robustness of the results (Cooper et al., 2012).

Results

Study Selection

The search in the five databases found 1400 articles. Once duplicates were eliminated, 728 were identified for reading titles and abstracts according to established inclusion and exclusion criteria. Forty-nine additional articles were found from the references of the included studies. We retrieved and assessed the eligibility of 79. Ultimately, we identified 16 articles that met our inclusion criteria. The 16 articles reported on 14 studies (four reports presented findings from the same study). The reasons for not including an article were: not related to the intervention, not RCT or quasi-experimental, did not evaluate the effectiveness of the intervention, not adolescents (10–19 years old), not school setting, and weak-quality assessment. Eight articles were included in the meta-analysis. The PRISMA diagram is presented in Fig. 1 below.

Study Characteristics

Out of the included studies, 13 were RCTs, two were quasi-experimental, and one was a controlled clinical trial. The control group (CG) interventions primarily consisted of traditional school-based teaching, except for PlayForward: Elm City Stories (Fiellin et al., 2016, 2017), which used control video games, and AIDS Fighter—Health Defense (Tang et al., 2022), which used an application called QQ chat. All interventions were conducted with adolescents aged 11 to 19 years, and the sample size varied between 60 and 4562 participants. In terms of retention rates, most interventions included in this systematic review reported a retention rate of more than 75%. However, three studies did not provide retention data (Arnab et al., 2013; Roberto et al., 2008, 2007a, 2007b), while one reported a retention rate of 51% and another a rate of 73% (Roberto et al., 2007a, 2007b). On average, the gender distribution among the participants was approximately 48.70% male, 51.27% female, and 0.04% gender not described. The interventions were implemented in a range of 1 to 20 different schools. The 16 articles included were published between 2001 and 2022, with 11 conducted in the USA (Fiellin et al., 2016, 2017; Markham et al., 2012; Peskin et al., 2015, 2019; Potter et al., 2016; Roberto et al., 2008, 2007a, 2007b; Rohrbach et al., 2019; Tortolero et al., 2010), two in Uganda (Ybarra et al., 2013, 2015), one in Sweden (Jerlström & Adolfsson, 2020), one in the China (Tang et al., 2022) and one in the UK (Arnab et al., 2013).

The focus of the interventions was to delay the introduction of any sex in adolescents in 11 studies (Fiellin et al., 2016, 2017; Markham et al., 2012; Peskin et al., 2015, 2019; Potter et al., 2016; Roberto et al., 2008, 2007a, 2007b; Rohrbach et al., 2019; Tortolero et al., 2010), to improve knowledge and attitudes for HIV prevention in four studies (Jerlström & Adolfsson, 2020; Tang et al., 2022; Ybarra et al., 2013, 2015) and to reduce the likelihood of coercion in one study (Arnab et al., 2013). In 11 of the selected studies, it was observed that between 6 and 31% of adolescents who participated in the proposed interventions to delay the onset of SR or improve knowledge, attitudes, and behaviours had already initiated SR (Fiellin et al., 2016, 2017; Jerlström & Adolfsson, 2020; Markham et al., 2012; Peskin et al., 2015; Potter et al., 2016; Roberto et al., 2007a, 2007b; Rohrbach et al., 2019; Tortolero et al., 2010; Ybarra et al., 2013, 2015). The remaining five did not specify data on this issue (Arnab et al., 2013; Peskin et al., 2019; Roberto et al., 2008, 2007a, 2007b; Tang et al., 2022).

Risk of Bias in Studies

The 16 selected articles were evaluated for quality. Twelve scored strong quality (Arnab et al., 2013; Fiellin et al., 2016, 2017; Peskin et al., 2015, 2019; Potter et al., 2016; Roberto et al., 2008, 2007a, 2007b; Tortolero et al., 2010; Ybarra et al., 2013, 2015) and four moderate quality (Jerlström & Adolfsson, 2020; Markham et al., 2012; Rohrbach et al., 2019; Tang et al., 2022). Finally, five studies were removed from the review for weak quality (Haruna et al., 2018, 2021, 2023; Kashibuchi & Sakamoto, 2001; Winskell et al., 2018). The most frequent biases were related to selection bias, confounders, withdrawals, and dropouts.

Effectiveness of Interventions

All studies showed some positive effect on adolescents' sexual health, either in knowledge, attitude, or behaviour, compared to receiving no sexual intervention or receiving their school's usual sexual intervention (Tables 1 and 2).

