**Review**
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# Effectiveness of digital educational technologies in knowledge acquisition for adolescent health promotion: a systematic review

Efetividade das tecnologias educacionais digitais na aquisição de conhecimentos para a promoção da saúde do adolescente: revisão sistemática

Efectividad de las tecnologías educativas digitales en la adquisición de conocimientos para la promoción de la salud del adolescente: revisión sistemática

Maria Eduarda Jucá da Paz Barbosa[a] https://orcid.org/0000-0002-5663-7663
Victor Andrew da Silva Teixeira[a] https://orcid.org/0009-0008-4784-5170
Jayne Ramos Araujo Moura[a] https://orcid.org/0000-0002-7311-7782
João Victor Lira Dourado[a] https://orcid.org/0000-0002-3269-1286
Paula Suene Pereira dos Santos[a] https://orcid.org/0000-0001-6463-7316
Neiva Francenely Cunha Vieira[a] https://orcid.org/0000-0002-9622-2462
Patricia Neyva da Costa Pinheiro[a] https://orcid.org/0000-0001-7022-8391
Viviane Martins da Silva[a] https://orcid.org/0000-0002-8033-8831

[a] Universidade Federal do Ceará, Departamento de Enfermagem, Fortaleza, Ceará, Brasil

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## ABSTRACT

**Objective:** to analyze the evidence on the effectiveness of digital educational technologies in knowledge acquisition for adolescent health promotion.

**Method:** this is a systematic review of effectiveness conducted in accordance with the JBI Manual for Evidence Synthesis guidelines. The search was performed in the Virtual Health Library (VHL), Scopus, Web of Science, Excerpta Medica dataBASE (EMBASE), Cumulative Index to Nursing and Allied Health Literature (CINAHL), and Educational Resources Information Center (ERIC). The analysis included a narrative synthesis and

categorization of effectiveness based on effect size and statistical significance, with the risk of bias assessed using the Cochrane Risk of Bias 2 tool.
**Results:** fifteen studies were included, encompassing 14,733 adolescents aged 10 to 19 years. Interventions were primarily conducted in school settings, followed by online, outpatient, and community environments. The main topics addressed included HIV prevention, drug use, pregnancy, and sexually transmitted infections, as well as the promotion of oral, mental, and sexual health. Different modalities were identified, with emphasis on mobile interventions, audiovisual resources, gamification, and interactive multimedia. Interactive and hybrid multimedia interventions, which combine digital elements with in-person support, demonstrated greater impact on knowledge acquisition. In contrast, digital educational technologies based on static or minimally interactive content showed lower effectiveness.
**Conclusion:** digital educational technologies (DETs) demonstrated different levels of effectiveness in enhancing adolescents' knowledge on health promotion, depending on the type of intervention, level of interactivity, and context of implementation. Interactive, multimedia, and hybrid interventions showed greater impact, whereas strategies based on static or minimally interactive content were less effective. It is noteworthy that factors such as inequalities in access to technology and cultural adaptation may influence these outcomes.
**Descriptors:** Educational Technology; Digital Health; Health Promotion; Disease Prevention; Adolescent; Health Education.

**RESUMO**

**Objetivo**: analisar as evidências sobre a efetividade das TEDs na aquisição de conhecimentos para a promoção da saúde do adolescente.
**Método**: trata-se de uma revisão sistemática de efetividade, conforme as diretrizes do *JBI Manual for Evidence Synthesis*. A busca foi realizada na Biblioteca Virtual em Saúde (BVS), S*copus, Web of Science, Excerpta Medica dataBASE (EMBASE), Cumulative Index to Nursing and Allied Health Literature (CINAHL) e Educational Resources Information Centre (ERIC).* A análise incluiu síntese narrativa e categorização da efetividade com base no tamanho do efeito e na significância estatística, sendo o risco de viés avaliado pela ferramenta Risk of Bias 2 da Cochrane.
**Resultados**: foram incluídos 15 estudos que analisaram 14.733 adolescentes de 10 a 19 anos. As intervenções ocorreram principalmente em escolas, seguidas de ambientes online, ambulatoriais e comunitários, abordando principalmente a prevenção de HIV, uso de drogas, gravidez e infecções sexualmente transmissíveis, além de promoção da saúde oral, mental e sexual. Identificaram-se diferentes modalidades, com destaque para as intervenções móveis, audiovisuais, gamificação e multimídia interativa. As multimídias interativas e híbridas, que combinam elementos digitais com suporte presencial, demonstraram maior impacto na aquisição de conhecimento. Em contrapartida, TEDs baseadas em conteúdos estáticos ou pouco interativos apresentaram menor efetividade.
**Conclusão**: as TEDs apresentaram diferentes níveis de efetividade na ampliação do conhecimento de adolescentes sobre promoção da saúde, variando conforme o tipo de intervenção, o nível de interatividade e o contexto de aplicação. Intervenções interativas, multimídia e híbridas demonstraram maior impacto, enquanto estratégias baseadas em conteúdos estáticos ou pouco interativos apresentaram menor efetividade. Ressalta-se que fatores como desigualdade no acesso à tecnologia e adaptação cultural podem influenciar esses resultados.
**Descritores:** Tecnologia Educacional; Saúde Digital; Promoção da Saúde; Prevenção de Doenças; Adolescente; Educação em Saúde.

**RESUMEN**

**Objetivo:** analizar la evidencia sobre la efectividad de las tecnologías educativas digitales en la adquisición de conocimientos para la promoción de la salud del adolescente.

**Método:** se trata de una revisión sistemática de efectividad, realizada conforme a las directrices del *JBI Manual for Evidence Synthesis*. La búsqueda se llevó a cabo en la Biblioteca Virtual en Salud (BVS), *Scopus, Web of Science, Excerpta Medica dataBASE* (EMBASE), *Cumulative Index to Nursing and Allied Health Literature* (CINAHL) y *Educational Resources Information Center* (ERIC). El análisis incluyó una síntesis narrativa y la categorización de la efectividad basada en el tamaño del efecto y la significación estadística, siendo el riesgo de sesgo evaluado mediante la herramienta Risk of Bias 2 de Cochrane.

**Resultados:** se incluyeron 15 estudios que analizaron a 14.733 adolescentes de 10 a 19 años. Las intervenciones se llevaron a cabo principalmente en entornos escolares, seguidos de contextos en línea, ambulatorios y comunitarios. Los principales temas abordados incluyeron la prevención del VIH, el consumo de drogas, el embarazo y las infecciones de transmisión sexual, así como la promoción de la salud oral, mental y sexual. Se identificaron diferentes modalidades, destacándose las intervenciones móviles, los recursos audiovisuales, la gamificación y la multimedia interactiva. Las intervenciones multimedia interactivas e híbridas, que combinan elementos digitales con apoyo presencial, demostraron mayor impacto en la adquisición de conocimientos. En contraste, las tecnologías educativas digitales basadas en contenidos estáticos o poco interactivos presentaron menor efectividad.

**Conclusión:** las tecnologías educativas digitales presentaron diferentes niveles de efectividad en la ampliación del conocimiento de los adolescentes sobre la promoción de la salud, variando según el tipo de intervención, el nivel de interactividad y el contexto de aplicación. Las intervenciones interactivas, multimedia e híbridas demostraron mayor impacto, mientras que las estrategias basadas en contenidos estáticos o poco interactivos presentaron menor efectividad. Se destaca que factores como la desigualdad en el acceso a la tecnología y la adaptación cultural pueden influir en estos resultados.

**Descriptores:** Tecnología Educacional; Salud Digital; Promoción de la Salud; Prevención de Enfermedades; Adolescente; Educación en Salud.

