

## Original Article

# Meta-analysis of the effectiveness of educational programs about HIV prevention on knowledge, attitude, and behavior among adolescents

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## Abstract

The prevalence of human immunodeficiency virus (HIV) among adolescents is on the rise due to a lack of comprehensive knowledge, leading to suboptimal attitudes and behaviors, which emphasizes the critical need for targeted interventions. The aim of this review study was to evaluate the effectiveness of educational interventions for HIV prevention among adolescents by assessing their impact on knowledge, attitude, and behavior. A systematic review of seven databases: PubMed, Science Direct, Cochrane, JSTOR, Embase, Scopus, and EBSCO were identified, and 14 eligible randomized controlled trials published until June 2023 were included. Two independent authors assessed quality appraisal using the Risk of Bias 2.0. Outcomes were measured using the standard mean difference (SMD) with random effects model and a 95% confidence interval. Subgroup analyses and meta-regression were performed to explore heterogeneity. The results showed significant improvements in participants' knowledge (SMD: 1.13, 95%CI: 0.78–1.49), behavior intentions (SMD: 1.22, 95%CI: 0.37–2.07), and attitude (SMD: 0.48, 95%CI: 0.02–0.95) after receiving HIV prevention education programs. Interventions grounded in theoretical principles and incorporating technology, group settings, and audio-visual aids were found to be effective in enhancing knowledge of HIV prevention and promoting behavioral intentions. Peer-led education positively impacted both knowledge and attitude. Moreover, excluding parents from these programs was identified as a crucial factor in improving adolescents' knowledge of HIV prevention. In conclusion, educational programs focused on HIV effectively enhance adolescents' knowledge, attitudes, and behavioral intentions among adolescents. Professionals planning interventions should consider these impactful components in designing comprehensive strategies.

**Keywords:** Attitude, behavioral, educational programs, HIV, knowledge

## Introduction

Human immunodeficiency virus (HIV) and acquired immune deficiency syndrome (AIDS) are infectious diseases that pose significant challenges for healthcare professionals around the world in terms of prevention, management, and eradication among specific populations and high-risk groups [1]. HIV and AIDS can be transmitted through several body fluids, including blood, semen, pre-ejaculate fluid, vaginal fluid, anal fluid, and breast milk [2,3]. The rapid transmission of HIV



has led to a significant annual rise in HIV cases [4]. The incidence of HIV infection among adolescents has risen over the past five years, with a prevalence rate of 35% or 480,000 cases among individuals aged 10–24 years, and 140,000 cases in those aged 10–19 years [5]. This high prevalence can be attributed to a lack of comprehensive knowledge, leading to poor attitudes and behaviors in avoiding HIV and AIDS in this age group [6]. Hence, devising an intervention specifically targeting HIV prevention in adolescents is crucial.

Attitudes toward HIV and AIDS prevention in adolescents reflect their positive outlook to engage in preventative measures against HIV/AIDS [7]. HIV/AIDS prevention behavior refers to an individual's capacity to engage in actions such as abstaining from sexual relations, avoiding multiple sexual partners, using condoms, and refraining from using injectable drugs [8-10]. Those two variables (attitude and behavior) are the protective variables that influence adolescents' decision-making regarding the enactment of behavior [3]. Enhancing these protective factors is essential to mitigate the risk of HIV and AIDS among adolescent by improving their knowledge, attitudes, and behaviors about prevention [11].

One of the prevention programs is the Determined, Resilient, Empowered, AIDS-free, Mentored, and Safe (DREAMS) program, which focuses on implementing various interventions for HIV and AIDS prevention among young women at high risk in sub-Saharan Africa through a comprehensive approach [12]. It includes HIV prevention education, mentorship for empowerment, the creation of safe spaces for open discussions, behavioral interventions promoting safe practices, and community engagement to address social norms. The program's primary objective is to reduce new HIV infections by addressing the social, economic, and health factors contributing to vulnerability, empowering young women with the knowledge and skills to protect themselves and lead healthy lives. Numerous intervention programs designed to enhance adolescents' understanding of HIV prevention have been implemented in community and school settings, involving educational and counseling initiatives facilitated by peers, instructors, and parents [13]. However, the existing investigations, employing both randomized control trials (RCTs) [14] and non-randomized control trial design [15], pose challenges in reaching definitive results [16,17]. Combining research with an RCT design to increase the sample size may offer advantageous outcomes [18] and yield more accurate outcomes [19].

The aim of this meta-analysis was to address a crucial research gap in existing systematic reviews and meta-analyses that have focused on different aspects of HIV prevention, such as knowledge enhancement, attitude, and behavior modifications, or the efficacy of educational interventions among adolescents [20-28]. There remains a scarcity of synthesized evidence that collectively examines the holistic outcomes of educational programs specifically targeting adolescents. The identified studies have primarily focused on either knowledge enhancement [25,29-33], attitude and behavior modifications [21,22,28,34], or the efficacy of educational interventions [21,32,35,36] among adolescents.

Adolescence is a period of significant and quick transformations in physical, mental, and intellectual capacities, making it crucial for the development of knowledge, attitudes, beliefs, and healthy behavior, including HIV and AIDS prevention [37]. To create an educational program tailored for adolescents, various elements like the content, delivery method, information source, setting, and format of the educational material should be adaptable to the specific needs and circumstances. Previous meta-analyses by Mirzazadeh *et al.* [13] and Kim *et al.* [38], have not clarified which specific program aspects and characteristics are linked to successful HIV prevention in terms of adolescent knowledge, behavior, and attitudes. The complex nature of the factors that influence behavior change also contributes to the lack of data on efficacy. Long-term and thorough tactics, as indicated by the research of Lonczak *et al.* [39], involving the active participation of peers, teachers, and parents have proven more effective than interventions solely focused on sexual education within schools [40-42]. Therefore, it is imperative to perform an analysis of the essential elements in developing an appropriate educational program to prevent HIV among adolescents.