In the 12 studies that assessed the delay of the onset of any SR, the results at follow-up of less than six months, eight studies showed significant positive effects (Markham

et al., 2012; Peskin et al., 2019; Roberto et al., 2008, 2007a, 2007b; Rohrbach et al., 2019; Tortolero et al., 2010; Ybarra et al., 2013) and four found non-statistically significant effects (Fiellin et al., 2016, 2017; Peskin et al., 2015; Potter et al., 2016). For the outcome of contraceptive use in the 13 studies that evaluated it, significant positive effects were shown in eight of them (Markham et al., 2012; Peskin et al., 2015, 2019; Roberto et al., 2007a, 2007b; Rohrbach et al., 2019; Tortolero et al., 2010; Ybarra et al., 2013, 2015) and five found non-statistically significant effects (Jerlström & Adolfsson, 2020; Potter et al., 2016; Roberto et al., 2008, 2007a, 2007b; Tang et al., 2022). For the knowledge outcome of the 15 studies that evaluated it, 13 obtained significantly positive effects (Arnab et al., 2013; Fiellin et al., 2016, 2017; Markham et al., 2012; Peskin et al., 2015, 2019; Potter et al., 2016; Roberto et al., 2008, 2007a, 2007b; Tang et al., 2022; Tortolero et al., 2010; Ybarra et al., 2015) and two had non-statistically significant effects (Jerlström & Adolfsson, 2020; Rohrbach et al., 2019). Finally, in the 11 studies that evaluated attitudes towards sexuality, there were eight significant positive effects (Fiellin et al., 2016, 2017; Jerlström & Adolfsson, 2020; Roberto et al., 2008, 2007a, 2007b; Rohrbach et al., 2019; Ybarra et al., 2015) and three non-statistically significant effects (Peskin et al., 2019; Potter et al., 2016; Tang et al., 2022).

In terms of follow-up after the intervention after six months, nine studies that evaluated delayed sexual debut found mixed results. On the one hand, three had significant positive effects (Markham et al., 2012; Rohrbach et al., 2019; Tortolero et al., 2010), five had non-significant effects (Fiellin et al., 2016, 2017; Peskin et al., 2015, 2019; Ybarra et al., 2013) and one found that the results were in the opposite direction to the main outcome, with a better CG than experimental group (EG) (Potter et al., 2016). For the outcome of contraceptive use, of the eight studies that followed up more than six months and evaluated it, three found significant positive effects (Markham et al., 2012; Peskin et al., 2015; Ybarra et al., 2015) and five non-statistically significant effects (Peskin et al., 2019; Potter et al., 2016; Rohrbach et al., 2019; Tortolero et al., 2010; Ybarra et al., 2013). In the 10 studies that carried out a six-month follow-up and evaluated the knowledge outcome, significant positive effects were observed in all 10 (Arnab et al., 2013; Fiellin et al., 2016, 2017; Markham et al., 2012; Peskin et al., 2015, 2019; Potter et al., 2016; Rohrbach et al., 2019; Tortolero et al., 2010; Ybarra et al., 2015). In the six studies that carried out a six-month follow-up and evaluated the attitude outcome, significant positive effects were observed in three of them (Fiellin et al., 2016, 2017; Ybarra et al., 2015) and three had non-statistically significant effects (Peskin et al., 2019; Potter et al., 2016; Tang et al., 2022).

When assessing the effect size with Cohen's d, most of the gamified interventions yielded low to moderate effects. One study reported a large effect size for knowledge (d = 0.90) (Roberto et al., 2008). Furthermore, some patterns emerged that indicated better outcomes for the EG, particularly in cases of increased exposure to the full gamified intervention, compared to those who did not receive full exposure (Peskin et al., 2015). On the other hand, effects on outcomes were observed in interventions that included booster sessions in contrast to those that provided only initial planned sessions (Roberto et al., 2008, 2007a, 2007b; Ybarra et al., 2013, 2015).

Another noteworthy aspect to mention is that five studies included parents in interventions with the aim of improving parent–child communication about sexuality. Among these, one study reported a significant increase in parental communication on sexual topics (Markham et al., 2012), no statistically significant effects were observed in three (Peskin et al., 2015, 2019; Potter et al., 2016) and parent–child communication was not evaluated in one study (Tortolero et al., 2010).

Characteristics of the Interventions

Participants were directly recruited from the schools they attended, where the interventions were primarily delivered. In one case, the intervention was also administered in urban after-school and summer camp programmes (Fiellin et al., 2016). Facilitator training to deliver these interventions varied in duration, ranging from two days to five days (Markham et al., 2012; Peskin et al., 2019; Potter et al., 2016; Rohrbach et al., 2019; Tortolero et al., 2010) or was not described (Arnab et al., 2013; Fiellin et al., 2016, 2017; Jerlström & Adolfsson, 2020; Peskin et al., 2015; Roberto et al., 2008, 2007a, 2007b; Tang et al., 2022; Ybarra et al., 2013, 2015). Two interventions were carried out by teachers or research personnel, three by teachers, one by health personnel, one by a school nurse and the staff of the municipality's youth counselling centre, and four were not described. The duration of the interventions displayed considerable variation: two were a single session, and the rest ranged from 18 days to two years of follow-up. Of the studies reviewed, 14 described a theoretical basis for their interventions: extended parallel process model; intervention mapping; cognitive social, social influence, and triadic influence; Kolb's experiential learning model; 4DF; preventive behaviour model; and theoretical basis (Arnab et al., 2013; Fiellin et al., 2016, 2017; Markham et al., 2012; Peskin et al., 2015, 2019; Potter et al., 2016; Roberto et al., 2008, 2007a, 2007b; Rohrbach et al., 2019; Tortolero et al., 2010; Ybarra et al., 2013, 2015). Of the studies reviewed, four included parent–child activities (Markham et al., 2012; Peskin et al., 2019; Potter et al., 2016; Tortolero et al., 2010).