## INTRODUCTION

The digital environment is an important source of information, particularly among young people, and has become a transformative tool with broad possibilities for health promotion[1]. In this context, digital educational technologies (DETs) have emerged as tools that facilitate communication and foster interaction through diverse forms of language, thereby enhancing health education[2].

Integrating digital resources into health education requires an understanding of the technological and generational evolution of adolescents. Considering the time frame of the evidence analyzed in this review (2008 to 2022), the study population reflects a transition encompassing the millennial generation, Generation Z, and the beginning of Generation Alpha[3].

Thus, a progressive familiarization of society with cyberspace has become evident, culminating in the profound immersion of contemporary adolescents, recognized as digital natives and characterized by their agility in navigating multiple sources of information. Simultaneously, adolescence is a complex stage of development, marked by intense neurobiological, cognitive, and emotional maturation that drives the search for autonomy. It is within this convergence of factors that young people's information behavior takes on specific characteristics, being strongly shaped by the digital ecosystem with which they interact[3-4].

The ease, immediacy, and privacy provided by the internet influence how these individuals seek answers to health-related questions, often leading them to forgo traditional services due to fear of judgment. Consequently, the autonomous and unmediated consumption of online content directly affects decision-making and, depending on the reliability of the sources, may increase exposure to vulnerabilities and the adoption of risk behaviors, particularly in sexual practices[5].

Adolescents are often reluctant to seek help for or discuss health issues with qualified professionals, mainly due to the personal and sensitive nature of the topics addressed[6]. They face numerous barriers when seeking health promotion, such as feelings of embarrassment regarding sensitive health issues, previous negative experiences with health services, and concerns about a lack of confidentiality and privacy, among others[7].

Understanding practices related to health promotion requires the adoption of a broader concept of this field. According to the World Health Organization (WHO), health promotion is a social and political process that goes beyond changing individual behaviors, encompassing the strengthening of personal capacities and action on the social, economic, and environmental determinants of health. In this context, the aim is to increase the control of individuals and communities over their own health through strategies such as advocacy, mediation of interests, and the promotion of equitable living conditions. It is therefore an intersectoral, participatory approach aimed at transforming the conditions that produce health and disease[8].

These concepts not only guide the understanding and categorization of digital educational technologies but also provide a benchmark for assessing the effectiveness of such interventions. In this regard, measuring the effectiveness of an intervention is directly related to the presentation of outcomes, which may be quantified through indicators or described in terms of the outcomes achieved, as well as to the consistency between the established objectives and the actions implemented[9].

Thus, the advancement of DETs and their increasing use have enabled a new approach to adolescent health promotion. However, the effectiveness of these interventions remains unclear due to the high heterogeneity of methods, variations among subgroups within the adolescent population, or the contexts in which the interventions are implemented.

Therefore, this review is expected to fill a gap in scientific knowledge, as it aims to analyze evidence regarding the effectiveness of DETs in fostering knowledge for adolescent health promotion. This critical examination of the effectiveness of DETs across multiple health domains may provide a broader understanding of their implementation and offer practical recommendations to support future educational interventions.

## METHOD

This is a systematic review, reported in compliance with the guidelines of the JBI Manual for Evidence Synthesis. The study protocol was previously registered on the International Prospective Register of Systematic Reviews (PROSPERO) platform under identification number CRD42023473934, ensuring transparency and reducing the risk of reporting bias. The review was conducted in five main stages: formulation of the review question, definition of inclusion and exclusion criteria, study selection, data extraction and analysis, and results synthesis[10].

To formulate the review's guiding question, it was used the Population, Intervention, Comparator, Outcomes, and Study Design (PICOD) strategy. This strategy was chosen due to the focus on effectiveness and the exclusive inclusion of randomized trials, making the study design a structural component of the question. The "D" component enhances methodological rigor by aligning eligibility criteria, search strategies, and quality assessment.

Thus, the review question was defined as follows: Population: adolescents of both sexes, aged 10 to 19 years, according to the World Health Organization's definition of adolescence[11]. It should be noted that the upper limit of this age range justifies the inclusion of university settings, as the early years of higher education overlap with the final stage of adolescence (18 to 19 years). Intervention: digital educational technologies, applied alone or in combination, understood in this study as tools that use computer-based resources, the internet, and interactive media to mediate, facilitate, and optimize the teaching-learning process in the health field[2]. Comparator: included two possibilities: control groups receiving traditional educational interventions (such as lectures, booklets, and printed materials, without the use of digital resources) or groups receiving no active intervention during the study period (individuals allocated to a waiting list who would receive the intervention subsequently).

Outcomes: knowledge acquisition aimed at promoting health and preventing diseases. Study Design: experimental trials (individually randomized or cluster-randomized).

Thus, this study was grounded on the following review question: “What is the evidence on the effectiveness of digital educational technologies in knowledge acquisition for adolescent health promotion?”

The search strategy was developed with the assistance of a librarian from the Porangabussu campus of the Universidade Federal do Ceará (UFC) on October 20, 2023, using controlled descriptors from the Health Sciences Descriptors (DeCS), Medical Subject Headings (MeSH), ERIC Thesaurus, and Emtree, combined with free-text terms. Due to the specific characteristics of each database, the search strategies were adapted to ensure greater sensitivity and are detailed in Chart 1, as well as in the review protocol registered in PROSPERO (https://www.crd.york.ac.uk/PROSPERO/view/CRD42023473934).

**Chart 1** - Search strategy by database.

| **Database/Data source** | **Search strategy** |
|---|---|
| BVS | (*adolescente* OR *adolescência* OR "*Saúde do Adolescente*" OR adolescent OR teen OR teenage OR adolescence) AND ("*Tecnologia Educacional*" OR *tecnologia* OR "Educational Technology" OR technology) AND ("*Promoção da saúde*" OR "*Prevenção de doenças*" OR "Health Promotion" OR "Primary Prevention" OR "Disease Prevention") AND ( type_of_study:("clinical_trials")) |
| Scopus | TITLE-ABS-KEY ( ( adolescent OR adolescence OR "adolescent health" ) AND ( technology OR "digital health" OR "Technology health" OR ehealth OR mhealth OR "Mobile health" ) AND ( "Health Promotion" OR "Primary Prevention" ) AND ( "clinical trial" OR "clinical trial (topic)" ) ) |
| Web of Science | ( adolescent* OR adolescence OR 'adolescent health' ) AND ( technology OR 'digital health' OR 'Technology health' OR ehealth OR mhealth OR 'Mobile health' ) AND ( 'Health Promotion' OR 'Primary Prevention' OR 'health education' ) AND ( 'clinical trial' OR 'clinical trial as topic' ) |
| EMBASE | 'adolescent'/exp AND (technology:ti,ab,kw OR 'digital health':ti,ab,kw OR 'technology health':ti,ab,kw OR ehealth:ti,ab,kw OR mhealth:ti,ab,kw OR 'mobile health':ti,ab,kw) AND ('health promotion':ti,ab,kw OR 'primary prevention':ti,ab,kw) AND 'clinical trial'/exp |

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|---|---|
| CINAHL | (adolescents or teenagers or adolescence or teens or adolescent health) AND (technology or digital education or Mobile Applications Utilization or technology in education or educational technology) AND (health education or knowledge or health promotion or primary prevention or outcomes of education) AND (clinical trial or randomized controlled trial or clinical trial as topic or control groups or experimental groups) |
| ERIC | (adolescents OR adolescence OR Teenagers) AND (technology OR "educational technology" OR "digital health" OR "Technology health" OR ehealth OR mhealth OR "Mobile health" OR "information technology") AND ("Health education" OR "Health promotion" OR "Primary health care") AND ("randomized controlled trials" OR "control groups" OR "experimental groups") |

Source: the authors, 2024.

