

Planning, implementation, evaluation, and sustainment of digital health interventions for adolescent substance use prevention: a systematic review of influencing factors based on the RE-AIM framework

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Abstract

School-based health interventions can help prevent adolescent substance use, but their success depends on various factors affecting planning and evaluation. This study examines the factors that facilitate or hinder the success of school-based digital health interventions. A systematic review was conducted in September–October 2024, following PRISMA guidelines, using PubMed, Scopus, Web of Science, CINAHL, and PsycINFO databases. From a total of 2530 studies, after removing duplicates and screening titles and abstracts, 51 full-text articles were assessed and 12 met the inclusion criteria. Data were extracted using an adapted tool for systematic reviews applying the RE-AIM (Reach, Effectiveness, Adoption, Implementation, and Maintenance) framework. The methodological quality was assessed with Joanna Briggs Institute tools. The studies included cluster-randomized controlled trials, quasi-experimental designs, and one cross-sectional study, primarily targeting adolescents aged 11.9–17.4 years, with sample sizes ranging from 90 to nearly 5000 participants. Most interventions were implemented in schools in the USA, Europe, and Taiwan, with balanced gender distribution. Many studies reported on reach and effectiveness in reducing substance use, particularly alcohol. However, adoption and implementation factors influencing school participation were less frequently addressed, and maintenance was not mentioned. To maximize impact, future efforts should focus on enhancing sustainment and participation by leveraging emerging technologies for personalization.

Introduction

Digital health technologies have the potential to transform healthcare delivery by enabling remote monitoring, improving disease management, and personalizing treatment [1]. These technologies can enhance health

outcomes, such as diagnosis, treatment decisions, digital therapeutics, and self-care, while also supporting healthcare professionals through evidence-based knowledge and skills [2]. Common digital health tools include telemedicine, mobile health apps, wearable

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devices, electronic health records, and artificial intelligence [1, 3].

Digital health interventions (DHIs) are defined as specific applications of these technologies aimed at achieving health objectives [4]. These interventions may facilitate communication, such as reminders and health promotion messages, to increase service demand and access to health information [3, 5]. Their use is becoming more prevalent in achieving health goals, especially for adolescents and young people, with previous studies highlighting their effectiveness in lifestyle management [6–8], mental health improvement [9–12], and addressing health system issues [13].

Adolescence, defined by the World Health Organization (WHO) as ages 10–19 years, is a crucial period for the emergence of behaviours that can impact health both immediately and later in life [14]. Substance use, a key unhealthy behaviour, is linked to higher morbidity and mortality, representing a major public health challenge [14, 15]. In the past decade, substance use has increased, with 292 million people globally estimated to have used drugs in 2022, a 20% rise from a decade earlier [16]. A WHO/Europe report [17] shows that over 50% of 15-year-old adolescents engage in alcohol use, while 20% use tobacco products, such as e-cigarettes. This highlights the diminishing gender gap in substance use and the need for targeted prevention efforts.

DHIs, including internet-based, computer-tailored, and mobile approaches, have become popular platforms for promoting health [18]. These interventions offer personalized feedback based on individual assessments [19] and have proven effective in preventing substance use among adolescents, including alcohol [20, 21], tobacco [22], and cannabis [23]. One of the key lessons learned by planners, evaluators, journal readers, funders, and policymakers is that DHIs are not a silver bullet but can effectively complement or enhance existing approaches [3]. These interventions, which incorporate policy, environmental, and individual components, require evaluation methods that are tailored to their specific settings, goals, and purposes [24]. In this context, applying a comprehensive evaluation framework is essential, and one of the most widely used frameworks is RE-AIM (Reach, Effectiveness, Adoption, Implementation, and Maintenance), which has been implemented across various contexts [25–28].

RE-AIM focuses on five critical dimensions of both individual- and setting-level outcomes that help assess the overall impact and sustainability of interventions [24]: reach, effectiveness, adoption, implementation, and maintenance. Reach refers to the absolute number, proportion, and representativeness of individuals participating in a programme; effectiveness assesses

the intervention's impact on outcomes, including any negative effects, quality of life, and economic factors; adoption considers the number and representativeness of settings and agents initiating the programme; implementation examines the fidelity, adaptations, delivery consistency, cost, and time involved; and maintenance evaluates the extent to which a programme becomes institutionalized in organizational practices and its long-term individual-level effects ≥ 6 months after the intervention [29, 30]. Recent reviews [25, 28] reported reach as the most frequently mentioned dimension, followed by effectiveness and implementation, while adoption and maintenance were rarely discussed.

RE-AIM is designed to assess the extent to which evidence-based practices are adopted by institutions. In the context of adolescent substance use, no reviews to date have examined the factors influencing the planning and evaluation of school-based DHIs using a guiding framework. In this regard, we analysed DHIs through this lens to identify multilevel contextual factors relevant to programme implementation and successful adoption, across all stages from planning to sustainment. This study aims to explore the factors that influence the success of such interventions in school settings and to identify key elements for optimizing their design, implementation, and sustainability. Specifically, we assessed which factors were addressed and which remained underdeveloped in each intervention, potentially affecting the overall success of the programmes.

Methods

A systematic review was conducted following the recommendations of the preferred reporting items for systematic reviews and meta-analyses (PRISMA) statement [31]. First, the Population/Exposition/Outcomes question was formulated for an adequate literature review (Table 1). For this, the following research question was developed: ‘What factors, evaluated through the five dimensions of RE-AIM, can either facilitate or impede the successful adoption and sustainability of school-based DHIs for substance use prevention among adolescents?’ This systematic review has been registered in PROSPERO, with code CRD42024582753. Neither humans nor animals were involved in this investigation; therefore, ethical approval was waived.

Search strategy

The search was conducted between September and October 2024 in PubMed, Scopus, Web of Science (WOS), CINAHL, and PsycINFO, which were selected

Table 1. Research question and search strategy

Population	Adolescents in the school context
Exposition	Influencing factors according to RE-AIM
Outcomes	Successful adoption and sustainability of school-based DHIs for substance use prevention
Research question	What factors, evaluated through the five dimensions of RE-AIM, can either facilitate or impede the successful adoption and sustainability of school-based DHIs for substance use prevention among adolescents?
Search strategy	(adolescen* OR minor* OR juvenile* OR teen* OR young* OR youth OR 'school-age children' OR highschool* OR college*) AND (factor* OR determinant* OR reason* OR barrier* OR facilitator*) AND (reach OR participation OR recruit* OR representativeness OR effect* OR efficacy OR impact OR satisfaction OR 'process evaluation' OR adopt* OR robustness OR implement* OR adhere* OR deliver* OR fidelity OR consistency OR maintain* OR maintenance OR continuation OR sustain*) AND ('digital health' OR 'digital intervention' OR e-health OR ehealth OR 'online intervention' OR 'internet intervention' OR 'web-based intervention' OR 'mobile health' OR m-health OR mhealth) AND ('substance use' OR 'substance abuse' OR 'alcohol drinking' OR 'alcohol use' OR 'alcohol consumption' OR 'alcohol intake' OR 'binge drinking' OR 'binge alcohol consumption' OR 'smoking' OR 'tobacco use' OR 'tobacco consumption' OR cannabis OR marijuana OR marihuana OR hashish OR cannabinoids OR cannabidiol OR dronabinol OR THC OR 'illegal drug' OR 'illicit drug' OR 'street drug' OR 'recreational drug')
Database	Results
PubMed	760
Scopus	405
WOS	967
CINAHL	170
PscINFO	228

for their broad coverage and relevance to the review topic.

The search strategy was established using the Medical Subject Headings (MeSH) thesaurus and the Boolean operators 'AND' and 'OR' (Table 1).

Selection criteria

Inclusion criteria were any studies with quantitative or qualitative design, which analysed school-based DHIs for substance use among adolescents, and those focused on substance use prevention rather than treatment. DHIs are discrete functionalities of digital and mobile technologies used to achieve health sector objectives and support health system needs. According to the WHO, DHIs primarily target public health audiences by promoting accessible language and helping health programme planners articulate the roles of digital health tools. In the context of this review, DHIs focus on 'students'—members of the public who are current or potential users of digital health services related to substance use—and include health promotion activities [3, 4, 32].

Exclusion criteria were articles that did not reach the cut-off point of methodological quality assessment, which will be conducted using the Joanna Briggs Institute (JBI) critical appraisal tools, as described in the following section. Articles that did not analyse interventions (e.g. design papers and protocols for interventions), as well as pilot studies, reviews, meta-analyses, doctoral theses, or conference proceedings, were not

included. The search was conducted without limitations on language or publication year.

Data selection and extraction

Two independent researchers conducted the review following the database search strategy. They performed an initial screening of articles based on titles and abstracts, followed by a full-text review of potentially relevant studies. Disagreements were resolved by a third researcher.

Zotero [33] was used to collect references and facilitate the removal of duplicates during the screening process.