Gamification Techniques

Various gamification methods were used to implement the programme interventions. In general, 15 studies used computer-created games, except for one that employed drama as a classroom tool (Jerlström & Adolfsson, 2020). Nine interventions were exclusively digital, incorporating gamification on the Internet (Arnab et al., 2013; Fiellin et al., 2016, 2017; Roberto et al., 2008, 2007a, 2007b; Tang et al., 2022; Ybarra et al., 2013, 2015). Six interventions combined gamified classroom activities with the use of computers (Markham et al., 2012; Peskin et al., 2015, 2019; Potter et al., 2016; Rohrbach et al., 2019; Tortolero et al., 2010). All interventions were designed to be inclusive for both genders. However, the CyberSenga intervention offered four different paths — Senga for women and Kojia for males, as well as whether they were absent or not — tailored to increase the personal relevance of the topics (Ybarra et al., 2013, 2015). Additionally, online activities were customised according to gender in another study (Markham et al., 2012). It is worth noting that only one study provided a description of the game mechanics used in the designed intervention, which included features such as question and answer, competition, time pressure, cooperation, rewards/penalties, feedback, action points, and more (Arnab et al., 2013).

The activities found in the review exhibit a wide range of characteristics. On the one hand, there are activities that make use of computer-based approaches. CD-ROM (Roberto et al., 2008, 2007a, 2007b), presented diverse virtual scenarios in which participants were required to make decisions pertaining to appointments. It's Your Game: Keep It Real (Markham et al., 2012; Peskin et al., 2015, 2019; Potter et al., 2016; Rohrbach et al., 2019; Tortolero et al., 2010), consists of classroom sessions and a computer game that includes a virtual world interface and educational activities (quizzes, animations, peer video, and fact sheets) to teach them to set limits and detect risky behaviour and to use their own skills to reject and protect themselves. Another intervention is PR:EPARe (Arnab et al., 2013), which involves a game show format in which participants must tackle rounds of questions and answers related to coercive situations, followed by role-playing scenarios presented via computer. CyberSenga (Ybarra et al., 2013, 2015), is a game consisting of five modules each delivering different lessons. To progress, players must pass through screens with information on HIV/AIDS. PlayForward: Elm City Stories (Fiellin et al., 2016, 2017) is a two-dimensional role-playing adventure game allowing players to observe how their individual decisions are influenced by their social environment. AIDS Fighter—Health Defense (Tang et al., 2022) presents a narrative in which HIV launches an attack on the human body, and players must control heroes to eliminate HIV, earning a minimum of 20 points per day. Lastly, in one intervention, gamification used theatre, incorporating games and performances (Jerlström & Adolfsson, 2020).

Meta-analysis

Eight studies (Fiellin 2017, Jerlström and Adolfsson, 2020, Peskin et al., 2019, Potter et al., 2016, Rohrbach et al., 2019, Tang et al., 2022, Tortolero et al., 2010, and Ybarra et al., 2013) included data suitable for meta-analysis, evaluating the following outcomes: (1) delay in sexual initiation, (2) intention to use condoms, and (3) engagement in unprotected sex. The meta-analysis revealed a significant improvement in the delay of sexual initiation following the interventions.

1. Delay in sexual initiation. This outcome includes the initiation of sexual activity (among adolescents who have never had sex), having sex during follow-up, and having sex in the past three months (among adolescents who have and have not had sex). Six studies (Fiellin et al., 2017; Peskin et al., 2019; Potter et al., 2016; Rohrbach et al., 2019; Tortolero et al., 2010; Ybarra et al., 2013) with 13 samples/subgroups provided data on the outcome of engaging in sexual activity, revealing a weak to moderate negative association (RR = 0.85; 95% confidence interval (CI): 0.78–0.93; N = 16,584; Average per study: 1275.7; Fig. 2). Individuals who received the intervention were 1.18 times less likely (1/0.85 * 100) to engage in sexual activity, and the intervention reduced this likelihood by 15% (1—0.85). There was no heterogeneity other than that due to chance among the results of the different studies (Q = 7.8; degrees of freedom: 12, p = 0.80; $I^2 = 0.0$). Additionally, the prediction interval (true value in 95% of comparable populations), which is 0.77–0.94, is very similar to the confidence interval, indicating minimal overall heterogeneity. Regarding publication bias, the funnel plot (Fig. 3) appears asymmetric; however, no effect in small studies is observed. The *p*-value from Egger's test is 0.98, and the adjusted effect size from the Trim and Fill method is 0.85 (0.0% variation), indicating a low risk of publication bias. In terms of sensitivity analysis, leave-one-out meta-analyses revealed a maximum variation of the combined effect of 5.9%, demonstrating an acceptably robust result.
2. Intention to use condoms. Two studies (Jerlström & Adolfsson, 2020; Tang et al., 2022) provided data on the effectiveness of interventions in promoting the intention to use condoms, showing no effect of these interventions (OR = 1.23; 95% confidence interval (CI): 0.90–1.67; N = 1,018; Average per study: 509.0; Fig. 4). There was no heterogeneity other than that due to chance among the results of the different studies (Q = 1.0; degrees of freedom: 1, p = 0.32; $I^2 = 0.0$). The prediction interval could not be calculated due to the inclusion of only two

