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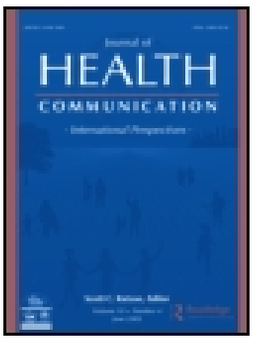

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A Systematic Review of the mHealth Interventions to Prevent Alcohol and Substance Abuse

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Substance abuse in young adults is a public health issue with costs to the individual and society. There is mounting evidence that the increased uses of mHealth approaches have promise as a way to facilitate reductions in substance use. This systematic review evaluated the recent body of research on mHealth-based interventions for substance use, with aims of (a) examining the functionality and effectiveness of these interventions, (b) evaluating the available research on the effectiveness of these interventions for substance use, and (c) evaluating the design, methodology, results, theoretical grounding, limitations, and implications of each study. We identified eligible studies by searching electronic databases using Boolean methods. The reviewed studies (N = 12) indicated that that a wide range of Internet-based, text messaging, and smartphone application interventions have been developed to address substance use. Interventions had an assortment of features; participants in each study highlighted the ease and convenience of the interventions; and the majority of studies provided support for the efficacy of mHealth in reducing substance use. Mobile technology is a promising tool for reducing substance use and warrants further development. Future practice including the use of mHealth interventions can be an integral part of reducing substance use.

Substance abuse and its related consequences are a major public health problem for young adults impacting individuals, families, communities and society as a whole (Shillington, Woodruff, Clapp, Reed, & Lemus, 2012). Substance use contributes to morbidity and mortality among youths and young adults with significant consequences including criminality, sexually transmitted diseases (STDs), HIV, academic failure, and violence (National Center for Health Statistics, 2014). Results of the 2014 National Survey on Drug Use and Health (NSDUH) demonstrated that the prevalence of substance use among young adults was 22% among those transitioning into young adulthood (18–25 years) (Center for Behavioral Health Statistics and Quality [CBHSQ], 2015). Alcohol is the most commonly used substance, with one out of three young adults reporting binge drinking (CBHSQ, 2015). Binge drinking is associated with substantial negative consequences including annual rates of 646,000 physical assaults, 97,000 sexual assaults, 599,000 unintentional injuries, and 1,825 deaths (NCHS, 2014; White et al., 2015). Excessive alcohol use is one of the greatest societal, medical burdens with an annual cost exceeding $250 billion per year, (Sacks, Gonzales, Bouchery, Tomedi, & Brewer, 2015). Next to alcohol, marijuana is the second most used substance and is also often found in victims of fatal automobile accidents, highlighting the potential negative consequences of the drug (National Institute on Drug Abuse [NIDA], 2016a). Additionally, among first-time substance users, about 25% use nonmedical psychotherapeutics, 6.3% use inhalants, and 2% use hallucinogens (NIDA, 2016b).

In the United States, 91% of adults use a mobile phone with over 50% owning smartphones (Milward, Day, Wadsworth, Strang, & Lynskey, 2015; Smith, 2015). Those in "Generation Z" who have extensive access to digital technology view communication using this technology (e.g., text messaging, online chat and email, cell phone app) as natural, comfortable, and essential to social environments (Issa & Isaias, 2016; Ozkan & Solmaz, 2015; Turner, 2015). Further, technologies such as mobile apps, text messaging and online chat increase receptivity to new information and verbalization in this age group (O'Keeffe & Clarke-Pearson, 2011; Ozkan & Solmaz, 2015). Young adults are "digital natives," comfortable with using mobile technology every day to communicate private information (O'Keefe & Clarke-Pearson, 2011; Shrier, Rhoads, Burke, Walls, & Blood, 2014). Mobile phone users exchange ideas, personal news, and photographs while also communicating with friends, family, and others who have similar interests (O'Keeffe & Clarke-Pearson, 2011). Mobile technology has evolved since the 90s to the current era of the smartphone.

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Smartphones are used for communicating, posting photos, entertainment, event planning, sending and receiving messages, meeting people, downloading applications and obtaining information (Bernhardt et al., 2009; Ozkan & Solmaz, 2015).