This aim of this meta-analysis was to provide a comprehensive understanding of the overall impact of educational programs on adolescents' knowledge, attitude, and behavior regarding HIV prevention by enhancing the comparability of study findings, assess the effectiveness of educational programs on HIV prevention knowledge and behavior among adolescents, and

identify the key components of successful programs in preventing HIV among this age group. The synthesis is intended to offer valuable insights into the complex nature of HIV prevention efforts, potentially guiding the development of more efficient and focused interventions.

## Methods

The present study offered a systematic review and meta-analysis of RCTs. The research procedure has been prospectively registered in the International Prospective Register of Systematic Reviews (PROSPERO), CRD42023406705. This study adhered to the guidelines set forth by Preferred Reporting Items for Systematic Reviews and Meta-Analysis 2020 (PRISMA 2020).

### Search strategy

Three independent authors (DR, MHH, and MAM) conducted article searches autonomously. A comprehensive literature search was conducted using various combinations of keywords, such as 'HIV' OR 'AIDS' AND 'prevention' AND 'education' OR 'knowledge' OR 'attitudes' OR 'behavior' OR 'practice' AND 'adolescents' OR 'teenager' AND 'randomized controlled trials' OR 'randomized controlled study'. Systematic searches were conducted in seven databases: PubMed, ScienceDirect, Cochrane, JSTOR, Embase, Scopus, and EBSCO, covering the period from January 1, 2010, to June 23, 2023. For a comprehensive literature search, the authors utilized Medical Subject Headings (MeSH) terms to ensure the retrieval of relevant and high-quality articles.

### Eligibility criteria

The researchers determined the following criteria for the included studies: (1) the study involved adolescents between the ages of 10 to 19 based on studies by Sawyer *et al.* [43] and World Health Organization (WHO) [44]; (2) all included studies followed an RCT design and published in the English language; (3) the intervention implemented was an educational program focused on HIV prevention aimed at enhancing HIV knowledge, attitudes, and behavioral intentions in both individuals and groups, including peers, family, and teachers, with the goal of transforming them into support networks for adolescents; (4) the intervention program described in the evaluation was implemented by a team comprising peers, teachers, social workers, and professional healthcare providers, including school nurses, health promotion specialists, psychologists, and psychiatrists, through in-person sessions in schools or communities, as well as online platforms using technology such as the web, Android applications, game therapy, and audiovisual aids such as videos, animations, and photos; and (5) the effectiveness of these programs was assessed by measuring the participants' HIV knowledge, attitude, and behavioral intentions using a validated questionnaire. The researchers excluded papers that did not have protocol designs, irrelevant studies, duplicates, no full-text access, failure to meet the study purpose, unreported sample sizes, or unreported outcomes of interventions (no effect size estimated presented and no HIV knowledge).

### Data screening and extraction

The removal of duplicate articles was automated by Endnote, with any remaining duplications manually eliminated by the researcher. Three researchers (DR, AS, and WW) initially reviewed the titles and abstracts using identical inclusion and exclusion criteria. Subsequently, the articles that satisfied the inclusion criteria, as determined by the title and abstract, were further screened by examining the complete text. Discussions were conducted with the third author (MHH) when discrepancies arose between the three writers throughout the screening process.

The researchers developed a systematic table for extracting the data, which was created based on the papers that were included. The variables that were retrieved comprised the following: (1) research characteristics, such as the authors, year, and country in which the research was conducted, the number of participants in both the experimental and control groups, and the average age of the respondents; (2) components of intervention including theoretical framework, intervention type, setting, content, format, intervention provider, and duration of intervention; and (3) outcomes including the results which were the acquisition of knowledge and the utilization of measurement instruments.

### Quality assessment

Two authors (DR and MAM) assessed the methodological rigor of the study using the Cochrane risk of bias tool for randomized controlled trials (RoB 2.0). Five domains were evaluated including the randomization method, variation of intended interventions, missing result data, outcome measurements, selection of reported outcomes, and overall bias. Every element was categorized as having a low risk of bias, a high risk of bias, or a presence of some concern [45–47]. Discrepancies in the authors' conclusions were resolved by engaging in a discussion with a third and fourth reviewer (MHH and AS) until a consensus was achieved.

### Data analysis

The meta-analysis was conducted using the Comprehensive Meta Analysis version 2.0 (CMA) software [48]. The mean, standard deviation (SD), and sample size of each group were utilized to calculate the standardized mean difference (SMD) and the 95% confidence interval (CI). These values were subsequently employed to generate aggregated effect estimates. Random effects model was employed to synthesize the effects of educational programs on HIV prevention. To explore the possible factors contributing to heterogeneity, moderator analyses were performed on the estimates of participant or intervention characteristics related to knowledge, behavior, and attitude. Subgroup analyses were generated by merging trials and comparing their impacts. Additionally, meta-regressions were conducted to assess the influence of continuous variables on outcomes, that is the duration of the intervention.

Publication bias was assessed by utilizing the Begg and Mazumdar's rank correlation test [49] and the Duval and Tweedie's trim-and-fill method [50,51]. Publication bias was detected using a modified Begg's rank adjustment test with a *p*-value of 0.05. Furthermore, a sensitivity analysis was performed to assess the resilience of our findings.

## Results

### Search results

A total of 1255 studies were retrieved from seven databases. Following the elimination of duplicate entries and papers that did not match our inclusion criteria, the complete texts of 612 publications were thoroughly examined and 598 were excluded for reasons listed in **Figure 1**. Fourteen full-text papers representing 14 specific studies were finally included in this meta-analysis.