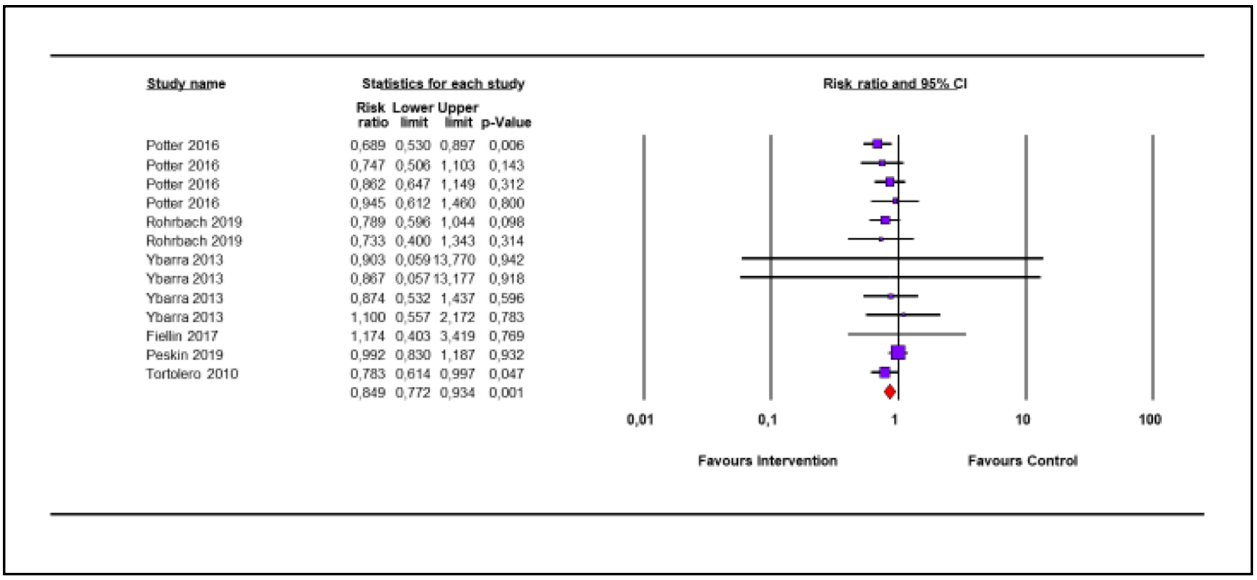

Fig. 2 Forest plot for the outcome of delaying sexual initiation

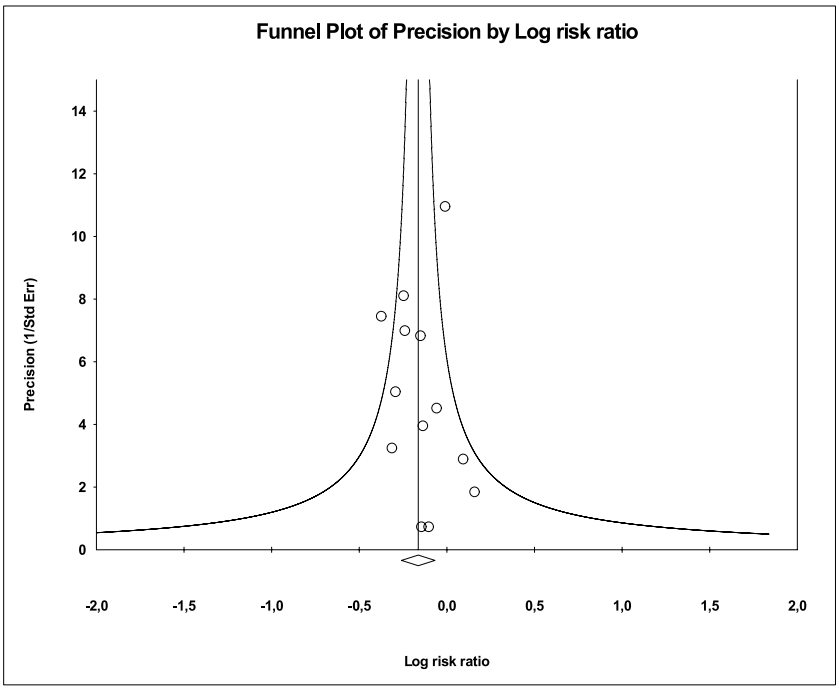

Fig. 3 Funnel plot for the outcome of delaying sexual initiation

studies, nor could publication bias be assessed for the same reason. In the sensitivity analysis, leave-one-out meta-analyses revealed a maximum variation of the combined effect of 23.6%, indicating a less robust result.