Short messaging service (or SMS, also referred to as text messaging) is a widely popular wireless service now used by the general public for pleasure, safety, and economics. Text messaging remains one of the most vital features of mobile phone users and is a vital source of communication for the public. Text messaging among Americans is now more widely used than phone calls (Cingel & Sundar, 2012), and in 2009, over one trillion text messages were received and transmitted in the United States. (see Cingel & Sundar, 2012). The overwhelming evidence that mobile technology is a preferred mode of communication in today's society has resulted in its use as a strategy for intervention for high-risk health behaviors (Cohn, Hunter-Reel, Hagman, & Mitchell, 2011; Underwood, Rosen, More, Ehrenreich, & Gentsch, 2012).

mHealth is a general term that stands for "mobile health" and describes the use of wireless technology in the delivery of medical care (Fjeldsoe, Marshall, & Miller, 2009; Patrick, Griswold, Raab, & Intille, 2008). mHealth interventions provide behavioral support through a variety of features including delivering educational information supportive, and positive text messages and goal selection. The content of the mobile features is tailored to specific populations, and the intervention may be delivered in conjunction with other therapies. mHealth interventions have been proven as evidence-based methods for concentrating on health treatments (Bock et al., 2015; Mason, Benotsch, Way, Kim, & Snipes, 2014) and have been used successfully for clinical assessment and education in medicine and public health (Christie, Dagfinrud, Dale, Schulz, & Hagen, 2014; Cooray, Matusevicius, Wahlgren, & Ahmed, 2015). Meta-analysis studies of mHealth clinical interventions for smoking cessation, weight loss, and diabetes control demonstrate these interventions are both cost effective and beneficial (Bakken et al., 2014; Gerber, Stolley, Thompson, Sharp, & Fitzgibbon, 2009; Pal et al., 2014; Riley, Obermayer, & Jean-Mary, 2008; Whittaker et al., 2012; Wieland et al., 2012). Results from these studies indicate that mHealth interventions are becoming increasingly popular in a variety of health settings across diverse cultures (Buhi et al., 2013). Limited research, however, has evaluated the application of mHealth to address substance use issues in adults (Bernhardt et al., 2009; Kazemi, Cochran, Kelly, Cornelius, & Belk, 2014; Kuntsche & Robert, 2009).

To date, researchers have primarily examined electronic-based interventions that utilize computer screenings and handheld devices for the intervention sessions (Bingham et al., 2010). For example, meta-analysis studies on alcohol use prevention over the past two decades focused solely on the use of technology-based interventions (TBI) web, handheld devices, and internet (Bewick et al., 2008; Donoghue, Patton, Phillips, Deluca, & Drummond, 2014; Elliott, Carey, & Bolles, 2008; Hester & Miller, 2006). Two recent reviews have evaluated the commercial applications available for substance intervention using smartphones via Apple's App Store and Google Play (Cohn et al., 2011; Savic, Best, Rodda, & Lubman, 2013). Common features of these apps included motivational and educational material, support tools, and instruments for monitoring and tracking alcohol use (Cohn et al., 2011; Savic et al., 2013). However, there is limited empirical evidence of the effectiveness of mHealth technology for substance use prevention (Cohn et al., 2011; Litvin, Abrantes, & Brown, 2013; Quanbeck, Chih, Isham, Johnson, & Gustafson, 2014; Savic et al., 2013). One review by Quanbeck et al. (2014) examined mobile applications for patients with Alcohol Use Disorder (AUD). The findings suggest that popular, text-based interventions may be inadequate for AUD recovery management. The review also highlighted the lack of studies which rigorously evaluate the feasibility of mHealth interventions, perhaps due to challenges including keeping up with technology advances, limitations in feature effects, and cost barriers (Quanbeck et al., 2014).

To address this gap, the purpose of this review is to provide a systematic critique of peer-reviewed research that identified mHealth intervention focused on substance use prevention. Specifically, the review presents the design, methods of mobile intervention, outcomes, strengths, and limitations of studies that were examined. This review seeks to address the following topics: (a) the current state of rigorous peer-reviewed original research designed with mHealth interventions for substance use; (b) the efficacy of mHealth interventions in reducing substance use; and (c) promising directions for future research and evidence-based professional practices in the use of mHealth interventions for substance use. This review is intended to contribute to the evidence-based literature and to inform health professionals on the feasibility and efficacy of mHealth interventions for reducing substance use.