The search was conducted independently and simultaneously by two reviewers on October 24, 2023, from 1:50 PM. to 3:00 PM., in the city of Fortaleza, Ceará, Brazil, using the following data sources: Medical Literature Analysis and Retrieval System Online (MEDLINE), Latin American and Caribbean Health Sciences Literature (LILACS), and the Brazilian Nursing Database (BDENF), via the Virtual Health Library (VHL); Scopus; Web of Science; Excerpta Medica dataBASE (EMBASE); Cumulative Index to Nursing and Allied Health Literature (CINAHL); and Educational Resources Information Centre (ERIC).

Manual searching of the reference lists of the included studies was not performed, which may have limited the identification of additional studies. However, the search strategy adopted was broad and conducted across multiple relevant databases, reducing the likelihood of omitting pertinent evidence. It should also be noted that the absence of manual searching did not compromise the robustness of the findings, as this is a complementary rather than mandatory strategy, according to JBI methodological guidelines[10].

For study selection, the following inclusion criteria were adopted: randomized experimental trials (individually or cluster-randomized), with no restrictions regarding language or publication period, that evaluated the effects of digital educational technologies, applied alone or in combined, in different settings, with knowledge acquisition aimed at health promotion among adolescents as the outcome. No restrictions regarding language or publication period were applied to reduce the risk of selection bias and ensure a broader search scope.

Studies that did not address the research question or did not provide a quantitative assessment of the outcome of interest were excluded. Clinical trials published exclusively as abstracts in conference proceedings (without the full text available) and ongoing research protocols without definitive results were also excluded. Additionally, studies in which digital tools had a strictly diagnostic or clinical screening purpose (without an educational component) were excluded, as were those in which the omission of statistical data in the original publication made it impossible to extract the variables required to calculate the effect size and classify effectiveness.

Additionally, gray literature was not considered, aiming to ensure greater methodological rigor among the included studies. After the initial search, duplicate publications were identified using the Rayyan Qatar Computing Research Institute reference management software, followed by the eligibility assessment process, with screening of the studies based on title and abstracts.

In the second stage, the articles selected during the screening phase were read in full to confirm their eligibility. Notably, the study selection process was conducted independently by two reviewers, who then compared their findings and resolved any disagreements. At the end of this process, a sample of 15 articles was obtained.

Data extraction was performed using a standardized approach, identifying the following variables: study characteristics (author, year, country), population, type of intervention, comparator group, outcomes assessed, and main statistical results. Subsequently, the data were compared using a spreadsheet.

Furthermore, to assess the risk of bias, two independent critical assessments of the selected studies were performed using the Cochrane tool for clinical trials, Risk of Bias 2 (RoB 2.0), which assesses six domains: sequence generation, allocation concealment, blinding, incomplete outcome data, selective outcome reporting, and "other" potential sources of bias. Each domain of the RoB 2.0 instrument can be judged as low risk of bias, some concerns, or high risk of bias.

The results were presented through a narrative and tabular synthesis that analyzed the risk of bias across each aspect of methodological quality, such as randomization, blinding, and measurement, both for each individual study and for the set of included studies. The analysis and synthesis of the reviewed articles followed the following steps: data extraction, outcome synthesis, presentation of descriptive data in tables, and visual representation of the article selection process through a figure.

This review focused exclusively on outcomes related to increased adolescent knowledge, without considering behavioral changes or other results. Despite comprehensive search strategies, it is possible that some relevant studies were excluded due to limitations in the search strategies.

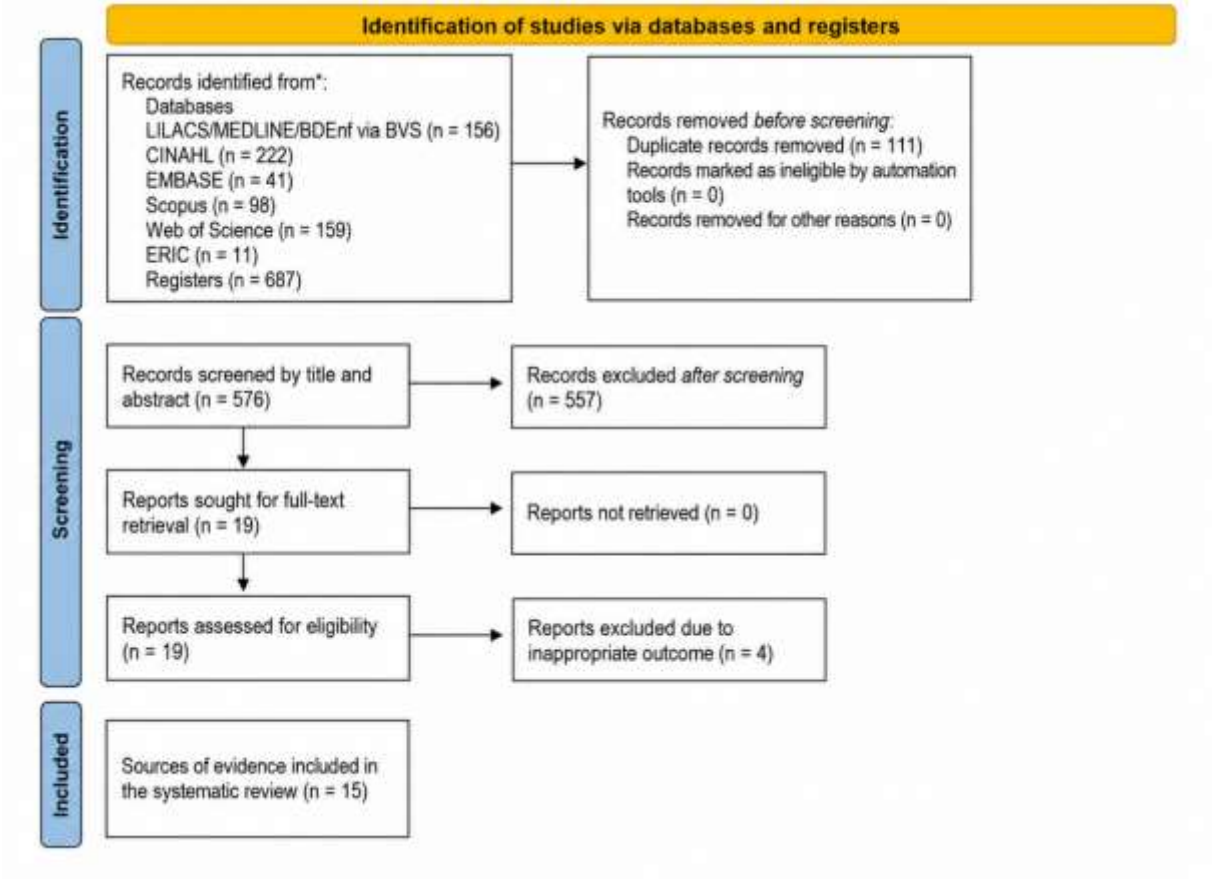
The possibility of conducting a meta-analysis was initially assessed. However, due to heterogeneity among populations, interventions, and outcome measures, a narrative synthesis was chosen, in accordance with the JBI Manual guidelines[10].

The research did not require submission to a Research Ethics Committee (REC), as it did not directly involve human subjects. Other ethical aspects, such as copyright, accuracy, and integrity of the information, were safeguarded.

