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REVIEW ARTICLE

The effectiveness of digital health technologies for reducing substance use among young people: a systematic review & meta-analysis

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ABSTRACT

Background: Substance use amongst young people poses developmental and clinical challenges, necessitating early detection and treatment. Considering the widespread use of technology in young people, delivering interventions digitally may help to reduce and monitor their substance use.

Aims: We conducted a systematic review and two meta-analyses to assess the effectiveness of digital interventions for reducing substance use (alcohol, smoking, and other substances) among young people aged 10 to 24 years old.

Method: Embase, Global Health, Medline, PsychINFO, Web of Science and reference lists of relevant papers were searched in November 2020. Studies were included if they quantitatively evaluated the effectiveness of digital health technologies for treating substance use. A narrative synthesis and meta-analysis were conducted.

Results: Forty-two studies were included in the systematic review and 18 in the meta-analyses. Digital interventions showed small, but statistically significant reductions in weekly alcohol consumption compared to controls (SMD=−0.12, 95% CI=−0.17 to −0.06, I^2=0%), but no overall effect was seen on 30-day smoking abstinence (OR = 1.12, 95% CI = 0.70 to 1.80, I^2=81%). The effectiveness of digital interventions for reducing substance use is generally weak, however, promising results such as reducing alcohol use were seen. Large-scale studies should investigate the viability of digital interventions, collect user feedback, and determine cost-effectiveness.

Prisma/Prospero: This systematic review was conducted following Cochrane methodology PRISMA guidelines. The review was registered with PROSPERO in November 2020 (CRD42020218442).

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Adolescents; e-health; digital health; meta-analysis; substance use

1. Introduction

In high-income countries, substance use is one of the leading causes for healthy life years lost in young people and represents a major public health challenge (Dick & Ferguson, 2015; Griswold et al., 2018; Peacock et al., 2018). Substance use most frequently co-occurs with psychiatric problems such as depression, suicide and psychosis (Patton et al., 2002; Sussman et al., 2008) and clusters with other adverse childhood experiences (ACEs) such as low socioeconomic status, incarceration and homelessness (Hughes et al., 2017; Kessler et al., 2006; Low et al., 2012; Settipani et al., 2018). Each of these circumstances can trigger an increase in current substance use to 'self-medicate' co-occurring psychiatric symptoms and/or create a stressful environment that can trigger a relapse in substance use.

The peak time for initiation of substance use is during adolescence and young adulthood, with tobacco and alcohol usually preceding the use of highly addictive and illegal substances such as heroin and methamphetamine (Degenhardt et al., 2016). Whilst there is no international consensus on the age range for adolescence and young adulthood, the World Health Organisation (WHO) recognises that adolescents include persons aged 10–19 years and youth includes those between 15–24 years for statistical purposes (WHO, 2022). Together, 'young people' are between the ages of 10–24 years, which is the definition we use in this paper. Young people undergo a period of key psychosocial transitions occur as the brain undergoes cognitive and emotional development that begins with the onset of puberty (approximately aged 10) and ends in the mid-20s (Squeglia et al., 2009). Therefore. preventing and reducing substance use during this time is critical.

The recent COVID-19 pandemic separated young people from some of the protective factors against substance use like school and family connectedness, strong neighbourhood attachment and academic competence (Nawi et al., 2021), which could have created conditions for substance use to begin or continue (Dumas et al., 2020). Alternatively, the pandemic demonstrated the value of digital health to address people's health needs. The term 'digital health interventions' denotes interventions that are responsive to user input and

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are delivered with the support of technology including targeted client communication; personal health tracking; and on-demand information services (Isioma et al., 2022; Quilty et al., 2021; WHO, 2019). Specifically, Web/Internet/Computer-based health interventions are primarily self-guided programmes that are executed by means of a "prescriptive online programme operated through a website and delivered through a computer" (Barak et al., 2009) and mobile phone-based health interventions are those delivered through a mobile/smart phone – including applications (apps) and text messages (WHO, 2011).

Young people are the most digitally connected age group worldwide – 70% use the internet, compared to 48% of the total population (United Nations Children's Fund, 2017). Digital health interventions could promote positive behaviour changes and potentially increase treatment engagement in this population, which might be more cost-effective than current methods, but there is a need to summarise their effectiveness to decide whether they are worth investing in.

There is currently no systematic review and meta-analysis that synthesises data on different types of digital interventions for the treatment of dependency, addiction or substance use disorder in young people aged 10–24 years. To add, this systematic review uses a broader search strategy to capture studies that may have tested digital interventions for e-cigarette use/vaping, since the uptake of these has increased considerably in recent years across the globe (Perikleous et al., 2018). This work comprises of a systematic review and two meta-analyses of randomised controlled trials (RCTs) with outcomes associated with smoking and alcohol use.

Previous systematic reviews and meta-analyses which have investigated the effect of digital health interventions on changing substance use behaviours among young people have produced conflicting results (Carey et al., 2012; Champion et al., 2013; Civljak et al., 2013; Dick et al., 2019; Hutton et al., 2011; Oosterveen et al., 2017; Tait & Christensen, 2010). Digital interventions show weak efficacy for smoking cessation (Civljak et al., 2013; Hutton et al., 2011), but seem to be more promising for reducing alcohol use. A 2012 meta-analysis by Carey et al. compared face-to-face interventions with computer-delivered alcohol interventions between 1998–2010 and conluded tthat face-to-face interventions ultimately provided the most effective and enduring effects (Carey et al., 2012). Apps and text messaging have alos been found to be acceptable and potentially effective ways to deliver messages about reducing alcohol consumption to young people (Hutton et al., 2020; Kazemi et al., 2021). However, each of these reviews did not investigate young people with dependency, or a pre-existing substance use disorder, therefore clinical relevance is difficult to determine.

The addiction field has experienced a rapid increase in digital health interventions. This review and meta-analysis aims to examine:

1. The effectiveness of digital treatments for young people (10–24 years) with problematic substance use, dependency or addiction.
2. Whether the type of substance, the type of digital intervention or particular features explain variability in effects.
3. The feasibility and acceptability of digital interventions in this age group.

Furthermore, we hope to aid researchers in evaluating new literature, give new directions for future research, and help to create useful digital treatments.

2. Material and methods

2.1. Design

This systematic review was conducted following Cochrane methodology and Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines (Moher et al., 2009). The review was registered with PROSPERO in November 2020 (CRD42020218442).

2.2. Search strategy

Embase, Global Health, Medline, PsychINFO and Web of Science databases were searched in November 2020 to identify peer-reviewed studies in English. No limits were placed on the dates that papers were published, as we wanted to provide an exhaustive overview of the literature by capturing any studies which previous reviews might have missed.

Search terms were based on a preliminary search of the relevant literature and reviewed and approved by all of the authors in a meeting. We combined the following search terms and their associated wildcard variants using Boolean operators:

- Adolescents, teenagers, youth, young people/person/adult
- Digital health, Telehealth, telemedicine, eHealth, mHealth, Internet, uHealth, smartphone, apps, mobile health, electronic health
- Drugs, alcohol, smoking, substance use/abuse/misuse

The search terms within groups were combined with OR whereas each domain was combined with AND. The search coding was defined by two of the authors (AW and DL), PhD scholars who have experience with search strategies from previous systematic reviews. The full search strategy can be found in Table A in O'Logbon et al., 2023. Reference lists of relevant studies and systematic reviews were also searched.

2.3. Eligibility criteria

Articles were eligible for inclusion if they (i) were published in English, (ii) quantitatively evaluated the effectiveness of a digital health intervention (exposure) for substance use (outcome), (iii) included participants who were between 10–24 years of age, and (iv) included participants with self-reported current problematic substance use at baseline

(one-off consumption such as using a substance once a year or once in their lifetime did not apply) or a formally diagnosed substance use disorder. Randomised controlled trials (RCTs) and non-RCTs were both included in the systematic review. Non-RCTs were not included in meta-analyses.

Digital health interventions were defined as interventions delivered with the support of computers, mobile phones or portable devices with the primary aim of changing substance use-related behaviours. Examples include binge drinking (drinking more than the recommend weekly allowance in a single session), smoking (tobacco, cannabis, other substances, or e-cigarettes) and illicit drug use. Interventions targeting additional behaviours (e.g. eating habits and exercise) or co-occurring conditions (e.g. depression) were only included if participants were screened into the trial as using substances and if substance use behaviours were reported separately.

Studies were excluded from the review if they (i) assessed passive digital health technologies, such as those developed for the sole purpose of screening, assessment or lacked any user input, (ii) the mean age of participants was <10 years or >24 years, or (iii) <50% of the participant population was between 10–24 years old.

2.4. Study selection and data extraction

Duplicate references were removed in Mendeley reference manager, then titles and abstracts of articles were independently reviewed for eligibility in November 2020 by JO and CW. Percentage agreement was high (Cohen's kappa: 0.81). Where disagreement existed, JO and CW agreed on an outcome through discussion. JO screened the full-texts and CW was responsible for second rating them – both agreed on all of the full-texts to be included in the final review. JO completed data extraction using the Cochrane Data Extraction and Assessment form as a guide and conducted the meta-analyses.

2.5. Outcomes

Our primary outcome was abstinence or reduction in substance use as reported by the trial authors. For secondary outcomes, we sought data on feasibility and acceptability. However, these were reported inconsistently, and so were included in a narrative synthesis.

2.6. Statistical analysis

The meta-analyses were conducted using RevMan 5.4.1. Studies were not included if they were not an RCT; lacked a control group; combined substance use was measured without stratification by the different types of substances; control groups contained elements or variations of the digital intervention, and if there were no outcome measures comparable to the other studies (Figure 1). The remaining 18 studies targeted either smoking or alcohol consumption.

The most common outcome measure for alcohol use was weekly alcohol consumption (continuous variable). Studies reported this in standard drink units, number of drinks, or grams of ethanol. Results from intention-to-treat analysis were used where available. If not already provided, means and standard deviations were converted from available confidence intervals, standard errors, medians, ranges, and sample sizes (Higgins et al., 2022; Hozo et al., 2005).

For smoking studies, the most common outcome measure was 30-day continuous abstinence (dichotomous variable). Percentages or fractions were converted to whole numbers based on the sample size, provided an intention-to-treat analysis had been used. If intention-to-treat results were not available, we used reported results for completers.

Outcomes were reported over a wide range of time points so we used the results reported at the last time point from each study. Authors of studies with missing or inconclusive results were contacted to provide additional information.

Due to anticipated heterogeneity in the study designs and scales used, we used a random-effects model to pool Standardised Mean Differences (SMD) between treatment and control arms for alcohol studies and odds ratios (OR) for smoking studies. For the main meta-analyses, if studies reported on multiple relevant study arms, we combined them to ensure that in each study a single treatment arm result was being compared to a single control arm result (Cochrane Handbook section 16.5.4) (Higgins et al., 2022). We calculated a mean average to combine study arms in the alcohol meta-analysis, and summed frequencies to combine study arms in the smoking meta-analysis. Heterogeneity was investigated using Cochran's Q and the I^2 statistic, and publication bias was explored using funnel plots.

Post hoc sensitivity analyses were conducted to investigate whether the pooled effect sizes varied according to the type of control group under study: face-to-face intervention, assessment only/no intervention, and passive intervention (e.g. leaflets, helplines). For these analyses, we did not combine multiple control arms as described above, such that studies could appear twice if they included multiple relevant control arms.

Due to journal restrictions on the number of figures that can be included in manuscripts, the remaining figures can be found on the Open Science Framework (O'Logbon et al., 2023).

2.7. Narrative synthesis

Findings which could not be included in the meta-analysis were summarised in a narrative synthesis. Effectiveness, acceptability, and feasibility were explored.

3. Results

The PRISMA diagram for this review can be found in Figure 1.

3.1. Study characteristics

Characteristics from 32 RCTs are summarised in Table 1 and 10 non-RCTs in Table 2. Most of the studies were

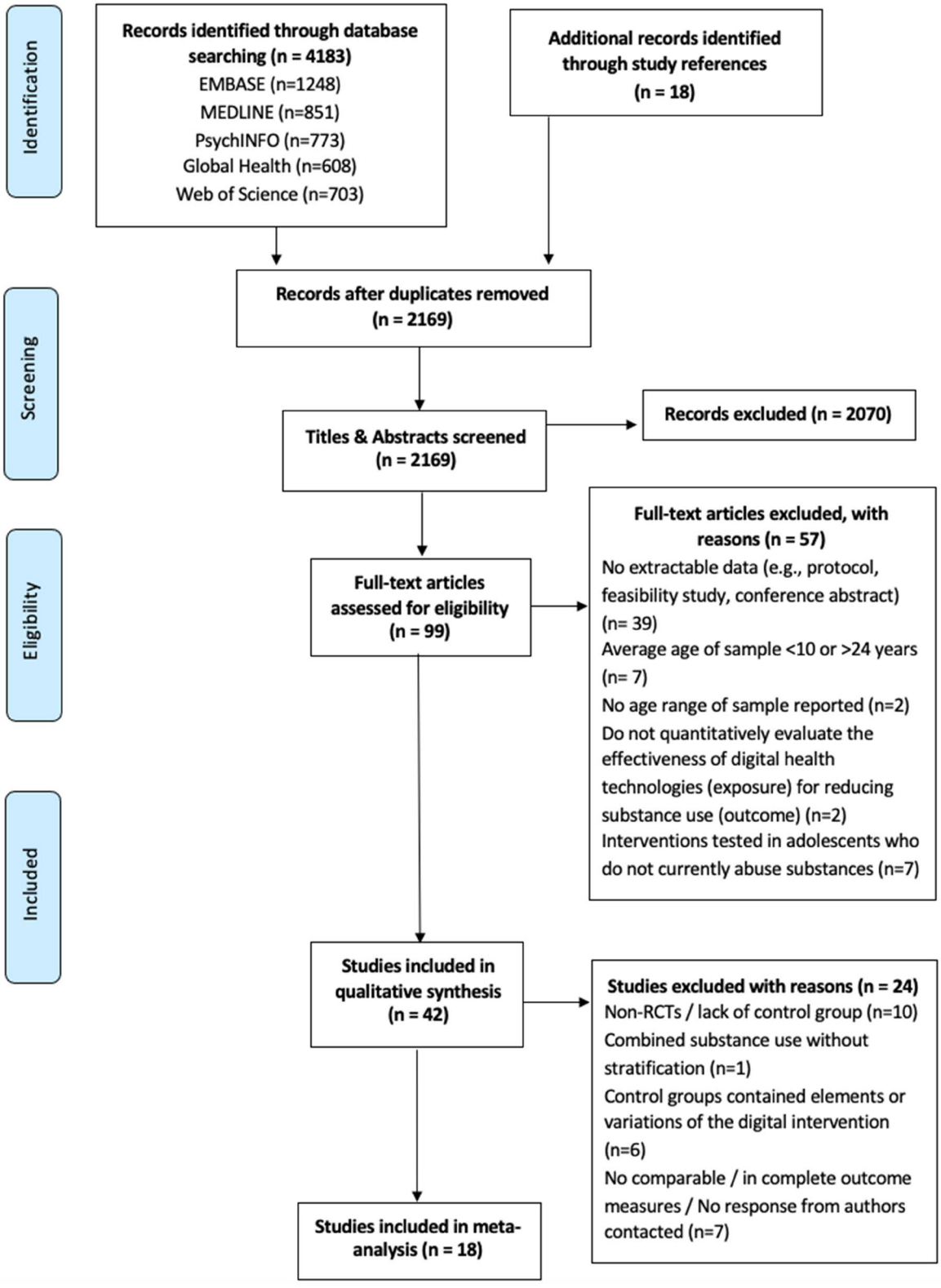

Figure 1. PRISMA Flow diagram.

conducted in the USA ($n = 29$) and the mean ages of the samples ranged from 15 to 24 years. Studies investigated digital health interventions for the following substances: alcohol ($n = 17$), smoking ($n = 19$), and polydrug use (combination of marijuana, methamphetamine, cocaine, heroin, prescription drugs and other including alcohol or smoking) ($n = 6$). Various digital platforms were used: Web/Internet/Computer-based ($n = 23$), Mobile phone-based ($n = 16$) and both web- and mobile phone-based ($n = 3$).