Method

Search Strategy

We conducted a search of the mobile intervention literature using Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher, Liberati, Tetzlaff, & Altman, 2009). Boolean searching methods were used for the literature review. Boolean concepts use AND, OR, NOT combinations when searching key terms (Goodwin & Johnson-Laird, 2013). The databases were searched simultaneously. Keywords used were variations of mobile interventions (SMS, text message, cell phone, mobile phone, telephone, mHealth), and substance use (alcohol, marijuana, substance use disorder). When the OR combination was used, either or term was featured in the search, but not necessarily both terms. The first search terms used were "mobile" OR "phone" OR "texting" OR "SMS." When two words or more were used with AND combination, all words were featured in the search. For example, we combined the original terms with the search terms: "mobile" OR "telephone" OR "texting" OR "messaging" OR "SMS" OR "cell" OR "smartphone" AND "treatment" OR "intervention" OR "behavioral intervention" OR "mHealth" AND "alcohol" OR "substances" OR "drug abuse" OR "addiction" OR "marijuana." Finally, a search using the NOT combination resulted in the exclusion of web pages with the term featured in the article.

We used the following databases to index articles: PubMed, Wiley, Science Direct, Web of Science, Cochrane, Medline, SAGE, CINAHL, PsychINFO, PsychARTICLES, and ERIC.

We also performed technical reports and manual searches of the reference sections in the resulting articles. The inclusion criteria for the articles included: (a) peer-reviewed original research, (b) published from 2005 to 2015 and in English, and (c) interventions used mobile communication (mHealth) and addressed substance use. Studies were eligible if they included adolescents or adults who reported using substances, had an intervention component and outcome measure. We excluded studies that assessed computer web-based interventions, used exclusively for electronic screening. Because the use of smartphones has seen dramatic growth in the past 10 years (Smith, 2015), we began our search in January 2005. Grey literature found in the search including book chapters, letters to the editor, and commentaries were excluded (Alberani, De Castro Pietrangeli, & Mazza, 1990).

Data Extraction and Analysis

For each of the final articles, data were extracted on the sample, design, intervention, results, and outcomes (see Table 1). Specifically, we examined data related to the research topics including design (e.g., randomized, single-blinded), clinical outcomes (e.g., drinks per drinking day, number of heavy drinking days), features of the mHealth intervention (e.g., app, SMS text based, real time, GPS content), and key finding and limitations of using mHealth interventions. A meta-analysis was not appropriate for the following reasons: (a) study populations for the studies are so different, including young college students and ED discharges; (b) not all the studies are randomized; (c) even among those randomized studies, primary outcomes are very different; and (d) statistical methods used to analyzed the data are also different.

Results

The initial electronic search resulted in 89,755 citations (see Figure 1). After we had removed duplicates, 18,540 citations remained. The research team then screened through the articles looking for inclusion criteria and eligible titles. A total of 274 abstracts were eligible to be screened. Three researchers then screened each abstract for relevance to the inclusion criteria. Out of 274 articles, 252 were found ineligible since they did not meet the inclusion criteria, leaving twenty-two full-text articles eligible for assessment. We excluded studies that used mobile technology only to assess substance use, rather than attempt to intervene (e.g., Kuntsche & Robert, 2009; Witkiewitz et al., 2014). Three researchers independently reviewed the final 22 articles. The researchers evaluated the studies and reached consensus on inclusion for the analysis. Using the Cochrane's approach the bias of risk assessment was conducted by the three independent reviewers until consensus was reached (Higgins & Green, 2008).

Interrater reliability between them for yes/no inclusion decision was 0.90, indicating strong agreement (Landis & Koch, 1977). Discrepancies in the selection of articles for review were discussed until consensus was reached. Ten articles were removed from the final selection for the following reasons, no interventions (screened/assessed substance use only) (n = 7), practitioner assessment tool (n = 1), and no use data provided (n = 2). Each researcher independently analyzed these articles reaching an agreement to include twelve final articles to code and analyze (n = 12).

Overview of Major Findings

This large degree of heterogeneity among the 12 studies precluded a formal meta-analysis. Instead, we provided a comprehensive summary and critique of the studies that included participants, design, intervention, theoretical constructs, major findings, strengths and limitations (see Table 1). Bias in five sources: selection, performance, detection, attribution, and reporting was examined using Cochrane's approach (Higgins & Green, 2008). We emphasized more on random number generation, allocation, and reporting to obtain our conclusion of low risk of bias in most of the studies.

Participants

The studies' participants varied across studies, to include adults with an alcohol disorder, college students experiencing problematic drinking, youth transitioning out of community-based substance abuse treatment programs, and individuals with psychotic disorders. The participants ranged from school-aged children 12–45 years, with the majority of participants between 18 and 25 years. The participants represented both genders were mostly European Americans with other races/ethnicities represented including African-Americans, Hispanic, Asian Pacific and Native American. A range of substances was used by the participants in the studies, but by far the most frequently reported substances were alcohol and marijuana.