## RESULTS

A total of 687 articles were identified in the databases. Duplicates were counted only once and 111 were removed. A total of 557 articles were excluded for note meeting the eligibility criteria, specifically regarding the outcome of interest: adolescents' knowledge. Thus, 19 articles were selected for full-text reading, four were excluded because they did not provide a clear answer regarding the outcome under analysis, that is, while they mentioned knowledge, the results did not clearly present this outcome. Thus, the final sample consisted of 15 studies. The selection process is detailed in the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) flowchart presented in Figure 1.

**Figure 1**. PRISMA flowchart for systematic reviews including searches of databases and registers**.**




Source: the authors, 2024

## Characteristics of the included studies

The 15 studies analyzed were published between 2008 and 2023 and the majority were international, predominantly from the United States (n = 8; 53.3%), followed by Australia (n

= 2), Canada (n = 1), the Netherlands (n = 1), Syria (n = 1), Spain (n = 1), and Brazil (n = 1). The total number of adolescents assessed was 14,733, aged between 10 and 19 years. CINAHL was the database that retrieved the largest number of articles, followed by Web of Science and VHL.

The most frequent intervention settings were schools (52.9%), followed by outpatient settings (11.8%) and university communities (11.8%). Only one study (6.6%) was categorized as a remote online intervention. In this specific study, the 'online' classification refers to an intervention with no physical setting serving as an anchor, in which participant recruitment was conducted entirely digitally through targeted advertisements on the Instagram and Facebook social media platforms.

The follow-up period of the studies ranged from one week to 24 months, while the period designated for evaluating the digital educational technologies (DETs) differed regarding the timing and duration of effectiveness assessments, highlighting heterogeneity among the studies.

To ensure greater transparency and facilitate a comprehensive understanding of the sample, Chart 2 details the methodological characteristics, country of origin, interventions applied, and effectiveness assessment of each trial included. To optimize the comparative analysis, the studies were stratified into three impact categories: High and Moderate Effectiveness, Low but Significant Effectiveness, and Indeterminate or Null Effectiveness, highlighting the direct effect of the interventions on adolescents' knowledge acquisition.

**Chart 2 -** Methodological synthesis, interventions applied, and effectiveness assessment of the studies included in the review.

| **Study** | **Author / Country** | **Objective** | **Setting / Sample / Duration / Follow Up** | **Control Group / Experimental Group** | **Assessment of intervention effectiveness (Cohen's *d**, *p*-value† and conclusion)** |
|---|---|---|---|---|---|
| **LEVEL 1: HIGH AND MODERATE EFFECTIVENESS** | | | | | |
| Bardaweel; Dashash, 2018[12] / Syria | To compare traditional educational leaflets and electronic applications in improving knowledge of oral health, oral hygiene, and gingival health among schoolchildren in the city of Damascus, Syria. | **S**‡ - Schools<br>**CG**§ - 100<br>**EG**‖ - 100<br>**D**¶ - 3 months<br>**FUp**** - 6 weeks and 12 weeks. | **CG**§ - An attractive, colorful, story-based leaflet entitled "Adnan Likes the Dentist".<br>**EG**‖ - An e-learning intervention on oral health delivered through a multimedia program (colorful images, videos, interactive quizzes, and age-appropriate developmental tasks). | ***d**:** 1.38<br>**p**† < 0.001<br>**Assessment:** High Effectiveness<br>**Description:** The use of multimedia in e-learning outperformed traditional leaflets in oral health education. |

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| Scull e*t al.*, 2018[13] / USA | To determine the feasibility of a mobile health media literacy education program, Media Aware (Sexual Health Program for Young Adults), to improve sexual health outcomes among adolescents and community college students aged 18 to 19 years | **S**‡ - Community colleges<br>**CG**§ - 88<br>**EG**‖ - 96<br>**D**¶ - 4 weeks<br>**FUp**** - 4 weeks | **CG**§ - No intervention (waitlist);<br>**EG**‖ - Comprehensive five-lesson, web-based sexual health program using a media literacy education framework and covering a wide range of sexual health topics, including pregnancy and sexually transmitted infection prevention, dating violence, relationship health, and communication with sexual partners and healthcare professionals. | ***d**** = 0.49<br>**p**† < 0.01<br>**Assessment:** Moderate Effectiveness<br>**Description:** The media literacy program had a moderate and significant impact on sexual health knowledge among young people. |
| Inhusen *et al*., 2022[14] / Netherlands | To evaluate the intervention Charge Your Brainzzz, including its effects on adolescents' sociocognitive determinants, sleep hygiene, and sleep duration and quality. | **S**‡ - Schools<br>**CG**§ - 367<br>**EG**‖ - 605<br>**D**¶ - 3 months<br>**FUp**** - 1,5 weeks and 3 months | **CG**§ - Did not undergo interventions (waitlist).<br>**EG**‖ - Consisted of three 45-minute classroom educational sessions with interactive tasks and a supporting educational website. | ***d***:* 0.72<br>**p**† < 0.05<br>**Assessment:** Indeterminate Effectiveness<br>**Description:** The educational intervention demonstrated a significant impact on increasing knowledge and other socio-cognitive determinants related to sleep hygiene. |
| **LEVEL 2: LOW SIGNIFICANT EFFECTIVENESS** | | | | |

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| Mosnaim *et al.*, 2008[15] / USA | To evaluate the efficacy of an asthma-tailored MP3-based system in increasing asthma knowledge among low-income African American adolescents. | **S**‡ - Outpatient clinic<br>**CG**§ - 12<br>**EG**‖ - 15<br>**D**¶ - 14 weeks<br>**FUp**** - 0, 6, 12 weeks. | **CG**§ - Music tracks plus celebrity health messages about asthma<br>**EG**‖ - Music tracks plus general health messages | ***d**** = 0.16<br>**p**† = 0.05<br>**Assessment:** Low Significant Effectiveness<br>**Description:** The adapted MP3 system had a small but significant impact on the acquisition of knowledge about asthma management. |
| Vogl *et al.*, 2014[16] / Australia | To evaluate the feasibility and efficacy of the computer-based Climate School Program: Psychostimulant and Cannabis Module. | **S**‡ - Schools<br>**CG**§ - 828<br>**EG**‖ - 906<br>**D**¶ - 3 months<br>**FUp**** - 5 e 10 months. | **CG**§ - Usual drug use prevention classes throughout the school year.<br>**EG**‖ - Psychostimulant and Cannabis Module consisting of online *cartoon* scenarios combined with interactive in-person activities. | **F**††**(1.970)** = 34.01<br>**η²**‡‡ = 0.07<br>***d**** = 0.28<br>**p**† < 0.001<br>**Assessment:** Low Significant Effectiveness<br>**Description:** the online program demonstrated a small but statistically significant impact on the acquisition of knowledge about the risks and prevention of substance use. |

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| Fiellin *et al.*, 2017[17] / USA | To test the efficacy of a theory-based digital health intervention in the form of an interactive video game, compared with a set of control games, on risky sexual behaviors, knowledge, attitudes, and intentions among a racial/ethnic minority adolescent population. | **S**‡ - Community settings<br>**CG**§ - 167<br>**EG**‖ - 166<br>**D**¶ - 6 weeks<br>**FUp**** - 6 weeks and 3, 6 e 12 months. | **CG**§ - The attention/time-control games consisted of 12 video games, such as Angry Birds, DragonBox, and Subway Surfer.<br>**EG**‖ - PlayForward is a 2D adventure video game developed based on theories regarding the impact of individual choices on the social environment. The game aims for players to acquire and practice skills to reduce risky behaviors and to develop healthier knowledge, attitudes, and intentions, with the goal of HIV prevention. | ***d****= 0.11<br>**p**† < 0.001<br>**Assessment:** Low Significant Effectiveness<br>**Description:** The educational game PlayForward had a small but statistically significant impact on knowledge acquisition aimed at reducing sexual risk. |