### Study characteristics

The majority of the studies (n=6) were conducted in the United States. The research sample comprised of 8,045 individuals, with respondents' average age ranging from 12.9 to 17 years. Several studies utilized various theories to develop educational programs, including a combination of social cognitive theory, reasoned action theory, and plan behavior theory [52], rational emotive behavior therapy (REBT) [53], the theory of planned behavior [54], interactive learning theory [55], a combination of social cognitive theory and the theory of planned behavior [56], and a combination of social cognitive theory and the theory of reasoned action [57].

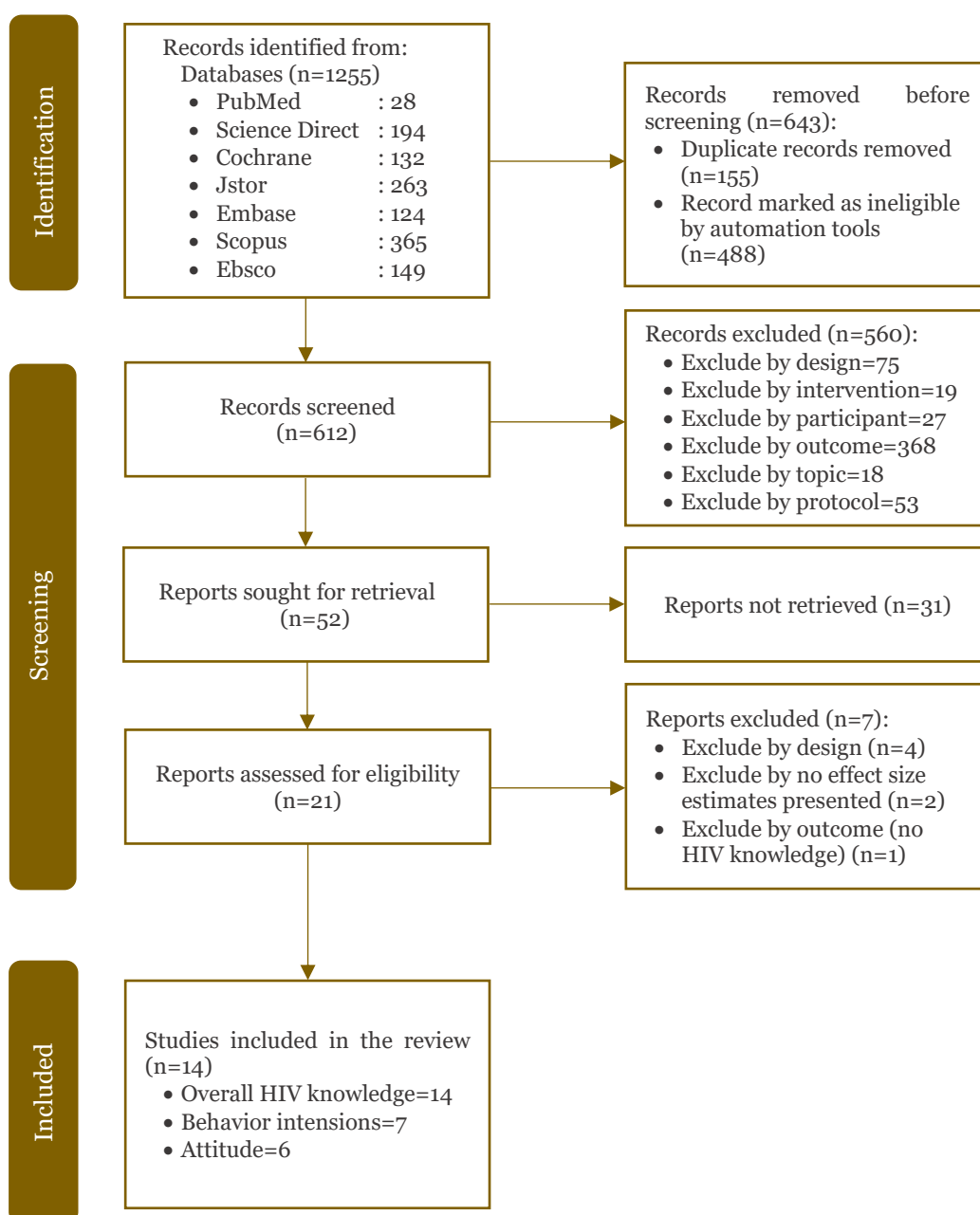


Figure 1. PRISMA flow diagram

The included studies exhibit diverse characteristics in terms of delivering educational programs. Various combinations of curriculum and skill based were used [52,58,59]. Some of these interventions were technology-based [53,55,60–63], while other interventions relied solely on a curriculum-based course without incorporating other types of interventions [54,56,57,64,65]. The educational programs were implemented in schools (n=7) and communities (n=7) with the utilization of group-based approaches (n=10). Intervention providers encompassed a range of professionals, including facilitators, nurses, peer educators, professional health promotion specialists, social workers, teachers, and therapists. Most of these studies did not include parental involvement and lacked the utilization of educational media to deliver educational programs (n=10). Furthermore, the instructional programs varied in length, ranging from a minimum of 2 days to a maximum of 4 months (**Table 1**).