3. Engagement in unprotected sex. Two studies (Rohrbach et al., 2019; Ybarra et al., 2013) provided data on the effectiveness of interventions in preventing engagement in unprotected sex, revealing no effect of these interventions (RR = 1.06; 95% confidence interval (CI): 0.67–1.72; N = 538; Average per study: 269.0; Fig. 5). There was no heterogeneity other than that due to chance among the results of the different studies (Q = 0.09; degrees of freedom: 1, p = 0.77; $I^2 = 0.0$). The prediction interval could not be calculated due to the inclusion of only two studies, nor could publication bias be assessed for the same reason. In the sensitivity analysis, leave-one-out meta-analyses revealed a maximum variation of the combined effect of 23.9%, indicating a less robust result.

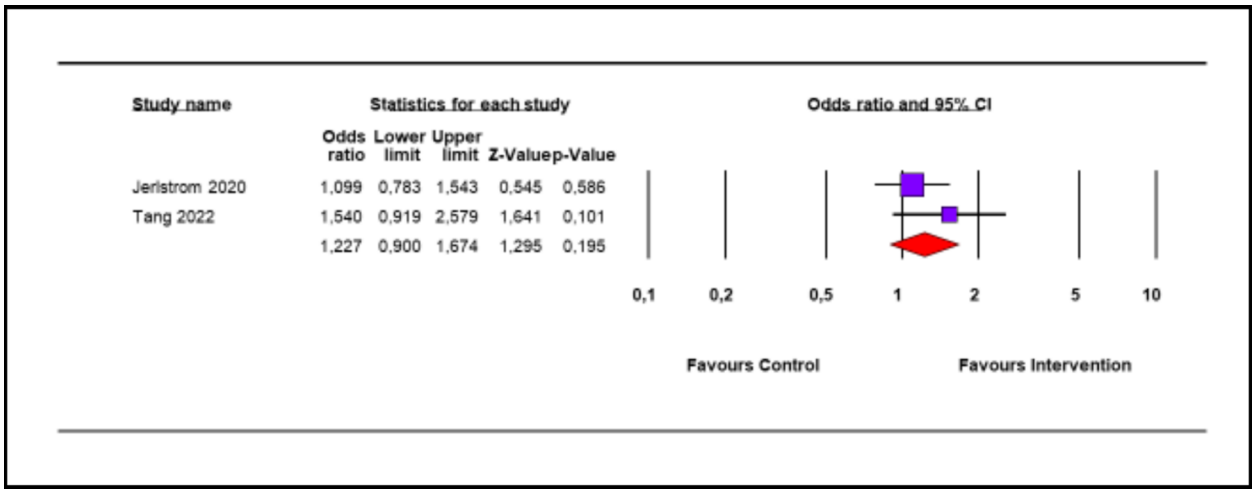

Fig. 4 Forest plot for the outcome of intention to use condoms

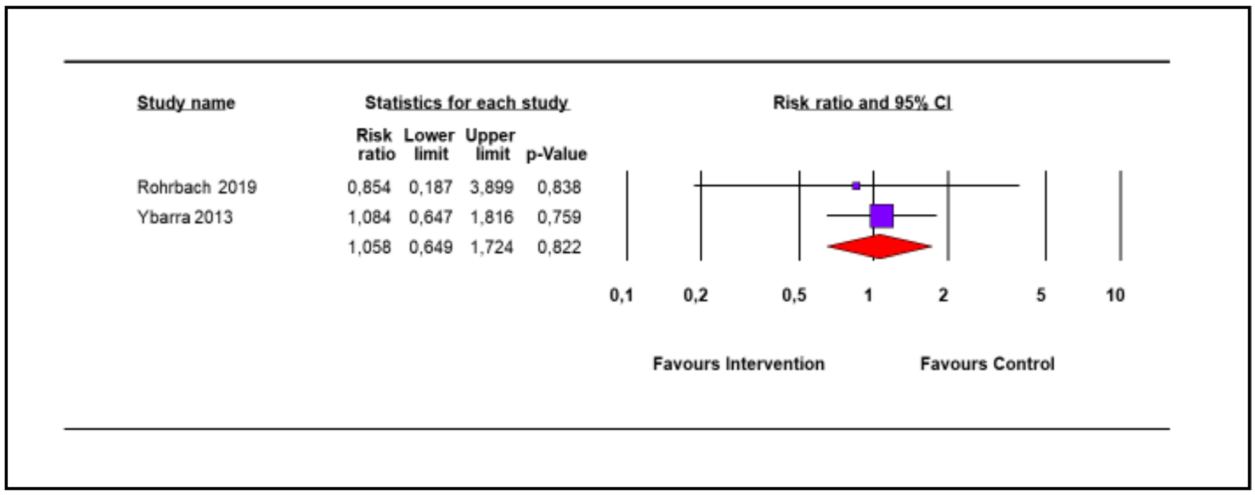

Fig. 5 Forest plot for the outcome of engagement in unprotected sex

Discussion

This review aims to analyse the literature on interventions for adolescent affective sexual health. It seeks to provide valuable insights to future researchers, policymakers, educators, and healthcare professionals by offering a comprehensive review, synthesis, and evaluation of the current body of research on gamification and serious game-based sexual education interventions to improve adolescent knowledge, attitudes, intention, and behaviours and how they are implemented.