For a peer-review purpose, a template was created to collect the main characteristics of each study. The data were then customized based on (I) the author(s) name, (II) year of publication, (III) country of origin, (IV) study objective, (V) methodology and population, (VI) intervention characteristics and contexts, (VII) main findings, and (VIII) JBI and GRADE (Grading of Recommendations Assessment, Development, and Evaluation) score. All relevant data was synthesized and categorized, and compared to resolve any possible discrepancies.

The data extraction for factors influencing the success of DHIs using the RE-AIM dimensions was performed with an adapted tool designed for systematic reviews [28]. The reach dimension was assessed through 12 indicators, including target population, inclusion/exclusion criteria, and participation rates.

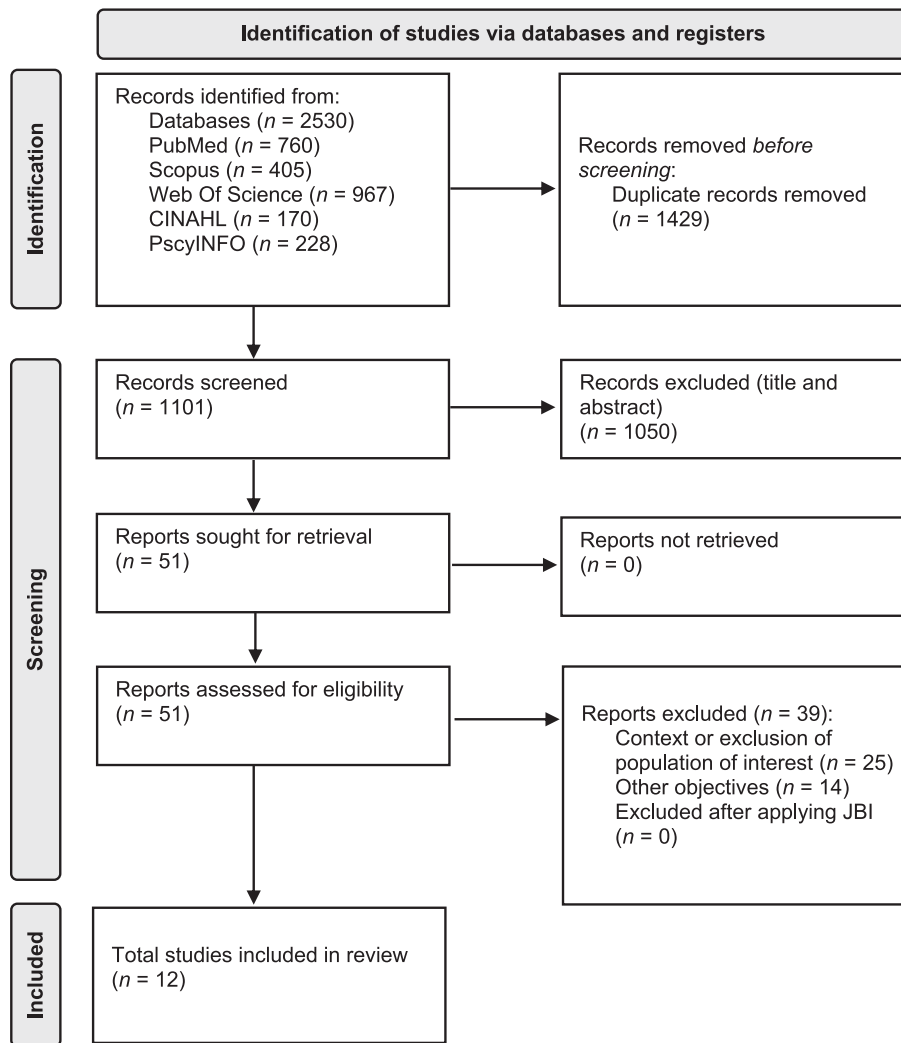


Figure. 1. PRISMA flow diagram.

Effectiveness was evaluated based on nine criteria such as mediators, data handling, quality of life outcomes, and attrition rates. Adoption was analysed at the setting and staff levels using 10 and 11 indicators, respectively, focusing on settings involved, recruitment, and representativeness. Implementation was examined through 11 indicators, including intervention theory, protocol fidelity, costs, and completion rates. Maintenance was assessed with nine factors, focusing on the long-term impact of the intervention.

Quality assessment of the studies

The methodological quality of the selected studies was double-checked by two investigators using the critical

appraisal tools of the JBI for randomized controlled trials (RCTs), quasi-experimental studies, and analytical cross-sectional studies [34]. These tools were used to assess the methodological quality of the studies and to determine the extent to which a study had minimized the possibility of bias in its design. For this purpose, a cut-off point was established for scores equal to or greater than half of their maximum value: RCT, 7 or more items out of 13 ([Supplementary Table 1](#)); quasi-experimental studies, 5 or more validated items out of 9 ([Supplementary Table 2](#)); and analytical cross-sectional studies, 4 or more validated items out of 8 ([Supplementary Table 3](#)). Articles that scored below these required thresholds were excluded from the review.

Table 2. Summary of DHIs

Author(s), year, country	Population and contexts	Methodology and Intervention characteristics (Content, Delivery Methods and Feedback)	Expected outcomes and effectiveness
Griffin et al., 2022, USA [37]	This study examined middle school students (ages 11–14 years) from 23 randomly selected US schools, representing diverse geographic regions. Schools were assigned to either an intervention group (13 schools) or a control group (10 schools) receiving standard health education. Participants completed online assessments before and after the intervention, typically during regular class periods or in computer lab sessions.	The LST intervention focused on substance abuse prevention and addressed alcohol and other addictive substances (smoking and e-cigarette use, marijuana, and prescription drugs). The programme provides information on the health and social consequences of substance abuse while teaching self-regulation, social skills, and other life skills necessary to resist social influences encouraging substance use. The intervention programme utilized a hybrid approach, combining digital learning with in-person instruction. It incorporated online platforms and interactive modules, consisting of 14 short e-learning modules that provided educational content on the adverse consequences of substance use and essential life skills. To reinforce these concepts, the programme was integrated into the school curriculum through six in-person classroom sessions adapted from an evidence-based programme. These sessions emphasized small-group discussions and hands-on skill practice, supported by classroom materials such as a teacher's manual and review slides. Successful implementation required active teacher participation, ensuring alignment with the curriculum. A teacher-facilitated approach was central to the intervention, with educators leading the in-person sessions. Teachers received online training on structuring the delivery of e-learning modules and classroom sessions, as well as on cognitive-behavioural skill-building techniques to enhance discussions and skill application. Participant feedback was gathered through focus groups with middle school students, teachers, and parents from diverse geographic (urban, suburban, and rural) and socioeconomic backgrounds.	It was a universal prevention programme, designed for implementation in a regular classroom setting with all students. The study hypothesized that the intervention would lead to significant improvements in these areas compared to a control group receiving standard health education. The programme aimed to prevent substance use, improve health knowledge, enhance skill comprehension, and strengthen life skills among middle school students. Results confirmed the programme's effectiveness, showing significant reductions in smoking, e-cigarette use, alcohol consumption, intoxication, marijuana use, and prescription drug misuse among intervention participants. Additionally, students in the intervention group demonstrated greater health knowledge, improved understanding of essential skills, and enhanced life skills such as decision-making, emotional regulation, communication, and conflict resolution.

(continued)

Table 2. (Continued)

Author(s), year, country	Population and contexts	Methodology and Intervention characteristics (Content, Delivery Methods and Feedback)	Expected outcomes and effectiveness
Doumas et al., 2014, USA [38]	The study was conducted with a population of ninth-grade students ($N = 513$), aged 13–16 years ($M = 14.21$, $SD = 0.47$). The educational context consisted of two junior high schools in the Northwestern USA. Students were recruited from these schools during regular class hours. The intervention and alcohol and drug education were implemented within this school setting.	The intervention content, delivered through the brief web-based programme eCHECKUP TO GO, specifically focused on preventing alcohol use. One school was assigned to the intervention group, where students participated in a brief web-based programme called eCHECKUP TO GO, while the other school served as the control group, receiving standard alcohol and drug education delivered by a school counsellor in a classroom presentation format. The standard education received by the control group covered health risks associated with tobacco, alcohol, and other drugs, reasons for substance use, and skills to resist peer pressure. The intervention group received the eCHECKUP TO GO programme. This online platform included an interactive assessment and personalized normative feedback. Students accessed the platform to complete the evaluation and receive individualized feedback. eCHECKUP TO GO was designed to be concise, with a duration of ~30 min. The control group received standard alcohol and drug education, delivered by a school counsellor in a classroom presentation format. This method represents a facilitated delivery approach, where a professional (in this case, the school counsellor) leads the instruction in a traditional group setting. Participant feedback in the intervention group was obtained through real-time feedback, immediately after completing the online assessment. Participants received individualized graphical feedback, providing instant insights based on their responses. The feedback aimed to reshape perceptions of peer alcohol consumption norms, adjust beliefs and expectations about alcohol, and deliver personalized normative feedback on alcohol use. Additionally, it provided individual risk factor assessments, highlighting potential vulnerabilities to alcohol-related issues.	The programme aimed to adjust perceptions and beliefs about alcohol use, provide personalized normative feedback, and offer individual risk assessments. It also delivered accurate information to debunk myths about alcohol consumption. As a cost-effective and easily scalable web-based intervention, it required minimal training and could be efficiently implemented in school settings, reaching large student groups within the existing educational framework. Furthermore, its integration into the school curriculum enhances programme fidelity and consistency. The study found the following results regarding the programme's effectiveness: At the 3 month follow-up, students in the intervention group reported a reduction in alcohol consumption frequency and alcohol-related consequences compared to the control group. At the 6 month follow-up, however, there were no significant differences between the intervention and control groups in terms of alcohol consumption frequency or related consequences. This indicates that the reductions observed at 3 months were not sustained throughout the academic year.