Table 1. Characteristics of included studies

Author (year, country)	Participant	Theory	Type of intervention	Setting	Content of intervention	Format	Conducted by	Duration	Outcomes measures	Measurement tools
Bauman <i>et al.</i> [52] (2021, United States)	n=397 I=200 C=197 Mean age=13.4	Social cognitive theory, theory of reasoned action and theory of plan behavior	Curriculum-based Skill-based	Group-based School	Sexual risk behavior Social cognitions Gender norms, relationships, and resilience	Lecture	Facilitator	14 weeks (11 sessions and 3-week internship)	HIV knowledge Behavioral intentions	18-items [66] CAPS Sexual behavior [67]
Ezegbe <i>et al.</i> [53] (2018, Nigeria)	n=80 I=40 C=40 Mean age=14.63-14.93	Rationale emotive behavior therapy (REBT)	Technology-based: digital storytelling	Group-based School	Signs, symptoms, and stages Mode of transmission Preventive measures	Lecture Audiovisual	-	Twice per week over 8 weeks	HIV knowledge	HIV Knowledge Questionnaire (HIV-KQ-18)
Farahani <i>et al.</i> [54] (2020, Iran)	n=578 I=289 C=289 Mean age=14.1	Theory planned behavior	Curriculum-based	Group-based School	HIV virus HIV prevention HIV transmission Risky behaviors	Lecture Brainstorming Workshop	Professional health promotion	6 phases, 2 hours each phase over 10 months	HIV knowledge Attitude Behavioral intentions	Structure questionnaire
Fiellin <i>et al.</i> [55] (2017, United States)	n=333 Mean age=12.9	Interactive learning theory	Technology-based	Individual-based Community	Sexual risk behaviors and knowledge Attitudes intentions	Video games	-	75 minutes twice/week over 6 weeks	HIV knowledge Attitude Behavioral intentions	Sexual health knowledge
Kaufman <i>et al.</i> [56] (2014, United States)	n=635 I=314 C=321 Mean age: 12.98	Social cognitive theory and theory of planned behavior	Curriculum-based	Group-based School	Knowledge structures Outcome expectancies Efficacy expectancies	Lecture	Social worker	12 months (30 hours)	HIV knowledge	Structured questionnaire National survey
Kennedy <i>et al.</i> [57] (2018, Liberia)	n=704 I=353 C=351 Mean age=16.03	Social cognitive theory and theory of reasoned action	Curriculum-based	Group-based Community	HIV/AIDS-knowledge, Peer norms Sexual attitudes Sexual behaviors	Lecture	-	6 months	HIV/AIDS knowledge	HIV-related knowledge scale

Author (year, country)	Participant	Theory	Type of intervention	Setting	Content of intervention	Format	Conducted by	Duration	Outcomes measures	Measurement tools
Khezri <i>et al.</i> [64] (2019, Iran)	n=60 I=30 C=30 Mean age=6–18	-	Curriculum-based	Group-based Community	Intensity, sensitivity, prevalence, and transmission High-risk actions HIV/AIDS prevention Wrong beliefs HIV/AIDS treatment	Lecture Movie Photos	-	2 days	HIV knowledge Attitude	Knowledge questionnaire about HIV and AIDS Attitude questionnaire about HIV and AIDS
Khosravi <i>et al.</i> [65] (2018, Iran)	n=61 I=30 C=31 Mean age=14.9	-	Curriculum-based	Group-based Community	The nature of the disease Mode of transmission, prevention methods Free of charge HIV/AIDS services Communicate and teach their friends	Lecture Brochures	Trained peers' educator	4 weeks	HIV knowledge Attitude Behavioral intentions	Behavioral surveillance surveys
Lescano <i>et al.</i> [59] (2020, United States)	n=227 I=117 C=110 Mean age I=43.43 (7.18) C=43.86 (6.98)	-	Curriculum-based Skill-based	Group-based Community	HIV prevention High-risk behavior Communication about sex and risk behavior Decision-making procedures	Lecture Discussion Parent involvement: +	Health professional	7 hours	HIV knowledge	HIV knowledge questionnaire and self-efficacy for HIV prevention
Marsch <i>et al.</i> [60] (2015, United States)	n=141 I=69 C=72 Mean age=12.9	-	Technology-based	Individual-based Community	Drug and sex-related factors Youth living with HIV and Hepatitis C Disease coping Managing stigma Disclosing serostatus Healthy style	Web-based	-	2 weeks	HIV knowledge Behavioral intentions	HIV, hepatitis, and STI knowledge test Behavioral intentions scale
Mathews <i>et al.</i> [58] (2016, South Africa)	n=3034 I=1515 C=1519 Mean age=13.7	Reason action theory and I-Change theoretical model	Curriculum-based Skill-based	Group-based School	Educational program School health service School safety program	Lecture-based	School nurse	21 weeks 1–1.5 hours per week	HIV knowledge Attitude Behavioral intentions	Structure questionnaire

Author (year, country)	Participant	Theory	Type of intervention	Setting	Content of intervention	Format	Conducted by	Duration	Outcomes measures	Measurement tools
Nelson <i>et al.</i> [61] (2021, United States)	n=154 I=77 C=77 Mean age=14-17	-	Technology-based	Individual-based  Community	Male anatomy HIV/STIs prevention information General sexual health information Pornography literacy skills	Games Animation video Infographic	-	18 weeks	HIV knowledge	HIV Knowledge Questionnaire (HIV-KQ-18) STD Knowledge Questionnaire (STD-KQ) Validated questionnaire HIV-KQ-18
Ofoegbu <i>et al.</i> [62] (2020, Nigeria)	n=98 I=49 C=49 Mean age=20.43 (0.89)		Technology-based	Group-based  School	Signs, symptoms, and stages Mode of transmission Preventive measures	Lecture (Audiovisual storytelling) Counselling	Therapist	16 sessions 8 weeks	HIV knowledge	
Peskin <i>et al.</i> [63] (2019, United States)	n=1543 I=804 C=739 Mean age=13	Theory planned behavior	Technology-based	Individual and group-based  School	Friendship qualities Dating Sexual behavior	Lecture Discussion  Parent involvement: +	Teachers	24 lessons over 4 months	HIV knowledge Attitude Behavioral intentions	Validated questionnaire

AIDS: acquired immunodeficiency syndrome; C: comparison; CAPS: condom attitude and practice scale; HIV: human immunodeficiency virus; I: intervention; n: total number; STIs: sexually transmitted infections; STD-KQ: sexually transmitted disease-knowledge questionnaire



### Effectiveness of educational programs on knowledge, behavior, and attitude

The study findings indicated that adolescents who underwent an educational program exhibited significantly higher knowledge scores compared to those who did not receive such a program (SMD: 1.13, 95%CI: 0.78–1.49,  $p < 0.001$ ). Additionally, the  $I^2$  value of 97.8 ( $p < 0.001$ ) suggested a high level of heterogeneity among the analyzed studies.

