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Systematic Review of Smartphone Apps as a mHealth Intervention to Address Substance Abuse in Adolescents and Adults

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Abstract

Background: Substance abuse represents a foremost national concern for adolescents and adults; investigators have implemented a variety of interventions, delivered with both in-person and mobile-based apps' modalities. The electronic techniques could be more effective because they avoid the cost, privacy, and accessibility issues associated with in-person intervention. To address this issue, a systematic review of the scientific evidence relative to the efficacy of app-based interventions delivered by mobile devices (smartphones) to reduce substance abuse in adolescents and adults was carried out.

Methods: To identify relevant studies published from 2005 to 2019, a comprehensive search was conducted. Databases that were searched include CINAHL, Cochrane CENTRAL, Embase, PsycINFO, PubMed, and Web of Science. Keywords and relevant controlled vocabulary terms related to substance abuse and technology were included. Studies were included if they had examined reductions in substance abuse and problem behaviors as a primary outcome with app-based interventions delivered to adolescents and adults.

Results: The initial search yielded 21,641 articles, duplicates were removed, and 14,797 citations remained; title/abstract screening yielded 190 full-text articles. One hundred seventy-three were excluded because they did not meet the inclusion criteria, leaving 17 final articles to be analyzed in this review. Use of app-based interventions showed some evidence of effectiveness in reducing substance abuse in the adolescent adult population.

Conclusion: Most intervention studies analyzed focused on alcohol reduction. Further research is needed on diverse substance abuse utilizing larger sample sizes, longitudinal studies, and theoretical foundations on the practice of delivering interventions using mobile-based apps.

Keywords: adolescents, adults, mHealth Interventions, smartphone App, substance Abuse

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INTRODUCTION

Substance abuse represents a foremost national concern; about 15.1 million abused alcohol, and 7.4 million abused illicit drugs, including 4 million who had a marijuana use disorder and 2.1 million who had an opioid use disorder (Substance Abuse and Mental Health Services Administration, 2017). Young adults (ages 18–30 years) are among those at the highest risk for initiation and misuse of opioids as well as related consequences, including overdose fatalities. National studies of adolescents and young adults show high rates of simultaneous alcohol and marijuana use (Terry et al., 2019). These findings amounted to more than 70,000 drug overdose deaths among Americans aged 12 years and older, with nearly two thirds related to heroin and synthetic opioids such as fentanyl (National Institute on Drug Abuse, 2019a, 2019b). In addition, 88,000 annual deaths are related to alcohol (National Institute on Alcohol Abuse and Alcoholism, 2018). The legalization of marijuana contributes to the public's growing tolerance toward substances (Zhang & Ho, 2016). New data, however, highlight public health dangers including increased risk for later psychotic disorders, the onset of psychosis in youths at risk for schizophrenia (McHugh

et al., 2017), and high rates of car accidents in states with legalized marijuana (Ingraham, 2017).

Evidence-based prevention, treatment, and recovery services are urgently needed because of gaps in the evidence base approaches that remain (National Institute on Drug Abuse, 2012). Very few individuals who require treatment seek it (i.e., of the approximately 21 million—people identified as needing substance use treatment, only 6 million received treatment [28.6%]; Substance Abuse and Mental Health Services Administration, 2017). Some explanations as to why individuals may not seek treatment include stigma associated with substances, accessibility of treatment, and costs (Litvin et al., 2013). To address barriers to treatment, alternative modes of treatment such as mobile-based interventions are beginning to exhibit efficacy (Litvin et al., 2013).

Mobile Health App Interventions to Address Substance Abuse

More than 60% of the global population owns a smartphone, and the average adult spends 2.3 hours per day on apps (ComScore, 2017)—adults of all ages appear eligible for mobile health (mHealth) interventions. mHealth is defined as the use of mobile devices to support health related practices (WHO, 2011). Although mobile apps represent a prime method for substance use interventions, the slate available today is lacking, according to data from several researchers (Crane et al., 2015; Hoeppner et al., 2017; Milward et al., 2016; Moreno & Whitehill, 2016; Perski et al., 2017). The most common apps focus on alcohol as entertainment, such as drinking games (Crane et al., 2015; Moreno & Whitehill, 2016); only 14% focused on alcohol reduction (Moreno & Whitehill, 2016). Few of these have been rigorously tested (Perski et al., 2017) or are evidence based (Milward et al., 2016). In addition to evidence-based practices, engagement is important because it translates to intervention efficacy (Perski et al., 2017). Individuals liked when apps incorporated information and feedback and disliked those that failed to measure alcohol consumption through drinking diaries. Young adults also said the app should incorporate tailored information (Milward et al., 2016).