Most of the studies reviewed demonstrated moderate to high quality. This can be attributed to several factors. Firstly, the study types were largely RCTs, with two quasi-experimental studies and one controlled clinical trial. Secondly, the recruitment process, conducted in schools, resulted in high acceptance rates for participation. Schools provided accessible settings for inclusion and follow-up of students. Additionally, all the programmes achieved retention rates of over 75%, as evident from the data. In terms of participant gender, the recruitment was well balanced, with 48.70% males, 51.27% females, and only 0.04% with gender not specified.

The findings from the analysis of gamification in adolescent affective sexual education indicate promising results in enhancing knowledge, attitudes, and sexual behaviours. While it is important to note that not all studies assessed the same outcomes, the overall impact was positive. These results suggest that gamified interventions can serve as valuable tools for improving various indicators, in both the short

and long term, with a particular emphasis on knowledge related to sexuality. The results from the meta-analysis of eight studies indicate that gamified interventions are effective in delaying sexual initiation among adolescents, achieving an 15% reduction in the probability of initiating sexual relationships. This suggests that strategies incorporating game elements may serve as a valuable tool for promoting safer sexual behaviours within this population.

Notably, two studies yielded results that differed from the rest. Specifically, Potter et al. (2016) found that the behavioural effects of the intervention were not replicated in other AIG studies. The authors hypothesised that this discrepancy may be attributed to the study's design and the specific rural context in which it was conducted, and further replication studies should be conducted to explore how these factors may affect the results obtained. These findings underscore the importance of considering the intervention's context and design, as well as the diverse characteristics of the population being studied such as gender, race, and ethnicity. By doing so, interventions can better motivate and impart knowledge to each adolescent (Markham et al., 2012; Tortolero et al., 2010).

We encountered a study which, despite not meeting the standards to determine the effectiveness of the intervention, presents a very interesting participatory approach to intervention design, aligning well with the guidelines set by the WHO. Research grounded in participatory approaches, designed in collaboration with young people themselves, may facilitate the development of interventions that are more feasible, idealistic, and sustainable over time in the future (Haruna, 2024).

This leads to a fundamental question: Should effective gamification interventions for affective-sexual education be replicated? Notably, a highly promising intervention known as the “It’s Your Game” programme has garnered attention in this regard (Markham et al., 2012; Peskin et al., 2015, 2019; Potter et al., 2016; Rohrbach et al., 2019; Tortolero et al., 2010). The primary objective of these interventions was to delay sexual initiation among adolescents. The results suggested the effectiveness in delaying sexual initiation compared to the CG, which received traditional teaching methods. In addition to the impact on the initiation of sexual activity, these studies also assessed psychosocial aspects related to sexual health, including knowledge and attitudes. Significantly positive effects were observed in these areas after the intervention when compared to the CG. Notably, the studies employing “It’s Your Game” as an educational tool considered factors such as race, ethnicity, and gender in their evaluations. Follow-up evaluations were conducted during the seventh, eighth, and ninth grades. Furthermore, it is noteworthy that facilitators involved in delivering these interventions were required to undergo prior training, suggesting that proper training of facilitators in the programme's content may contribute to the positive outcomes achieved.

Another interesting finding was the follow-up of the students after the interventions. The duration of these follow-ups varied, ranging from the immediate end of the intervention to as long as 24 months later. However, some trends that improve outcomes in the EG were found. In the study by Peskin et al. (2015) a relationship was observed between exposure to the intervention and improved outcomes (knowledge, attitudes, behaviour, delay of sexual initiation); that is, the greater the exposure, the lower the likelihood of initiating sex. Therefore, it is suggested for future interventions to control the exposure of the participants to improve the expected results. In this context, we can affirm that the execution of educational interventions within the school schedule enables an accurate assessment of participants' actual exposure to the interventions, resulting in increased retention and, consequently, improvements in outcomes related to the affective sexual health of adolescents.

On the other hand, Ybarra et al., (2013, 2015) demonstrated a trend of improvement in abstinence for the EG, which received an intervention plus booster at four to six months, as well as an improvement, although not significant, for unprotected sex in the EG. These results suggest that the administration of reinforcement over time could improve the objectives established by the study, in this case, knowledge, attitudes, intentions, and behaviours on affective-sexual education in adolescents.

The use of gamification as an educational tool is relatively recent. Despite its increasing popularity and growing adoption, the development of a gamified intervention remains fragmented, primarily due to the absence of standardised processes that describe gamification methods suitable for implementation in educational settings (Wiklund & Wakerius, 2016). The various studies included in this review provide important data, such as the days of implementation, trainers, place of implementation, activity, and evaluation of efficacy after the end of the intervention. However, only Arnab et al. (2013) described the game elements included for each activity.