The educational program led to a substantial improvement in behavioral intention among adolescents who received therapy (SMD: 0.48, 95%CI: 0.02–0.95,  $p < 0.05$ ), compared to those in the control group. The analysis revealed a significant level of heterogeneity among the included studies, as indicated by an  $I^2$  value of 98.30 and a  $p < 0.001$ .

The analysis revealed that adolescents who underwent an educational program showed a significant increase in their attitude score toward HIV prevention compared to those who did not undergo the program (SMD: 1.22, 95%CI: 0.37–2.07,  $p < 0.001$ ). The  $I^2$  value of 93.4 ( $p < 0.001$ ) indicated a high level of heterogeneity among the studies. Fourteen studies were combined to explore the effects of educational programs (Table 2). Three separate figures depicting the overall effect of educational programs on knowledge (A), behavioral intention (B), and attitude (C) are included in Figure 2.

### Subgroup analysis and meta-regression

The subgroup analysis revealed that theory-based educational programs, technology-based interventions, and group-based education were significantly associated with an increase in knowledge scores regarding HIV prevention (SMD: 1.24, 95%CI: 0.55, 1.92,  $p < 0.001$ ; SMD: 1.69, 95%CI: 0.17–1.75,  $p < 0.001$ ; SMD: 1.64, 95%CI: 0.18–1.10,  $p < 0.001$ , respectively). The analysis findings also indicated that the implementation of peer educators, exclusion of parental involvement, and utilization of audio-visuals are beneficial strategies for enhancing knowledge of HIV prevention (SMD: 2.51, 95%CI: 1.84–3.19,  $p < 0.001$ ; SMD: 1.35, 95%CI: 0.91–1.8,  $p < 0.001$ ; SMD: 6.88, 95%CI: 5.73–8.04,  $p < 0.001$ , respectively).

From the analysis, we found that the use of theory and technology, as well as a combination of individual and group modes, led to an increase in behavioral intention (SMD: 0.21, 95%CI: 0.16–0.26,  $p < 0.001$ ; SMD: 1.14, 95%CI: 0.05–1.23,  $p < 0.001$ ; SMD: 0.15, 95%CI: -0.05–0.25,  $p < 0.01$ , respectively). Adolescent behavior was considerably improved by educational programs offered by experts in health promotion through the use of brochures with an extended intervention duration (SMD: 2.02, 95%CI: 1.82–2.22,  $p < 0.001$ ; SMD: 0.69, 95%CI: 0.17–1.21,  $p < 0.001$ ). The intervention's impact was also supported by a positive regression coefficient (B: 0.04,  $p < 0.08$ ) (Table 3).

The study's findings also indicated that longer educational sessions offered by health promotion professionals considerably enhanced adolescents' attitudes toward HIV prevention (SMD: 4.74, 95%CI: 4.42–5.05,  $p < 0.001$ ). The regression analysis further supported this, showing a positive relationship between session length and improved attitudes (B: 0.09,  $p < 0.04$ ). The subgroup analysis and meta-regression of the included studies are depicted in Table 3.

Table 2. Effectiveness of educational programs about HIV prevention on knowledge, behavioral intention, and attitude

Outcome	Number of studies	Standardized mean difference (95%CI)	Heterogeneity	
			$I^2$	$p$ -value
Knowledge about HIV	14	1.13 (0.78–1.49) ***	97.80	<0.001
Behavioral intention	7	0.48 (0.02–0.95) *	98.30	<0.001
Attitude	6	1.22 (0.37–2.07) **	93.40	<0.001