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Table 2. (Continued)

Author(s), year, country	Population and contexts	Methodology and Intervention characteristics (Content, Delivery Methods and Feedback)	Expected outcomes and effectiveness
Doumas et al., 2014, USA [39]	The study was conducted with a population of ninth-grade students from two junior high schools in the Northwestern USA. Participants ranged in age from 13 to 16 years ($M = 14.21$). The study included both male and female students. The study was conducted within the school setting.	While the control group received their standard alcohol and drug prevention education, the intervention itself, eCHECKUP TO GO, primarily focused on alcohol use prevention and the consequences related to its consumption, beliefs, and expectations. The two participating schools were randomly assigned to either the intervention group or the control group. The intervention consisted of a brief web-based personalized feedback programme implemented in the school. Students in the intervention group participated in an additional class session, where a school counsellor guided them through accessing the online intervention. The control group received traditional alcohol and drug education from a school counsellor, delivered as a classroom presentation covering the health risks of tobacco, alcohol, and other drugs, reasons for substance use, and peer pressure resistance skills. The main intervention, the eCHECKUP TO GO programme, was implemented through an online platform. Students accessed a website where they completed an online assessment that included interactive modules to gather information about their alcohol consumption, drinking behaviours, and related consequences. Immediately after the assessment, they were provided with real-time personalized normative feedback, delivered through the online platform, which included graphs and information tailored to their responses with basis on comparisons to normative data at both the national and school levels. During the feedback presentation, students were shown strategies to reduce their alcohol consumption. Students could also revisit their feedback using a unique identification number. This particular study does not detail whether it was formally integrated into the scholar curriculum beyond the guided session.	The primary purpose of the study was to test the effectiveness of a brief online intervention programme based on social normalization and motivation enhancement models to reduce alcohol consumption risk factors, alcohol use, and alcohol-related consequences among students. The study supports the effectiveness of a brief, personalized, web-based intervention in reducing positive alcohol beliefs and decreasing alcohol-related consequences. Students in the intervention group reported lower levels of positive beliefs and expectations about alcohol and a greater reduction in these expectations over time. In contrast, students in the control group showed an increase in these expectations. Students in the control group reported a significantly greater increase in the frequency of alcohol consumption over time compared to the intervention group. However, no significant effects were found in the weekly quantity of alcohol consumed. Students in the intervention group reported a significantly greater reduction in alcohol-related consequences compared to the control group.

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Table 2. (Continued)

Author(s), year, country	Population and contexts	Methodology and Intervention characteristics (Content, Delivery Methods and Feedback)	Expected outcomes and effectiveness
Doumas et al., 2020, USA [40]	The study was conducted on a population of high school seniors. The sample consisted of 311 participants, with a mean age of ~17.15 years. The gender distribution was 44.4% male and 55.6% female. The study was carried out in the educational context of two urban high schools in the Northwest USA. Participants were recruited from their classes, and assessments were conducted in the school's computer laboratory.	The intervention programme, eCHECKUP TO GO, focused on preventing alcohol use among high school seniors. It was not designed as a treatment for individuals with problematic alcohol consumption but rather aimed at reducing cognitive risk factors and alcohol use itself (i.e. alcohol consumption patterns, including quantity and frequency, risk of experiencing negative consequences associated with alcohol use, alcohol tolerance, and economic cost of alcohol consumption). The study included both an intervention group and a control group. It was designed as an RCT. Participants, all high school seniors, were randomly assigned by class period to one of two groups. The intervention group completed the eCHECKUP TO GO intervention. The control group participated in an assessment-only condition and did not receive the eCHECKUP TO GO intervention immediately after the initial evaluation. The effectiveness of the intervention was assessed by comparing the outcomes of the intervention group with those of the control group at the 30-day follow-up evaluation. There was normative feedback, comparing the student's alcohol use with national data on adults (by sex), college students (by sex), and adolescents aged 12–17 years (regardless of sex). It also included comparisons between the student's perceptions of their peers' drinking behaviours and local data from their high school. The primary delivery method was an online platform with interactive modules, accompanied by researchers who supervised and standardized the administration process. The eCHECKUP TO GO programme was a brief, web-based, and personalized intervention that provided individualized feedback.	The eCHECKUP TO GO programme was expected to achieve three key outcomes in reducing alcohol consumption among high school seniors. First, it was anticipated that there would be a reduction in normative perceptions of peer alcohol consumption and positive expectations towards alcohol. Second, no significant differences were expected in the use of protective behavioural strategies. Finally, the study predicted a decrease in alcohol consumption. The findings confirmed that eCHECKUP TO GO was effective for the three outcomes. However, certain effects were more pronounced among women. Specifically, the intervention significantly impacted their perceptions of the frequency of peer drunkenness and their own drinking frequency. eCHECKUP TO GO shows promise as a preventive tool for alcohol consumption, although certain aspects related to normative feedback and protective behavioural strategies may require refinement to enhance its effectiveness, especially for male participants.

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Table 2. (Continued)

Author(s), year, country	Population and contexts	Methodology and Intervention characteristics (Content, Delivery Methods and Feedback)	Expected outcomes and effectiveness
de Josselin de Jong et al., 2014, Netherlands [22]	The study was conducted on a population of Dutch adolescents aged between 10 and 20 years. The participants were students from secondary schools in the Netherlands. The study was carried out within the educational context of secondary schools across the country. A total of 89 secondary schools were recruited. Initial data collection took place in schools, where students completed a web-based questionnaire in the classroom.	The Smoke Alert intervention focused exclusively on tobacco use, aiming to prevent smoking initiation among adolescents, and did not address alcohol consumption or other addictive substances. The intervention was tested as part of a cluster-RCT, in which schools were randomly assigned to either an intervention condition or a nonintervention control condition. Students in schools assigned to the experimental condition accessed the intervention website at school, using a unique login credential provided by their teachers. The primary delivery methods of the Smoke Alert intervention included online platforms and interactive modules, with an integrated component within the school environment and teacher facilitation in scheduling the activity. The follow-up process was primarily self-guided through online platforms. Upon completing the questionnaire, students in the experimental group received immediate feedback, which was displayed on their computer screens. The intervention involved an online questionnaire and fully automated, personalized computerized feedback. For nonsmokers, the feedback content was designed to help them maintain their abstinence, assessing factors such as their intention to smoke, beliefs about tobacco (attitudes), perceived social influence, self-efficacy to remain smoke-free, and action plans/strategies for prevention. The feedback combined textual information with other elements such as graphs and animated videos. It also displayed facts and figures related to the students' responses. A 6-month follow-up was conducted by inviting students via email to complete a self-guided online questionnaire.	The Smoke Alert programme was shown to be effective in preventing the initiation of tobacco use, particularly in the 14- to 16-year-old age group, at the 6-month follow-up. While the programme also provided feedback for adolescents who were already smokers, the primary objective of this study was to assess its effectiveness in smoking prevention. The results suggest the potential of personalized, web-based computerized interventions for adolescent smoking prevention. In the general population of students aged 10–20 years, tobacco initiation was significantly lower in the experimental group compared to the control group at the 6-month follow-up. In the specific age group of 14–16 years, a significant effect was observed, with 5.7% (10/176) of students in the experimental group reporting initiation compared to 11.5% (24/209) in the control group (odds ratio 0.22, 95% confidence interval 0.05–1.02, $P = .05$).