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| Khan *et al.*, 2018[18] / USA | To evaluate the efficacy of low-cost, technology-based intervention approaches in high schools to improve hearing protection use among adolescent agricultural workers. | **S**‡ - Schools<br>**CG**§ - 12<br>**EG**1‖ - 20<br>**EG**2‖ - 18<br>**D**¶ - 6 weeks;<br>**FUp**** - 6 weeks. | **CG**§ - Traditional classroom training;<br>**EG**1‖ - traditional classroom training combined with the use of selected applications to measure noise from agricultural sources;<br>**EG**2‖ - computer-based training using the cTRAIN e-Learning software, which divides information into smaller units, requires mastery of the material before proceeding, is individualized, and includes photos and videos, as well as pre- and post-tests.<br>*This study had two intervention groups. | ***d**** = 0.185§§<br>**p**† 0.0155§§<br>**Assessment:** Low Significant Effectiveness<br>**Description:** The digital interventions improved knowledge about hearing protection, with a small but statistically significant impact. |
| Teesson *et al.*, 2020[19] / Australia | To investigate the efficacy of a combined approach for the primary prevention of substance use (specifically alcohol and cannabis), depression, and anxiety. | **S**‡ - Schools<br>**CG**§ - 1.556<br>**EG**1‖ - 1.739<br>**EG**2‖ - 1.594<br>**EG**3‖ - 1.497<br>**D**¶ - 2 years<br>**FUp**** - 6, 12, 15, 18, 24 and 30 months | **CG**§ - Usual health education classes throughout the year, including classes on alcohol, drugs, and mental health.<br>**EG**1‖ - Substance use prevention program with online *cartoon* scenarios combined with interactive in-person activities.<br>**EG**2‖ - Mental health program with online cartoon scenarios.<br>**EG**3‖ - Combination of the | ***d**** = 0.19§§<br>**p**† = 0.009§§<br>**Assessment:** Low Significant Effectiveness<br>**Description:** There was a positive and statistically significant impact on increasing knowledge related to substance use prevention and mental health promotion. |

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| | | | interventions: substance use prevention and mental health with online cartoon scenarios.<br>*This study had three intervention groups. | |
| Martínez-Garcia *et al*., 2022[20] / USA | To test the efficacy of Crush, a mobile application aimed at improving sexual and reproductive health (SRH) by promoting the use of SRH services and contraception among adolescent females. | **S**‡ - Remote<br>**CG**§ - 615<br>**EG**‖ - 595<br>**D**¶ - 6 months<br>**FUp**** - 3 and 6 months. | **CG**§ - Participants were directed to an existing free nutrition and fitness app developed for adolescent females.<br>**EG**‖ - Unlimited access to Crush, a mobile application with multimedia content. | ***d**** = 0.228<br>***p***† = 0.01<br>**Assessment:** Low Significant Effectiveness<br>**Description:** The Crush mobile application demonstrated a small but statistically significant impact on increasing knowledge about sexual and reproductive health among adolescent females. |
| **LEVEL 3: INDETERMINATE OR NULL EFFECTIVENESS, OR INSUFFICIENT DATA** | | | | |
| Muzaffar *et al*., 2014[21] / USA | To improve knowledge, outcome expectations, self-efficacy, and self-reported dietary intake and skills, and to compare a passive online learning (POL) | **S**‡ - Schools<br>**CG**§ - 80<br>**EG**‖ - 101<br>**D**¶ - 7 to 14 days.<br>**FUp**** - immediately after the test. | **CG**§ - Passive online learning with passive, non-interactive texts.<br>**EG**‖ - Active online learning with interactive resources, such as videos, narrated text, and games. | ***d**** = -0.16<br>**p**† 0.191<br>**Assessment:** Indeterminate Effectiveness<br>**Description:** Active online intervention showed no significant efficacy in increasing knowledge compared to the control group. |

| | | | | |
|---|---|---|---|---|
| | control group with an active online learning (AOL) treatment group, implementing a social cognitive theory. | | | |
| Marsch *et al.*, 2015[6] / USA | To evaluate the comparative efficacy of a web-based intervention (Therapeutic Education System - TES) versus a traditional educator-delivered intervention when offered to youth receiving outpatient substance abuse treatment. | **S**‡ - Outpatient clinic<br>**CG**§ - 72<br>**EG**‖ - 69<br>**D**¶ - Not reported<br>**FUp**** - 14 days | **CG**§ - Small-group intervention delivered by an educator trained as a specialist in HIV, hepatitis, and sexually transmitted infection prevention.<br>**EG**‖ - Interactive multimedia intervention delivered via the Internet, focused on HIV, hepatitis, and sexually transmitted infection prevention. | ***d**** = 0.520<br>**p**† > 0.05<br>**Assessment:** Moderate Non-Significant Effectiveness<br>**Description:** Despite a moderate effect on knowledge about infection prevention, statistical significance was not achieved, suggesting indeterminate effectiveness. |

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|---|---|---|---|---|
| Peskin *et al.*, 2015¶ [22] / USA | To test the efficacy of It's Your Game-Tech, a fully computer-based sexual health educational game for high schools. | **S**‡ - Schools<br>**CG**§ - 606<br>**EG**‖ - 768<br>**D**¶ - 13 lessons, each approximately 35 to 45 minutes in duration.<br>**FUp**** - 1 year | **CG**§ - State-approved health education, generally based on a textbook.<br>**EG**‖ - Digital and interactive game with animated scenarios, skills practice, peer modeling videos ("teen talk"), quizzes, fact sheets, a graffiti wall for personalization and reflection, and virtual "point-of-view" role-playing activities. | ***d**** = N/A***<br>**p**† < 0.05<br>**Assessment:** Insufficient data to calculate the effect size<br>**Description:** N/A*** |
| Oliveira *et al.*, 2020¶ [23] / Brazil | To evaluate the effectiveness of education on rheumatic heart disease in schools, comparing the conventional expository teaching method with worked examples provided on tablets. | **S**‡ - Schools<br>**CG**§ - 651<br>**EG**‖ - 650<br>**D**¶ - 8 months<br>**FUp**** - 10 days and 3 months. | **CG**§ - Conventional educational process structured around slides (lectures).<br>**EG**‖ - Learning strategy based on examples provided in individual interactive modules for tablets. | ***d**** = N/A***<br>**p**† 0.68<br>**Assessment:** Insufficient data to calculate the effect size<br>**Description:** N/A*** |

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|---|---|---|---|---|
| Febrero *et al.*, 2021¶ [24] / Spain | To analyze the impact of an innovative educational initiative (Donarfest) on attitudes, knowledge, and social interaction regarding organ donation and transplantation in schools, based on the creation of short audiovisual films about organ donation and transplantation that were disseminated on social media via a YouTube channel. | **S**‡ - Schools<br>**CG**§ - 224<br>**EG**‖ - 391<br>**D**¶ - 7 months<br>**FUp**** - 5 months | **CG**§ - None<br>**EG**‖ - Short films made available on a website focused on addressing the most important issues affecting organ donation and transplantation, with interviews and a media database. | ***d**** = N/A***<br>**p**† < 0.001<br>**Assessment:** Insufficient data to calculate the effect size<br>**Description:** N/A*** |
| Pais *et al.*, 2021[25] / Canada | To evaluate an Internet-based educational module on carbohydrate counting accuracy among adolescents with type 1 diabetes. | **S**‡ - Hospital<br>**CG**§ - 14<br>**EG**‖ - 11<br>**D**¶ - 7 days<br>**FUp**** - 3 months | **CG**§ - Classroom session (standard of care).<br>**EG**‖ - Online module with educational videos, with remote access. | ***d**** = 0.0055<br>**p**† = 0.99<br>**Assessment:** Low Non-Significant Effectiveness;<br>**Description:** The digital intervention did not show a significant impact on adolescents' knowledge about carbohydrate counting. |