Researchers have been investigating the effectiveness of app-based interventions at reducing risky alcohol use for many years (Earle et al., 2018; Fowler et al., 2016; Gajecki et al., 2017; Hides et al., 2018; Palmer et al., 2018; Prosser et al., 2018). Prosser et al. (2018) ran a meta-analysis on e-interventions and found small, but significant, evidence that e-interventions reduced drinking in college students compared with controls. Additional research has found that apps with personalized normative feedback (PNF) improved college students' drinking behaviors and perceptions (Earle et al., 2018) and also improved their knowledge about alcohol, alcohol-related problems, and drinking quantity in young Australians (Hides et al., 2018). A skills training app improved alcohol consumption in university students (Gajecki et al., 2017), alcohol consumption with engaged app users (Attwood et al., 2017), and binge drinking with young adults (Carra et al., 2016). The effect of health education on other substances merits investigation—Awosusi and Adegboyega (2013) found a direct correlation between use and knowledge. Students in their study primarily consumed alcohol, followed by tobacco and marijuana—those who knew more about the substances used less. This suggests information could improve the efficacy of substance interventions.

Although app-based interventions are shown to reduce risky drinking behavior, Tebb et al. (2016) found that interventions formulated on theoretical models provide a larger percentage of positive outcomes for alcohol reduction. Whereas in-person interventions have been shown to decrease marijuana use, online interventions may be more realistic. From an administrator's perspective, in-person interventions are expensive and difficult to arrange. As for patients, they may see a stigma in attending a session and therefore may not show up (Tait et al., 2013).

A 2019 review investigated whether digital interventions could reduce cannabis use (Boumparis et al., 2019). Digital intervention referred to both computer- and mobile-based models. Researchers found that digital intervention helped prevent and treat cannabis use. Ramo et al. (2015) analyzed the content of marijuana-focused apps available in the Google Play Store and the iPhone App Store. They found that only one app in the top results of either store was related to abuse, addiction, or treatment; most results from both stores were either information- or recreation-based (Ramo et al., 2015). Few apps are being tested for cannabis reduction or cessation (Kells & Shrier, 2017; Monney et al., 2015; Shrier et al., 2014). Aggerwal and Borycki (2019) reviewed mobile apps targeting opioid-related harm. They identified 27 apps available to the public that targeted opioid-related harm. They found 20 apps that were designed to educate users about opioids and associated harm, but only six used clearly defined evidence-based support in-app development—this review was not intended to determine the effectiveness of apps for reducing opioid-related harm, so further research is needed to identify effective apps and features.

Why It Is Important to Do This Review

Previous meta-analyses and reviews have been completed investigating the use of digital interventions on substance use (Aggerwal & Borycki, 2019; Boumparis et al., 2019; Field et al., 2019; Hutton et al., 2020; Kaner et al., 2017; Tofighi et al., 2017). Although all of these reviews provide evidence around the use of digital interventions, none focused specifically on apps used for substance use (Kaner et al., 2017). Some of the reviews investigated text-messaging-based interventions only instead of app-based interventions (Vodopivec-Jamsek et al., 2012). Digital intervention options are evolving rapidly. In light of the personal, financial, and social harm, the current review was designed to expand our understanding of the effectiveness of app-based interventions to address substance abuse. To accomplish this goal, we examined the current state of evidence-based app-based interventions and identified directions for future app research and development.