All the studies used self-reported substance use outcomes and 12 used biochemical validation of abstinence (Alfonso et al., 2013; An et al., 2008; Carey et al., 2009; Doumas et al., 2009; Gonzales et al., 2014; Kong et al., 2017; Obermayer et al., 2004; Pbert et al., 2020; Ramo et al., 2018;

Table 1. Summary of included RCTs (n = 32).

Author, year, location	Study design	Intervention arm(s)	Control arm(s)	Substance	Participant characteristics (N, eligibility criteria, % female, mean and range of ages)	Longest follow- up	Key outcome measures 1. Primary outcomes 2. Secondary outcomes Method of follow-up Attrition rates	Statistical measures	Key findings
Alfonso et al. (2013), USA	3 arm RCT	eCHECKUP TO GO (e-CHUG) website	i) Brief Alcohol Screening and Intervention for College Students (individual): Two 50-min face-to-face sessions and includes cognitive-behavioural skills training, motivational enhancement, and personalised feedback ii) CHOICES (group): Preferred modality across colleges and universities. Group counselling.	Alcohol	*N* = 173 Undergraduate students recruited from alcohol-related referrals from to the university alcohol and drug counselling service. 43% female Mean age: 18.77 years Range: 18–25 years	3 months	1. Negative alcohol-related consequences, Average blood alcohol content over a 4-week period, Peak blood alcohol content (BAC) over a 4-week period, Peak number of drinks consumed in 1 sitting over a 4-week period. 2. Adherence to motivational interviewing 3-month anonymous follow-up online questionnaire. 100% response rate.[a]	Chi-square analyses were conducted on discrete participant characteristics of sex, race, ethnicity, class standing and type of residence at baseline across treatment conditions. Multivariate analysis of variance was used to examineall dependent variables measuring alcohol use (i.e. average and peak BAC, peak number of drinks consumed in one sitting)	No significant alcohol use decreases were found for the electronic intervention. However, there was a trend toward a significant reduction of alcohol use for the individual and group conditions on average BAC and for the group condition on peak BAC. The individual intervention produced significant reductions in the highest number of drinks consumed during a single drinking occasion, as well as peak BAC. Simple effect tests indicated significant reductions in alcohol-related harms from pre-intervention to post-intervention in the individual [F(1,165) = 7.308, p = 0.008; within-group (WG) effect size (Cohen's d) = 0.41] and electronic [F(1, 165) = 7.214, p = 0.008; WG effect size (Cohen's d) = 0.40] conditions, with participants experiencing an average decrease in harms of 8.92 and 9.04, respectively. Results were not significant for the group condition.
An et al. (2008), USA	2-arm RCT	RealU Website - 'tailored' smoking cessation site	Standard government website QuitNet.com	Smoking	*N* = 517 college smokers at University of Minnesota 72.9% female Mean age: 20 years Range: 18–24 years	30 weeks	1. Self-reported 30-day abstinence at week 30, 7-day abstinence from smoking, quit attempts. 2. Carbon monoxide (CO) breath testing (for participants reporting 30-day abstinence at week 30). Smoking outcomes were determined by online surveys 8, 20, and 30 weeks after enrolment. Survey response rates exceeded 90% and did not differ between the groups at any time point.[a]	Logistic regression modelling to compare the rates of 30-day and 7-day abstinence. ITT analysis with all non-respondents classified as continuing smokers.	At week 30, 40.5% of individuals in the RealU intervention group (104/257) reported not smoking any cigarettes in the prior 30 days compared with 23.1% (60/260) in the usual care group (OR: 2.26, 95% CI: 1.55–3.32). No difference in the rates of self-reported prolonged abstinence of ≥6 months measured at 30 weeks.
An et al. (2013), USA	3 arm RCT	i) RealU2 (an avatar-hosted website) + tailored health messages ii) RealU2 + tailored messages + online peer support	RealU2 + untailored / general lifestyle health messages	Smoking	*N* = 1698 National online sample of young adults who had smoked at least one puff of a cigarette in the last 30 days 72.4% female Mean age: 24 years Range: 18–30 years	12 weeks	1. Self-reported 30-day abstinence from cigarette smoking at 12 weeks post-enrolment 2. Change in the number of days of alcohol use (days drinking and episodes of binge drinking), eating breakfast, and exercise in the previous 30 days Online survey follow-up rates were 80% at week 7 and 75% at week 12 in all study groups.[a]	ITT analysis with all non-respondents classified as continuing smokers.	Rates of smoking abstinence were 11%, 23%, and 31% for Treatment 1 (general lifestyle), Treatment 2 (tailored health message), and Treatment 3 (tailored health + peer coaching). These differences were statistically significant: P value < .0001 overall and for each tailored message group compared with the general lifestyle message group. Adherence to the weekly Web sessions was similarly high among all three groups, completing at least 4 of the 6 weeks of the weekly sessions (80.78%, 81.98%, and 78.94%; P = .429).

(*Continued*)

Table 1. Continued.

Author, year, location	Study design	Intervention arm(s)	Control arm(s)	Substance	Participant characteristics (N, eligibility criteria, % female, mean and range of ages)	Longest follow- up	Key outcome measures 1. Primary outcomes 2. Secondary outcomes Method of follow-up Attrition rates	Statistical measures	Key findings
Baskerville et al. (2018), USA	2 arm RCT	Crush the Crave (CTC) smoking cessation smartphone app.	Standard self-help guide known as On the Road to Quitting (OnRQ) that was developed by Health Canada for young adult smokers. Participants were able to both view and download the self-help guide via the internet and request a printed version of the guide.	Smoking	*N* = 1599 Young adult smokers 45.6% female Mean age: N/A Range: 19–29 years	6 months	1. 30-day point prevalence abstinence from smoking at 3 and 6 months, 7-day point prevalence abstinence, number of quit attempt and the reduction in consumption of cigarettes/day. 2. Nicotine dependence using the Heaviness of Smoking Index (HSI) from the FTQ, Self-confidence in quitting using the Likert scale, perceived stress. Follow-up data were collected from the same participants at 3- and 6-months via online questionnaires. Overall response rate of 60.48% at 6-month follow-up.[a]	Chi-square test of association or a Fisher exact test for binary variables. Logistic regression was used to test between-group comparisons on the primary outcome variable. Continuous outcomes (number of quit attempts and cigarettes per day) that did not meet normal distribution assumptions, a nonparametric Mann-Whitney test was conducted. T test for independent groups was applied. ITT analysis with imputation using the observation carried forward or classifying non-responders at 3 and 6 months as smokers.	CTC was feasible for delivering cessation support but was not superior to a self-help guide in helping motivated young adults to quit smoking. CTC was not superior to the control condition OnRQ. Rather, the primary outcome and secondary outcome measures at 6 months favored the self-help booklet control condition. CTC did not show a significant difference from a usual care self-help guide. Lower levels of satisfaction and helpfulness suggest that future research should explore the app's usability using qualitative research.
Bertholet et al. (2015), Switzerland	2 arm RCT	Internet-based normative feedback program	Assessment only / no intervention	Alcohol	*N* = 734 21-year-old men with unhealthy alcohol use (> 14 drinks/week or ≥ 6 drinks /occasion at least monthly or AUDIT score ≥ 8) 0% female Mean age: 20.8 years Range: N/A	6 months	1. Number of drinks per week 2. Binge drinking prevalence at 1 and 6 months, AUDIT score at 6 months (range= 0–12) and number of alcohol-related consequences at 6 months. Electronic assessments were at baseline (before randomization) and at 1 and 6 months. Participants received a personal e-mail link for online access. Follow-up rates were 92% at 1 month and 91% at 6 months.[a]	Wilcoxon's rank-sum tests and Pearson's χ^2 tests were used to investigate the occurrence of potential selection and attrition biases. Intervention impacts were assessed with a random-effects negative binomial model for mean number of drinks/week. All analyses were based on an ITT approach (i.e. individuals were analysed according to their initial group allocation).	At 6 months, participants in the intervention group ($n = 367$) reported greater reductions in the number of drinks/ week than participants in the control group ($n = 370$) [treatment × time interaction, incidence rate ratio (RR) = 0.86, 95% confidence interval (CI) = 0.78; 0.96], but no significant differences were observed on binge drinking prevalence.
Bewick et al. (2010), UK	3 arm RCT	i) Immediate access to Unitcheck website (www.unitcheck.co.uk). The site provides personalised feedback on alcohol consumption and social norms information. ii) Delayed access to site (8 weeks later than first group)	Assessment only	Alcohol	*N* = 1112 University students (<21 years) who were consumers of alcohol and provided details of their alcohol consumption at Time 0 and those who consumed alcohol at least once every 6 months Mean age: 21.5 years Range: 18–67 years	24 weeks	1. Total units of alcohol consumed over the last week and number of units consumed per average drinking occasion. Participants completed the AUDIT at Times 0 through 4. 2. Readiness to change drinking behaviour was measured (at Times 1 through 4) using a 3-question algorithm developed by Epler et al [21]. All assessments were carried out via email. Following the initial assessment at Time 1, additional assessments were completed at week 8 (Time 2), week 16 (Time 3), and week 24 (Time 4). By week 24, response rates for each intervention were: Control (49%), Intervention (29%), Delayed intervention (25%).[a]	Repeated measures multivariate analysis of covariance (general linear model) (MANCOVA).	Participants who completed at least two assessments reduced their drinking. In the intervention arm, there was an additional effect that increased across time with the model predicting that at week 24 females in the intervention arm had reduced their previous week unit consumption to 3.7 and males in the intervention arm had reduced their previous week consumption to 5.2 units per week.
Bryant et al. (2013), USA	2 arm RCT	Personalised feedback emailed to participants about their drinking (generated from information gathered at baseline).	Generic feedback emailed about the risks of alcohol consumption among college students as an attachment consistent with the way personalised feedback was sent.	Alcohol	*N* = 310 Psychology undergraduates enrolled for the 2006 fall semester at a large southern US university. AUDIT scores were used to risk-stratify those who signed up. 76% female Mean age: 18.7 years Range: N/A	6 weeks	1. The AUDIT was used to assess the frequency and quantity of alcohol and risky drinkers, The DDQ was used to assess the typical number of drinks consumed per week, and the average number of hours spent consuming alcohol on those days. RAPI was used to measure alcohol-related problem frequency 2. Normative beliefs about the alcohol use of peers were assessed with items using a 5-point Likert scale. 6 weeks after the intervention, students were asked to complete the follow-up assessment battery and once again return it to the Psychology department. 191/310 participants completed the follow-up survey at 6 weeks.	T-tests and chi-square analyses were conducted to confirm that the two intervention groups (personalised and generic feedback) did not differ at baseline with regard to any demographic or alcohol use variables. Repeated-measures ANOVAs were conducted to ascertain whether students' alcohol-related behaviour changed from baseline to follow-up, and to determine if changes varied as a function of group assignment.	Students who received e-mailed personalised feedback reported consuming significantly fewer drinks in a given week, as well as a fewer number of days being drunk in the previous 30 days ($p < 0.05$).