Source: the authors, 2024

d* = Cohen’s d, referring to the effect size; p[†]= p-value, referring to the level of statistical significance; S[‡] = Setting; CG[§] = Control Group; GE[‖] = Experimental Group; D[¶] = Duration; FUp** = Follow Up; F[††] = F-statistic, referring to the ratio of variance between groups; $\eta^{2}$[‡‡] = eta squared, referring to the effect size between groups; [§§] = The Cohen's *d* and *p*-values presented are means, considering multiple intervention groups; [¶¶] = The analyzed article did not provide information on the knowledge means and standard deviations for the compared groups. The available analyses are based on percentages and p-values; N/A*** = not applicable for calculating the effect size and classifying effectiveness due to the lack of post-intervention means and standard deviations; Effectiveness Classification (assessment parameters): High Effectiveness: large impact with statistically significant results ($d \geq 0.80$ e $p < 0.05$). Moderate to High Effectiveness: moderate to high impact with statistical significance (d between 0.50 and 0.79 and $p < 0.05$). Moderate Effectiveness: moderate impact with statistical significance (d between 0.30 and 0.49 and $p < 0.05$). Low Significant Effectiveness: small but statistically significant impact (d between 0.10 and 0.29 and $p < 0.05$). Low Non-Significant Effectiveness: very small or null impact, without statistical significance ($d < 0.10$ and $p \geq 0.05$). Indeterminate Effectiveness: statistical significance was not achieved, indicating an inconclusive effect (any value of d with $p > 0.05$).

**Effectiveness of Digital Educational Technologies**

The effectiveness of Digital Educational Technologies (DETs) was classified based on effect size (Cohen's d) and statistical significance (p-value). According to the criteria described in the note for Chart 2, interventions were organized into distinct categories, ranging from High Effectiveness to Indeterminate Effectiveness. This categorization allows for a detailed assessment of the interventions, considering both the magnitude of the effect and its statistical relevance.

The studies also showed considerable diversity in terms of context, interventions, and target populations, resulting in different levels of effectiveness. In Chart 2, the results are detailed according to the objectives, methods, interventions applied to each group, and assessment of effectiveness.

The main findings indicate that interactive and hybrid multimedia interventions, which combine digital elements with in-person support, had a greater impact on knowledge acquisition. In contrast, DETs based on static or minimally interactive content showed lower effectiveness.

**High-Effectiveness Interventions**

A study comparing a multimedia e-learning program with printed materials on oral health showed a large impact *($d = 1.38$, $p < 0.001$)*, making it the most effective intervention according to the assessment criteria of the review[12]. Meanwhile, the Charge Your Brainzzz program[14], focused on sleep hygiene, demonstrated moderate to high effectiveness *($d = 0.72$, $p < 0.05$)*, reinforcing the potential of hybrid approaches that combine in-person classes with digital support.

**Interventions with Significant Low Effectiveness**

A study comparing an online course with in-person classes regarding the prevention of Human Immunodeficiency Virus (HIV) and Sexually Transmitted Infections (STIs) showed a small yet significant impact *($d = 0.19$, $p = 0.009$)*[6]. The Crush app[19], aimed at adolescent sexual and reproductive health, showed a small but statistically significant effect *($d = 0.23$, $p = 0.01$)*.

**Interventions with Indeterminate Effectiveness or Non-Significant Low Effectiveness**

The Healthy Outcomes for Teens (HOT) program[21], which compared passive online learning with an interactive approach, showed no significant difference between the groups *(d = -0.16, p = 0.191)*, indicating indeterminate effectiveness.

The intervention based on audio messages for adolescents with asthma[15] showed a small statistically significant effect *(d = 0.16, p = 0.05)*, suggesting that non-interactive methods have lower effectiveness.

**Risk of Bias Analysis**

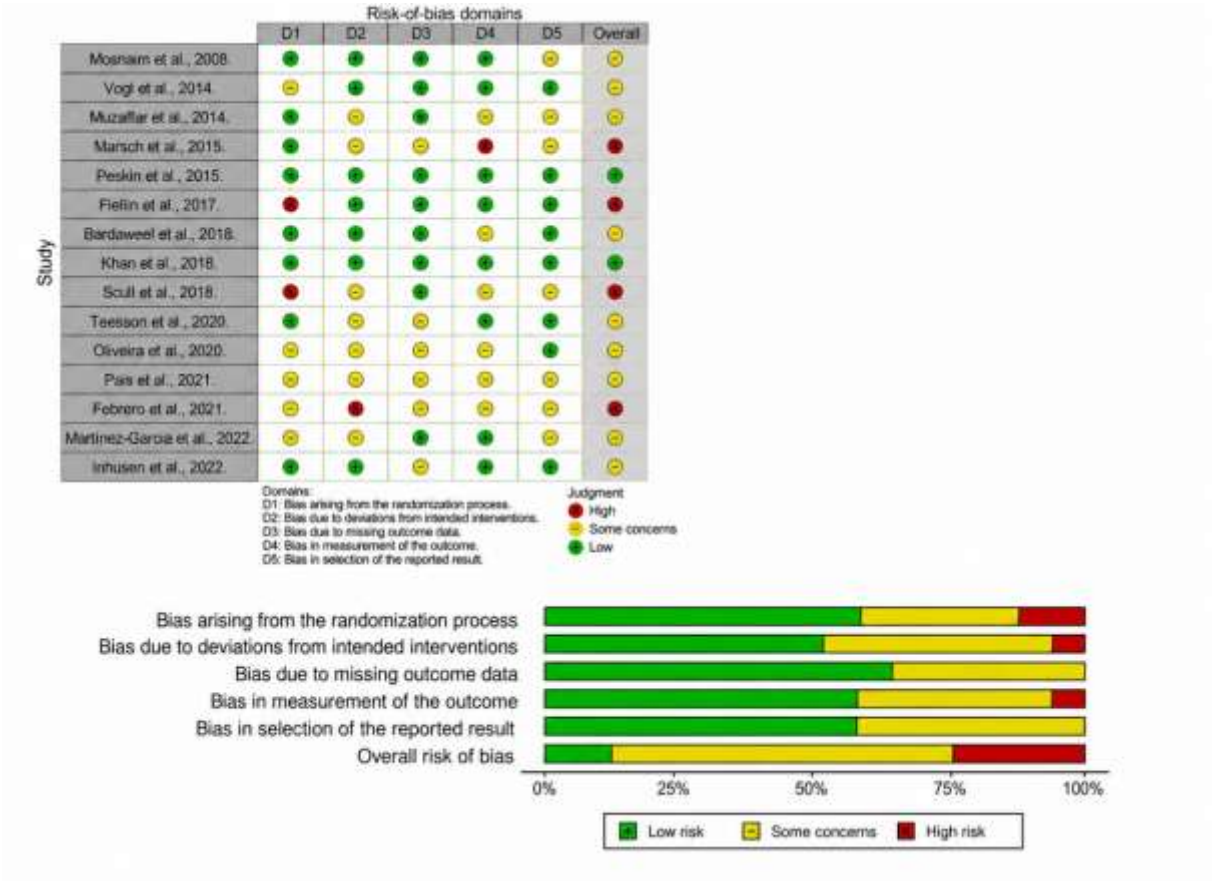
The Cochrane RoB 2.0 tool was used to assess the risk of bias in the studies selected for the final sample. This tool assessed study validity based on five domains: bias arising from the randomization process, bias due to deviations from intended interventions, bias due to missing outcome data, bias in outcome measurement, and bias in the selection of the reported result.