METHOD

Search Strategy

The current review was carried out according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses

(PRISMA) guidelines (PRISMA, 2015) and is registered with PROSPERO. Literature searches were performed by a librarian in Web of Science (Clarivate Analytics, 1900–present) and in PubMed (U.S. National Library of Medicine, 1809–present), Embase (Elsevier), the Cochrane Central Register of Controlled Trials (CENTRAL; Wiley, no inception date), PsycINFO (EBSCO, 17th century to present), and CINAHL Plus with Full Text (EBSCO). The literature search strategies used a combination of title–abstract keywords and controlled vocabulary terms when available (MeSH in PubMed and Cochrane CENTRAL, Emtree subject headings in Embase, Thesaurus of Psychological Index terms in PsycINFO, CINAHL Subject Headings). The Web of Science search strategy included keywords only. The librarian worked with the primary investigator and other team members who have subject matter expertise in addictive behavior and mobile technologies to develop an extensive list of terms related to the following concepts: alcohol abuse, cannabis use, drug abuse (including specific drugs of abuse), and substance abuse; and mobile health, including mhealth, ehealth, device types, applications, text messaging, short message service, interactive voice response, and related terms. Citations retrieved from the searches were added to an EndNote library and deduplicated using the automated deduplication process before title–abstract review. An example of a segment of the search string used for PsycINFO is as follows: (MH "Cannabis") OR (MM "Ethanol") OR (MH "Alcohol Drinking+") OR (MH "Alcohol-Related Disorders") OR (MH "Alcoholic Intoxication+") OR (MH "Alcoholism") OR (MH "Substance Abuse") OR (MH "Substance Abuse, Intravenous") OR (MH "Substance Dependence") OR (MH "Substance Abusers+") OR (MH "Narcotics") OR (MH "Fentanyl") OR (MH "Heroin") OR (MH "Morphine") OR (MH "Opium") OR (MH "Oxycodone") OR (MH "Codeine") OR (MH "Alcoholic Beverages") OR (MH "Wine") OR (MM "Drugs, Prescription")] AND [TI "mobile-device*" OR AB "mobile-device*" OR TI "mobile-app*" OR AB "mobile-app*" OR TI "mobile-gam*" OR AB "mobile-gam*" OR TI gamification OR AB gamification OR TI smartphone* OR AB smartphone* OR TI "mobile-health" OR AB "mobile-health" OR TI "health app*" OR AB "health app*" OR TI "mobile intervention*" OR AB "mobile intervention*" OR TI "cell-phone*" OR AB "cell-phone*" OR TI "cellular-phone*" OR AB "cellular-phone*" OR TI mhealth OR AB mhealth OR TI m-health OR AB m-health OR TI ehealth OR AB ehealth OR TI e-health OR AB e-health OR TI "health information technology."

Our search excluded gray literature (Alberani et al., 1990). The Cochrane Database of Systematic Reviews (Wiley) was searched with the same strategy used for PubMed and CENTRAL to identify related systematic reviews, allowing the reviewers to manually evaluate the citations.

Eligibility Criteria

Studies in the analysis were included if they had evaluated the effects of mobile-based interventions on substance use/behavioral outcomes. Participants had to be adolescents (14+ years old) or adults (18+ years old) who had used alcohol and/or other drugs and/or had experienced negative behavioral consequences from substance use. Eligible articles were included if outcomes focused on the quantity of alcohol consumed, a reduction/cessation of substance use, and/or the reduction/cessation of engagement in problem behaviors. Studies were included if they had a comparison condition that was placebo, assessment only, other intervention/education, or no intervention or were published before 2005. Original research articles were also included if interventions were mobile-based apps that incorporated user input and generated personalized content to change substance-related behavior. Interventions were defined as meeting the following criteria: (a) directed toward people seeking help or treatment for substance consumption, (b) brief interventions and motivational interviewing, (c) brief skills orientation and motivational enhancement therapy (MET), (d) other brief interventions and interventions limited to replicating real-time talk-based interventions, and (e) mobile interventions compared with no control arm. Randomized controlled trials (RCTs) were included. Studies were excluded if they used mobile-based technology only for screening, evaluated nonmobile apps, included interventions targeted toward providers, or were published before 2005.