Carey et al. (2009), USA	2 arm RCT	**i) Alcohol 101 Plus:** Interactive computer program allows students to explore alcohol-related issues across a virtual campus, engage in social decision making at a virtual party, and learn about factors affecting their own BAC in a virtual bar. **ii) Brief Motivational Intervention (BMI):** BMI uses personalized feedback and alcohol education to prompt exploration of options for reducing risks related to alcohol use.	In-person brief motivational intervention (BMI): uses personalised feedback and alcohol education to prompt exploration of options for reducing risks related to alcohol use.	Alcohol	*N* = 198 College students sanctioned for alcohol violations 46% female Mean age: 19.17 years Range: N/A	12 months	1. Typical drinking (average drinks per week, drinks per typical drinking day) measured by DDQ, Risky drinking (drinks in heaviest week, heavy drinking frequency, peak blood alcohol concentration [BAC]), Drinking-related problems measured by RAPI. AUDIT score >10 grouped students into hazardous versus non-hazardous drinkers. 2. Repeated contacts with the university judicial system and grade point average (GPA), The Readiness-to-Change Questionnaire assessed stage of change. All participants provided assessment data at four points: at baseline and at 1-, 6-, and 12-month follow-ups. 68% of 198 students completed all three follow-ups.[a]	Piecewise latent growth models (PLGMs) were used to model change in alcohol use from the presanction baseline to the 1-month follow-up (intervention effect) while simultaneously modelling outcomes across follow-ups as a linear function of the 1-, 6-, and 12-month data (postintervention change). A piecewise factor-of-curve model (PFOC) was used to distinguish behavioural changes following the sanction event but before the intervention from behavioural changes after intervention. T-tests were used to measure significance.	The pattern of change across multiple, related measures of alcohol consumption and consequences indicates superior efficacy for the BMI at 1 month. Neither intervention predicted additional drinking change beyond what was already achieved post sanction.
Cunningham et al. (2015), USA	3 arm RCT:	**i) Computerised Brief Intervention (CBI):** A tailored computer BI. Facebook-styled program delivered by using touchscreen tablets with audio (via headphones). **ii) Therapistled brief intervention (TBI):** therapist intervention with computerised workbook for real-time clinical decision support, presenting tailored feedback and screens to prompt content.	Brochure listing resources	Alcohol	*N* = 836, Aged 14–20 years, underage drinkers presenting to emergency department (ED) 48.4% female Mean age: 18.6 years Range: 14-20 years	12 months	1. Reported alcohol use in the past year using AUDIT-C, Past 3-month alcohol-related consequences using RAPI, Young Adult Driving Questions to assess past 3-month drinking and driving. 2. Adolescent Injury Checklist evaluated past 12-month alcohol-related injury. The National Institute on Drug Abuse Alcohol, Smoking, and Substance Involvement Screening Test assessed use and consequences of 6 illicit drugs (marijuana, cocaine, inhalants, hallucinogens, methamphetamine, street opioids) and the non-medical use and consequences of 3 prescription drugs. Follow-up assessments at 3, 6, and 12 months were self-administered by participants either on a computer that was provided by staff in-person or via a Web link that was sent to participants to self-administer online. The follow-up rate was 86.8% at 3 months, 87.1% at 6 months, and 88.0% at 12 months[a]	ITT approach was used (e.g. includes those who did not receive assigned condition).	At 3 months, the CBI and TBI significantly decreased the alcohol consumption index score and alcohol consequences compared with control. At 6 months, there were no significant effects for either of the BIs. The main effect of the post-ED session was significant for alcohol consequences but not for consumption (data not shown, Cohen's d = 0.12). At 12 months, the therapist BI and computer BI did not significantly affect alcohol consumption index scores but did reduce alcohol consequences (Cohen's d effect sizes = 0.12 [therapist BI versus enhanced usual care] and 0.17 [computer BI versus enhanced usual care]). There were no main effects of the post-ED session on alcohol-related outcomes at 12 months.
Deady et al. (2016), Australia	2 arm RCT	DEpression-ALcohol (DEAL) Project: automated Web-based self-help intervention with 4 1-hr modules across 4 weeks	HealthWatch website	Alcohol	*N* = 104 Young people with moderate depression symptoms and drinking at hazardous levels (recruited largely via social media) Female: 59.6% Mean age: 21.74 years Range: 18 to 25 years	6 months	1. Frequency of alcohol use – drinks/week and drinking days/week (using TOT-AL), Change in depression severity according to the Patient Health Questionnaire-9. Follow-up assessment at posttreatment and at 3 and 6 months postbaseline. The follow-up rates at posttreatment and at 3 and 6 months postbaseline were 53.8% (56/104), 43.3% (45/104), and 38.5% (40/104), respectively.[a]	Baseline differences between groups were examined using chi-square and independent-samples t tests. Results reported as the unstandardised mean difference (beta) with Wald-type 95% confidence interval (95% CI) and chi-square for linear models and the risk ratio (RR) with 95% CI for negative binomial models. Standardised effect sizes (Cohen's d) were calculated for primary outcomes.ITT analyses with multiple imputation for missing data.	There were statistically significant greater reductions in depression and alcohol use in those randomised to the DEAL project compared to the control group immediately post-treatment. At 3-month follow-up, drinking occasions had halved and participants were drinking just over nine drinks per week in both groups. Although positive outcomes were maintained at 3- and 6-month follow-ups, between-group differences at these later time points disappeared because of statistically nonsignificant shifts in both control and treatment.

(*Continued*)

Table 1. Continued.

Author, year, location	Study design	Intervention arm(s)	Control arm(s)	Substance	Participant characteristics (N, eligibility criteria, % female, mean and range of ages)	Longest follow- up	Key outcome measures 1. Primary outcomes 2. Secondary outcomes Method of follow-up Attrition rates	Statistical measures	Key findings
Doumas et al. (2009), USA	2 arm RCT	Web-based personalised normative feedback (WPNF): Participants completed a 15-minute Web-based program designed to reduce high-risk drinking by providing personalised feedback and normative data regarding drinking and the risks associated with drinking: http://www.checkyourdrinking.net/	Web-based education (WE): Participants completed www.reslife.net modules (university-provided)	Alcohol	$N = 76$ University students who were referred to University Counselling Services for violating the University policy for alcohol and other drugs. 27.6% female Mean age: 19.24 years Range: 18–24 years	30 days	1. Alcohol consumption – Drinking quantity, peak consumption, and frequency of drinking to intoxication. 2. Alcohol-related problems: Alcohol-related problems were assessed using the RAPI All questionnaires at baseline and 30-day follow-up were completed in pen-and-paper format. 67 (88.2%) out of 76 participants completed the 30-day follow-up assessment.	Repeated measures multivariate analyses of variance (MANOVA). Descriptive statistics.	For weekly drinking ($p < 0.05$), peak alcohol consumption ($p < 0.03$), and frequency of drinking to intoxication ($p < 0.05$), students in the WPNF intervention group reduced their drinking significantly more than those in the WE condition. Students in the WPNF group reduced their weekly drinking quantity by an average of 3.27 drinks per week at the 30-day follow-up (approximately 40% reduction in quantity) compared to a reduction of 1.27 drinks in the WE group (an 18% reduction).
Ekman et al. (2011), Sweden	2 arm RCT	e-SBI (a web-based program developed to screen individuals for risky alcohol use and provide a brief intervention) with extensive normative feedback. The control group (CG) received short feedback.	Very brief feedback consisting of only three statements	Alcohol	$N = 158$ Third-semester students enrolled for the 2007 fall semester at Linköping University with (a) weekly alcohol consumption >120g alcohol (women) or 180g alcohol (men) per week in a typical week in the last 3 months and (b) HED occasions defined as consuming 48g of alcohol (women) and 60 g (men) on 2 or more occasions in the preceding month. 58.2% female Mean age: N/A Range: 18–25 years	6 months	1. Average weekly alcohol consumption (g), number of heavy episodic drinking occasions/month, average highest blood alcohol concentration, change from risky to non-risky drinker (%) Follow-up was performed at 3 and 6 months after baseline. Emails sent to students' university email addresses. About a quarter (25%) of this cohort of risky drinkers, who took the first e-SBI voluntarily, remained participants throughout the 6-month project.	The significance level of this study was set at ≤ 0.05. Pearson's χ^2 test and Fisher's exact test were used to analyse the differences in distribution regarding sociodemographic characteristics categorized by the type of feedback. Differences in continuous variables, including average weekly consumption and BACs, were tested with one-way ANOVA when differences involved more than two groups; otherwise, t-tests were used. Differences related to frequency of HED occasions per month were regarded as non-parametric and tested with the Kruskal–Wallis and Mann–Whitney tests.	Findings showed no differences in alcohol consumption after 3 and 6 months.
Gonzales et al. (2014), USA	2 arm RCT (pilot)	12-week text messaging service: Project ESQYIR-*Educating and Supporting inQuisitive Youth in Recovery* to monitor relapse and recovery processes, provide feedback, reminders, support, and education	Face-to-face substance abuse facility care ('aftercare as usual')	Marijuana, methamphetamine, cocaine, heroin, prescription drugs and other/polydrug use including alcohol	$N = 80$ Smokers 27% female Mean age: 20.4 years Range: 14–26 years	90 days	1. Relapse from the primary substance that youth received SUD treatment for (measured dichotomously in terms of any use in the past month by the Teen Addiction Severity Index and validated by urinalysis) 2. Mediating variables: participation in self-help and extracurricular activities, were measured by the Brief Addiction Monitor. All participants met with the study research assistant at program discharge and 90-day follow-up to complete self-assessments and received bi-monthly telephone calls for recovery monitoring during the active 12-week program. No information on attrition rates[a]	2-tailed tests with $p < 0.05$ as the Alpha level. Multilevel modelling or hierarchical linear modelling (HLM), was performed to explore relationships and differences between independent and dependent variables described across different time points (from baseline to discharge).	Participants in the texting aftercare intervention were less likely to relapse from their primary substance, $F(1, 76.9) = 4.22$, $p = 0.043$, with an interaction effect of time and condition, $F(1, 74.5) = 15.6$, $p = 0.001$. There was no significant difference between the two groups in terms of self-help ($t(78) = 1.36$, 95%CI (−1.40, 7.50), $p = 0.1768$) and extracurricular activities ($t(78) = -1.03$, 95%CI (−6.96, 2.21), $p = 0.3057$).

Haug et al. (2017), Switzerland	2 arm RCT	MobileCoach Tobacco+ (MCT+) integrates smoking cessation and alcohol reduction into one	MobileCoach Tobacco (MCT) targets only smoking cessation http://mobile-coach.eu/	Smoking and alcohol	*N* = 1471 360 Swiss schools Students who met the following criteria: (1) daily or occasional cigarette smoking (at least 4 cigarettes over the preceding month and at least one cigarette within the preceding week) and (2) ownership of a mobile phone. 60.7% (*n* = 893) females Mean age: 18.6 years Range: N/A	6 months	1. 7-day point prevalence of smoking abstinence, Mean number of cigarettes smoked per day, 30-day point prevalence 2. Health Action Process Approach (HAPA) stage of change, any attempts to quit over the 6-month observation period and level of alcohol consumption.6-month follow-up assessment via computer-assisted telephone interview conducted by trained interviewers (psychology graduates). 1.8% participants in the single intervention unsubscribed, compared to 18 of the 730 (2.5%) participants in the combined intervention[a]	Baseline differences between participants in the study groups were identified by Pearson chi-square analysis for categorical variables, and either by Student's t-tests or Mann-Whitney U tests for continuous variables that were normally and non-normally distributed, respectively. ITT analyses with multiple imputation	No significant inter-group differences were observed for either of the primary outcomes: 7-day point prevalence rates for smoking abstinence or the number of cigarettes smoked daily. MCT + exhibited no extra beneficial or detrimental effects relative to MCT, with respect to any of the primary or secondary outcomes. Among the subgroup of adolescent smokers with high-risk alcohol consumption, moderation analysis indicated that the integrated intervention might be more effective at supporting smoking cessation.
Hides et al. (2018), Australia	2 arm RCT	Immediate access to Ray's Night Out app	1-month delayed access	Alcohol	*N* = 197 Drank alcohol in the previous month 77.7% female Mean age: 20.4 years Range: 16–25 years	6 months	1. Alcohol knowledge (16 item survey), Risky Single Occasion Drinking frequency (> 4 Standard drink units i.e. 40g alcohol in 1 occasion), Quantity of alcohol use – typical and maximum quantity of alcohol consumed on 1 occasion, Frequency and number of alcohol -related problems using RAPI and AUDIT scores. 2. Mobile application rating (uMARS), Data on the date, time and duration of app use, and all app actions including food and drinks provided to Ray, dancing, chillaxing and flirting were collected, App engagement (aggregate number of app actions per participant) Participants were assessed at baseline, 1, 2, 3 and 6 months. Follow-up rates were high with 98.0% (n = 194), 93.4% (n = 184), 92.4% (n = 182) and 92.9% (n = 183) completing the 1-, 2-, 3- and 6-months follow-ups respectively.[a]	Demographic and substance use variables were compared using a series of logistic regressions. Linear mixed models in SPSS were used to conduct ITT analyses without prediction of missing data for all outcome variables	Immediate use of the Ray app increased alcohol knowledge. No differences in alcohol use or related problems were found.
Kypri et al. (2004), New Zealand	2 arm RCT	Web-based electronic screening and brief intervention based on personalised feedback	Leaflet only	Alcohol	*N* = 104 Students recruited from a university student health service who scored ≥8 on the AUDIT and had exceeded 4 standard drinks for women, 6 for men, in the last 4 weeks 50% female Mean age: 20.2 years Range: 17–26 years	6 months	1. Frequency of drinking: number of drinking days in the preceding 2 weeks, Typical occasion quantity: number of standard drinks consumed per typical drinking occasion in the preceding 4 weeks, Total volume: number of standard drinks consumed in the preceding 2 weeks, Frequency of very heavy episodes: number of occasions in the preceding 2 weeks where a threshold of 80/120 g ethanol was breached, for women/ men, respectively, Alcohol Problems Scale (APS: range 0–14) 2. Consequences related to academic performance: a score on the Academic Role Expectations and Alcohol Scale (AREAS: range 0–35). Participants were invited by e-mail to complete a 6-week follow-up survey. A short pen-and-paper questionnaire posted with an invitation letter to interview was used for follow-up at 6 months. Total with at least one response was 49/51 for intervention and 50/53 for control.[a]	Outcomes 1–5 were analysed using negative binomial regression for panel data. This took into account the over-dispersion in the data, which were based on counts. For outcome 6, which is a scale, we used linear regression analysis for panel data, after a log transformation. The models adjusted for baseline differences by including the AUDIT score.	e-SBI reduced hazardous drinking among university students, to an extent similar to that found for practitioner-delivered brief interventions in the general population. At 6 weeks, participants receiving e-SBI reported significantly lower total consumption (geometric mean ratio = 0.74; 95% confidence interval: 0.56–0.96), lower heavy episode frequency (0.63; 0.42–0.92) and fewer personal problems (0.70; 0.54–0.91). Only alcohol-related problems remained significantly reduced at 6 months.