Study Designs

Nine of the twelve studies were randomized trials. Two of the nonrandomized studies used a single group, pre–postdesign (Haug et al., 2013; Shrier et al., 2014) and the third nonrandomized study used block/sequential assignment (Lucht et al., 2014). Most of the studies did not blind interventions to participants and researchers; no significant difference in dropout rates was reported in different intervention groups. No obvious selective reporting was observed. Overall, most of the studies reviewed are believed to bare a low risk of bias.

Interventions

mHealth interventions were delivered in a variety of formats: web-based, text messaging, SMS, or smartphone applications (app). Some interventions were provided as stand-alone (Agyapong, Ahern, McLoughlin, & Farren, 2012), while others were delivered in combination. For example, combined interventions included both an app and web-based components while others were only text based (Gajecki, Berman, Sinadinovic, Rosendahl, & Andersson, 2014; Gonzalez & Dulin, 2015; Haug et al., 2013; Weitzel, Bernhardt, Usdan, Mays, & Glanz, 2007).

The length of the interventions varied considerably, ranging from 2 weeks (Weitzel et al., 2007) to 3 months (e.g., Suffoletto et al., 2014) to 8 months (Gustafson et al., 2014). Also, several mHealth interventions were used as a supplement to in-person treatment protocols. For example, to supplement youths transitioning out of residential treatment or emergency departments (Gonzales, Ang, Murphy, Glik, & Anglin, 2014; Gustafson et al., 2014; Haug, Lucht, John, Meyer, & Schaub, 2015;

Table 1. Published studies evaluating mobile interventions for alcohol and substance use ($N = 12$).

Citation	Sample characteristics	Design	Intervention components	Results	Key findings
Weitzel et al. (2007)	U.S. college students Eligibility 18+ years old Drinking 1x or more per week Alcohol Use Wireless Handheld Computers (Provided) Study staff sent messages Screened: 140 Eligible: 79 HH and HHM: 40 Average Age: 19.2 Males: 18 (45%) Female: 22 (55%)	Randomized Pilot Trial Pre/postdesign Groups Handheld Only (HH; $n = 20$) Handheld + Messaging (HHM; $n = 20$) Assessments Baseline 2 week Outcome variables Total drinks during study Drinking Days Drinks per Drinking Day Negative Consequences Negative Consequences per day Alcohol Consequences Expectancies Scale Alcohol Consequences Self-Efficacy Scale	Handheld only (HH): Received daily instructions to record drinking experiences: Amount and type of alcohol consumed, consequences, and if not drinking whether had been with drinkers and where. Handheld ± Messaging (HHM) In addition to HH assessment, received daily (by 5 pm) messages about avoiding alcohol-related consequences, tailored to self-reported baseline drinking levels and daily reported drinking Not able to respond to text Intervention period 2 weeks	High levels of survey completion in both HH (83%) and HHM (85%) ANCOVA revealed HHM group reported fewer drinks per drinking day ($p = .02$) No other group differences on alcohol variables	Demonstrated feasibility of assessing alcohol use and delivering messages via handheld computers Text messages developed for study and may not generalize to other samples Texts were sent by study staff, automation may make approach more feasible Providing handheld computers may not be feasible given current widespread use of SMS on personal phones Small sample size and low dose intervention limited power of analyses
Agyapong et al. (2012)	Adults in Ireland completing 4 week inpatient treatment. Alcohol Use Personal phone Eligibility Diagnosis of major depressive disorder and alcohol dependence/ abuse Screened: 120 Eligible: 54 Average Age: 49.48 Males: 25 (46.3%) Females: 29 (53.7%)	Single-blinded, Randomized, Pilot Trial Pre/postdesign Groups: SMS ($n = 26$) Control ($n = 28$) Assessments Baseline 3 months Outcome variables Cumulative Abstinence Duration (CAD) = total days abstinent since discharge	SMS group participant received Twice Daily supportive messages sent at 10 am and 7 pm by computer program 180 messages addressing stress, mental well-being, abstinence from alcohol, dealing with cravings, compliance with medication, and developing a support system. Control group received texts every 14 days thanking them for participation in the study. Not able to respond to texts Intervention period 3 months	No significant group differences on: CAD ($p = .08$) Alcohol Abstinence Self-Efficacy ($p = .09$) Obsessive Compulsive Drinking Scale ($p = .40$) Days to first drink ($p = .49$) Units of alcohol per drinking day ($p = .10$) SMS group reported significantly more satisfaction with postinpatient care [$t(48) = 2.4$, $p = .02$] and overall satisfaction with treatment [$t(48) = 2.2$, $p = .04$].	High follow-up rate and satisfaction ratings indicate that SMS is a feasible intervention for dual diagnosis population Trends toward significant reductions in CAD and other alcohol variables may have been affected by small sample size SMS messages tended to be directive and instructive Automated times and lack of personalization of messages may enhance future SMS efforts Small sample size