Study Selection

Three members of the research team independently looked at the electronic database results and reviewed the titles, abstracts, and full text of articles. The initial search yielded 21,641 articles. An additional eight references were identified by examining reference lists. After removing duplicates, 14,797 citations remained. Guided by the inclusion and exclusion criteria, three researchers screened these 14,797 titles and abstracts. After screening, 190 full-text articles were identified as potentially relevant for the review and were examined for eligibility. Two of the three researchers reviewed the full-text articles. Of those 190, 173 were excluded for various reasons: Mobile-based technology was used only to screen participants (2), the article did not relate to substance use (1), the article was a review (3), the article was not in a peer-reviewed journal (e.g., a conference abstract or dissertation; 28), the article did not include a mobile app (20), the intervention was web- or text-based (26), the intervention targeted smoking behavior (56), the article used biophysical sensors (6), none of the outcomes in the article was focused on reducing substance use (23), or the article used the same study population as was included in previous articles (8). The third researcher served as a tiebreaker when there were discrepancies. Each researcher independently analyzed the remaining articles and agreed to include 17 final articles to code and analyze. See Figure 1 for the PRISMA flowchart (Moher et al., 2009). All articles matching inclusion criteria were included in data extraction.

Data Extraction

A standardized form was used to extract data from studies for quality assessment and review of the evidence. Extracted data included author(s), title, publication date, sample/substance,

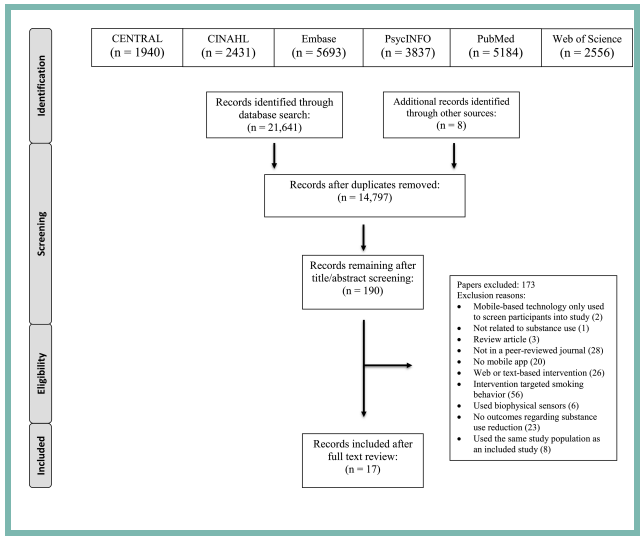

Figure 1. Preferred Reporting Items for Systematic Reviews and Meta-Analyses flowchart.

study design, and app-based intervention (see Table 1, Supplemental Digital Content, http://links.lww.com/JAN/A12).

Two reviewers independently conducted quality assessment reviews. Discrepancies were resolved through discussion, with a third reviewer serving as a tiebreaker when necessary. The Cochrane risk of bias tool did not apply to our review because we assessed studies that use mixed methods and therefore not all the studies were randomized. Therefore, to categorize each article, we used a rating method described by Melnyk and Fineout-Overholt (2011). Using Melnyk and Fineout-Overholt's (2011) rating method, we evaluated the scientific merit of each article. For example, Level II denoted a high degree of strength (RCT), Level III articles were rated as medium (quasi-experimental), and Level VI was used to denote a descriptive study (see Table 1). A meta-analysis was not conducted because the selected studies are at different phases; therefore, primary outcomes were not comparable. The studied populations and statistical analysis tools are also very different, with only a relatively small number of studies being randomized.