(continued)

Table 2. (Continued)

Author(s), year, country	Population and contexts	Methodology and Intervention characteristics (Content, Delivery Methods and Feedback)	Expected outcomes and effectiveness
Jander et al., 2016, Netherlands [41]	The study was conducted on a population of Dutch adolescents aged between 15 and 19 years. The educational context in which the research took place was Dutch lower secondary schools, vocational education schools, and upper secondary education institutions. The adolescents were recruited from these schools, and the intervention was implemented within the school environment.	A cluster-RCT was conducted with an intervention group receiving an online programme and a control group completing only an initial online questionnaire. Both groups completed a follow-up assessment 4 months later using the same questionnaire. Schools were randomly assigned to either the experimental or control condition. The intervention content focused on the prevention of excessive alcohol consumption, specifically binge drinking. The intervention did not aim at treating individuals with existing substance use problems, but rather at preventing such behaviours in adolescents. The intervention, called 'Alcohol Alert', consisted of an online game titled 'What happened?!', in which adolescents, after completing an initial questionnaire, played three sessions. Each session focused on common alcohol consumption situations for adolescents (at home, at a bar, and at a party). This approach can be considered an element of gamification designed to make the intervention more engaging. During the game sessions, adolescents received questions and real-time, computer-tailored feedback. This feedback was based on the I-Change Model and addressed various concepts related to motivation and behaviour change. Additionally, action plans were provided to enhance self-efficacy in risky situations. A fourth session, conducted outside of the game, evaluated recent alcohol consumption and offered adolescents the opportunity to challenge themselves to drink less at future events where they had previously engaged in binge drinking. The study employed a variety of delivery methods, including online platforms, interactive modules, and personalized computer-generated feedback. Teachers scheduled time for adolescents to participate. Email reminders were used to maintain engagement, and a separate online platform was created for parents.	The programme was effective in preventing binge drinking among younger adolescents (15 and 16 years old, particularly with higher adherence), but did not show a significant effect in older adolescents or in secondary outcomes such as excessive alcohol consumption and weekly consumption across the entire sample. The overall low adherence to the programme was a major limitation. Regarding the programme's effectiveness, adolescents in the experimental group reported a significant decrease in the frequency of binge drinking in the 30 days prior to the follow-up assessment, compared to the control group. The programme was also found to be effective in reducing binge drinking among 16-year-old adolescents when they participated in at least two sessions of the intervention. It was observed that higher adherence to the intervention was associated with stronger effects in reducing binge drinking among adolescents aged 15 and 16 years.

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Table 2. (Continued)

Author(s), year, country	Population and contexts	Methodology and Intervention characteristics (Content, Delivery Methods and Feedback)	Expected outcomes and effectiveness
Drost et al., 2016, Netherlands [42]	The study was conducted on a population of Dutch adolescents aged between 15 and 19 years. The educational context in which the study took place included upper secondary schools, lower secondary schools, and vocational education institutions. The participants were students from these schools.	The study was designed as a cluster-RCT, with schools randomly assigned to the intervention group, who took part in the programme, and the control group, who received usual care and could access the game only after the final measurement. Measurements were conducted at Baseline (T0) in January/February 2014, and follow-up (T1) four months later, in May/June 2014. The programme, called 'Alcoholic Alert', was a web-based intervention with computer-tailored individual adaptation. The content of the intervention focused on the prevention of excessive alcohol use and binge drinking among adolescents. Although the study also measured the use of other addictive substances such as cigarettes, soft drugs, and hard drugs for cost analysis purposes, the intervention content itself was centred on alcohol use prevention. The intervention consisted of an online game ('Watske-burt') that engaged participants with socio-cognitive factors related to alcohol consumption. After completing the game, participants were challenged to reduce alcohol consumption at upcoming events. Follow-up sessions included feedback on their behaviour, with encouragement for meeting challenges and the opportunity to try again if they did not succeed. The programme aimed to encourage reduced alcohol consumption and provide continuous support. The intervention, 'Alcoholic Alert', was delivered through an online platform with interactive modules. Participants completed an online questionnaire and played the game, receiving immediate computer-tailored, personalized feedback based on their answers. The programme was self-guided, with email reminders used for follow-up, and although teachers provided instructions for data collection, the intervention was mainly conducted online.	The expected outcomes of the 'Alcoholic Alert' programme were the reduction of alcohol consumption and binge-drinking episodes among adolescents. The programme proved to be effective in reducing alcohol consumption and, in particular, in decreasing episodes of excessive alcohol consumption among participating adolescents, although overall consumption increased in both groups during the follow-up period. The effectiveness and cost-effectiveness also varied across different subgroups of adolescents. The intervention was progressively more effective than usual prevention in reducing both weekly alcohol consumption and the number of binge drinking-episodes in the 30 days prior. Although there was an increase in the number of alcoholic drinks consumed per week in both the intervention and control groups during the study period, the increase was smaller in the intervention group. Regarding binge drinking, a small decrease was observed in the intervention group, while an increase was seen in the control group.

(continued)

Table 2. (Continued)

Author(s), year, country	Population and contexts	Methodology and Intervention characteristics (Content, Delivery Methods and Feedback)	Expected outcomes and effectiveness
Guo et al., 2023, Taiwan [43]	The study was conducted with a population of 90 students from a senior high school in Taipei, Taiwan. The majority of participants were male (67.77%), and 41.11% were first-year students. The educational context pertains to drug use prevention programmes offered in senior high schools in Taiwan. These programmes are already delivered through official health education courses in senior high schools.	Participants were volunteer students who expressed their interest in participating by informing the school after the programme announcement. The intervention content focused on the prevention of illegal drug use, rather than the treatment of individuals who were already using substances. The programme was designed as a supplementary resource for adolescent-targeted drug prevention programmes. It was a 3D virtual reality intervention that included five educational activities and five serious games within a virtual environment, addressing the following key topics: high-risk situations, the harms of illegal drugs, zero tolerance, determination to quit drugs, and a healthy lifestyle. The method was primarily characterized by the use of digital tools (virtual reality technology) to interact with virtual environments and complete in-game activities and tasks, with a facilitation component provided by the research staff. Students used virtual reality glasses to have immersive experiences in situations of illegal drug use and joysticks to operate and interact with the virtual environments. The intervention was conducted within the educational school context, although it was offered as a voluntary and complementary activity. The primary method for obtaining feedback from participants was the administration of a structured questionnaire with Likert scale items following the intervention with the 3D virtual reality programme.	The goal of the programme was to offer a more innovative and interactive approach to increase students' interest in learning about drug use prevention, assessing its acceptability among senior high school students, and identifying factors influencing their intention to continue using VR-based learning. Findings showed high user acceptance and strong willingness to continue using the programme, with attitudes, subjective norms, and perceived behavioural control significantly influencing students' intention to use it. Participants found the experience engaging, particularly with the use of headsets and joysticks. Although the study did not measure direct prevention outcomes, the high intention of continued use suggests potential for virtual reality-based programmes in school drug prevention efforts. The authors recommend integrating similar interventions into other preventive education programmes.

(continued)

Table 2. (Continued)

Author(s), year, country	Population and contexts	Methodology and Intervention characteristics (Content, Delivery Methods and Feedback)	Expected outcomes and effectiveness
Haug et al., 2013, Switzerland [44]	The study was conducted among students from vocational schools in the canton of Zurich, Switzerland. A total of 364 students from seven schools participated in the programme. The participants were primarily between 15 and 20 years old, and 24.5% of them were female. The study was carried out in a school context and schools collaborated in the invitation and evaluations.	The Alk-Check intervention focused on preventing and reducing problematic alcohol consumption among young adults. The sources do not indicate that the intervention addressed the use of other addictive substances. The study's methodology included online platforms and interactive modules that provided individualized online feedback through a web-based platform. This feedback allowed participants to compare their alcohol consumption patterns with the norms of a reference group of the same age and gender. Participants accessed this feedback after completing an online assessment. The feedback included information on their drinking patterns compared to the reference group, financial costs, calorie intake, and frequency of binge drinking. Additionally, text messaging (SMS) technology was used via mobile phones to deliver short, recurring feedback messages. These messages were personalized and sent directly to participants, providing ongoing feedback on the topics covered. They were delivered automatically. The intervention had a self-guided component, as once students registered in the programme, the online feedback and SMS messages were delivered automatically, allowing participants to engage at their own pace. The intervention was not directly teacher-facilitated and was not described as being fully integrated into the school curriculum.	The expected outcomes of the programme were to assess the feasibility and initial effectiveness of a combined web-based and text message (SMS) intervention aimed at reducing problematic alcohol consumption among vocational school students over a 3-month study period. The authors concluded that the results demonstrate high acceptance and promising effectiveness of this intervention approach, which could be easily and cost-effectively implemented within school classes. A statistically significant reduction was observed in the average number of standard drinks per week, alcohol-related problems, risky consumption, and the number of drinks per binge-drinking episode.