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Author, year, location	Study design	Intervention arm(s)	Control arm(s)	Substance	Participant characteristics (N, eligibility criteria, % female, mean and range of ages)	Longest follow- up	Key outcome measures 1. Primary outcomes 2. Secondary outcomes Method of follow-up Attrition rates	Statistical measures	Key findings
Kypri et al. (2009), Australia	2 arm RCT	THRIVE (Tertiary Health Research Intervention Via Email): Web-based electronic screening and brief motivational intervention (e-SBI)	Assessment only	Alcohol	*N* = 2435 Full-time undergraduates who scored ≥8 on the AUDIT and had exceeded 4 standard drinks for women, 6 for men in the last 4 weeks 45% female Mean age: 19.7 years Range: 17–24 years	6 months	1. Number of drinking days, number of standard drinks per typical drinking occasion, number of drinks per week, alcohol-related problems (measured using The Alcohol Problems Scale (APS)). All had a 4-week reference period. 2. The Academic Role Expectation and Alcohol Scale (AREAS), participants' impressions of the intervention 1 month and 6 months after the initial assessment, all participants were sent a letter and then an e-mail containing a hyperlink to a Web-based follow-up questionnaire. Attrition was 22% at 1month and 35% at 6 months.[a]	The primary outcomes and the AREAS scores were analysed with negative binomial regression.The APS scores were analysed with linear regression after log transformation. ITT analysis models (Random-effects and sensitivity analysis using multiple imputation).	Heavy drinkers who received the e-SBI drank 17% less alcohol than controls 1 month after screening and 11% less alcohol 6 months after screening. Mean (SD) baseline AUDIT scores for control and intervention groups were 14.3 (5.1) and 14.2 (5.1), respectively. At 6 months, intervention effects persisted for drinking frequency (RR, 0.91; 95% CI, 0.85 – 0.97) and overall volume (RR, 0.89; 95% CI, 0.82 – 0.96) but not for other variables.
Mason et al. (2015), USA	2 arm RCT	Motivational interviewing-based counselling texts	Generic health-based texts	Smoking	*N* = 72 Adolescents with a score above the cut-off score (≥1) on the modified version of the FTQ, a screening measure for tobacco use and potential dependence. 43.4% female Mean age: 16.4 years Range: 14–18 years	6 months	1. Days smoked cigarettes in past 30 days, number of cigarettes smoked/day in past 30 days using FTQ 2. Smoking intention, refuse cigarettes from peers, family smoking context (from Centres for Disease Control and Prevention's (CDC) Youth Risk Behaviour Survey (YRBS)), Readiness to stop smoking (Readiness Ruler), Peer social support and Peer smoking behaviour (Adolescent Social Network). All participants completed the baseline and the 1-, 3-, and 6-month follow-up assessments.[a]	General linear model repeated measures used to compare follow-up assessment (Time 2, 3, 4) scores with baseline (Time 1) scores on key outcome variables: smoking behaviours, smoking intentions, and peer support. Effect sizes were obtained using partial eta-squared statistic.	Reduction in the number of cigarettes smoked increased intentions not to smoke in the future, and increased peer support relative to controls. The strongest effect was in reducing the number of cigarettes smoked, but not the number of days smoked during the past 30 days. No significant condition × time result was found.
Müssener et al. (2020), Sweden	2 arm RCT	Nicotine Exit Junior (NEXit Junior): 12-week automated programme with a total of 121 text messages.	Helpline information provided – 'treatment as usual'	Smoking	*N* = 535 High school students who were daily or weekly smokers willing to attempt to quit smoking and owned a mobile phone. 60.9% female Median age: 17 years (IQR: 16–18) Range: N/A	3 months	1. Prolonged abstinence (defined as not having smoked >5 cigarettes in the past 8 weeks - Russel standard for smoking interventions), 4-week point prevalence of not having smoked a single cigarette at the time of follow up. Follow-up responses were collected by sending a text message to all participants' 3-months after randomisation. The text message included a hyperlink to a web questionnaire. Two reminders were sent 2 days apart. Those who had not responded after the third message were called by phone (a maximum of 10 attempts per participant). Attrition rate of 23.2%.	Logistic regression, results presented as odds ratios and 95% confidence intervals (CIs). Attrition and sensitivity analyses using MAR assumption in the main analysis.	Adjusted logistic regression did not identify a statistically significant difference between the two groups (adjusted OR, 1.87; 95% CI, 1.12–3.17; P value, .018). Considering that participants were recruited from a non-treatment seeking population, it is still quite astonishing that an OR of 1.87 can be attributed to a 12-week text message-based intervention.

Patten et al. (2006), USA	2 arm RCT	Stomp Out Smokes (SOS): An Internet website (home-based intervention). Adolescents in SOS had access to the SOS site for 24 weeks.	Brief office intervention (BOI) consisting of 4 face-to-face individual counselling sessions	Smoking	$N = 139$ Young smokers 49% female Mean age: 15.7 years Range: 11–18 years	36 weeks	1. Point-prevalence smoking abstinence at week 24, Cigarettes smoked per day and days smoked at week 24, % reductions from baseline in average number of cigarettes smoked per day (CPD) and days smoked (based on the TLFB at week 24 and FTQ). 2. Treatment compliance: counsellor recorded the participant's attendance and compliance with homework assignments Face-to-face, clinic-based assessments took place at weeks 0 (baseline), 4, 8, 12, 24 and 36 weeks. The percentage attending each assessment visit in the BOI and SOS conditions, respectively, was 73 and 86% at week 4, 64 and 69% at week 8, 54 and 69% at week 12, 52 and 59% at week 24 and 42 and 53% at week 36.[a]	Chi-square test for categorical variables and the two-sample rank sum test for continuous variables. Fisher's exact test compared treatments on study retention and smoking abstinence rates, and the 2-sample rank sum test compared treatments on percent reduction from baseline in number of CPD and days smoked. Repeated measures analysis was performed using generalized estimating equations (GEE). 2-tailed P-values ≤0.050 were considered statistically significant.	The home-based, Internet-delivered intervention (SOS) was ineffective for adolescent smoking cessation. None of the 139 participants were abstinent from smoking at week 4.
Pbert et al. (2020), USA	3 arm RCT	Craving to Quit (C2Q) app: smoking cessation app with mindfulness training.	i) National cancer institute (NCI) QuitSTART app (smoking cessation app without mindfulness training) ii) Smoking cessation written materials only	Smoking	$N = 146$ High school students who are smokers from 9 schools 56.2% female Mean age: 16.9 years Range: 14–18 years (9th to 12th grade)	6 months	1. 7-day point prevalence abstinence confirmed by cotinine, number of cigarettes smoked in the past week. 2. Programme usage/ engagement 3. Study assessments were collected at baseline and at 3- and 6-month follow-up periods in the privacy of the school nurse's office. Participants lost to follow up for each intervention were: 8% (C2Q), 2% (NCI) and 4% (Materials).[a]	Total time spent with the school nurse analysed using nonparametric analysis of variance (Kruskal-Wallis test) and *t* tests (Wilcoxon rank-sum test). Abstinence compared longitudinally across arms using a random effects logistic regression model with a random effect for school to account for within-school correlation.	Overall, 22 participants (15.8%) were abstinent (cotinine-validated) at 6 months, and this did not differ significantly by condition (13.6% for the C2Q condition, 16.3% in the NCI condition, and 17.4% in the Materials condition ($p = 0.88$)). Among adolescents unable to quit and still smoking at 6 months, decreases in the number of cigarettes smoked associated with intervention engagement were significantly greater for those using the C2Q app.
Ramo et al. (2018) USA	2 arm RCT	Tobacco Status Project: Facebook smoking cessation intervention tailored to stage of change to quit smoking, daily contacts, weekly live counselling sessions, and for those ready to quit, 7 cognitive behavioural therapy counselling sessions.	Online smoking cessation resource, Smokefree.gov	Smoking (tobacco and cannabis)	$N = 500$ Participants were young adults aged 18–25 who had smoked at least 100 cigarettes in their lifetime, currently smoked at least 3 days per week, and used Facebook at least 4 days per week at the time of recruitment. 54.6% female Mean age: 20.9 years Range: 18-25 years	12 months	1. Saliva cotinine levels (biochemically verified abstinence) and self-reported abstinence (7-day point prevalence abstinence over 12 months 2. 7-day abstinence from cigarettes (including all reports of abstinence not verified biochemically); reduction of cigarette consumption by 50% or more between baseline and each follow-up; presence of at least one 24-hour tobacco quit attempt in the assessment time period; and proportion of participants in preparation, action or maintenance stages of change at all time-points (The Smoking Stages of Change Questionnaire). Assessments were conducted on-line at baseline, 3-, 6- and 12-months follow-up. Follow-up completion was 71.0% (355/500) at 3 months, 68.4% (342 of 500) at 6 months and 70.8% (354 of 500) at 12 months.[a]	Logistic regression model using a mixed-effects model. Kruskal–Wallis tests were used to compare comment volume by stage of change and incentive condition. Bivariate models predicted whether demographic and smoking variables predicted comment volume. Two analyses tested the effects of comment volume (Wilcoxon's signed rank) and incentive (Person's χ^2) on 3-month abstinence.	No significant difference by treatment condition [(month 3 [8.3% vs. 3.2%]), 6 [6.2% vs. 6.0%], and 12 [5.9% vs. 10.0%]; odds ratio (OR) = 1.07; 95% confidence interval (CI) = 0.23, 4.97; $P = 0.924$). There were no significant treatment effects over 12 months for reduction in cigarettes smoked, quit attempts or likelihood of being ready to quit or quit.

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Simmons et al. (2013), USA	4-arm RCT	Web-Smoke: A website designed specifically for college students addressing common misconceptions about smoking. These discussions were led by a master's level clinical psychology doctoral student.	**i)** Group-based intervention: Average group size was 5 students. Groups were presented with the paper versions of the Web-Smoke website (i.e. identical content and visual presentation), and the video message was created during group discussion. **ii)** Web-based didactic smoking: Participants were asked to view a website identical to the Web-Smoke condition with respect to content and visual presentation; however, interactive features were absent. **iii)** Web-Nutrition: Participants were guided to choose to view a nutrition version of the website.	Smoking	*N* = 331 US college students who smoked ≥5 cigarettes per week 44.1% female Mean age: 20.45 years Range: 18–24 years	6 months	1. Motivation to quit smoking: measured using The Contemplation Ladder and Stages of Change Questionnaire, Smoking status: 7-day point prevalence at 1- and 6-month follow-ups using TLFB. Self-reported abstinence was biochemically verified using breath CO testing. Participants with carbon monoxide levels of < 10 ppm were classified as abstinent 2. Smoking knowledge, Risk perceptions, Perceived pros and cons of smoking One and 6 months after the intervention, participants were contacted by telephone and administered the smoking outcome measures. The completed follow-up assessments at 6 months for each intervention were Didactic (97.6%), Web-Smoke (90.6%), Group (95.2%) and Web-Nutrition (89.4%)[a]	Chi-square and analyses of variance (ANOVAs) were used to examine potential group differences among baseline measures for a check of the randomization procedures. Logistic regressions to examine smoking abstinence at the 1- and 6-month follow-up points. ITT analyses with missing outcome data imputed as smoking.	Abstinence rates did not differ between the Web-Smoke and Didactic or Group interventions, across the full sample. 1 month after the intervention, the Web-Smoke group had significantly higher abstinence rates (7-day point-prevalence) than the Web-Nutrition group (14.8% vs. 4.9%; OR = 3.39, 95% CI = 1.05 − 11.00, p = .042). However, abstinence rates did not differ between the Web-Smoke and either the Group intervention (14.8% vs. 7.1%) or the Didactic intervention (14.8% vs. 10.7%; OR = 2.26, 95% CI = .81 − 6.35, p = .121. 6 months after the intervention, 7-day point prevalence abstinence rates for the Web-Smoke condition (32.1%) did not differ from any of the control conditions (Group: 22.6%, OR = 1.62, 95% CI = .81 − 3.23, p = .173; Didactic: 25.0%, OR = 1.42, 95% CI = .72 − 2.80, p = .313; Web-Nutrition: 23.2%, OR = 1.57, 95% CI = .78 − 3.14, p = .204).
Skov-Ettrup et al. (2014), Denmark	2 arm RCT	https://xhale.dk website + tailored text messages	https://xhale.dk website + untailored text messages	Smoking	*N* = 2030 Daily smokers 59.3% female Mean age: 19.4 years Range: 15–25 years	12 months	1. Self-reported 30-day point abstinence (smoke free >30 days) 2. Changes in smoking related self-efficacy and beliefs about smoking. Follow-up was conducted 12 months after the self-chosen quit date. At 12-month follow-up, response rates were 36.3% in the tailored text messages group and 38.1% in the untailored text messages group.	30-day point abstinence was compared between the two groups using logistic regression analysis. Differences in mean values were tested using student's t-test. ITT analyses with multiple imputation for missing data. Odds ratios, confidence intervals and p values reported.	No overall statistically significant difference in 30-day point abstinence. No statistically significant difference between groups regarding change in self-efficacy and beliefs about smoking. More than 60% in both intervention groups reported that they would recommend xhale.dk to others.
Suffoletto et al. (2015), USA	3 arm RCT	**i)** SMS Assessments + Feedback (SA + F) group: Brief two-way text message dialogue sessions for 12-weeks with feedback aimed toward reducing alcohol consumption. **ii)** SMS Assessments (SA) group: Participants received SMS drinking queries every Sunday for 12-weeks that were identical to SA + F, without any alcohol-related feedback.	No-SMS group: No texts.	Alcohol	*N* = 765 Reported hazardous drinking based on an AUDIT-C score >3/4 women/men, but not seeking alcohol treatment, were enrolled from 4 Emergency Departments (EDs) in Pittsburgh, PA. 65% female Mean age: 22 years Range: 18–25 years	9 months	1. Number of self-reported binge drinking days (4+/5+ drinks for females/males) and binge drinking prevalence (yes/no) over the past 30 days. 2. Drinks per drinking day over the past 30 days and alcohol-related injury prevalence (yes/no) over the past 3 months. All alcohol consumption outcomes were calculated using the TLFB method. All alcohol-related injury outcomes were calculated using the Injury Behaviour Checklist (IBC). Outcomes were measured at: baseline, three, six and nine months. Follow-up retention was 78.2% (n = 598) at 3-months, 63.5% (n = 486) at 6-months and 54.9% (n = 420) at 9-months.[a]	Multiple imputation-derived, ITT models were used for primary analysis. Population-average models, i.e. generalized estimating equations (GEE) to estimate the average impact of the intervention over time.	At 9 months, participants in the SA + F group reported greater reductions in the number of binge drinking days than participants in the control group (incident rate ratio [IRR] 0.69; 95% CI .59 to.79), lower binge drinking prevalence (odds ratio [OR] 0.52; 95% CI 0.26 to 0.98]), less drinks per drinking day (beta −.62; 95% CI −1.10 to −0.15) and lower alcohol-related injury prevalence (OR 0.42; 95% CI 0.21 to 0.88). Participants in the SA group did not reduce drinking or alcohol-related injury relative to controls. Findings were similar using complete case analyses. Mean effect size in this study: Cohen's d = 0.13.