RESULTS

Characteristics of Studies Included

The 17 articles analyzed in this review were organized according to the target substances. Most of these studies (12 of 17) target alcohol addiction (Attwood et al., 2017; Barrio et al., 2017; Bertholet et al., 2017; Carra et al., 2016; Crane et al., 2018; Davies et al., 2017; Earle et al., 2018; Gajecki et al., 2014; Gonzalez & Dulin, 2015; Gustafson et al., 2014; Hamamura et al., 2018; Leightley et al., 2018). Two studies target cannabis use (Monney et al., 2015; Shrier et al., 2014), and the remaining three studies evaluate the feasibility and efficacy of smartphone apps on general substance use, including alcohol, tobacco, and cannabis (Dennis et al., 2015; Haug et al., 2017; Rizvi et al., 2011). All these studies took place in developed countries: one in Japan (Hamamara et al., 2018), four in the United Kingdom (Attwood et al., 2017; Crane et al., 2018; Davies et al., 2017; Leightley et al., 2018), one in Switzerland and Canada (Bertholet et al., 2017), one in Switzerland (Haug et al., 2017), one in Sweden (Gajecki et al., 2014), and the other nine in the United States. In terms of study design, only five of the studies implemented an RCT design (Crane et al., 2018; Davies et al., 2017; Earle et al., 2018; Gajecki et al., 2014; Gustafson et al., 2014). The RCT studies all had a moderate-to-large sample size ($n > 100$). The smartphone apps developed and/or evaluated were Drinkaware, SIDEAL, Alcooquiz, D-Arianna, A-CHESS, Drink Less, Drinks Meter, CampusGANDR V2, Promillekoll, Location-Based Monitoring and Intervention for Alcohol Use Disorders (LBMI-A), Self-Record, ready4life, Information about Drinking for Ex-military serving personnel (InDEx), Stop-Cannabis, DBT Coach, and MOMENT. Notably, A-CHESS was studied by two research teams. Gustafson et al. (2014) studied the effect of A-CHESS on patients leaving treatment for alcohol use disorder; Dennis et al. (2015) used A-CHESS to deliver ecological momentary assessment and ecological momentary intervention to a group of adolescents ($n = 29$) recruited from residential treatment.

Despite these reviewed studies all having smartphone app interventions to reduce substance consumption, there is not much agreement because each research team used a different therapeutic component, dose levels are not comparable, and their targeted study population was different. In addition, most studies were very small and not randomized. Most apps were shown to be feasible and useful. However, some apps were still in their development stage and only have shown to be feasible, and for others, mixed evidence on the efficacy to reduce substance usage was reported. A rigorous meta-analysis, therefore, is considered not practical, and we review these studies by summarizing their study population, target substance, study design, implemented intervention components, and major findings (see Table 1). Studies are also discussed by their stages: app development, feasibility, and potential efficacy.

App Development

Leightley et al. (2018) developed a tailored smartphone app, named InDEx, and tested the usability and feasibility of the app in an ex-serving population. The study reported the median number of initiations (15 times during the 4-week study period) and interactions as well as time spent on the app. It concluded feasibility was good. Researchers observed a decrease in median units of alcohol consumed (from 5.6 to 4.7), but future RCTs will be needed to test the efficacy of InDEx in the target population.

Feasibility and Acceptability

All selected studies reported positive results on the feasibility and/or usability of their app. Commonly used measurements for feasibility include how often the app was used and how much time the participants spent on the app. In Monney et al.'s (2015) study "Stop-Cannabis," 482 users completed the survey. Of those, 348 participants (~70%) used the app daily, and 397 (80%) said it helped them stop or reduce cannabis use "a little" or "a lot." The study did not address efficacy. Shrier et al. (2014) found MOMENT, a combined

intervention that uses a mobile electronic device for momentary and daily self-monitoring and daily messages as means of extending in-person clinic-based motivational counseling, to be very feasible and potentially effective in young adults who use marijuana frequently (more than 3 times per week). Dennis et al. (2015) showed the feasibility of using smartphones with adolescents to help with recovery monitoring and support services after treatment. As none of these studies provides evidence about the efficacy of their apps, more well-designed studies with an adequate number of participants are needed to determine the actual merit of such approaches.