(continued)

Table 2. (Continued)

Author(s), year, country	Population and contexts	Methodology and Intervention characteristics (Content, Delivery Methods and Feedback)	Expected outcomes and effectiveness
Haug et al., 2017, Switzerland [45]	The study was conducted with students from vocational schools in Switzerland. A total of 877 students participated in the programme and the associated study. The average age of the participants was 17.4 years, and 58.3% of the participants were female. The educational context was in 13 different vocational schools across Switzerland, covering 118 school classes. The invitation to participate in the study was made during 30-min sessions within regular school lessons reserved for health education.	The intervention focused on the prevention of the initiation and escalation of substance use among adolescents. The study was conducted with students who were not regular cigarette smokers. The effectiveness of the programme was explored in relation to the consumption of alcohol, tobacco, and cannabis, and changes in the use of these substances were assessed. The delivery methods outlined in the 'ready4life' study primarily focused on the use of digital tools, with a particular emphasis on adolescents' mobile phones. The programme was largely self-guided, as there is no mention of 'teacher-facilitated' delivery for the continuous programme delivery, nor of 'virtual counselling'. Participants interacted with the content individually and at their own pace through their mobile phones. They received text messages and accessed web content independently. Some messages also included hyperlinks to audio files, video clips, images, and related websites. The programme consisted of interactive features such as quizzes and message/image contests, as well as viewing other participants' contributions through a mobile-accessible website. A web platform was used for the initial assessment to provide individualized feedback immediately after the assessment and was used for participation in contests. While the invitation to participate took place within the context of school classes, the continuous delivery of the programme was not part of the regular daily curriculum. Participant feedback was obtained immediately through the web, by observing their participation in gamified elements, through a limited form of peer interaction in the contests, and through direct evaluations of the programme and its components at the end of the intervention.	The objectives of the study were to test the acceptance, use, and evaluation of a mobile phone-based LST programme among vocational school students and to explore its potential effectiveness. The proportion of adolescents with risky alcohol use decreased significantly from 20.2% at baseline to 13.5% at follow-up. No significant changes were observed in the prevalence of tobacco use or cannabis use. These initial results reveal high acceptance and promising effectiveness of this intervention approach, which could be implemented easily and cost-effectively. However, the authors note that due to the pre-post design of the study, no definitive conclusions can be drawn about the programme's effectiveness, as other factors that could have influenced the results over time were not controlled for.

(continued)

Table 2. (Continued)

Author(s), year, country	Population and contexts	Methodology and Intervention characteristics (Content, Delivery Methods and Feedback)	Expected outcomes and effectiveness
Martínez-Montilla et al., 2020, Spain [20]	The study was conducted with a population of Spanish adolescents aged 15–19 years. A total of 742 participants were in the experimental group and 505 were in the control group. At baseline, 46.99% were male and 53.01% were female. The study was carried out in an educational school context, specifically in 15 public secondary schools. The 'Alerta Alcohol' intervention was implemented in these schools as part of the health promotion curriculum during school hours.	The content of the 'Alerta Alcohol' intervention focused on preventing alcohol consumption and, specifically, episodes of heavy drinking or binge drinking among adolescents. The content was presented through short stories in which the main character had experienced an episode of heavy alcohol consumption the previous night, and their friends discussed what had happened. These stories took place in three different settings: at home, at a celebration, and in a public place, and were adapted to the participant's gender. Participants could personalize the story by choosing an avatar and the names of the characters. After presenting the stories, personalized questions and messages were displayed. These messages were based on the I-Change Model of behaviour change, which focuses on attitude, social influences, self-efficacy, and action planning. The 'Alerta Alcohol' intervention was web-based. Students in the experimental group received help from their teachers when logging into the website and continuing the intervention during school sessions. After the initial school sessions, two reinforcement sessions were scheduled to be completed at home. Email reminders were sent to participants who had not completed the intervention procedures, so they could finish them outside of school. Personalized feedback (computer-tailored) was provided. This feedback was based on their responses to the interactive questions. The messages were customized with the participants' names and offered motivational feedback. After completing each intervention session, participants were asked about their experience and satisfaction with the programme. A follow-up evaluation (post-test) was conducted 4 months after the intervention to assess their behaviour in relation to the intervention's objectives.	The expected objectives of the programme focused on the prevention of binge drinking and alcohol consumption in general among adolescents. The hypothesis was that a web-based, computerized, and personalized intervention would be effective in reducing these patterns of alcohol consumption in this population. The 'Alerta Alcohol' programme was effective in reducing heavy alcohol consumption among participants, but no significant effects were found on binge drinking, weekly consumption, or any alcohol consumption. The results of the process evaluation indicated that adolescents were generally satisfied with the programme and that women and nonheavy alcohol consumers showed better responses in this evaluation.

(continued)

Table 2. (Continued)

Author(s), year, country	Population and contexts	Methodology and Intervention characteristics (Content, Delivery Methods and Feedback)	Expected outcomes and effectiveness
Vargas-Martínez et al., 2023, Spain [46]	The study was conducted with a population of 1247 adolescents aged 15–19 years in the context of 15 secondary schools. The sample included 367 adolescents, of whom 119 were female and 91 were male in the intervention group, and 77 were female and 80 were male in the control group. The study was carried out in class in computer labs through the intervention's website.	The content of the intervention, called Alerta Alcohol, focused on the prevention of alcohol consumption in adolescents, specifically to prevent binge drinking. The study also collected information on the use of other addictive substances such as cocaine, tranquilizers, sedatives, sleeping pills, and cannabis through questionnaires, and the economic evaluation considered the costs associated with cigarette and shisha consumption. The programme consisted of six sessions, including questionnaires and narrative scenarios related to situations of excessive alcohol consumption. The intervention was carried out through a specific website where each student created a user account. The questionnaires were completed during school classes, and the students were advised by a research technician and supervised by a teacher. The feedback to participants in the intervention was obtained through preventive messages and personalized information presented within the web programme. This feedback was based on the responses that the adolescents provided in the initial questionnaires and during the different sessions of the programme.	The expected outcomes of the Alerta Alcohol programme were the prevention of binge drinking among adolescents aged 15–19 years. Specifically, the programme aimed to address cognitive factors (knowledge and risk perception) and motivational factors (attitude, social influence, and self-efficacy). The study evaluated both the reduction in the number of binge-drinking episodes and improvements in quality-adjusted life years. The programme was found to be cost-effective and useful in terms of reducing binge-drinking episodes and increasing quality-adjusted life years among Spanish adolescents, particularly in certain subgroups such as females and older adolescents. However, the authors highlight the need for long-term follow-up to fully assess the changes.

Table 3. Summary of the selected articles

Author(s), year, country	Objective of the research	Study characteristics	Targeted substances	Main findings	JBI and level of evidence
Griffin et al., 2022, USA [37]	To evaluate the effectiveness of a hybrid substance abuse prevention programme for high school students, which combines e-learning modules and in-person classroom sessions.	The study evaluated the effectiveness of a digital hybrid substance abuse prevention programme for high school students (1447 participants) in the context of US middle schools, using a randomized controlled group design, which consisted of 14 brief e-learning modules and six in-person classroom sessions adapted from the LST programme.	The intervention focused on alcohol, tobacco, e-cigarette, Marijuana, and prescription drugs (including opioids).	The main findings indicate that the digital hybrid substance abuse prevention programme was effective, achieving significant reductions in the consumption of tobacco, e-cigarettes, alcohol, marijuana, and the misuse of prescription medications compared to the control group. Additionally, participants in the intervention showed significant increases in knowledge about health and the adverse effects of substance use, as well as in life skills knowledge. Improvements were also observed in life skills related to decision-making, anxiety and anger management, communication, social skills, assertiveness, and conflict resolution, positively influencing resistance to social influences related to substance use.	JBI for RCT 9/13 GRADE: A1
Doumas et al., 2014, USA [38]	To examine whether the reductions in alcohol consumption and alcohol-related consequences observed at 3 months would be maintained throughout the academic year.	The study involved 513 ninth-grade students in an RCT design, conducted by scholars from the fields of education for counsellors, addiction studies, and community and environmental health, to test the effectiveness of a brief web-based personalized feedback digital intervention.	The intervention focused on alcohol. The education of the control group included alcohol, tobacco, and other drugs.	The study evaluated the effectiveness of a brief digital intervention to reduce alcohol consumption in ninth-grade students. Although initial reductions were observed in the frequency of consumption and alcohol-related consequences at 3 months, these effects did not persist at 6 months. The programme, based on social norm theory and motivation enhancement models, aimed to modify perceptions of peer consumption norms, beliefs, and expectations about alcohol. However, the long-term results suggest that this brief intervention alone was not sufficient to generate sustained changes in alcohol consumption behaviours and their consequences, nor to influence the social dynamics related to consumption in this age group.	JBI for RCT 10/13 GRADE: B1

(continued)

Table 3. (Continued)

Author(s), year, country	Objective of the research	Study characteristics	Targeted substances	Main findings	JB1 and level of evidence
Doumas et al., 2014, USA [39]	To test the effectiveness of a brief web-based intervention and personalized feedback to reduce alcohol consumption risk factors, alcohol use, and alcohol-related consequences among ninth-grade students.	The study, with an RCT design, targeted 513 ninth-grade students from two high schools, investigating the effectiveness of a brief digital intervention of personalized web-based feedback (eCHECKUP TO GO) in the context of research on addictive behaviours and prevention in adolescence by scholars.	The intervention focused on alcohol. The education of the control group included alcohol, tobacco, and other drugs.	The main results indicate that the brief web intervention was effective in reducing alcohol consumption risk factors, alcohol use, and related consequences among ninth-grade students. Reductions were observed in positive expectations and beliefs about alcohol in the intervention group compared to the control group. Regarding behaviours, the frequency of consumption remained the same in the intervention group, while it increased in the control group, and a greater reduction in alcohol-related consequences was reported in the intervention group. However, no significant effects were found on normative beliefs about peer alcohol consumption or on the weekly amount of consumption.	JB1 for RCT 10/13 GRADE: B1
Doumas et al., 2020, USA [40]	To examine the gender differences in the effectiveness of eCHECKUP TO GO among high school senior students.	This study with an RCT design examined the effectiveness of eCHECKUP TO GO, a brief web-based personalized digital intervention, in 311 high school seniors within the context of research on adolescent alcohol use prevention and behavioural risk factors.	The intervention focused on alcohol.	The main results indicate that eCHECKUP TO GO was effective in reducing perceptions of alcohol consumption among peers, sex-specific BD, positive expectations towards alcohol, and the maximum amount of alcohol consumed, showing effectiveness for both genders. Regarding knowledge changes, the intervention reduced misperceptions about peer alcohol consumption. In terms of attitudes and behaviours, a reduction was observed in positive expectations towards alcohol, maximum consumption, and frequency of consumption for women. As for social influences, the intervention influenced the perception of peer drunkenness frequency, especially in women. No significant effects were found on protective behaviour strategies.	JB1 for RCT 10/13 GRADE: A1