Figure 2 presents a detailed analysis of the risk of bias for each included study, with classifications divided into high, moderate, and low risk. The final column presents the overall assessment. Thus, four studies were categorized as having a high risk of bias, nine as having a moderate risk, and two as having a low risk of bias. A high-risk classification was assigned to studies that demonstrated a high risk in at least one of the domains assessed.

The percentage breakdown of risk-of-bias categorizations by domain is also presented. In Domain 1, approximately 53% of the studies showed low risk, 33% showed medium risk, and 13% showed high risk of bias. In Domain 2, approximately 46% of the studies showed low risk, 46% moderate risk, and 6% high risk. In Domain 3, approximately 59% of the studies were classified as low risk and 39% as moderate risk, with no studies categorized as high risk in this domain. In Domain 4, about 53% of the studies presented low risk, 39% moderate risk, and 6% high risk. Finally, in Domain 5, approximately 53% of the studies showed low risk and 47% moderate risk.

Thus, the overall assessment of risk of bias reveals that the majority of the studies, approximately 59%, had a moderate risk of bias, while approximately 13% had a low risk and 26% had a high risk. It is important to note that the values presented are approximations and are not exact.

**Figure 2 -** Assessment and percentage distribution of risk of bias by domain. Fortaleza, CE, Brazil, 2024



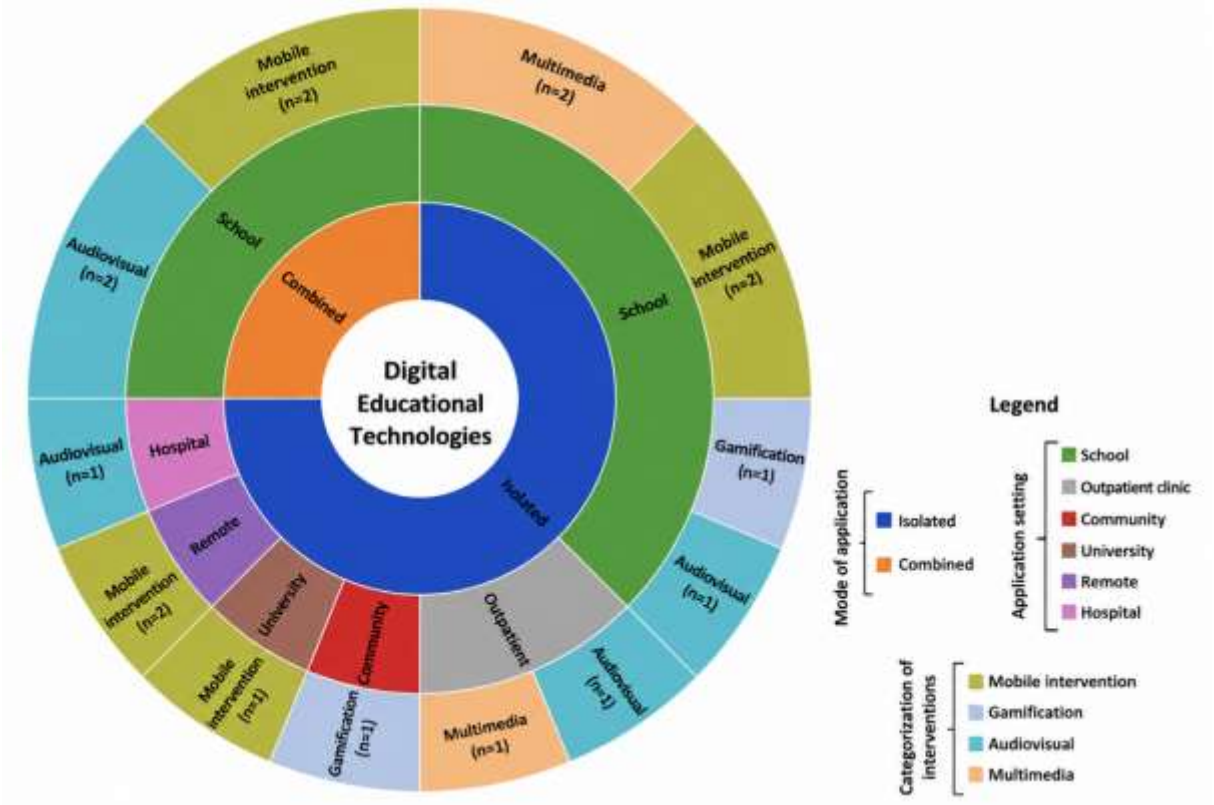

Source: the authors, 2024.

**Characterization of technologies**

Figure 3 presents an analysis of the digital educational technologies identified, categorized into two modes of application: isolated (in blue) and combined with other types of technologies (in orange). Each application mode is further divided into categories based on the setting in which the technology was applied, including school, outpatient, community, university, remote, and hospital settings. The outermost layer of the chart details the subcategories of interventions used in each setting, such as mobile interventions, gamification, audiovisual interventions, and multimedia.

These four subcategories were derived from the typology of the technologies identified: mobile interventions (mobile apps, mobile software, tablet-based examples, and websites); gamification (digital games and video games); audiovisuals (online cartoons, music tracks, educational videos, and short films); and interactive multimedia (technology combining various media types, such as videos, narrated text, color images, interactive questionnaires, and developmental activities).

**Figure 3** – Sunburst chart showing the division of interventions by application mode (first inner ring), technology application setting (second ring), and intervention subcategories (outer ring). Fortaleza, CE, Brazil, 2024.




Source: the authors, 2024.

It was observed that the isolated mode of application had a greater variety of settings, including schools, outpatient clinics, communities, universities, hospitals, and remote settings, totaling 12 interventions, with a predominance of mobile interventions, particularly in educational settings (schools and universities) and remote settings.

Schools stand out as the primary setting, with mobile and audiovisual interventions being the most frequent. In the combined mode of application, there were a total of four interventions, with mobile and audiovisual interventions in schools (n = 2 each). Multimedia was used exclusively in outpatient settings in the isolated mode (n = 2), whereas mobile and audiovisual interventions appeared in various contexts in both isolated and combined modes, indicating the broad applicability of these technologies.

The analysis of the sample revealed a predominance of thematic areas focused on prevention, particularly the use of psychoactive substances, sexually transmitted infections (STIs), including HIV, and pregnancy. Additionally, within the scope of health promotion and disease prevention, the interventions demonstrated substantial applicability in areas such as

oral health, sexual and reproductive health, as well as mental health promotion and the reduction of anxiety and depression.

## DISCUSSION

The findings of this systematic review demonstrate that digital educational technologies show different levels of effectiveness regarding knowledge acquisition among adolescents, with differences linked to the type of intervention, the level of interactivity, and context of application, particularly in domains such as sexual and reproductive health, substance use prevention, and mental health promotion.

However, an in-depth analysis of the data indicates that educational success does not result from the presence of technology itself but is directly related to the instructional design and degree of interactivity incorporated into the interventions. In this regard, technologies structured around interactive multimedia and hybrid models demonstrated larger effect sizes[26-27], whereas passive approaches based on one-dimensional content showed low effectiveness or inconclusive results[21-15].