Trudeau et al. (2017), USA	2 arm RCT	www.navigatingmyjourney.com (NmJ), an online, web-based educational, relapse-prevention intervention.	Attention control: face-to-face counselling treatment as usual and a link to non-substance use-related online health articles from the Nemours Foundation (http://teenshealth.org/en/teens/).	Alcohol, drugs or both	*N* = 129 13–21 years old, currently having treatment for alcohol or drug abuse or both 56.6% female (*n* = 73)Mean age: 17.6 years Range: 13-21 years	6 months	1. 30-day alcohol and drug use (assessed via Comprehensive Health Assessment for Teens (CHAT) alcohol and drug composite scores), Motivation and self-efficacy to avoid substance use, Relapse coping skills 2. Therapeutic alliance, User engagement, client satisfaction Participants completed the online assessments at a location of their convenience. Most completed assessments in computer room at treatment centre site. A total of 31 participants were excluded from the analyses. 27% of the total dataset were treated as missing data in the LMM analyses.[a]	Linear mixed modelling (LMM) approach to test for differences between conditions on each outcome.	Post hoc comparisons revealed that the participants in the experimental condition reported a greater decrease in composite drugs score from baseline to 3-month follow up (Effects Size, ES = −8.317, t 225 = −2.76, p = 0.006), as compared to the control participants. Drug scores did not change significantly from baseline to post (ES = −5.546) or from baseline to 6-month follow up (ES = −2.362).
Voogt et al. (2013), Denmark	2 arm RCT	Web-based session 'What do you drink?' (WDYD) – brief alcohol intervention to detect and reduce heavy drinking of adolescents.	No intervention	Alcohol	*N* = 913 Reported heavy drinking in the past 6 months 39.8% female Mean age: 20.8 years Range: 18–24 years	6 months	1. Heavy drinking (defined as consuming >21 glasses for males and >14 glasses for females of standard alcohol units/week AND/OR ≥5 glasses of standard alcohol units/single occasion (binge drinking) at least once a week, Frequency of binge drinking (≥5 units of standard alcohol in the previous week on one drinking occasion), Weekly alcohol consumption (Dutch version of the Alcohol Weekly Recall). 2. Moderators: readiness to change, Problem drinking frequency (The AUDIT). Online assessments at baseline, 1- and 6-month follow-up. Retention rates were 93.5% (n = 848) at the 1-month follow-up and 91.3% (n = 828) at the 6-month follow-up.[a]	ITT analysis and the completers-only framework. Missing data were imputed using the predictive mean matching method (MMS). Odd ratios (ORs) and 95% confidence intervals (CIs) were reported, and linear regression was conducted to assess effectiveness of the intervention on weekly alcohol consumption by reporting the r^2-value, standardised coefficient (β), and the P-value.	There were no significant main effects of the WDYD intervention on any of the alcohol measures at the follow-up assessments.
Walters, (2007), USA	2 arm RCT	The e-CHUG; http://www.e-chug.com is a commercially available feedback program that is managed by the non-profit San Diego State University Foundation. Students in intervention were presented with a personalized feedback report.	Assessment only	Alcohol	*N* = 106 First-year students ≥ 18 years at a large Southern USA public university who reported at least 1 heavy drinking episode in the previous month (≥5 on one occasion for men, ≥4 drinks for women) 48.1% female Mean age: 18.25 Range: 18–23 years	16 weeks	1. Alcohol consumption: measured using a 7-day drinking calendar similar to the DDQ. Peak blood alcohol concentration (BAC), heaviest drinking episode during the past 30 days, the number of hours over which the alcohol was consumed, and the student's gender and weight. Consequences related to drinking in the last 30 days: measured with RAPI 2. AUDIT screening questions, genetic risk of alcoholism, weight, amount of money spent on alcohol Measures were completed at baseline, 8 weeks, and 16 weeks. All responses were self-report and entered into the research website. 71.7% students completed the 8-week assessment, 77.4% completed the 16-week assessment.[a]	Mixed effects repeated measures analysis with linear and quadratic time effects were used to test patterns in mean drinks per week and peak BAC between groups over time.	Personalised feedback accelerated a decline in drinking over 16-weeks, as compared to students who did not receive any feedback. For the entire group, there was a significant decrease from baseline to 8 weeks in drinks per week (t = −4.87, 64.2 d.f., p<.001) and peak BAC (t=−5.28, 64.2 d.f., p<.001) but not in RAPI score (t=−1.53, 45.1 d.f., p=.134). From baseline to 16 weeks there was a significant overall decrease in drinks per week (t=−6.00, 50.7 d.f., p<.001), peak BAC (t=−6.33, 54.4 d.f., p<.001), and RAPI score (t=−3.96, 73.8 d.f., p<.001). By 16 weeks, the control group also declined to a point where there were no differences between groups.

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Table 1. Continued.

Author, year, location	Study design	Intervention arm(s)	Control arm(s)	Substance	Participant characteristics (N, eligibility criteria, % female, mean and range of ages)	Longest follow- up	Key outcome measures 1. Primary outcomes 2. Secondary outcomes Method of follow-up Attrition rates	Statistical measures	Key findings
Walton et al. (2013), USA	3 arm RCT	**i)** CBI: Stand-alone interactive animated program, with touch screens. A 'virtual buddy' guided participants through the programme and provided audio feedback (via headphones). **ii)** TBI: Research therapists who were trained in motivational interviewing conducted the TBI	Tri-fold brochure ("enhanced usual care" control as clinics did not routinely provide this information).	Cannabis	*N* = 328 12–18 years old presenting to 7 community health clinics in urban areas in the Midwest (USA) reporting past-year cannabis use 66.5% female Mean age: 16.3 years Range: 12-18 years	12 months	1. 3-month frequency of cannabis or other drug use 2. Perceived risk of occasional and regular cannabis use, Self-efficacy to avoid cannabis use, Intention to use cannabis in the next three months, BI likeability using Likert scales Participants self-administered computerised follow-ups in community locations (i.e. clinic, restaurants, home) at 3, 6 and 12-months with $25, $30, and $35 remuneration respectively, and $5 for a urine drug screening.[a] At 12-month follow-up, the response rate was 83.8%.	Paired analyses (Wilcoxon signed rank test) were used to examine changes over time for the BIs. Generalized estimating equations (GEEs) were used to predict outcomes for TBI vs. control and CBI vs. control at 3, 6, and 12 months (either negative binomial or Poisson based on distribution). ITT approach for missing data.	The BIs did not reduce cannabis use. The number of cannabis-related consequences significantly decreased in the CBI condition at 3 and 6 months, while the therapist condition showed significant decreases at 6 and 12 months; no significant decreases were observed in the control condition. Other drug use significantly decreased at 3 and 6 months for both CBI and TBI, whereas the control condition did not change. No significant decreases were found in frequency of alcohol use in any condition. At post-test, 77.4% rated the BIs as "liked" or "liked a lot", with no significant differences between BIs (c2(1) = 0.329; p>.05).
Witkiewitz et al. (2014), USA	3 arm RCT	BASICS-Mobile: Ecological Momentary Assessment is (EMAs) and web-based intervention module after completing each one. Daily monitoring only: Completions of EMAs only.	Minimal assessment (control): Completed only initial screening and baseline assessments and the 1 month follow up.	Alcohol Smoking	N = 94 Non-treatment-seeking college students who engaged in at ≥1 heavy drinking episode in the past 2 weeks and reported concurrent smoking and drinking at least once a week. 27.7% female Mean age: 20.5 years Range: N/A	1 month	1. Drinks/drinking days, frequency of heavy drinking days (measured using DDQ), cigarettes/smoking day (measured using DSQ), days of drinking + smoking, alcohol-related problems (measured using the YAAPST). At the end of the 14-day EMA monitoring period, we administered a satisfaction questionnaire to participants in the BASICS-Mobile and daily monitoring conditions to assess acceptability, feasibility, perceived utility, and overall satisfaction. Online assessments were sent at 1-month follow-up. Across all conditions, 89.4% completed the 1-month follow-up assessment.[a]	Generalised linear mixed models with fixed effects of intervention condition and random effects of time were used for the analysis of mean differences in outcomes across groups at the 1-month follow-up using an ITT approach.	Preliminary analyses revealed no significant differences in drinking/smoking rates or other variables of interest across random and event (i.e. participant initiated) assessments.
Woodruff et al., USA	2 arm RCT	'The Breathing Room' website: Internet-based, virtual reality world	Assessment only	Smoking	*N* = 136 Adolescent smokers recruited from high schools in San Diego County. 45% female Mean age: 16 years Range: 14–19 years	12 months	1. Past-week abstinence (yes versus no), number of days smoked in the past 7 days, number of cigarettes smoked per day during the past 7 days, number of lifetime quit attempts, latency to first cigarette of the day 2. Readiness/intentions to quit, participant's self-described Current Smoking Category (experimenter, occasional smoker, daily smoker, or former smoker). Online surveys were used to examine outcome variables.Overall non-response or loss to follow-up was 25% for the post-intervention survey, 21% for the 3-month follow-up survey, and 27% for the 12-month follow-up survey.[a]	Analyses were based on intention to treat. Differential rate of change in abstinence rates and other measures of smoking/abstinence relied on analysis of repeated measures over time.	Of the 7 outcomes examined, only the number of times quit was statistically significant long-term (i.e. one-year post intervention). These results suggest that continued support, perhaps in the form of online booster sessions, is needed to reinforce what the smoker has learned and to help deal with relapse. Booster sessions are an integral part of most adult smoking cessation programs and are an important component for effective tobacco use prevention programs for youth.

Ybarra et al. (2013), USA	2 arm RCT	Stop My Smoking (SMS) USA: mHealth texting smoking cessation program for young adult smokers. Intervention group participants had access to two program components: (a) Text Buddy (another person in the program that a participant was assigned to so they could text one another for support anonymously; assignment was sequential so that buddies would be in similar stages during the quitting process); (b) Text Crave (immediate, on-demand messages aimed at helping the participant through a craving).	Untailored texts and no additional features	Smoking	*N* = 164 Young adult smokers 43.9% Female Mean age: 21.6 years Range: 18–25 years	3 months	1. 3-month continuous abstinence verified by a significant other, 2. Self-reported abstinence (smoking ≤5 cigarettes 4 weeks since their quit date), 7-day point prevalence abstinence at 4 weeks, Acceptability (e.g. participant rating of frequency and timing of messages; dropout rates) Survey data were collected online for the baseline survey, via text message at 4 weeks post-quit, and a combination of text and online for the 3-month post-quit follow-up. 87% of participants responded at 4 weeks post-quit and 80% at 3 months post-quit. 5 withdrew from intervention arm, 0 withdrew from control.[a]	Baseline characteristics of participants were compared using chi-square or t tests. Logistic regression models were used to estimate the odds of quitting for the intervention vs. control groups. Analyses were conducted in two ways: intent-to-treat (ITT) such that all randomized individuals were included in the analysis (all participants lost to follow-up were assumed to still be smoking) and per-protocol analysis such that only those who completed the follow-up measures were included in the analysis. Models were adjusted for additional factors that may influence smoking outcomes in this population (denoted as "aOR" for adjusted odds ratio).	Quitting rates were not significantly different for SMS USA participants and control participants at 3 months post quit. The intervention appeared to be helpful for men (44% intervention vs. 29% control had quit at 3 months; p = .14), young adults not currently enrolled in higher education settings (45% vs. 26% control had quit at 3 months; p = .07), and participants of non-White race (42% intervention vs. 23% control had quit at 3 months; p = .14). Based on ITT analysis, 40% of the participants in the intervention arm had a verified quit status compared with 30% in the control arm at 3 months post-quit. The observed difference was not statistically significant (OR = 1.62, 95% CI: 0.82, 3.21). Findings also suggest that SMS USA is acceptable among this understudied population.

[a]Participants were incentivised to complete follow-up measures.

AUDIT: Alcohol Use Disorders Identification Test (Saunders et al., 1993); RAPI: Rutgers Alcohol Problem Index (White & Labouvie, 1989); YAAPST: Young Adult Alcohol Problems Screening Test (Hurlbut & Sher, 1992); DDQ: Daily Drinking Questionnaire (Collins et al., 1985); TOT-AL: Test-retest reliability of an online measure of past week alcohol consumption (Khadjesari et al., 2009); Nicotine Dependence Syndrome Scale (NDSS) (Shiffman et al., 2004); FTQ: Fagerstrom Tolerance Questionnaire (Fagerström, 1978); mFTQ: Modified Fagerstrom Tolerance Questionnaire (Heatherton et al., 1991); TLFB: Timeline Follow-Back (Sobell & Sobell, 1992).

Table 2. Summary of included non-RCTs (*n* = 10).

Study	Study design	Intervention	Substance (s)	Participant characteristics (N, eligibility criteria, % female, mean and range of ages)	Longest follow-up	Key outcome measures 1. Primary outcomes 2. Secondary outcomes Method of follow-up Attrition rates	Statistical measures	Key findings
Baskerville et al. (2016), Canada	Quasi-experimental pre/post	Intervention: Break-It-Off (BIO) app (campaign http://Breakitoff.ca) Unmatched comparison with control: Smokers' Helpline (SHL) Programs – 'standard treatment'	Smoking	*N* = 238 Young adult smokers 57.1% female Mean age: N/A Range: 19–29 years	3 months	7-day and 30-day point prevalence abstinence If participants used any other cessation aid, at least one action taken toward quitting, user satisfaction (measured using the Larsen satisfaction score) Online baseline and follow-up questionnaire at 3 months. A total of 322 participants were lost to follow-up (66% for BIO vs. 48% for SHL) = 42.5% completion rate[a]	Mean ± SD for continuous variables and frequency percentages for categorical variables, compared between groups using the t test for independent groups or the chi-square test, respectively. To test for attrition bias, chi-square test was used. Separate analysis of smoking abstinence rates was conducted using the chi-square test that assumed participants lost to 3-month follow-up were smokers with logistic regression models.	Although not statistically significant, 89.4% of BIO participants versus 79.4% of SHL participants cut-down amount smoked, OR = 2.18, 95% CI = 0.88 to 5.44, P = .09. BIO users had significantly higher 7-day and 30-day quit rates compared with users of SHL (47.1% vs 15.4%), OR = 4.87, 95% CI = 2.66 to 8.93, P < .001 and AOR = 3.89, 95% CI = 1.98 to 7.67, P < .001, controlling for education, ethnicity and daily or occasional cigarette use. For secondary outcomes, 91% of BIO participants made a quit attempt during the 3-month intervention period compared to 79.1% of SHL participants, OR = 2.69, 95% CI = 1.03 to 6.99, P = .04.

(*Continued*)

Table 2. Continued.