Consequently, it is imperative that researchers conduct rigorous studies that allow the development of standardised frameworks such as those established by WHO (WHO, 2019). These frameworks should be based on the effectiveness of the programmes and adhere to uniform guidelines, allowing the extrapolation and comparison of results. This will lead to the creation of a protocolised plan aimed at preventing risky sexual behaviours in a comprehensive and systematic manner.

Only five of the studies involved parents in the interventions. The authors examined the effectiveness of interventions for improving parent–child communication on the

topic of sexuality in four of them. A significant increase was found in one study, positive improvements were found in three studies, and one study found no statistically significant effect. González et al. (2017) discovered that the primary impediments to these conversations were the lack of information among parents, their uncertainty about how to approach the subject, and taboos and gender stereotypes relating to sexuality. It would be intriguing to conduct further research to comprehensively assess the impact of parent–child communication on children's emotional and sexual health.

Limitations and Strengths

This review included 16 experimental studies (RCTs, controlled trials, and quasi-experimental trials) to obtain the highest level of evidence. The search was conducted in five databases to gather comprehensive information on the subject, without any restrictions on publication date, language, or other limitations. Additionally, a search of the grey literature and a forward and backward reference search of all articles were performed to identify potential new studies for inclusion in the review. The methodological quality of the included studies ranged from high to moderate. It is possible that some relevant studies may have been inadvertently omitted, despite our careful selection of comprehensive keywords. Furthermore, only interventions conducted within schools were considered for inclusion. Regarding the studies, we were unable to calculate Cohen's d due to the lack of data in the published results and establishing the temporality of the short- and long-term objectives was challenging due to the heterogeneity of each study. Finally, we were unable to determine the specific game mechanics used in the interventions, as well as a standardised methodology for gamification. On the other hand, none of the included articles measured the cost- effectiveness of the interventions implemented, which is essential to allocate resources efficiently and ensure that the selected interventions provide the maximum positive impact on the sexual health of the population.

This review provides interesting aspects to be considered for future research. Firstly, a methodology is needed to develop universal gamified interventions with the aim of standardising design criteria, thus allowing for in-depth analysis and comparison of the effectiveness of interventions when gamification is used as a learning tool (Wiklund & Wakerius, 2016). Despite the existence of staged models such as those of the National Institutes of Health, they are not always used as guidelines, such as by utilising interventions that have proven to be effective and adapting them to different contexts. This approach ensures the use of consistent outcomes, analysis methods, gamification tools, and results that can be extrapolated to various contexts. Additionally, it is essential to consider gender and cultural diversity in each case to enhance participation, retention, and motivation and to improve the behaviour, knowledge, and attitudes of the participants (Markham et al., 2012; Tortolero et al., 2010). Furthermore, initiating these interventions as early as possible is necessary to address sexuality as a right for all adolescents through health education, thus preventing risky sexual behaviours from becoming ingrained lifestyles (World Health Organization, n.d.-b). For future research, the authors could conduct qualitative studies to gain insight into adolescents' experience of sexual education, uncover perceived unmet needs, and gather perspectives from teachers and parents (UNESCO et al., 2021).

In conclusion, this review has identified potential aspects related to the effectiveness of gamified interventions in affective sexual education for adolescents. Given the need for advancements in the field of sexual education, these findings may assist future researchers in developing effective and high-quality interventions.