This phenomenon is strongly supported by the literature on Digital Health Literacy (*eHealth Literacy*), which makes explicit that literacy is not limited to the ability to operate a device, but encompasses the competence to seek, understand, and evaluate health information in electronic environments in order to make appropriate decisions[28]. Static and passive DETs fail to engage adolescent audiences because they erroneously assume that simply making information available leads to its assimilation. In contrast, interactive and hybrid interventions, which combine gamification and in-person support, act as active mediators of this literacy, translating complex concepts into a fluid language that requires cognitive engagement, aligning with the neurobiological needs for reward and stimulation characteristic of this stage of development[29].

The superiority of hybrid models, often implemented in school settings, highlights another key finding of this review: technology reaches its highest effectiveness when it acts as a bridge rather than as a substitute for human relationships. The WHO guideline for adolescent- and youth-friendly health services advocates participatory approaches that respect adolescents' autonomy. In-person support combined with DETs provides a safe environment for clarifying doubts and alleviating concerns, overcoming the informational isolation that often drives young people toward unverified online sources and risk behaviors[2,8].

From a critical perspective, it is imperative to analyze the effectiveness of DETs through the lens of the Digital Determinants of Health (DDH). This review observed that the

effectiveness of technologically complex interventions may substantially decrease when they are implemented in contexts of socioeconomic vulnerability. Digital exclusion, manifested by limited access to adequate mobile devices, quality internet connectivity, or culturally adapted tools, acts as a vector of inequity[7,30]. The introduction of advanced technologies without equitable access planning risks widening health disparities, benefiting only segments of the adolescent population that are already privileged[31].

Thus, one finding that corroborates this asymmetry is the geographical distribution of the selected evidence. A predominance of studies conducted in high-income countries was observed, with the United States accounting for more than half of the sample, followed by countries such as Australia, Canada, and the Netherlands. In contrast, the representation of low- and middle-income countries, such as Brazil and Syria, was minimal. This geopolitical polarization has direct implications for knowledge translation, as DETs developed in the so-called "Global North" are based on assumptions of continuous connectivity infrastructure, access to state-of-the-art hardware, and prior digital literacy that often do not reflect the reality of developing countries[32].

Consequently, the unrestricted extrapolation of the 'high effectiveness' of these interventions to the Latin American context, and specifically to the reality of users of the Unified Health System (*Sistema Único de Saúde* - SUS) in Brazil, requires extreme caution, highlighting the urgent need to decentralize digital health research to foster technologies that address local vulnerabilities and infrastructures.

Moreover, the interpretation of these findings requires caution regarding the knowledge translation into practice. The primary outcome metric of the studies analyzed was knowledge acquisition. However, health psychology demonstrates that knowledge alone is insufficient to ensure sustainable changes in complex behaviors[33]. An adolescent may acquire extensive knowledge about contraceptive methods through an app, but psychosocial barriers, peer pressure, and lack of access to health services may prevent the adoption of safe practices. Therefore, high effectiveness in knowledge transfer should be viewed as the first step, rather than the definitive outcome of health promotion.

It is worth noting that this review has certain limitations that must be considered, although they do not invalidate the presented results. Significant methodological heterogeneity among the primary trials, including variations in measurement instruments and follow-up periods, precluded the conduct of a meta-analysis. A scarcity of cost-effectiveness analyses was also observed, such data are relevant for the sustainability and integration of

these technologies into public policies. Additionally, the risk-of-bias assessment revealed weaknesses in part of the sample, requiring caution when universally presenting the results.

Regarding clinical and educational practice, particularly in nursing, it is recommended that future DETs aimed at adolescents move beyond one-way informational approaches. Nurses, who occupy a strategic position in health education, whether in primary care, school settings, or outpatient care, should act not merely as prescribers of these tools, but as essential mediators in hybrid interventions. It is imperative to prioritize participatory designs that combine the autonomy of digital media with a supportive approach and sociocultural validation.

Finally, longitudinal clinical trials with low risk of bias are encouraged, focusing not only on immediate knowledge acquisition but also on assessing the sustainability of this learning and its actual capacity to induce protective behavioral changes.

## CONCLUSION

In response to the objective of this study, it is concluded that digital educational technologies present different levels of effectiveness regarding health knowledge acquisition among adolescents, varying according to the type of intervention, the level of interactivity, and the context of application. Analysis of the sample revealed a predominance of thematic areas focused on prevention, particularly regarding psychoactive substance use, HIV infection, STIs, and adolescent pregnancy.

Additionally, within the scope of health promotion and disease prevention, the interventions demonstrated substantial applicability in areas such as oral health and sexual and reproductive health, as well as mental health promotion and the prevention of anxiety and depression.

It was found that effectiveness stems not from the use of technology in isolation, but from the level of interactivity provided being significantly higher in gamified interventions and hybrid models that include in-person mediation. However, when considering the quality of the evidence, the risk-of-bias assessment identified methodological weaknesses in the primary literature, with a considerable proportion of studies presenting ‘some concerns’ or ‘high risk’ of bias.

Consequently, caution is warranted when assuming that these tools are universally highly effective. The integration of digital educational technologies into clinical practice, particularly in nursing, requires the development of future clinical trials with greater

methodological rigor, representative samples, and longitudinal follow-up to assess knowledge retention and actual behavioral change.

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## DATA AND MATERIAL AVAILABILITY

The data supporting this systematic review, including the extraction instruments and the analysis dataset for the included studies, are available upon request from the corresponding author. No dataset was deposited in an external repository.

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## AUTHORSHIP CONTRIBUTION

**Project administration:** Maria Eduarda Jucá da Paz Barbosa, Victor Andrew da Silva Teixeira;

**Conceptualization:** Maria Eduarda Jucá da Paz Barbosa, Victor Andrew da Silva Teixeira, Neiva Francenely Cunha Vieira, Patrícia Neyva da Costa Pinheiro, Viviane Martins da Silva;

**Data curation:** Maria Eduarda Jucá da Paz Barbosa, Victor Andrew da Silva Teixeira, Jayne Ramos Araujo Moura;

**Formal analysis:** Maria Eduarda Jucá da Paz Barbosa, Victor Andrew da Silva Teixeira, Jayne Ramos Araujo Moura, Neiva Francenely Cunha Vieira, Patrícia Neyva da Costa Pinheiro;

**Investigation:** Maria Eduarda Jucá da Paz Barbosa, Victor Andrew da Silva Teixeira;

**Methodology:** Maria Eduarda Jucá da Paz Barbosa, Victor Andrew da Silva Teixeira, Neiva Francenely Cunha Vieira, Patrícia Neyva da Costa Pinheiro, Viviane Martins da Silva;

**Supervision:** Neiva Francenely Cunha Vieira, Patrícia Neyva da Costa Pinheiro, Viviane Martins da Silva;

**Writing-original draft:** Maria Eduarda Jucá da Paz Barbosa, Victor Andrew da Silva Teixeira.

**Writing-review & editing:** Maria Eduarda Jucá da Paz Barbosa, Victor Andrew da Silva Teixeira, Jayne Ramos Araujo Moura, João Victor Lira Dourado, Paula Suene Pereira dos Santos, Neiva Francenely Cunha Vieira, Patrícia Neyva da Costa Pinheiro, Viviane Martins da Silva.

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**Corresponding author**
João Victor Lira Dourado
jvdourado1996@gmail.com

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Bruna Hinnah Borges Martins de Freitas

**Editor-in-chief:**
João Lucas Campos de Oliveira