\* Statistically significant at  $p < 0.05$

\*\* Statistically significant at  $p < 0.01$

\*\*\* Statistically significant at  $p < 0.001$

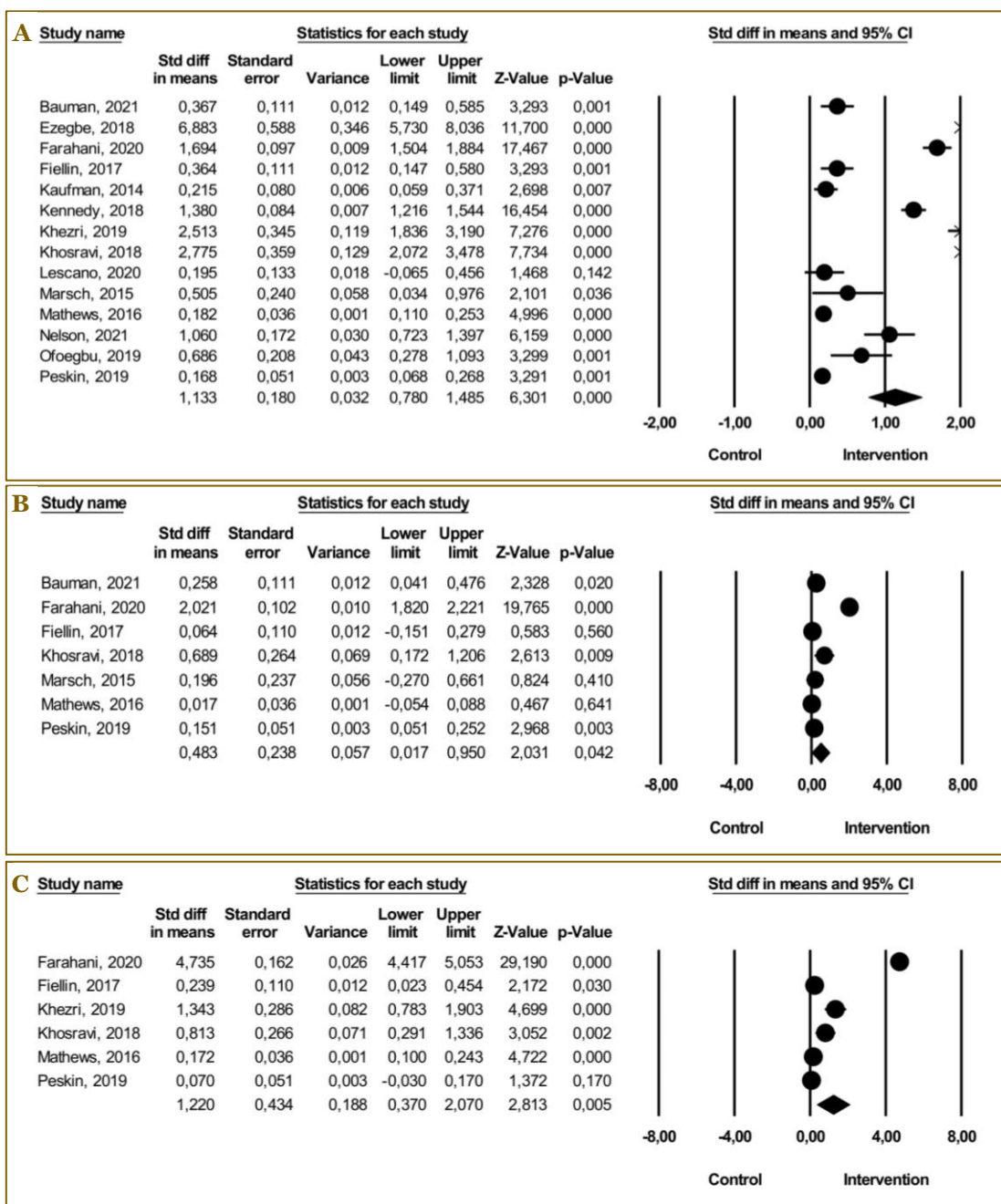


Figure 2. The overall effect of educational programs about HIV prevention on knowledge (A), behavioral intention (B), and attitude (C).

Table 3. Subgroup analysis and meta-regression of educational programs about HIV prevention on knowledge, behavioral intention, and attitude

Variables	Knowledge about HIV			Behavioral intention			Attitude		
	n	SMD (95%CI)	p-value	n	SMD (95%CI)	p-value	n	SMD (95%CI)	p-value
Theory-based intervention	14		<0.001	7		0.013	6		0.712
Yes	6	1.24 (0.55–1.92) ***		5	0.21 (0.16–0.26) ***		4	1.29 (0.24–2.34) *	
No	8	1.07 (0.62–1.52) ***		2	0.42 (0.07–0.76)		2	1.07 (0.55–1.59) ***	
Type of intervention	14		<0.001	7		<0.001	6		0.268
Curriculum-based	5	1.66 (0.89–2.43) ***		3	0.91 (-0.60–2.42)		3	2.30 (-0.43–5.03)	
Curriculum-based + skill-based	3	0.21 (0.12–0.31) ***		1	0.26 (0.04–0.48) *		1	0.17 (0.10–0.24) ***	
Technology based	6	1.69 (0.17–1.75) ***		3	1.14 (0.05–1.23) **		2	0.13 (-0.03–0.28)	
Setting	14		0.969	7		0.360	6		0.093
School	7	1.05 (0.59–1.51) ***		4	0.61 (-0.05–1.27)		4	1.57 (0.42–2.72) **	
Community	7	1.19 (0.64–1.75) ***		3	0.26 (-0.09–0.61)		2	0.48 (-0.08–1.03)	
Mode	14		<0.001	7		0.002	6		0.158
Group-based	10	1.64 (0.18–1.10) **		4	0.75 (-0.27–1.76)		4	1.77(-0.70–4.23)	
Individual-based	3	1.47 (0.96–1.98) ***		2	0.09 (-0.11–0.28)		1	0.24 (0.02–0.45) *	
Combination	1	0.17 (0.07–0.27) **		1	0.15 (0.05–0.25) **		1	0.07 (-0.03–0.17)	
Provider	8		<0.001	4		<0.001	4		<0.001
Facilitator	1	0.37 (0.15–0.59) **		1	0.23 (0.04–0.48) *		-		
Nurse	1	0.18 (0.11–0.25) ***		1	0.02 (-0.05–0.09)		1	0.17 (0.10–0.24) ***	
Peer educator	1	2.51 (1.84–3.19) ***		-	-		1	1.34 (0.78–1.90) ***	
Professional health promotion	2	0.95 (-0.52–2.42)		1	2.02 (1.82–2.22) ***		1	4.74 (4.42–5.05) ***	
Social worker	1	0.22 (0.06–0.37) **		-	-		-		
Teacher	1	0.17 (0.07–0.27) **		1	0.15 (0.01–0.25) **		1	0.07 (-0.03–0.17)	
Therapist	1	0.69 (0.28–1.09) **		-	-		-		
Parent involvement	14		<0.001	7		0.271	6		0.072
Yes	2	0.17 (0.08–0.27) ***		1	0.15 (0.05–0.25) **		1	0.07 (-0.03–0.17)	
No	12	1.35 (0.91–1.80) ***		6	0.54 (-0.15–1.23)		5	1.46 (-0.05–2.97)	
Promotion tools	14		<0.001	7		0.002	6		0.368
Animation + infographic	1	1.06 (0.72–1.40) ***		-	-		-		
Audiovisual	1	6.88 (5.73–8.04) ***		-	-		-		
Brochure	1	2.78 (2.07–3.48) ***		1	0.69 (0.17–1.21) **		1	0.81 (0.29–1.34) **	
Movie + photo	1	2.51 (0.12–1.84) ***		-	-		1	1.34 (0.78–1.90) ***	
None used	10	0.58 (0.24–0.91) **		6	0.45 (-0.05–0.96)		4	1.28 (0.24–2.34) **	
Duration	14	B=0.02	0.206	7	B=0.04	0.008	6	B=0.09	0.004
Age	11	B=-0.01	0.507	7	B=0.54	0.173	5	B=0.62	0.532

B: coefficient beta; CI: confident interval; n: number of studies; SMD: standardized mean difference

\* Statistically significant at  $p < 0.05$ \*\* Statistically significant at  $p < 0.01$ \*\*\* Statistically significant at  $p < 0.001$

### Risk of bias among included studies

Following the evaluation of the studies that were included, it was determined that six studies had low chance of bias, six studies had certain concerns, and one study had a significant risk of bias (Table 4). The majority of studies expressed issues in the domains of randomization procedure (n=5), deviation from intended intervention (n=2), n domain, and assessment of the outcome (n=1).