Study	Study design	Intervention	Substance (s)	Participant characteristics (N, eligibility criteria, % female, mean and range of ages)	Longest follow-up	Key outcome measures 1. Primary outcomes 2. Secondary outcomes Method of follow-up Attrition rates	Statistical measures	Key findings
Carrà et al. (2016), Italy	Pre-/post	D-ARIANNA app (Digital–Alcohol Risk Alertness Notifying Network for Adolescents and Young Adults)	Alcohol	*N* = 507 Binged on alcohol at least once in the past 6 months 52.1% female Mean age: 20.6 years Range: 18–24 years	2 weeks	Any differences between the rate of binge drinking 2 weeks before and after the e-Health app self-administration. Facilitators arranged to phone all participants after 14 days, to establish whether they had engaged in BD in the intervening period. Follow-up data obtained from 507 (86%) participants who had self-administered the e-Health app.[a]	Logistic generalized estimating equation (GEE) analyses for the binary outcome BD in the past 2 weeks. Sensitivity analyses were done via t tests and cross tabulations, comparing those who dropped out versus those who did not, and implemented a weighted GEE model that accounted for data from those who dropped out. To exclude systematic errors involving those lost at follow-up and verify whether unobserved outcome data were missing: MCAR, MAR and MNAR analyses done	At the follow-up of the use of D-ARIANNA, young people reported a reduction in BD in the preceding 2-week period (37% at baseline vs. 18% at follow-up).
Dennis et al. (2015), USA	Pilot observational	Addiction Comprehensive Health Enhancement Support System (ACHESS): Ecological momentary assessments (EMA) + attendance to ecological momentary interventions (EMI) (recovery support) via smartphones.	Marijuana, alcohol, and poly-drug use.	*N* = 29 Adolescents ≥18 years discharged from residential treatment (regardless of discharge status or length of stay) 31% female Mean age: 16.6 years Range: N/A	1 week	Time to first alcohol or drug use in the next 7 days; Any alcohol or drug use in the next 7 days Utilisation (% of EMAs completed and EMIs accessed and usefulness of the EMIs. Participants met with research staff at the research office twice during each 7-day period and provide a urine sample. 100% of the adolescents accessed EMIs during the pilot.[a]	Chi-square Automatic Interaction Detection (CHAID) to identify subgroups of risk, Kaplan-Meier methods (to analyse time to first-use) and Wilcoxon (Gehen) from Life-Tables analysis for pairwise comparisons of sub-groups. Differences in next 7-day use by Observation Risk Groups and EMI utilization were evaluated also by using logistic regression analysis. Odds ratios, confidence intervals and p values.	When an EMI was accessed 2 or more times within the hour following an EMA, the rate of using during the next week was significantly lower than when EMIs were not accessed (32% vs. 43%, OR = 0.62, 95% confidence interval of 0.52 to 0.74). Recovery support was the most commonly used suite of EMIs. The majority of adolescents felt that the EMA "was not too long" (95%), "very easy" or "easy to learn how to do" (100%), and that it was "very easy" or "easy to complete 6 EMAs per day" (94%).
Hussey and Flynn (2019), USA	Mixed methods pilot study	Addiction Comprehensive Health Enhancement Support System (ACHESS) mobile phone app	Cannabis, Alcohol, Other drug, Multiple substance use	*N* = 28 < 21 years of age with a substance use disorder who were receiving care in intensive outpatient treatment setting. Mean age: 16.9 years Range: 0–21 years	3 years	Abstinence at discharge Programme completion, discharge against staff advice/admin, Days in treatment, Overall user experience. Data was collected by the centre staff. 4 participants did not complete treatment by end of pilot study.	Propensity score matching (PSM) from the de-identified historical client data to construct a comparison group. Comparisons conducted using a Pearson's Chi-Squared procedure and T-test.	58.3% (n =14) of the youth in the pilot study group and 60.7% (n = 17) in the comparison group achieved abstinence at discharge. A slightly larger proportion of the pilot study group (54.2%, n = 13) completed treatment compared to the comparison group (42.9%, n = 12), however, this was not statistically significant.

Kong et al. (2017), USA	Pilot observational	CBT + CM CBT: Weekly in-person CBT for smoking cessation. Contingent Management (CM): Contingent monetary reinforcement for abstinence was provided remotely via mobile phones based on CO levels (≤ 8 ppm) daily during the first two weeks. Semi-quantitative saliva cotinine levels ≤ 2 (≤ 100 ng/ml) determined abstinence remotely thrice per week in the last two weeks.	Smoking	*N* = 13 Daily smokers 60% female Mean age: 16.47 years Range: 13–18 years	1 month	7-day point-prevalence abstinence verified by saliva cotinine. Feasibility - determined using the number of on-time, valid CO and saliva videos submitted during the four-week intervention; Acceptability - perceptions of various components of the treatment were assessed at the end of treatment Face-to-face assessments at end of treatment and 1-month follow-up. 3 participants dropped out and 1 of them still completed follow-up assessment[a]	Descriptive statistics	The quit rate (7-day end-of-treatment [EOT] point prevalence [PP]) using mobile phone CM (60%) was not significantly different to that observed using in-person CM procedures in our earlier CM trials with adolescent smokers (38–57%). In general, the program was also rated very positively (e.g. enjoyed being in the program and wanting to recommend the program to a friend. The open-ended responses revealed appealing aspects: 1) support received 2) being on a quit schedule and setting goals and 3) the monetary reinforcement. Some suggested areas for improvement included more in person support, more payment, sending videos on time and providing saliva samples remotely.
Mays et al. (2020), USA	Pilot observational	MMS (multimedia messaging service) intervention to convey the short- and long-term health harm, toxicant exposure, and addiction risks of hookah tobacco.	Hookah (tobacco)	*N* = 20, 18–30 years old who were current hookah smokers (defined as smoking hookah at least once in the past 30 days and now smoking hookah at least monthly). 50% (*n* = 10) female Mean age: 24 years Range: N/A	6 weeks	Hookah tobacco use – use in the past 30 days, typical frequency of use. Motivation to quit , Message response and engagement, Hookah tobacco risk beliefs, Perceived relative harm and addictiveness of hookah tobacco Completion of online baseline and 6-week post-intervention assessments. All participants completed baseline and follow-up assessments.[a]	Descriptive statistics were used to characterize the sample and paired sample t-tests to examine change in measures administered at baseline and follow-up, and we calculated Cohen's d as a measure of effect size. For risk belief items corresponding to message themes and the message tailoring process, change in the proportion of participants indicating low- and high-risk beliefs from baseline to follow-up were analysed using McNemar's test.	Motivation to quit smoking hookah increased significantly from baseline (mean = 2.5, median = 2.5, SD = 1.7, range = 1.0–5.0) to follow-up (mean = 4.4, median = 4.5, SD = 1.9, range = 2.0–7.0; P = .003, Cohen's d = 0.97) among those who had not reported quitting at follow-up. At follow-up, 6 participants (30%) reported quitting smoking hookah tobacco completely, 4 participants (20%) decreased frequency of smoking hookah, and the remaining 10 participants (50%) reported no change in frequency of smoking hookah. Participants responded to nearly all text message prompts during the exposure period and indicated that message content was helpful.
Obermayer et al. (2004), USA.	Pre/post	Text messages informing participants about their smoking habits/ patterns that were obtained through assessment questions on the Web site. The program also provided a social support component that allowed selected others to follow the smoker's progress on the Web site and send additional text messages encouraging the smokers in their progress in quitting. Once successful smoking cessation had been achieved, the program provided interactive, real-time relapse prevention strategies.	Smoking	*N* = 46 College students who self-report a minimum of 28 cigarettes smoked/ week (average 4/day) and smoking on at least 6/7 days each week 46% female Mean age: 19.9 years Range: 18–25 years	6 weeks	7-day point prevalence abstinence (TLFB), Drive (craving and withdrawal symptoms), Priority (behavioural preference of smoking over other reinforcers, Tolerance (reduced sensitivity to smoking's effects), Continuity (regularity of smoking), and Stereotype (smoking pattern invariance), measured with the Nicotine-Dependence Syndrome Scale (NDSS). If abstinence was indicated, this was validated with cotinine measurements from saliva samples. Programme-use feedback questionnaire. Participants answered assessment questions on the Web site. Of the 46 initial participants, full data was obtained for only 31 individuals (67% completion rate).	Descriptive statistics	Of all participants entered in the study (N = 46), nearly half (43%) reported a 24-hour quit attempt, and 22% had quit smoking after 6 weeks in the program (17% reported cotinine validation). Among those who actually initiated the program on the Web and received text messages, 34% had quit smoking at 6 weeks (28% with cotinine validation). Participants' self-reports indicated that the text messaging component was easier to use and more acceptable than the Web component was.

(*Continued*)

Table 2. Continued.

Study	Study design	Intervention	Substance (s)	Participant characteristics (N, eligibility criteria, % female, mean and range of ages)	Longest follow-up	Key outcome measures 1. Primary outcomes 2. Secondary outcomes Method of follow-up Attrition rates	Statistical measures	Key findings
Riley et al. (2008), USA	Pilot observational	Online educational modules, progress-monitoring tools, and e-mail alerts to user-selected significant others who would provide social support at critical junctures in the program	Smoking	*N* = 31 University students smoking > 28 cigarettes/ week, smoking > 6 days/week, desire to quit within 30 days, no current other tobacco use, no past-month nicotine replacement or bupropion use, and no past-year substance abuse treatment. 53.2% female Mean age: 20 years Range: 18–24 years old	6 weeks	Smoking frequency and quantity measured by 7-day smoking TLFB, reported quit attempts and the Nicotine Dependence Syndrome Scale (NDSS). Saliva samples were requested from participants reporting abstinence for biochemical validation (cotinine < 15 ng/ mL). To test acceptability /satisfaction with the programme, mean ratings of 3.5 or higher on 5-point Likert scales were used. 6 weeks after baseline, telephone interviews were conducted to obtain completed TLFB, reported quite attempts and programme ratings. Completed NDSS was obtained via mail. All participants took part.[a]	T tests for significance between means of 2 groups.	Six weeks after program initiation, 42% of participants were abstinent, and continued smokers reported reduced smoking rates and nicotine dependence. These findings replicate the results from the prior study using the same program with a comparable sample. Both the current and combined samples had quit rates higher than the a priori criterion of 20% biochemically validated quit rate, supporting the primary hypothesis of the study. The program, particularly the text messaging component, was well accepted by participants, many of whom suggested improving the program by increasing the number of text messages.
Shrier et al. (2014), USA	Pilot observational	MOMENT: brief motivational enhancement therapy with mobile self-monitoring and responsive messaging. Participant met with a trained counsellor to complete two 1-hour motivational enhancement therapy (MET) sessions, separated by one week.	Marijuana	*N* = 27 Patients of 2adolescent clinics affiliated with a paediatric hospital in a Northeast city were recruited if reported using marijuana at least 3 times per week, on average. 70% female Mean age: 19.2 years Range: 15–24 years old	3 months	1. Marijuana and other substance use in past 30 days (TLFB), Number of times they used marijuana in the past 24 h. 2. Momentary desire to use marijuana, Marijuana use since the last EMA completed, Momentary emotional contexts were assessed with questions adapted from the Positive Affect–Negative Affect Schedule Study participation occurred over 17 weeks and included 3 study phases (baseline, intervention, and follow-up at 3 months), 6 study visits and 3 periods of mobile momentary reports and daily diaries. Of the 22 participants who began the intervention, 16 (73%) completed it.[a]	Univariate statistics were used to characterise the sample and summarise the feedback responses. Generalised estimating equations examined changes across study phases in momentary-, daily-, and individual-level measures.	Percent days abstinent over the past 30 days increased slightly, but non-significantly, from baseline to follow-up (37.9% vs. 47.3%, S = 27, p = 0.13). POSIT scores decreased, on average, from baseline to follow-up, although not significantly (M = 5.67 vs. 3.93, S = − 15.5, p = 0.16).
Woodruff et al. (2001), USA	Pre/post	'The Breathing Room' Internet-based, virtual reality world	Smoking	*N* = 26 Smoked at least one cigarette within the past month 34% female Mean age: 15 years Range: 13–17 years	1 month	% of past-week abstinence (0 cigarettes smoked = abstinence), number of cigarettes smoked per day in the past 30 days, number of quit attempts during the past 12 months that lasted 1 day or longer Intentions to quit, attitudes toward quitting, acceptability of several components of Breathing Room (Likert scales) Online self-report surveys at baseline, after intervention, and 1-month follow-up. Among the 26 participants, 18 provided complete survey data.[a]	Changes over the 3 time periods were analysed by using Cochran Q for dichotomous variables (i.e. percentage of those abstinent, percentage of those reporting they are former smokers), and multivariate analysis of variance for interval or continuous level variables. Acceptability measures were analysed with descriptive statistics, including mean ratings and the percentage of those reporting "yes."	No significant changes were seen post-intervention on every outcome variable examined.

[a]Participants were incentivised to complete follow-up measures.

Riley et al., 2008; Simmons et al., 2013; Walters et al., 2007). For smoking, this was determined by urine or saliva cotinine levels or carbon monoxide breath testing. For alcohol consumption, peak blood alcohol concentrations (BAC) were measured.

All the studies assessed substance use outcomes using variants of the surveys noted in Table 1 (Collins et al., 1985; Fagerström, 1978; Heatherton et al., 1991; Hurlbut & Sher, 1992; Khadjesari et al., 2009; Raskin White & Labouvie, 1989; Saunders et al., 1993; Shiffman et al., 2004; Sobell & Sobell, 1992). Intervention periods ranged from 2 weeks to 12 months, with most studies conducting follow-ups via online questionnaires or telephone interviews.

3.2. Quality assessment

The Cochrane risk of bias tool (Higgins et al., 2011) was used to assess risk of bias for RCTs (see Table B in O'Logbon et al., 2023) and the ROBINS-I tool was used for non-RCTs (Sterne et al., 2016) (see Table C in O'Logbon et al., 2023).

Ten studies were non-RCTs (Table 2) and lacked randomisation and a control group, leading to confounders which were not controlled for. Eight were potentially underpowered, with small sample sizes (<100) (Dennis et al., 2015; Hussey & Flynn, 2019; Kong et al., 2017; Mays et al., 2020; Obermayer et al., 2004; Riley et al., 2008; Shrier et al., 2014; Woodruff et al., 2001).

A loss to follow up was seen in most studies. We took a good response rate as 60%, which four RCTs (Bewick et al., 2010; Deady et al., 2016; Ekman et al., 2011; Skov-Ettrup et al., 2014) and one non-RCT (Baskerville et al., 2016) failed to achieve, suggesting high attrition rates. Their statistical analyses sought to minimise attrition bias in analyses, using methods such as multiple imputation, last observation carried forward, and sensitivity analysis.

All studies were vulnerable to response bias because they used self-reported measures of substance use and intervention adherence, although some used biochemical validation. Further biases could have arisen due to the settings where participants were sampled, such as outside clubs and bars (Carrà et al., 2016) or in rehabilitation centres (Hussey & Flynn, 2019; Trudeau et al., 2017). Finally, there were limited discussions of participant and investigator blinding, perhaps because the concealment of group allocation is challenging for these types of interventions.

3.3. Alcohol meta-analysis

Table 3 depicts the characteristics of the studies that were included in the meta-analysis.

Eleven of these studies measured the effectiveness of a digital intervention on alcohol consumption (Alfonso et al., 2013; Bertholet et al., 2015; Bewick et al., 2010; Deady et al., 2016; Doumas et al., 2009; Kypri et al., 2004, 2009; Suffoletto et al., 2015; Voogt et al., 2013; Walters et al., 2007; Witkiewitz et al., 2014). The pooled SMD demonstrated a small but statistically significant effect of digital interventions on reducing weekly alcohol consumption at follow-up compared to control arms (SMD = −0.12, 95% CI = −0.17 to −0.06) (Figure 2(a)).

There was evidence of low heterogeneity (I^2=0%; Q (10) =6.20, P=.80). Visual inspection of the funnel plot (see Figure A in O'Logbon et al., 2023) showed symmetry, indicating little publication bias.