Suffoletto et al. (2012)	Young adults in 3 urban emergency department (ED) Alcohol Eligibility: Own cell phone, hazardous drinking (AUDIT-C Score 4+ for men/3+ for women) Personal phones with SMS Approached: 109 Screened: 106 Average Age: 21.0 Males: 16 (35.6%) Female: 29 (64.4%)	Randomized Pilot Trail Pre/postdesign Groups SMS (n = 15) Assessment (n = 15) Control (n = 15) Assessments Baseline 3 Month Outcome Variables No. HDDs No. DPDDs Percent of Subjects with No Drinking Days	SMS Received weekly text messages assessing use and received computer-sent personalized text messages based on response. Responses included requests and tips for reducing alcohol use. Two way communication with texts Assessment Each week for 12 weeks, received a text asking them to report drinking. Control Received weekly text messages reminding them of upcoming 3 month assessment. All participants provided 16 page booklet *Rethinking Drinking* Intervention period 3 months	The SMS group reported significantly greater change in HDD (p = .04) and DPDD (p = .0002) in the past month. 8 participants (31%) read the 16 page booklet 93% of participant's responded to at least one text over 12 week study period. 73% of assessment group and 80% of SMS group completed all 12 weeks of text queries.	20% of participants did not respond to texts in the 11th week of the study, indicating that engagement and interest may have been waning. Text messaging may be a useful approach to collecting drinking data Limitations included small sample size, potential response bias.

(*Continued*)

Table 1. (Continued)

Citation	Sample characteristics	Design	Intervention components	Results	Key findings
Haug et al. (2013)	Students from 7 vocational schools in 36 school classes from Switzerland. Eligibility: Personal Phone Fully automated LANPP system Screened:488 Mobile Phones: 477 Intervention: 364 Follow-up: 280 Withdrew: 23 Participants entered into drawing for ten 50 euro prizes	Longitudinal pre–postdesign Group Alk-Check (n = 364) Assessments Baseline 3 months Outcome Variables Risky single-occasion drinking (RSOD) DPW PDDD Alcohol-related problems	Alk-Check A tailored Web and SMS with computer generated online feedback and SMS messages. Feedback included graphical and textual information content and number of text messages were tailored according to baseline Alk-Check assessment. Messages tailored to High, Low and Nonrisk groups. High and low risk groups both received one text message per week and additional biweekly text messages on individual typical day and time. All the participants were sent weekly messages about motivation of sensible drinking and risks of binge drinking and information customized depending on the group. Not able to respond to texts Intervention period 3 months	Participants had a lower level of educational attainment and a higher maximum number of drinks on a single occasion. GEE models indicated a significant decrease from baseline to follow-up on: RSOD (OR = 0.66, 95% CI = 0.53–0.83, p < .001). DPW (OR = 0.83, 95% CI = 0.74–0.93, p = .002) Alcohol-related problems (OR = 0.60, 95% CI = 0.41–0.88, p = .009)	The program was available to approximately 75% of students. Acceptance of program was good with 94% of participants staying logged in and reading SMS messages. Only 6.3% unsubscribed, indicating overall willingness for frequent contact. The SMS messages were perceived as being individually tailored by only 34% of participants, while 50% perceived the web feedback was perceived as being tailored. This difference may reflect limits of personalization due to SMS character counts. Limitations include lack of randomized control group, differentia dropout rate (18%)