(continued)

Table 3. (Continued)

Author(s), year, country	Objective of the research	Study characteristics	Targeted substances	Main findings	JBI and level of evidence
de Josselin de Jong et al., 2014, Netherlands [22]	To describe the characteristics of the intervention and demonstrate its effectiveness in preventing the initiation of smoking among Dutch adolescents, particularly in the age group of 14–16 years.	The study was a group RCT aimed at Dutch secondary school adolescents aged 10–20 years ($n = 897$ with complete data) in the context of adolescent smoking prevention using personalized digital interventions. The digital intervention ‘Smoke Alert’ consisted of a web questionnaire with automatic and personalized feedback on smoking intention and motivational factors, including multimedia elements.	The intervention focused on tobacco.	The study found a borderline significant effectiveness in preventing smoking initiation in adolescents and a significant effectiveness in the 14–16-year-old group. The digital intervention ‘Smoke Alert’ focused on smoking intentions and motivational determinants, addressing attitudes against smoking and strengthening negative beliefs. It influenced social influences by informing about smoking prevalence and offering refusal skills. Although changes in knowledge were not directly measured, the intervention provided personalized information. The results suggest that digital prevention programmes are promising, especially in middle adolescence.	JBI for RCT 10/13 GRADE: A1
Jander et al., 2016, Netherlands [41]	To evaluate whether a personalized web intervention is effective in reducing BD in Dutch adolescents aged 15–19 years.	This study was a cluster-RCT that evaluated a personalized web-based intervention in the form of a game called ‘What happened?!’ based on the I-Change Model to reduce BD among Dutch adolescents aged 15–19 years, with the participation of 2649 adolescents at the start, conducted by university researchers.	The intervention focused on alcohol.	The custom web game was effective in reducing excessive alcohol consumption in 15- and 16-year-old adolescents, particularly with greater adherence. Although the game aimed to increase knowledge and modify attitudes and behaviours, no significant effects were found on overall excessive consumption or weekly consumption. The intervention addressed social influences such as role models, norms, and peer pressure, which could explain its effectiveness in younger adolescents, who are more susceptible to these influences. Parental involvement was associated with lower excessive alcohol intake in their children.	JBI for RCT 11/13 GRADE: A1

(continued)

Table 3. (Continued)

Author(s), year, country	Objective of the research	Study characteristics	Targeted substances	Main findings	JB1 and level of evidence
Drost et al., 2016, Netherlands [42]	To evaluate the cost-effectiveness of a personalized web intervention to reduce alcohol consumption and BD in adolescents from a health and social perspective.	The study was a cluster-RCT that assessed the cost-effectiveness of a personalized web-based digital intervention for reducing alcohol consumption and BD in 2493 Dutch adolescents aged 15–19 years, from a health and societal perspective, including intersectoral costs.	The intervention focused on alcohol. The study also measured the use and costs associated with the use of cigarettes, soft drugs, and hard drugs.	The study evaluated the cost-effectiveness of a personalized web intervention to reduce alcohol consumption and BD in adolescents. The main results showed that the intervention was incrementally more effective than usual care in reducing weekly alcohol consumption and BD occasions. The digital programme included a game with personalized feedback on alcohol awareness. The questions in the game were based on the I-Change Model, addressing attitudes, social influences, self-efficacy, and action plans related to alcohol consumption, aiming to change these determinants and, therefore, the behaviours.	JB1 for RCT 10/13 GRADE: A1
Guo et al., 2023, Taiwan [43]	To evaluate the user acceptability of a 3D immersive virtual reality educational programme for the prevention of illegal drug use and identify the factors associated with the intention of continued use of 3D virtual reality learning among high school students.	The study, a cross-sectional observational study with 90 high school students in Taipei, Taiwan, conducted by researchers from various academic and hospital institutions, assessed the acceptability of a 3D immersive virtual reality educational programme that included five educational activities and five serious games for the prevention of illegal drug use.	The intervention focused on illegal drugs.	The study found that the DTPB model was applicable for evaluating the virtual reality programme. Participants showed a high intention for continuous use, suggesting acceptability. The perceived usefulness of the programme positively influenced attitudes towards its use. Although knowledge change was not directly measured, the programme aimed to raise awareness about drugs. Attitudes and subjective norms (influence of school staff) were significantly associated with the intention to use. These results support the integration of similar programmes in drug prevention in schools.	JB1 for analytical cross-sectional study 6/8 GRADE: C2

(continued)

Table 3. (Continued)

Author(s), year, country	Objective of the research	Study characteristics	Targeted substances	Main findings	JBI and level of evidence
Haug et al., 2013, Switzerland [44]	To test the suitability and initial effectiveness of a combined web-based and text message (SMS) intervention programme to reduce problematic alcohol consumption among vocational school students.	The research was a pre-post longitudinal study that evaluated, in 364 students from vocational training schools in academic contexts in Switzerland and Germany, a combined digital intervention of personalized web feedback and individualized SMS messages.	The intervention focused on alcohol. The study also measured the use of tobacco.	The main results showed a promising initial effectiveness of the intervention, with significant reductions in risky drinking and alcohol-related problems, as well as a decrease in the average number of standard drinks per week. The intervention used feedback based on social norms and messages on how to resist peer pressure. Participants reported high comprehensibility of the messages, although direct changes in knowledge or attitudes towards substance use were not measured.	JBI for quasi-experimental study 7/9 GRADE: B2
Haug et al., 2017, Switzerland [45]	To test the acceptance and initial effectiveness of a mobile phone-based LST programme, individually tailored for vocational school students.	This pre-post study tested the acceptance and initial effectiveness of an LST programme based on text messages (SMS) aimed at vocational school students (N = 877) in the context of substance use prevention among adolescents, using a pre-post longitudinal design.	The intervention focused on alcohol, tobacco, and marijuana	The results of this pre-post study revealed a promising initial effectiveness of the mobile programme. A significant decrease in perceived stress was observed, along with increases in social skills, social support seeking, and palliative emotional regulation. Regarding behaviours, there was a reduction in the proportion of adolescents with risky alcohol consumption. No significant changes were found in tobacco or cannabis use. Although the programme addressed social influences through resistance skills, the direct results regarding changes in these influences are not specifically detailed in the effectiveness results. Direct changes in knowledge were not measured.	JBI for quasi-experimental study 7/9 GRADE: B2
Martínez-Montilla et al., 2020, Spain [20]	To test the effectiveness of the online intervention Alerta Alcohol for the prevention of excessive alcohol consumption in Spanish adolescents.	The study was a group RCT that evaluated the effectiveness of the digital intervention Alerta Alcohol, a web platform with short stories and personalized feedback based on the I-Change Model, for the prevention of excessive alcohol consumption in Spanish adolescents aged 15–19 years (N = 1247 at baseline, N = 612 at follow-up), within the context of public health education and the prevention of risk behaviours in adolescents.	The intervention focused on alcohol.	The Alerta Alcohol programme proved to be effective in reducing excessive episodic drinking (HED) among Spanish adolescents. Although no significant effects were found on BD, weekly consumption, or any consumption in the regression analysis, the process evaluation revealed that 59.7% of participants felt that their knowledge improved. Regarding attitudes and behaviours, 50.9% reported changes in their attitude, and 55.3% showed improvement in their skills to reduce BD. The programme was based on the I-Change Model, addressing social influences, although its impact on BD, influenced by social norms like 'street drinking,' was not significant.	JBI for RCT 10/13 GRADE: A1

(continued)

Table 3. (Continued)

Author(s), year, country	Objective of the research	Study characteristics	Targeted substances	Main findings	JBI and level of evidence
Vargas-Martínez et al., 2023, Spain [46]	To analyse the cost-effectiveness and usefulness of Alerta Alcohol, a personalized web intervention to prevent excessive alcohol consumption among adolescents aged 15–19 years in Andalusia, Spain, comparing it with the absence of intervention.	The study evaluated the cost-effectiveness and utility of Alerta Alcohol, a personalized web-based digital intervention based on the I-Change Model for the prevention of excessive alcohol consumption among adolescents aged 15–19 years in Andalusia, Spain, through a group RCT with a sample of 367 participants for the economic analysis, in a context of concern about adolescent BD and the lack of economic evaluations of similar digital interventions in Europe.	The intervention focused on alcohol. The study also measured the use of tobacco (including cigarettes and shishas or hookahs), cannabis, tranquilizers, sedatives, or sleeping pills (both prescription and nonprescription), and cocaine.	The study evaluated the cost-effectiveness of Alerta Alcohol, showing it to be effective in reducing BD occasions and increasing quality-adjusted life years. The intervention, based on the I-Change Model, aimed to change positive attitudes towards excessive alcohol consumption and reduce this behaviour. It assessed social influences such as family and friends' consumption. In particular, older adolescents (≥ 17 years) and women showed a greater reduction in BD occasions. Although the specific change in knowledge is not detailed, the programme addressed cognitive factors and risk perception.	JBI for RCT 9/13 GRADE: A1

BD: binge drinking, DTPB: decomposed theory of planned behaviour, HED: heavy episodic drinking.