Digital interventions yielded stronger reductions in alcohol use than assessment only/no intervention, and comparable reductions to passive interventions and face-to-face therapy (Table 4).

3.4. Smoking meta-analysis

Seven studies were included in the smoking meta-analysis (An et al., 2008; Baskerville et al., 2018; Müssener et al., 2020; Patten et al., 2006; Pbert et al., 2020; Simmons et al., 2013; Woodruff et al., 2001) (Table 3). There was no statistically significant effect of digital interventions on 30-day smoking abstinence (OR = 1.12, 95% CI = 0.70 to 1.80) (Figure 2(b)). There was evidence for considerable and statistically significant heterogeneity (I^2=81%; Q (6) =32.09, P < 0.0001). Visual inspection of the funnel plot (see Figure B in O'Logbon et al., 2023) also showed asymmetry, indicating potential publication bias.

Sensitivity analyses yielded similar, non-significant effect sizes when limiting the meta-analysis to different control arms (Table 4).

3.5. Narrative synthesis

Non-RCTs (in Table 2) and the 14 RCTs that could not be included in the meta-analyses are discussed below.

3.5.1. Effectiveness

3.5.1.1. Alcohol use. A total of six studies could not be included in the alcohol meta-analysis (Bryant et al., 2013; Carey et al., 2009; Carrà et al., 2016; Cunningham et al., 2015; Ekman et al., 2011; Hides et al., 2018). Carrà et al. (2016) was not an RCT; Bryant et al. (2013) and Hides et al. (2018) included elements or variations of the digital intervention in their control groups and there were no comparable outcome measures in the other three studies despite authors being contacted (Carey et al., 2009; Cunningham et al., 2015; Ekman et al., 2011).

Overall, digital interventions for alcohol use did not show significant long-term effects on young people's drinking habits. Carrà et al. (2016) piloted an app to reduce binge drinking in young adults which showed a reduction in binge drinking (37% at baseline vs. 18% at 2-week follow-up), however longer-term effects were not studied and there was a lack of control group.

Three studies investigated electronic screening brief interventions (e-SBIs) (Bertholet et al., 2015; Carey et al., 2009; Ekman et al., 2011). SBIs are completed in primary care settings and consist of a conversation with a healthcare professional to screen for substance-related risk or harm and provide personalised feedback and coping strategies to

Table 3. Studies included in meta-analyses.

	Author, year, location	Population	Measurement recording	Intervention type (sample size)	Control(s) (sample size)	Substance & substance use measure	Latest follow-up
Alcohol studies	Alfonso et al. (2013), USA	Undergraduate students recruited from alcohol-related referrals from to the university alcohol and drug counselling service.	Self-report	Web-based (eCHECKUP TO GO) ($n=48$)	Face-to-face i. Brief Alcohol Screening and Intervention for College Students ('individual') ii. ($n=53$) iii. CHOICES 'group' counselling. iv. ($n=72$)	Average blood alcohol content (SD)	3 months
	Bertholet et al. (2015), Switzerland	21-year-old men with unhealthy alcohol use (> 14 drinks/week or ≥ 6 drinks / occasion at least monthly or AUDIT score ≥ 8)	Self-report	Web-based (Normative feedback program) ($n=367$)	Assessment only / no intervention ($n=370$)	Number of drinks per week, mean (SD)	6 months
	Bewick et al. (2010), UK	University students (<21 years) who were consumers of alcohol	Self-report	i. Web-based (www.unitcheck.co.uk). ($n=334$) ii. Delayed access to site (8 weeks later than first group) ($n=424$)	Assessment only / no intervention ($n=354$)	Units consumed in previous week (1 unit = 8g ethanol), mean, SD	24 weeks
	Deady et al. (2016), Australia	Young people with moderate depression symptoms and drinking at hazardous levels (recruited via social media)	Self-report	Web-based DEpression-ALcohol (DEAL) Project ($n=24$)	Passive HealthWatch website (standard treatment as usual) ($n=16$)	Drinks/week and drinking days/week (using TOT-AL)	6 months
	Doumas et al. (2009), USA	University students who were referred to University Counselling Services for violating the University policy for alcohol and other drugs.	Self-report	Web-based (personalised normative feedback) ($n=37$)	PassiveWeb-based education (standard treatment provided by university www.reslife.net) ($n=24$)	No. of drinks per week (mean, SD)	30 days
	Kypri et al. (2004), New Zealand	Students recruited from a university student health service who scored ≥8 on the AUDIT and had exceeded 4 standard drinks for women, 6 for men, in the last 4 weeks	Self-report	Web-based (electronic screening and brief intervention based on personalised feedback) (n = $n=47$)	Passive Leaflet ($n=47$)	No. of standard drinks consumed in the preceding 2 weeks (1 standard drink = 10g ethanol), median, range	6 months
	Kypri et al. (2009), New Zealand	Full-time undergraduates who scored ≥8 on the AUDIT and had exceeded 4 standard drinks for women, 6 for men in the last 4 weeks	Self-report	Web-based (THRIVE=Tertiary Health Research Intervention Via Email) ($n=811$)	Assessment only ($n=767$)	Average weekly alcohol volume [(28-day frequency × typical quantity)/4].	6 months
	Suffoletto et al. (2015), USA	Reported hazardous drinking based on an AUDIT-C score >3/4 women/men, but not seeking alcohol treatment, were enrolled from 4 Emergency Departments (EDs) in Pittsburgh, PA	Self-report	Mobile phone-based i. SMS Assessments + Feedback (SA + F) group ($n=199$): ii. SMS Assessments (SA) group ($n=109$): No alcohol-related feedback	Standard care / no texts ($n=112$)	Drinks per drinking day over the past 30 days (TLFB)	9 months
	Voogt et al. (2013), Denmark	Young people who reported heavy drinking in the past 6 months	Self-report	Web-based ('What do you drink?' (WDYD) – brief alcohol intervention) ($n=416$)	No intervention ($n=412$)	Weekly alcohol consumption (Dutch version of the Alcohol Weekly Recall).	6 months
	Walters et al. (2007), USA	First-year students ≥ 18 years at a large Southern USA public university who reported at least 1 heavy drinking episode in the previous month (≥5 on one occasion for men, ≥4 drinks for women)	Self-report	Web-based(electronic-Check-Up to Go http://www.e-chug.com) ($n=39$)	Assessment only ($n=43$)	Alcohol consumption: measured using a 7-day drinking calendar similar to the DDQ)	16 weeks
	Witkiewitz et al. (2014), USA	Non-treatment-seeking college students who engaged in at ≥1 heavy drinking episode in the past 2 weeks and reported concurrent smoking and drinking at least once a week	Self-report	Mobile phone-based i. BASICS-Mobile ($n=30$) ii. Daily monitoring only ($n=29$) Both completed 14 days of EMA via web-enabled phone, a brief online assessment immediately following the monitoring period, and an online follow-up assessment 1-month after the monitoring period	Assessment only ($n=26$)	Number of drinks per week, based on DDQ follow-up (mean, SD)	1 month

Smoking studies	An et al. (2008), USA	College smokers at University of Minnesota	Self-report	Web-based (RealU Website - 'tailored' smoking cessation site) ($n = 257$)	Passive Standard government website QuitNet.com ($n = 260$)	30-day abstinence	30 weeks
	Baskerville et al. (2018), USA	Young adult smokers	Self-report	App (Crush the Crave) ($n = 820$)	PassiveStandard self-help guide, On the Road to Quitting (OnRQ) ($n = 779$)	30-day abstinence	6 months
	Müssener et al. (2020), Sweden	High school students who were daily or weekly smokers willing to attempt to quit smoking and owned a mobile phone.	Self-report	Mobile phone-basedNicotine Exit Junior (NEXit Junior): 12-week automated programme with text messages. ($n = 212$)	PassiveHelpline information ($n = 201$)	4-week point prevalence of not having smoked a single cigarette at the time of follow up	3 months
	Patten et al. (2006), USA	Young smokers	Self-report	Web-based (Stomp Out Smokes (SOS) website) ($n = 70$)	Face-to-face Individual counselling sessions ($n = 69$)	Point-prevalence smoking abstinence at week 24	36 weeks
	Pbert et al. (2020), USA	High school students who are smokers from 9 schools	Self-report & observed (abstinence confirmed by cotinine samples)	App i. Craving to Quit app ($n = 43$) ii. NCI QuitSTART app (smoking cessation app without mindfulness training) ($n = 31$)	PassiveSmoking cessation written materials only ($n = 43$)	7-day point prevalence abstinence	6 months
	Simmons et al. (2013), USA	US college students who smoked ≥5 cigarettes per week	Self-report & observed (Self-reported abstinence was biochemically verified using breath CO testing. Participants with carbon monoxide levels of < 10 ppm were classified as abstinent)	Web-based Web-Smoke website ($n = 81$)	Face-to-face i. Group-based intervention (+ given paper versions of website) ($n = 84$)	7-day point prevalence at 1- and 6-month follow-ups using TLFB	6 months
	Woodruff et al. (2007), USA	Adolescent smokers recruited from high schools in San Diego County	Self-report	Web-based 'The Breathing Room' website	Assessment only	Past-week abstinence (yes versus no)	12 months

reduce use. Cunningham et al. (2015) compared the e-SBI to an in-person SBI and an information brochure (control group). At three months, both SBIs significantly decreased alcohol consumption compared to the control but this was not maintained at six months. These results are echoed in Ekman et al.'s (2011) study that compared an e-SBI to a control group receiving generic feedback on their alcohol use. Carey, Henson, et al. (2009) compared an e-SBI to an in-person SBI among college students sanctioned for alcohol violations. The in-person SBI was more effective after one month but neither intervention predicted additional drinking change beyond what was already achieved post-sanction.

Personalised feedback and interactive monitoring interventions were also investigated. Bryant et al. (2013) trialled personalised feedback sent via email to undergraduate students on their drinking (generated from information gathered at baseline). Students consumed significantly fewer drinks per week and spent less days being drunk compared to their previous 30 days. Conversely, interactive monitoring and feedback of drinking behaviour via the Ray's Night Out app in Hides et al.'s (2018) study produced no differences in alcohol use or related problems but improved young people's alcohol knowledge, which was maintained at the one-year follow-up.

3.5.1.2. Smoking. A total of twelve studies could not be included in the smoking meta-analysis (An et al., 2013; Baskerville et al., 2016; Kong et al., 2017; Mason et al., 2015; Mays et al., 2020; Obermayer et al., 2004; Ramo et al., 2018; Riley et al., 2008; Shrier et al., 2014; Skov-Ettrup et al., 2014; Woodruff et al., 2001; Ybarra et al., 2013). Seven were excluded because they were non-RCTs (Baskerville et al., 2016; Kong et al., 2017; Mays et al., 2020; Obermayer et al., 2004; Riley et al., 2008; Shrier et al., 2014; Woodruff et al., 2001) and three studies contained elements or variations of the digital intervention (An et al., 2013; Skov-Ettrup et al., 2014; Ybarra et al., 2013). There were no comparable outcome measures in the other two studies despite authors being contacted (Mason et al., 2015; Ramo et al., 2018).

Combined web- and mobile-based interventions involved the completion of educational modules and tools to monitor progress. This helped generate text messages which either reminded participants of quit dates or were health/lifestyle related (An et al., 2013; Riley et al., 2008). Increased abstinence rates were seen in these studies. In particular, in An et al.'s (2013) 3-arm RCT, the addition of online peer coaching to the web-based modules and text messages showed the highest abstinence rate.

Mays et al. (2020) and Obermayer et al. (2004) trialled mobile phone text-messaging interventions that informed participants on the short- and long-term harm of their smoking habits. Mays et al. (2020) found that six participants (30%) reported quitting smoking completely and four participants (20%) had decreased frequency of smoking at the six-week follow-up. In Obermayer et al.'s (2004) study, nearly half (43%) of the 46 participants reported a 24-hour quit attempt, and 22% had quit smoking after six weeks in the programme (17% validated by cotinine).

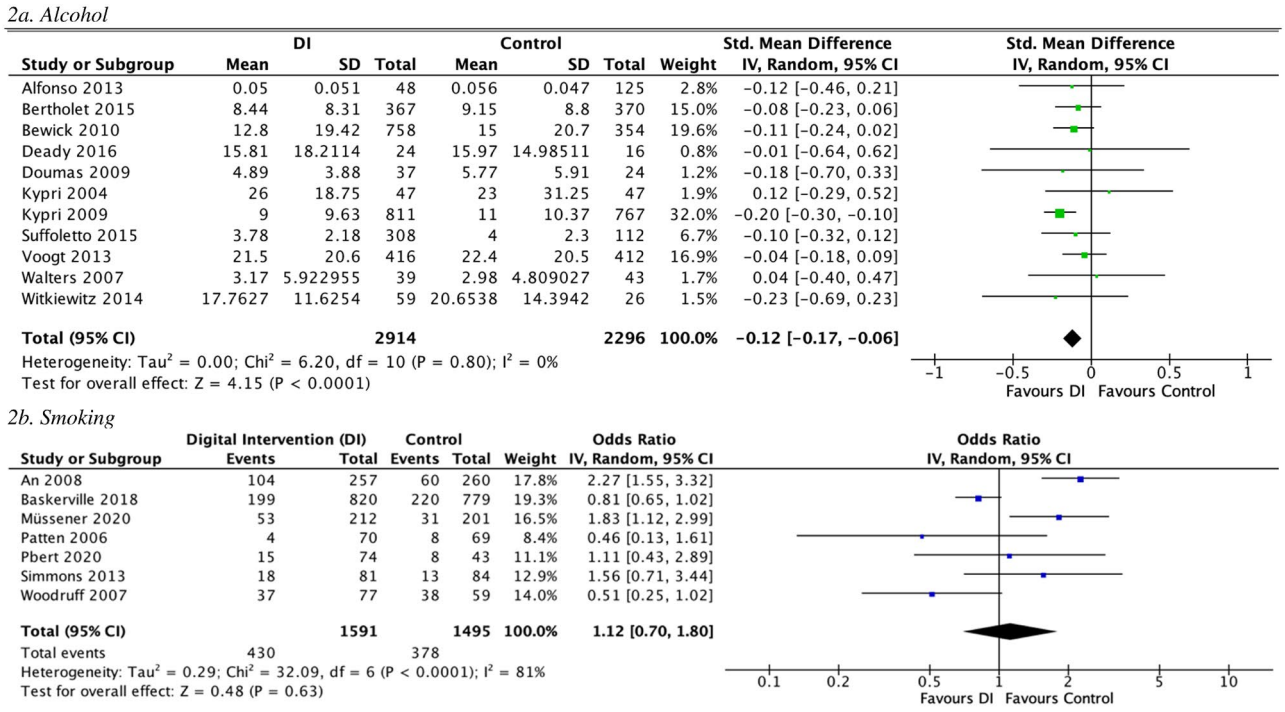

Figure 2. Panel of Forest plots of alcohol and smoking substance use outcomes.