Table 4. Risk of bias among included studies

Study	D1	D2	D3	D4	D5	Overall
Bauman <i>et al.</i> 2021 [52] United States						
Ezegbe <i>et al.</i> 2018 [53] Nigeria						
Farahani <i>et al.</i> 2020 [54] Iran						
Fiellin <i>et al.</i> 2017 [55] United States						
Kaufman <i>et al.</i> 2014 [56] United States						
Kennedy <i>et al.</i> 2018 [57] Liberia						
Khezri <i>et al.</i> 2019 [64] Iran						
Khosravi <i>et al.</i> 2018 [65] Iran						
Lescano <i>et al.</i> 2020 [59] United States						
Marsch <i>et al.</i> 2015 [60] United States						
Mathews <i>et al.</i> 2016 [58] South Africa						
Nelson <i>et al.</i> 2021 [61] United States						
Ofoegbu <i>et al.</i> 2020 [62] Nigeria						
Peskin <i>et al.</i> 2019 [63] United States						

D1: randomization process; D2: deviation from intended intervention; D3: missing outcome data; D4: measurement of the outcome; D5: selection of the reported result

Judgement:



### Publication bias

Begg and Mazumdar's rank correlation test was employed using Kendall's tau statistics with a continuity adjustment to evaluate the presence of publication bias. Kendall's statistic for knowledge was determined to be 0.27, with a corresponding z-score of 0.75 and a p-value of 0.45. The results of our analysis showed that Kendall's statistics for behavioral intention and attitude were 0.00, z=0.00, p=1.00, and -0.50, z=1.02, p=0.31, respectively. These findings indicate that there was no substantial bias concerning these variables.

### Sensitivity analysis

No outliers were identified in the sensitivity analysis when the study with the greatest effect size on knowledge, behavioral intention, and attitude was excluded. Significant SMD values were obtained for knowledge (SMD: 1.10, 95%CI: 0.77–1.46, p<0.001), behavioral intention (SMD: 0.48, 95%CI: 0.02, 0.95; p<0.05), and attitude (SMD: 1.02, 95%CI: 0.34, 2.05; p<0.001); these values suggest that the findings were robust.

## Discussion

To the best of our knowledge, this is the first systematic review and meta-analysis to assess the effectiveness of educational programs in enhancing knowledge, attitude, and behavior intentions regarding HIV/AIDS prevention among adolescents. Our findings indicate that these programs significantly improve knowledge, behavior, and attitude toward HIV/AIDS prevention. This improvement is in line with the studies from Iran [30] and India [68]. Moreover, the study by Angrist *et al.* [69] in Botswana showed that educational programs have the potential to enhance HIV knowledge by providing accurate information through interactive and participatory methods such as games, videos, discussions, and group activities [70,71]. These programs also foster self-confidence, self-awareness, and healthy lifestyle skills among adolescents [72]. Therefore, it is imperative to consistently implement and incorporate educational initiatives focused on HIV prevention into the school curricula [73,74].

Behavioral intentions are also positively influenced by educational programs, aligning with findings by Moeini *et al.* [75]. These programs aim to enhance positive behavioral intention by modifying and developing individual protection factors, such as self-efficacy and attitude intention, as well as sociocultural protection factors, such as communication and peer teaching [76-78]. Enhancing protection factors in school settings can be achieved through the implementation of novel learning and training approaches that are centered on curriculum, group dynamics, and technology [28,79,80]. It is crucial for health workers in educational institutions to incorporate this information into their programs to enhance behavioral intentions toward HIV prevention.

Furthermore, our review revealed that educational programs positively impact adolescents' attitudes toward HIV prevention. This finding was consistent with the study by Thammaraksa *et al.* [81] in Thailand. The programs address misconceptions and promote positive behavior by offering accurate information, addressing personal beliefs and values, fostering a supportive school and peer environment, and promoting positive social norms [82]. Hence, educational programs can significantly enhance health behavior, as they are integrated into a holistic strategy that tackles several aspects influencing attitudes and behavior [35].

The effectiveness of educational programs is rooted in theoretical frameworks. A study by Siuki *et al.* [83] also used theoretical frameworks in the development of therapies. The educational programs often incorporated theories of health promotion, including the theory of reasoned action [84], social cognitive theory [85], the theory of planned action [86][87], REBT [88,89], and interactive learning theory [90]. These theories enhance knowledge and behavioral intention by emphasizing observational learning, the conviction that HIV/AIDS prevention behavior is secure, socially acceptable, and socially anticipated, and the ability to exert control and actively participate in HIV prevention behavior [91]. The educational program that implemented activities through the dissemination of information and the demonstration of behavior aimed to shape attitudes by influencing individuals' perceptions of behavior and its outcomes. Additionally, it promotes healthier behavior by fostering positive intentions and perceived control over behavior [92]. Thus, incorporating these theoretical frameworks is crucial for developing interventions that effectively enhance HIV-related knowledge, attitudes, and behavior among adolescents in the context of HIV prevention [36,93].