Apps' Effectiveness and Features

Most of the selected studies focused on studying the potential effectiveness of smartphone apps and features. Nonrandomized studies tended to provide positive results. In Rizvi et al. (2011), participants who used the "DBT Coach" app significantly decreased both their emotion intensity ($t = -6.17$, $p < .001$) and their urge to use substances ($t = -4.22$, $p < .001$) within each coaching session. Carra et al. (2016) found that D-ARIANNA reduced young people's binge drinking from baseline to the 2-week follow-up (37% at baseline to 18%). As far as alcohol is concerned, Haug et al. (2017) found no significant changes in tobacco and cannabis use ($p = .76$ and .54, respectively). However, they observed significantly decreased perceived stress ($OR = 0.93$, $p = .03$), and the proportion of adolescents with at-risk alcohol use declined from 20.2% at baseline to 15.5% ($OR = 0.70$, $p = .01$). Bertholet et al. (2017) found a correlation between the frequency of app usage and decreased drinking, measured in fewer drinks per week ($p = .01$) and binge drinking ($p < .0001$). Barrio et al. (2017) found SIDEAL significantly reduced alcohol consumption among alcohol-dependent outpatients: The average daily drinking declined from 6.5 to 1.9 units ($p < .001$), the number of binge drinking days dropped from 25 to 5.8 ($p < .001$), and patients achieved their self-imposed objectives on about 88% of days. Gonzalez and Dulin (2015) compared the LBMI-A with an online Drinker's Check-up plus bibliotherapy. They found that LBMI-A, a smartphone-based intervention, significantly increased the number of days abstinent from baseline (13.30, $p < .001$) and decreased heavy drinking days (−19.45, $p < .001$) and drinks per week (−11.93, $p < .001$). Gustafson et al. (2014) administered an unblinded RCT to recruit inpatients experiencing an alcohol use disorder. They tested if A-CHESS could help in recovery where patients would have fewer risky drinking days than the control group patients. Their analyses showed significantly fewer risky drinking days in the A-CHESS group than for patients in the control group ($p = .003$). Attwood et al. (2017) used a mixed-method design to study the properties of their app, Drinkaware. They first retrospectively looked into the app pattern of usage data, followed by prospective recruitment of a subset of the participants for in-depth interviews. They found that "high-risk" drinkers and those who interacted with the app over time reported being motivated "to reduce drinking" were engaged users.

Interestingly, results from the randomized controlled studies were mixed. Gajecki et al.'s (2014) study showed a significant increase in the frequency of drinking occasions for the smartphone group compared with the control group ($p = .001$). Earle et al. (2018) reported that participants in the intervention group have a significantly higher reduction (Cohen's $d = 0.6$) in normative perceptions and alcohol consumed 2 months after treatment (CampusGANDR). Crane et al. (2018) applied a factorial randomized controlled design to evaluate the effect of five app modules, each at two dose levels: enhanced and minimal. They did not find significant effects of individual modules; however, they did report significant two-way interactions between enhanced normative feedback and cognitive bias retraining on weekly alcohol use ($F = 4.68$, $p = .03$) and between enhanced self-monitoring and feedback and action planning on Alcohol Use Disorders Identification Test score ($F = 5.82$, $p = .02$). These results suggest multiple modules could interact and function jointly to affect the outcome and dose level of module matters. Davies et al. (2017) conducted a randomized controlled pilot study of the Drinks Meter app and found no significant difference in Alcohol Use Disorders Identification Test-Concise (Incident Risk Ratios (IRR) = 0.98, 95% CI [0.89, 1.09]), preloading (IRR = 1.01, 95% CI [0.95, 1.07]), and harms (IRR = 0.97, 95% CI [0.79, 1.20]). Hamamura et al.'s (2018) study reported low adherence rates; 64.8% of participants in the intervention group discontinued using the app on the first day. They also observed that the intervention group reported increased anxiety ($\eta^2 = .006$), typical drinking ($\eta^2 = .005$), and heavy drinking ($\eta^2 = .007$).

DISCUSSION

This systematic review examined 17 studies to identify the current status of evidence with app-based interventions to prevent substance use. Because the reviewed studies used a variety of app-based intervention features, several gaps were revealed. These studies had diverse app-based intervention features, and all varied regarding the theoretical basis, participant population, methodology and interventions, and study design (see Table 1). Nor did the studies apply the same app tools—some used personalized feedback, some used consumption tracking, and others did both. Tools varied from automated text messages, alcohol consumption log, and blood alcohol concentration (BAC) calculators to interactive gaming mechanisms. Several features were found to be effective in changing health behaviors (including health education and PNF; Cronce & Larimer, 2011), motivational support messages, substance use consumption tracking features, and BAC calculators. A number of the studies provided education about the health consequences associated with substance use, which may contribute to the intervention's efficacy (Attwood et al., 2017; Barrio et al., 2017; Bertholet et al., 2017; Gonzales, 2015; Monney et al., 2015). Thus, further examination of health education on other substance use behavior is warranted. Smartphone apps designed to change health behaviors are common; however, few apps that address substance abuse

use gamification (Edwards et al., 2016). Earle et al.'s (2018) study presented one of the few gaming interventions that reduced alcohol-related outcomes, suggesting effective and engaging gaming could be effective if done well. Gamified app interventions can become self-sustaining interventions targeting alcohol use (Earle et al., 2018). Expansion of using gamification in other substance use interventions could contribute to the effectiveness of these app interventions.