Table 4. Sensitivity analyses.

Stratified analyses	Alcohol				Smoking			
Control group type	n	SMD (95% CI)	Cochran's Q	I^2	n	Odds Ratio (95% CI)	Cochran's Q	I^2
Face-to-face	2	−0.11 (−0.29, 0.07)	Q(1)=0.02 $p=0.90$	0%	2	0.94 (0.29, 3.05)	$Q(1)=2.60$ $p=0.11$	62%
Assessment only / no intervention	6	−0.13 (−0.19, −0.06)	Q(5)=4.66 $p=0.46$	0%	1	—	—	—
Passive (e.g. *leaflets, standard government websites)*	3	−0.00 (−0.28, 0.28)	Q(2)=0.79 $p=0.67$	0%	4	1.40 (0.76–2.59)	Q(3)=24.74P < 0.0001	88%

The other studies reported no significant effects on smoking rates (Baskerville et al., 2016; Kong et al., 2017; Mason et al., 2015; Ramo et al., 2018; Shrier et al., 2014; Skov-Ettrup et al., 2014; Woodruff et al., 2001).

3.5.1.3. Other substances and combined drug use. Five studies (Dennis et al., 2015; Gonzales et al., 2014; Hussey & Flynn, 2019; Trudeau et al., 2017; Walton et al., 2013) investigated the effects of digital interventions for combined drug use including marijuana, methamphetamine, cocaine, heroin, prescription drugs and alcohol. Unfortunately, all were excluded from the meta-analysis because they were either non-RCTs (Dennis et al., 2015; Hussey & Flynn, 2019) or had no comparable outcome measures, despite contacting authors (Gonzales et al., 2014; Trudeau et al., 2017; Walton et al., 2013).

In Gonzales et al.'s (2014) study of a 12-week text messaging intervention, the participants who received texts (to monitor relapse and recovery, provide feedback, reminders, support, and education) were significantly less likely to relapse compared to control participants in community-based treatment programs (OR = 0.52, $p=0.002$). Primary drug use was detected from urinalysis which bolsters these results.

Trudeau et al. (2017) compared an online relapse-prevention programme to face-to-face therapy. Participants who used the website indicated a greater decrease drug use at 3-month follow up compared to controls, but this was not maintained at the 6-month follow-up.

Two studies (Dennis et al., 2015; Hussey & Flynn, 2019) assessed the effectiveness of ACHESS (Addiction Comprehensive Health Enhancement Support System) (Gustafson et al., 2014), a mobile app that includes substance use monitoring, educational tools, and ecological momentary assessments and interventions (EMA/Is). A high rate of participants completed the prompted EMAs (87%) and reported lower substance use in the next week after accessing an EMI (Dennis et al., 2015). Hussey & Flynn (2019) found that ACHESS led to approximately the same proportion of young people achieving abstinence compared to those receiving treatment at a rehabilitation centre (58.3% vs 60.7%).

Finally, an e-SBI for cannabis use showed a short-term decrease in cannabis-related consequences (at 3 and 6 months) (Walton et al., 2013), but did not significantly reduce use, compared to a therapist-delivered SBI and a brochure.

3.5.2. Feasibility & acceptability

Seven studies reported on feasibility and acceptability in detail (Hides et al., 2018; Kong et al., 2017; Trudeau et al., 2017; Witkiewitz et al., 2014; Woodruff et al., 2001; Ybarra et al., 2013). We comment on the overall findings by each digital platform type.

3.5.2.1. Mobile phone-based interventions. Mobile phone-based interventions showed high acceptability and engagement. Hides et al.'s (2018) *Ray's Night Out* app was rated 3 out of 5 stars. The uMARS (Mobile application rating scale – user version (Stoyanov et al., 2016)) indicated that the app had high quality, functionality, aesthetics and information. There was an acceptable level of engagement, but participants reported they were unlikely to pay for the app.

In Ybarra et al.'s (2013) study of an mHealth smoking cessation programme, Stop My Smoking (SMS) USA, at the 3-month follow-up, the intervention appeared to be most helpful for quitting smoking in men (44% intervention vs. 29% control; $p = .14$), young adults not currently enrolled in higher education (45% vs. 26% control; $p = .07$), and participants of non-White race (42% intervention vs. 23% control; $p = .14$). This may suggest that a digital intervention like SMS USA is particularly acceptable among this sub-population (Ybarra et al., 2013).

Participants of Kong et al.'s (2017) mobile phone-based contingency management programme expressed that they enjoyed being in the programme and would recommend it to a friend. Appealing aspects were quality of support received, being on a quit schedule, setting goals and monetary incentives. Suggested areas for improvement included more *in-person* support, more incentives, and making it easier to send videos and provide saliva samples remotely.

In Dennis et al.'s (2015) pilot study of an app for EMAs, high acceptability was seen, measured by the number of EMAs completed by adolescents. When surveyed on their experience of the app, most felt that the EMA "was not too long" (95%), "easy to learn how to do" (100%), and it was "easy to complete 6 per day" (94%).

Witkiewitz et al. (2014) assessed the effectiveness and feasibility of BASICS-Mobile (Brief Alcohol Screening and Intervention for College Students programme (Hanewinkel & Wiborg, 2005)) – an e-SBI for college students that incorporates personalised feedback about drinking behaviour with components of cognitive behavioural therapy. Many participants reported that they learned something new about alcohol or smoking and that it helped them develop a goal to change their habits (Witkiewitz et al., 2014). However, five participants reported that participation in the study made them want to smoke or drink more than usual, suggesting that reactivity to repeated assessment may be an issue for digital interventions. Yet analysis of the smoking and drinking behaviour of these individuals indicated that they reported similar reductions in drinking and smoking as those who did not provide this feedback.

3.5.2.2. Web-based interventions. Notable positive aspects of web-based interventions included ease of use and ability to interact with a counsellor and other smokers (Woodruff et al., 2001). In Trudeau et al.'s (2017) relapse-prevention website, '*Navigating My Journey*', participants wanted "actual footage" of addicts in situations to be added to the site (the website already included video interviews with former users); guest speakers; and additional content on family issues.

4. Discussion

4.1. Main findings

We found evidence that digital interventions produced a small but significant overall reduction in alcohol consumption compared to no intervention controls, whilst digital interventions were not effective for smoking abstinence. Overall, improvements were short-lived and inconsistent.

4.2. Comparison to wider literature

4.2.1. Abstinence vs harm reduction

Addiction recovery is a personal journey and different strategies work for different people. The two most common approaches are abstinence and harm reduction. Abstinence-based addiction treatment focuses on quitting the substance whilst harm reduction focuses on educating people about safer substance use and tends to be more appropriate for an individual who is not ready to commit to abstinence by meeting them 'where they are at' (Marlatt & Witkiewitz, 2010). This is easier with alcohol since there are national maximimum recommended units, whilst there is no such 'recommended allowance' for smoking or illicit drug use. Learning about how to drink more safely and the dangerous consequences of binge drinking rather than enforcing abstinence is consistent with findings that most adolescents see drinking as normative (Borsari & Carey, 2001; Jenkins et al., 2017), which may explain the results seen.

It is important to acknowledge that primary prevention programmes for substance use need to differ in focus from those aimed at secondary prevention (where substance use is already established) – the latter was the focus in this systematic review. This requires careful consideration of the intended target population and the context in which the digital intervention and treatment approach are used. Future research could be done to compare abstinence-based and harm reduction-based digital interventions and determine which has longer-term effects.

4.2.2. Alcohol

Overall, digital interventions may help people reduce binge drinking better than doing nothing or providing only general health information but may have similar effects in reducing drinking when compared to face-to-face treatment, as concluded in other reviews (Cadigan et al., 2015; Dotson et al., 2015; Leeman et al., 2015). Yet, they do have the advantage that they can be delivered to a far larger proportion of the target population (Tait & Christensen, 2010). Effect sizes similar to those presented in our meta-analyses were found in Kaner et al.'s (2017) systematic review and

meta-analysis which investigated personalised digital interventions for reducing harmful alcohol use (Kaner et al., 2017).

4.2.3. Smoking

We found weak evidence to support the efficacy of digital interventions for smoking cessation which coincides with two systematic reviews (Civljak et al., 2013; Hutton et al., 2011). Conversely, a meta-analysis that compared internet smoking cessation interventions to face-to-face or no support found that digital interventions were superior, however, the types of Internet interventions were highly heterogeneous – e.g. photo-aging software, a list of Internet resources and a telehealth clinic with accompanying in-person support (Kant et al., 2021).

Mobile text-messaging may be particularly powerful for smoking behaviours such as abstinence and reduction of use, particularly automated reminders and motivating messages that can be sent during times of cravings (Scott-Sheldon et al., 2016). However, further work is needed to detect specific moderators of interventions such as follow-up length and message frequency.

4.2.4. Notable features of digital interventions

A personalised or tailored component was highlighted in most included studies (Bryant et al., 2013; Doumas et al., 2009; Skov-Ettrup et al., 2014; Suffoletto et al., 2015, Bewick et al., 2010). Personalised feedback, for example, aims to reduce negative substance use outcomes by providing feedback and tracking progress of substance use behaviours. Typically, personalised feedback is used in counselling sessions delivered using the principles of motivational interviewing (Miller & Rollnick, 2013) and often requires trained providers, clinical training, and supervision.

Providing personalised feedback digitally is an appealing alternative as it is can be automated, delivered in a variety of formats such as texts, apps or emails, and may be quicker to disseminate (e.g. app algorithms can analyse and track data provided by the young person to generate personalised messages at times when they may need it most). These features are thought to maintain abstinence for longer (Cadigan et al., 2015; Civljak et al., 2013). However, a lack of efficacy has been shown for illicit drug use (Saxton et al., 2021). The limited number of studies on digital interventions for illicit drug use suggest further research is needed to ascertain their efficacy for this substance type.

Online peer coaching was another particularly useful component highlighted in An et al.'s (2013) study. There is limited evidence for the use of digital peer-based interventions for substance use, but face-to-face mentoring has shown positive effects (DuBois et al., 2011; Macarthur et al., 2016; Thomas et al., 2011). Across adolescence, young people tend to seek support from peers to solve problems more often than from their parents and teachers (Bokhorst et al., 2010). Innovative ways to connect young people to one another and effectively communicate substance use behaviour change to the target population at scale can be facilitated by technology. Studies are now underway to investigate the use of a digital peer-led approach to influence substance use behaviour change (Musyoka et al., 2021; Quilty et al., 2022).

Other desirable features of digital interventions for young people include the ability to receive information confidentially and anonymously for free, 24-hour availability and convenience of access (Franklin et al., 2006; Hawke et al., 2021; Wickersham et al., 2019).

4.2.5. Acceptability and engagement

High attrition rates indicate a potential challenge for implementing digital health technologies. They are likely to depend on factors associated with the participant (such as personal motivation) and the intervention (such as user experience design). Substance use disorders require long-term treatment and there is currently a lack of long-term efficacy data on digital interventions to suggest they can fulfil this. Even when interventions are well-designed, engagement hovers at 'acceptable' levels and attrition rates remain high. While clinical trials often try to keep drop-out rates low by frequent clinician contact and cash incentives (the latter of which majority of studies in this review provided), this is unlikely to be sustainable in a real-life clinical setting. Finally, if the costs associated with maintaining adherence equals that of face-to-face treatment then digital interventions may not be as low-cost or scalable as anticipated.

Fortunately, there are several emerging features that have increased engagement such as ease of use, gamification, personalisation, symptom monitoring, numerical feedback (ratings, scores), ability to chart progress, socialisation within the app (such as forums and peer support) and integration with clinical services (Nwosu et al., 2022). However, fears around privacy and data security, particularly surrounding susbtance use and addiction, can also cause attrition and should be addressed upfront (Huckvale et al., 2019).

4.2.6. Implications for clinical practice

The use of digital interventions to change behaviour is a necessary area of research to help develop and implement these tools to enhance current substance use treatment for young people. This review provides an assessment of the effectiveness of a broad range of digital health interventions and useful features. Digital interventions may have a role in monitoring substance use habits short-term, which could be useful when adolescents do not currently have an assigned counsellor, are on a waiting list for treatment, or do not want to seek help face-to-face. Data collected by EMAs/EMIs, or apps could inform therapist-led CBT and be used alongside it. Nevertheless, future digital interventions must be designed with input from young people, collect user feedback, remain free of charge wherever possible, and be easy to use so engagement is maximised. It may also be worth considering which treatment approaches work best for the adolescent age range – perhaps focusing on harm reduction as a first step towards abstinence could be initiated and maintained by digital interventions.

4.3. Limitations

This review is subject to some limitations. Firstly, our age range for substance use was 10 – 24 years to capture 'young

people', but this is a wide age range with a number of heterogenous developmental periods that can affect the extent of substance use and the uptake of interventions. In addition, our meta-analysis did not include all of the RCTs due to lack of comparable outcomes, even when attempts to contact authors were made. Some of the included studies also very short follow-up periods between the use of the digital intervention and the substance use outcome, and this is important to keep in mind when looking at pooled estimates. Nevertheless, we used the longest follow-up period provided. We also only included studies published in the English language, which may limit generalisability of results. Finally, the range of studies included in this review, the variability between measurement of participants' substance use outcomes, the unadjusted estimates used in the meta-analyses, and the small number of studies in the stratified analyses, should be considered when interpreting results.

4.4. Conclusion

Evidence for the effectiveness of digital health interventions for reducing substance use was generally weak, however, a small, significant and short-lived impact on alcohol use was seen in our meta-analysis. Digital health technologies may be appropriate for short-term use and monitoring – an ideal opportunity for this could be whilst waiting for treatment. In-person treatment is likely to be supplemented, instead of replaced, by these interventions.

Their acceptability is notable and there is potential for them to overcome various barriers associated with access to substance use services. However, additional user feedback and programme development is still warranted to continue to optimise user experience and reduce attrition rates. There was high attrition with longer follow-up periods, which makes it difficult to determine if significant improvements can be maintained long-term.

Future research should continue to investigate the viability of these interventions using large-scale studies and their cost-effectiveness should also be further explored, especially since it was indicated in one study that young people would not pay to use digital interventions. Furthermore, differential effects for vulnerable groups such as homeless, single-parent and looked-after young people could yield important discussion points as to whether digital interventions could be tailored for different sub-groups. Finally, the next review on this topic should investigate the use of digital interventions to combat the trend of increasing e-cigarette use/vaping young people particularly in adolescents who have never used substances before.

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