Certainty and synthesis of data

To further enhance the quality of this study, the GRADE methodology [35] was employed (Supplementary Table 4). This tool considers the certainty of the evidence and the strength of the recommendations, with the aim of supporting health decision-making [35, 36]. If the evidence supporting the therapeutic intervention is of high quality and consensus determines that the recommendation should be strong, this is classified as evidence and recommendation A1. If high-quality evidence weakly supports the use of the therapeutic intervention, it is classified as A2. Moderate-quality evidence supporting a weak recommendation to the intervention is classified as B2, and if the quality of the evidence is low, with a weak recommendation, it is classified as C2.

Flowchart of the study using the PRISMA methodology

Finally, the flowchart is presented in accordance with the PRISMA methodology [31], illustrating the search results and the reasons for the exclusion of discarded articles (Fig. 1). This review initially identified a total of $n=2530$ studies from database searches. A total of $n=1429$ were removed as duplicates, and $n=1101$ were screened by title and abstract. Of these, $n=51$ were selected for full-text review, with $n=25$ subsequently excluded because they did not focus on the school context or target population, or because the objectives did not align with the review outcomes ($n=14$). Ultimately, $n=12$ studies were included in this review [20, 22, 37–46].

Results

Main results

The included studies were conducted in the following countries: USA [37–40], Netherlands [22, 41, 42], Taiwan [43], Switzerland [44, 45], and Spain [20, 46]. These studies were published in the following years: 2013 [44], 2014 [22, 38, 39], 2016 [41, 42], 2017 [45], 2020 [20, 40], 2022 [37], and 2023 [43, 46]. The study designs included cluster-RCTs [20, 22, 37–42, 46], quasi-experimental longitudinal studies [44, 45], and one analytical cross-sectional study [43].

The reviewed studies involved adolescent populations, with sample sizes ranging from 90 [43] to 4979 participants [22]. The average age of participants across studies ranged from ~11.9 to 17.4 years, with a general mean of ~15.3 years. The DHIs reviewed primarily targeted adolescent and young adult populations, with schools serving as the most common implementation context. These included secondary schools,

as well as vocational schools. Regarding gender distribution, the proportions were generally balanced. On average, ~49% of participants were male and 51% female, with some variation across individual studies. For example, Guo et al. [43] reported 67.77% male participants, while Haug et al. [45] had a female majority of 58.3%.

Table 2 shows the characteristics of the DHI that were selected for this review. Most interventions focused on preventing substance use—mainly alcohol [20, 22, 37–42, 44–46] and tobacco [22, 37, 45]—with some addressing multiple substances, including marijuana [37, 45] and prescription or illicit drugs [37, 43]. Reported outcomes included reductions in substance use and related harms [43], improved health knowledge, strengthened life skills [38–40], and modified peer-related perceptions and substance-related beliefs.

A variety of digital strategies have been used for substance use education, from hybrid programmes to virtual reality-based interventions, and interactive games. A recurring emphasis was placed on educating participants about the health and social consequences of substance use and on developing life skills such as self-regulation, emotional management [37, 45], social communication [37, 41, 45], decision-making [37], and conflict resolution [37]. Alcohol-related interventions often aimed to reshape normative perceptions and beliefs around drinking through personalized normative feedback [20, 41, 42, 44, 46].

Delivery methods frequently involved interactive web-based platforms [22, 38–40, 42, 45], often integrated into school hours with teacher facilitation or in hybrid formats. Features like immediate, tailored feedback [22, 38–40, 44], short message service (SMS) reminders and email follow-ups [20, 41, 42, 44, 45], gamified content [20, 41–43, 46], and immersive virtual reality experiences [43] were commonly used to enhance engagement and effectiveness. Intervention administration varied, with some being researcher-supervised [41] and others self-guided.

Table 3 shows the outcomes of each of the 12 final articles for this review. Digital interventions have shown promising results in reducing substance use among adolescents. Hybrid [37] and web-based programmes [44, 45] effectively decreased alcohol use, binge drinking, and related harms, with personalized tools like eCHECKUP TO GO [38–40] and interactive games showing particular success [20, 41, 42, 46]. The Alerta Alcohol programme proved both effective and cost-efficient, especially for older teens and females, although some interventions had limited long-term impact. For tobacco and e-cigarettes, hybrid programmes [37] and the Smoke Alert [22] intervention reduced use and initiation, particularly in younger

teens. Additionally, digital strategies effectively reduced marijuana use and prescription drug misuse [43], while immersive virtual reality programmes for illegal drugs showed high acceptability and engagement, suggesting strong potential for prevention.

Results according to the RE-AIM framework

A detailed description about the factors influencing the success of DHIs using the RE-AIM dimensions can be found in Supplementary Table 5.

Reach

This dimension was reported by seven of the studies [20, 38, 39, 41, 43–45]. All studies described consistently the target population, demographic and behavioural about the target population, the method to identify the target population, the recruitment strategies, the inclusion/exclusion criteria for individuals, and the sample size. Other factors such as the individual participation rate were described in all studies except one [43]. Six studies [20, 38, 39, 41, 44, 45] noted the eligible and invited (exposed to recruitment) potential participants. Four studies [38, 39, 44, 45] reported the comparisons between the target population and the study sample and also detailed the statistical comparisons between both. Lastly, the cost of recruitment was described in only one study [43] and no studies provided the qualitative methods to measure reach.

Effectiveness

Of all the RE-AIM dimensions, this was the most thoroughly reported on by all the included studies [20, 22, 37–46]. All studies described exhaustively the intent-to-treat and the percent attrition (at programme completion). Other factors such as the report of mediators and moderators were described in most studies but not all [20, 44, 45]. Eight studies [20, 22, 37, 41, 42, 44–46] described the imputation procedures and four studies [37, 42, 43, 46] the unintended consequences measures/results. The cost-effectiveness was reported in two studies [42, 46] and the quality-of-life measures only in one study [46]. Finally, no studies provided qualitative methods to measure efficacy/effectiveness.

Adoption

Overall, adoption was very poorly reported by all studies in our review due to only three studies [20, 42, 46] providing information to assess this dimension. About the setting level, no studies described factors such as the comparisons between the targeted and participating settings, and the statistical comparisons between both. About the provider/staff level, most factors were not detailed except in two studies [20, 46] in which

some of them such as the eligible and invited potential providers (staff), the number of participating providers (staff), and the method to identify target providers were noted. Furthermore, in only one of these studies [20] an element of the dissemination beyond originally planned could be inferred.

Implementation

This dimension was reported by nine of the studies [20, 22, 37, 39–42, 44, 45]. All studies described thoroughly the theory-based, the number, timing, and duration of intervention contacts, the tailoring of intervention, and the participant attendance/completion rates. Other factors such as the extent protocol delivered as intended (fidelity) were noted in all studies except one [42], just like the consistency of implementation across settings or providers [40]. Six studies [20, 37, 39, 41, 44, 45] indicated the engagement to inform intervention. Finally, the measure of intervention cost was described in only one study [42], and no studies provided the qualitative methods to measure implementation.

Maintenance

No studies assessed consistently this dimension. Two studies focused on short-term effects [20, 41], but none described either the extent to which the DHI becomes institutionalized or part of the routine organizational practices and policies at the setting level or its long-term effects on outcomes after it is completed at the individual level.

Discussion

Overall, this review yields promising evidence that digital interventions can be an effective tool for preventing and reducing substance use in adolescents. However, results vary depending on the type of intervention, the target population, and other factors. In this sense, the evaluation of interventions using the RE-AIM framework provides a complete view of their application in the real world.

Regarding reach, the participation rate is a significant indicator of an intervention's initial success. Some studies [44, 45] report substantial reach due to proactive recruitment and appealing activity designs. Parental involvement also plays a crucial role; Jander *et al.* [41] found that it was associated with lower binge drinking rates among adolescents. Interventions involving families, particularly those aimed at strengthening family functioning, have shown positive—though modest—long-term effects in reducing alcohol and drug use [14, 47, 48]. Other crucial success factors for achieving strong reach in health interventions include clearly identifying the target population [20, 38, 39, 41, 43, 45], employing active school-based

recruitment strategies such as incentives and parental involvement [20, 38, 39, 41, 43–45], providing detailed demographic and behavioural data [41, 43, 44], and achieving high initial participation [20, 38, 39, 41, 43–45].