Researchers have provided support for the effectiveness of PNF in reducing risky drinking behavior (Cronce & Larimer, 2011). Personalized feedback provides a profile of drinking/consequences with comparisons to peer drinking behaviors. Several studies used PNF to inform users of their drinking behavior relative to their peers' behavior (Bertholet et al., 2017; Carra et al., 2016; Crane et al., 2018; Davies et al., 2017; Earle et al., 2018). These studies suggest that PNF can be used in a range of mobile-based interventions for substance use. Some studies used a combination of features, including motivational support text messages, substance use tracking features, and BAC calculators (Attwood et al., 2017; Barrio et al., 2017; Bertholet et al., 2017; Crane et al., 2018; Davies et al., 2017; Dennis et al., 2015; Gajecki et al., 2014; Gonzales, 2015; Leightley et al., 2018; Monney et al., 2015).

Most studies looked at apps directed toward alcohol use only (Attwood et al., 2017; Davies et al., 2017; Earle et al., 2018; Gajecki et al., 2014; Gustafson et al., 2014; Hamamura et al., 2018; Leightley et al., 2018). Two apps addressed only marijuana (Monney et al., 2015; Shrier et al., 2014). A few apps addressed multiple substances (Dennis et al., 2015; Haug et al., 2017; Rizvi et al., 2011). Because most of the study apps targeted alcohol reduction, it is difficult to assess whether efficacy varied by substances. Shrier et al.'s (2014) marijuana MOMENT (momentary self-monitoring feedback + MET) used apps alongside in-person therapies and found the combination reduced desire to use marijuana after exposure to a triggering situation. Users accepted the personalized tailored messaging approach in Monney et al. (2015) "Stop-cannabis" app (available on Android and iPhone), suggesting it could lower cannabis use. It is uncertain whether lower cannabis use can be associated with lower alcohol consumption. Some studies found it a secondary outcome of a reduction in marijuana use (Dennhardt & Murphy, 2013), whereas others have found no positive secondary effect (White et al., 2015; Yurasek et al., 2017). The inconsistent findings could be because of the effectiveness of interventions at reducing their primary outcome. Noteworthy, several of the app interventions were based on the following theoretical models: Ajzen's (1985) theory of planned behavior, self-determination theory, social cognitive theory, and MET (Gajecki et al., 2014; Gonzales et al., 2015; Gustafson et al., 2014; Shrier et al., 2014).

The studies were limited by several factors—high attrition rates, small sample sizes, short trial periods, limitations with app structure, reliance on self-reporting, and heavy reliance on user consistency. The authors agree that further study is needed to determine usefulness in reducing substance use. When apps did focus on substance reduction, very few were grounded in theoretical behavior change techniques. Hoeppner et al. (2017) found that the most popular types of apps (i.e., downloaded more than 10,000 times) utilized tailoring, but there was a rare use of tailoring features related to addictive health behavior change.

The studies varied in methodological rigor with few using randomization, adequate sample sizes, follow-up periods, and theoretical formulations. Further research is needed with adequate sample sizes, varied settings, more longitudinal follow-up periods, and theoretical perspectives incorporating behavior change in substance use prevention. Although we conducted an extensive search using PRISMA methods, we may not have captured all pertinent articles. In addition, with the inclusion of the English language as a criterion, we may have not captured important international articles published in other languages.

CONCLUSION

In summary, there is still a lot to learn before we know how smartphone-based apps can help reduce substance usage. A potentially effective app may need to be tailored when applied to a different population. For example, dose levels for the heavy drinkers and voluntary participants could be different. The long-term effects of most smartphone app interventions to address substance abuse remain unknown. Regardless of whether they are used as stand-alone self-help programs or as part of larger guided programs, app-based interventions may provide people with portable and relatively anonymous ways to address their alcohol and drug use. The use of mHealth apps to address intervention for high-risk substance use behaviors among adolescents and adults is showing promise in terms of acceptability and feasibility. The issue of efficacy as an effective intervention, however, remains modest, and further research is required.

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