Appendix A

Table 4 Search terms used

Database	Dates	No. of results	Used Syntax
Pubmed	20/3/2022	228	(Adolescen* OR student* OR teen* OR "school age" OR minor*) AND (gamification OR "serious gam*" OR "Game-based learning" OR "Game-based intervention*" OR game* OR "video game*" OR "gamified instruction" OR "games-based" OR "digital game*") AND ("sexual behavior*" OR "sexual health" OR "STD" OR "sexually transmitted disease*" OR "sexual and reproductive health" OR "HIV" OR "pregnancy, unwanted" OR "sex offence*") AND (intervention* OR "sex education" OR "health education" OR program* OR prevention OR "health promotion")
	26/11/2022	16	
	13/02/2023	15	
	07/12/2023	14	
	05/04/2024	8	
Web of science	20/3/2022	322	(((TS=(Adolescen* OR student* OR teen* OR "school age" OR minor*)) AND TS=(gamification OR "serious gam*" OR "Game-based learning" OR "Game-based intervention*" OR game* OR "video game*" OR "gamified instruction" OR "games-based" OR "digital game*")) AND TS=("sexual behavior*" OR "sexual health" OR "STD" OR "sexually transmitted disease*" OR "sexual and reproductive health" OR "HIV" OR "pregnancy, unwanted" OR "sex offence*")) AND TS=(intervention* OR "sex education" OR "health education" OR program* OR prevention OR "health promotion")
	26/11/2022	17	
	13/02/2023	13	
	07/12/2023	13	
	05/04/2024	5	
PsychInfo	20/3/2022	157	(Adolescen* OR student* OR teen* OR "school age" OR minor*) AND (gamification OR "serious gam*" OR "Game-based learning" OR "Game-based intervention*" OR game* OR "video game*" OR "gamified instruction" OR "games-based" OR "digital game*") AND ("sexual behavior*" OR "sexual health" OR "STD" OR "sexually transmitted disease*" OR "sexual and reproductive health" OR "HIV" OR "pregnancy, unwanted" OR "sex offence*") AND (intervention* OR "sex education" OR "health education" OR program* OR prevention OR "health promotion")
	26/11/2022	3	
	13/02/2023	5	
	07/12/2023	2	
	05/04/2024	3	
Scopus	20/3/2022	256	(TITLE-ABS-KEY (adolescen* OR student* OR teen* OR "school age" OR minor*) AND TITLE-ABS-KEY (gamification OR "serious gam*" OR "Game-based learning" OR "Game-based intervention*" OR game* OR "video game*" OR "gamified instruction" OR "games-based" OR "digital game*") AND TITLE-ABS-KEY ("sexual behavior*" OR "sexual health" OR "STD" OR "sexually transmitted disease*" OR "sexual and reproductive health" OR "HIV" OR "pregnancy, unwanted" OR "sex offence*") AND TITLE-ABS-KEY (intervention* OR "sex education" OR "health education" OR program* OR prevention OR "health promotion"))
	26/11/2022	8	
	13/02/2023	11	
	07/12/2023	12	
	05/04/2024	5	
Embase	20/3/2022	248	(adolescen* OR student* OR teen* OR 'school age'/exp OR 'school age' OR minor*) AND ('gamification'/exp OR gamification OR 'serious gam*' OR 'game-based learning'/exp OR 'game-based learning' OR 'game-based intervention*' OR game* OR 'video game*' OR 'gamified instruction' OR 'games-based' OR 'digital game*') AND ('sexual behavior*' OR 'sexual health'/exp OR 'sexual health' OR 'std' OR 'sexually transmitted disease*' OR 'sexual and reproductive health' OR 'hiv'/exp OR 'hiv' OR 'pregnancy, unwanted'/exp OR 'pregnancy, unwanted' OR 'sex offence*') AND (intervention* OR 'sex education'/exp OR 'sex education' OR 'health education'/exp OR 'health education' OR program* OR 'prevention'/exp OR prevention OR 'health promotion'/exp OR 'health promotion')
	26/11/2022	13	
	13/02/2023	5	
	07/12/2023	23	
	05/04/2024	10	

Appendix B

Table 5 Abstract Checklist

Section and Topic	Item #	Checklist item	Reported (Yes/No)
TITLE			
Title	1	Identify the report as a systematic review.	Yes
BACKGROUND			
Objectives	2	Provide an explicit statement of the main objective(s) or question(s) the review addresses.	Yes
METHODS			
Eligibility criteria	3	Specify the inclusion and exclusion criteria for the review.	Yes
Information sources	4	Specify the information sources (e.g. databases, registers) used to identify studies and the date when each was last searched.	Yes
Risk of bias	5	Specify the methods used to assess risk of bias in the included studies.	Yes
Synthesis of results	6	Specify the methods used to present and synthesise results.	Yes
RESULTS			
Included studies	7	Give the total number of included studies and participants and summarise relevant characteristics of studies.	Yes
Synthesis of results	8	Present results for main outcomes, preferably indicating the number of included studies and participants for each. If meta-analysis was done, report the summary estimate and confidence/credible interval. If comparing groups, indicate the direction of the effect (i.e. which group is favoured).	Yes
DISCUSSION			
Limitations of evidence	9	Provide a brief summary of the limitations of the evidence included in the review (e.g. study risk of bias, inconsistency and imprecision).	Yes
Interpretation	10	Provide a general interpretation of the results and important implications.	Yes
OTHER			
Funding	11	Specify the primary source of funding for the review.	N.A
Registration	12	Provide the register name and registration number.	Yes

Appendix C

Table 6 Prisma checklist

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	(title page)
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	Appendice B
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	p.1
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	p.3
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	p.5-6
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	p.5
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	Appendices A
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	p.5-6
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	p.5-6
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	p.5-6
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	p.5-6
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	p.6
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	p.5-6
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	p.5-6
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	p.5-6
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	p.5-6

Table 6 (continued)

Section and Topic	Item #	Checklist item	Location where item is reported
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	p.5-6
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	N.A
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	N.A
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	p.6
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	N.A
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	p.8-9
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	N.A
Study characteristics	17	Cite each included study and present its characteristics.	p.10-22; p.28-34
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	p. 10-22
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	p. 10-22
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	p.7-9
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	p.22-25
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	N.A
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	N.A
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	N.A
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	p.22-25
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	p. 35-37
	23b	Discuss any limitations of the evidence included in the review.	p. 35-37
	23c	Discuss any limitations of the review processes used.	p. 35-37
	23d	Discuss implications of the results for practice, policy, and future research.	p. 35-37
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	p.4

Table 6 (continued)

Section and Topic	Item #	Checklist item	Location where item is reported
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	N.A.
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	N.A.
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	Declaration of Interest Statement page
Competing interests	26		Declaration of Interest Statement page
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	N.A

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Declarations

Competing Interest The authors declare no competing interests.

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