However, challenges remain, such as obtaining consent [39, 40, 43], low retention in follow-ups [20, 38, 39, 44], lack of sample representativeness [20, 38, 39, 41], limited school participation [20, 38, 39, 41–44], insufficient data on eligible participants [20, 22, 41, 43, 46], and difficulties in generalizing findings due to specific sample characteristics [20, 22, 38, 40, 44, 45]. Overall, to improve reach, it is essential to address retention issues, track participation, and use engaging strategies that align with youth preferences, while ensuring equitable access to technology [49].

Several studies identify key factors influencing intervention effectiveness. While some report mixed or no significant effects based on individual characteristics and substance use patterns, most show positive results in reducing substance use [22, 37, 40, 42, 44–46]. Two studies [42, 46] found digital interventions more cost-effective than traditional methods, suggesting that they may efficiently reach more adolescents. Programmes based on solid theoretical models, such as life skills training (LST) [37], motivational enhancement [38], and social-cognitive theory [45], tend to be more successful. Personalizing feedback and adapting content to individual characteristics enhances outcomes [20, 22, 38, 39, 41, 42, 44–46], while involving stakeholders like students, teachers, and parents ensures programme relevance and acceptance [37, 39, 41, 44]. Traditional methods are valuable for peer interaction and educator support, but digital interventions provide flexible, scalable, and engaging alternatives. A hybrid approach could optimize school-based prevention [49, 50].

Despite this, high dropout rates hinder long-term impact assessments [20, 22, 41, 42, 46]. Many studies fail to measure important outcomes, such as quality of life and cost-effectiveness, complicating intervention evaluation [20, 37–39, 41, 43–45]. Other challenges, such as missing data and inconsistent implementation, affect results [37, 39, 41, 44, 45]. Some studies also found no significant moderation effects, highlighting the difficulty of tailoring interventions to specific needs [22, 37, 39].

The adoption of digital interventions in schools depends on factors like perceived usefulness and ease of implementation. Some programmes showed acceptable adoption rates [20, 42, 46], but only Martínez-Montilla et al. [20] detailed influencing factors. This gap echoes findings in other reviews [28, 51]. Clear definitions of target populations and inclusion criteria improved adoption, as did effective recruitment combining school outreach with student-focused strategies [20, 22, 38,

39, 41, 42, 44–46]. Involving school staff and offering small incentives also supported engagement [20, 38, 39, 41, 43–46]. Adapting programmes to local school contexts further boosted participation [20, 39, 46].

However, obstacles like school withdrawal, missing staff data, and voluntary participation limited adoption [20, 42, 46]. Addressing these challenges requires understanding school acceptance, offering flexible designs, resources, and evidence-based teacher training [52].

Institutional barriers and practical challenges identified in the studies could be addressed, especially during implementation. Hybrid approaches integrating interactive technology, such as combining digital modules with face-to-face sessions, have been shown to enhance implementation [37]. The use of interactive technologies like games [41, 42] and virtual reality [43] improves participation and outcomes, making implementation easier within health promotion curricula [53].

Implementation was more successful when grounded in theoretical frameworks, like LST [37], and when standardized protocols sustained fidelity across settings. Tailoring interventions to the target population's needs improved relevance [22, 38–40, 44]. Challenges included compromised fidelity due to flexible delivery, lack of adherence measures, and minimal stakeholder engagement [22, 40, 42]. Practical issues such as session length and low participation hindered implementation [20, 22, 41]. To improve future efforts, monitoring adaptations, costs, and alignment with teaching processes is crucial. Ensuring feasibility, integrating into school routines, fostering collaboration, and assessing adolescent participation are key to success [54, 55].

Although the selected studies do not address maintenance, it is essential to evaluate whether behavioural changes are sustained over time. To ensure lasting effects, interventions must continuously reinforce acquired skills, offer ongoing support to prevent relapse, and be integrated into daily routines with the necessary resources and involvement of essential personnel. This requires a long-term approach that includes periodic evaluations to adapt the programme as needed and maintain flexibility to accommodate changes in the environment or target population. Strong alliances with the educational community and relevant stakeholders are also crucial for ensuring continuity and support [25, 56, 57]. Additionally, regular strategies to monitor, reinforce, and support adolescents' learning should be implemented, with teacher training playing a vital role in sustaining key messages beyond the researchers' presence in both school and community settings. Finally, assessing cost-effectiveness in the short, medium, and long

term is fundamental to promoting sustainability and maximizing impact [49, 58].

Limitations

The main limitations of the reviewed studies include the high heterogeneity in intervention designs, making direct comparison of results difficult. While the RE-AIM framework helped evaluate multiple dimensions, some areas, such as adoption and maintenance, were insufficiently explored. For example, there is limited information on factors influencing school participation, and most studies inadequately report on sustainment, highlighting the need to tailor interventions to specific contexts for real-world application [59, 60]. Although RCTs are considered the gold standard for assessing intervention efficacy, they also have limitations, such as being conducted in controlled environments that may not fully represent real-world complexity. Regarding intervention content, most focused on preventing and reducing substance use in the general population, rather than treating addiction cases. The substances that were most often addressed were alcohol, tobacco, and both illicit and prescription drugs. Some programmes targeted specific substances, while others addressed multiple substances simultaneously. Consequently, the study selection was comprehensive, covering all these areas.

Insights from health education to enhance the relevance of the review's findings in the school context

The reviewed studies highlighted institutional barriers, practical challenges, and significant issues during the implementation of DHIs. These include problems with participant retention, high dropout rates, and limitations in adoption due to time and resource constraints in some educational settings. From a health education perspective, these findings emphasize the need for innovative approaches to engage adolescents, especially in programmes targeting substance abuse [61]. The importance of longitudinal studies to assess the long-term effectiveness of these interventions is also noted. Additionally, addressing technological barriers, such as limited access to devices and connectivity, is essential for improving the impact of digital interventions [62]. The introduction of AI offers promising opportunities to personalize interventions, enhance participation, and increase their effectiveness. Future research should focus on overcoming implementation challenges, adapting interventions to various contexts, and exploring AI's potential to create more engaging and personalized programmes that are accessible and sustainable.

Research on behavioural and substance use interventions requires long-term studies to assess the sustainability of digital solutions and identify success factors. There is also a need for evaluations of digital interventions across diverse populations, including adolescents from different socioeconomic and cultural backgrounds, to ensure their broad applicability and effectiveness [59]. Emerging technologies like AI and mobile apps show promise in personalizing interventions and enhancing their impact [62–64]. However, more research is needed specifically for adolescents and young adults. Future intervention programmes must consider the RE-AIM framework and be designed for lasting, meaningful impact.

Conclusions

This study highlights the potential of digital interventions in schools to prevent and reduce substance use among adolescents. Using the RE-AIM framework, findings show these interventions can be effective—especially those based on theory and incorporating interactive elements like virtual reality or educational games—although they face challenges in implementation and long-term maintenance. While many programmes achieved broad reach and positive changes in mediators like social norms and skills, issues such as high dropout rates, limited adoption, and lack of sustained impact remain. To enhance success, future efforts should focus on developing more adaptable, integrated, and sustainable interventions, increasing school and family engagement, and exploring emerging technologies like artificial intelligence.

Author contributions

Pablo Fernández-León (Conceptualization [lead], Data curation [lead], Formal analysis [lead], Funding acquisition [lead], Investigation [lead], Methodology [lead], Project administration [lead], Resources [lead], Software [lead], Supervision [lead], Validation [lead], Visualization [lead], Writing—original draft [lead], Writing—review & editing [lead]), Marta Lima-Serrano (Conceptualization [lead], Data curation [lead], Formal analysis [lead], Funding acquisition [lead], Investigation [lead], Methodology [lead], Project administration [lead], Resources [lead], Software [lead], Supervision [lead], Validation [lead], Visualization [lead], Writing—original draft [lead], Writing—review & editing [lead]), Javier Fagundo-Rivera (Conceptualization [equal], Data curation [equal], Formal analysis [equal], Investigation [equal], Methodology [equal], Project administration [equal], Resources

[equal], Software [equal], Supervision [equal], Validation [equal], Visualization [equal], Writing—original draft [equal], Writing—review & editing [equal]), and Jose Manuel Martínez-Montilla (Conceptualization [equal], Data curation [equal], Formal analysis [equal], Investigation [equal], Methodology [equal], Project administration [equal], Resources [equal], Software [equal], Supervision [equal], Validation [equal], Visualization [equal], Writing—original draft [equal], Writing—review & editing [equal]).

Supplementary data

Supplementary data is available at *HEAL* online.

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Data availability

The authors confirm that the data supporting the findings of this study are available within the article and its supplementary materials.

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