Technology-based educational programs are particularly effective in increasing knowledge and behavior regarding HIV prevention, as demonstrated in a study conducted in KwaZulu-Natal, South Africa [94]. Adolescents exhibit a high acceptance of technology-based solutions due to their familiarity and proficiency with digital systems. These programs offer adaptability, accessibility, user-friendliness, and opportunities for peer connections and interaction, which facilitate optimal learning [95,96]. Furthermore, it is imperative to involve adolescents in the development of health-related technology applications as they have already benefited from digital technology [97]. Technology enables adolescents to engage in optimal learning at any time [98,99]. Therefore, when developing educational programs for adolescents, technology is the most effective tool.

Group-based educational programs are more effective than individual approaches in enhancing knowledge of HIV prevention. The programs promote interactive learning, exchange of experiences, and critical thinking [100], which are essential for a deeper comprehension of

knowledge, attitudes, and behavior related to HIV/AIDS prevention [101]. Moreover, educational programs incorporating group discussions can foster critical thinking and encourage problem-solving skills from diverse perspectives among adolescents. Additionally, engaging in group study can offer social support and motivate individuals to modify their behavior [102]. Consequently, delivering HIV prevention education in a group setting is important.

Peer educators also play a crucial role in improving adolescents' comprehension and disposition toward HIV prevention. This study is supported by the study conducted by Joorbonyan *et al.* [103] in Ramsar, Iran. Adolescents are more likely to engage with and trust information delivered by their peers, as peer educators are often more relatable and relevant to their experiences [104]. Information obtained from peers is often considered more credible and reliable [105]. Peer educators enhance their trustworthiness among adolescents by customizing the curriculum to be more relevant and applicable to the experiences of their peers [106]. Peer-led learning experiences provide robust emotional, informational, and material support, fostering a sense of community and mutual assistance, which can enhance the retention of knowledge [72]. Therefore, incorporating peer educators into HIV prevention programs is essential for effectively reaching and influencing adolescents.

Contrary to the findings of Jones *et al.* [107] and Okigbo *et al.* [108], our review suggests that parental participation may not have a significant positive impact on adolescents' knowledge and behavior in HIV prevention. This phenomenon could be due to societal taboos surrounding sexual matters and HIV prevention, which might cause discomfort among adolescents during discussions related to these topics [109]. According to a study by Tolli [110], adolescents are more likely to share knowledge with their peers due to their shared origins, hobbies, and language usage. These similarities facilitate the exchange of information and help develop good life skills. Therefore, while parental involvement is important, it should be approached with sensitivity and appropriate knowledge.

The utilization of animation, infographics, audio-visual materials, and brochures as educational tools has proven effective in enhancing adolescents' knowledge and promoting behaviors related to HIV prevention. Research by Jeihooni *et al.* [80] in Fasa, Iran, demonstrates that these tools foster emotional connections, enabling youngsters to comprehend and retain educational messages. Educational content is presented in various formats, such as animation, infographics, audio-visual material, brochures, modules, and web-based or Android applications, captures attention, encourages interactivity, and effectively communicates complex messages [111,112]. To effectively engage the adolescent audience, it is crucial to create HIV teaching materials in formats such as animation, infographics, audio-visual materials, brochures, modules, and web-based or Android applications [113]. These tools offer a sense of ease and confidentiality for adolescents, who might feel ashamed or fearful about expressing their curiosity about this subject [114-116]. However, traditional teaching methods, such as lectures and presentations, remain effective due to their adaptability to adolescents' learning preferences [117].

This study demonstrated that an increase in intervention duration has a positive correlation with the changes in adolescents' attitudes and behaviors regarding HIV prevention, align with the findings of Siuki *et al.* [83]. Altering attitudes and behaviors is a sustained process influenced by various factors, including cultural, social, psychological, and adolescent behavioral aspects [118,119]. Ongoing educational efforts are necessary to foster substantial shifts in attitudes among adolescents toward HIV/AIDS prevention and to instill the necessary values and standards for engaging in preventative behaviors [120,121]. To facilitate the comprehension of potential hazards, repercussions, and suitable preventive measures, substantial behavioral modifications among adolescents necessitate ongoing engagement, participation, and interaction throughout any educational programming [23,122,123]. Longer-term interventions can effectively influence adolescents' attitudes and behaviors regarding HIV prevention through the implementation of a comprehensive strategy, ongoing education, and consistent support. However, the efficacy of these interventions may depend on various variables, including the program's content, delivery method, and the target population.

This review has several strengths. First, it employs Cochrane RoB 2.0 for systematic reviews and other risk assessment tools to avoid bias. Second, the study identified specific program

aspects and characteristics that effectively increase knowledge, behavior, and attitudes in HIV prevention among adolescents. Third, because this meta-analysis focused on adolescents or students rather than active adults, the findings are valuable to professionals who focus on adolescents, particularly concerning health education strategies.

This study also has limitations. There was considerable heterogeneity among the included studies, which was addressed through subgroup analysis and meta-regression. Additionally, the individual studies showed an elevated risk of bias due to factors such as randomization procedures, deviation from the intervention, and outcome measurement. Future RCTs should provide comprehensive information regarding the randomization procedure to enhance the reliability of findings.

## Conclusion

This meta-analysis suggests that educational programs can effectively improve knowledge, behavioral intention, and attitude in preventing HIV among adolescents. Studies with theory-based, curriculum-based, group-based models, providers in the form of peer educators, no parent involvement, and promotion tools with audio visuals in educational programs are more effective. These findings provide evidence that it is more effective to increase adolescents' knowledge when they are in a group. Simultaneously, educational programs with peer educators trained in group-based are more effective. When creating educational programs, healthcare professionals must consider the factors that significantly influence knowledge, behavior, and attitude in preventing HIV.

## Ethics approval

Not required.

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## Competing interests

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## Underlying data

Derived data supporting the findings of this study are available from the corresponding author on request.

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