Suffoletto et al. (2014)	Emergency department (ED) patients Eligibility: Aged 18–25; Nontreatment seeking; not been enrolled in alcohol-related study in past year; hazardous alcohol use (AUDIT-C Score 4+ for men/3+ for women) Own cell phone with text messaging Eligible for screening: 4141 Approached: 3879 Screened: 3061 Eligible: 1021 Randomized: 765	Randomized clinical trial Pre/postdesign Groups: SMS Assessment + Feedback (SA+F; n = 384) SA (SA; n = 196) Control (n = 185) Assessments Baseline 3-month follow up Outcome variables Self-reported No. binge drinking days No. drinks per drinking day	SMS assessment + feedback: Participants responded to drinking-related queries and received real-time feedback through SMS each Thursday and Sunday for 12 weeks. Two way communication with texts SMS only: Participants responded to alcohol consumption queries each Sunday but did not receive any feedback. Control Did not participate in any SMS Intervention period 3 months	No baseline differences between groups on demographic, substance use, and medical variables examined No difference in response rate between SA+F and SA groups Decreases number of binge drinking days from baseline to 3 months in the SA+F group (−0.51, 95% CI = [−0.10, −0.95]); Increased number of binge drinking days in the SA group (0.90, 95% CI = [0.23, 1.6]); Decreased number of drinks per drinking day in the SA+F group (−0.31, 95% CI = [−0.07, −0.55]) Increased number of drinks per drinking day in the control group (0.39, 95% CI = [0.06, 0.72])	The text message based intervention produced small reduction in self-reported binge drinking and number of drinks consumed per drinking day in hazardous-drinking young adults after ED discharge Participants not blinded to the intervention condition Differential loss to follow-up among heavier drinkers may introduce attrition bias The conclusion cannot be applied to more general population

(*Continued*)

Table 1. (Continued)

Citation	Sample characteristics	Design	Intervention components	Results	Key findings
Gajecki et al. (2014)	University Students in Sweden Eligibility: Personal Phone with Andriod or iOS Reporting AUDIT cutoffs of ≥6 for women and ≥ 8 for men) for hazardous drinking. Invited: 28574 No response:23751 Consented: 4832 Incomplete:415 Below AUDIT Cutoff: 2378 No phone: 98 Randomized: 1932 *Age* = 24.72; Males: 931 (48.3%) Females: 998	Randomized Clinical Trial Pre/postdesign Groups No Treatment Control (n = 649) Promillekroll (n = 643) Party Planner (n = 640) Assessments Baseline 7 Weeks Outcome variables DPW OPW HED per week eBAC (past week) pBAC (past month)	Promillekoll (smartphone app) Planned Behavior (TPB) with informational texts. Stand-alone publicly available app. Registering alcohol consumption with instant visual eBAC. Real time BAC Warning BAC eBAC over 0.06. No user data are collected. Party Planner (web-based app requiring internet connection) Simulated events where alcohol consumed. Pre-party planning simulations. Real-time registrations with feedback. Color codes indicated eBAC risk level. Usage not measured. Intervention period 7 weeks	Promillekoll Rated easier to use than Party Planner Male users increased the frequency “episodes” of drinking. Does not display eBACs over 0.08 limiting how far the “game” can go. App negative effect for men but not for women. Reported greater HED than control at 7 week assessment ($Z = 3.39$, $P = .001$); no other differences ($p > .20$) Party Planner Attrition rate of 39% higher than Promilekoll (26.4%) and Control (22.7%) Higher proportion of male attrition with higher alcohol consumption. Did not affect men negatively with planning ahead and comparing real drinking events with plans. No differences from control in drinking variables ($p > .20$)	Promillekoll users may have relied on the app to reduce negative effects of drinking therefore drank more often. Feasibility to offer app based intervention to large number of college students. App design to ensure minimum of human interaction. Theory based protective cognitive and behavioral strategies. University students are a highly important target group where risking drinking and smartphone app use are prevalent. May be important to adapt apps for women and heavier drinkers (linking to services) Attrition considerable, apps can be adapted to increase interest and engagement eBAC calculator in app form is not effective for reducing alcohol consumption among college students

Gonzales et al. (2014)	Youths transitioning out of outpatient and residential treatment programs. Substance Use Eligibility: Age between 12 and 25 years old Personal phone with SMS Invited: n/a Consented: 80 Randomized: 80 *Average Age* : 20.4 Males (73%) Caucasian (43.2%) Hispanic (37.8%), African American (9.5%), Asian/Pacific Islanders (8.1%), Native American (1.4%) Primary drug use: marijuana (55%), methamphetamine (29%), cocaine (15%), heroin (11%)	Randomized Pilot Trial Groups ESQYIR (Educating and Supporting Inquisitive Youth in Recovery) Mobile-based aftercare intervention (n = 40). Aftercare as usual standard control (n = 41). Assessments Baseline (1 week post discharge) 1 month 2 month Discharge from Aftercare 90 Days Outcome Variables Urinalysis (yes/no) Substance Use (T-ASI) Substance Use Severity (GAIN) Participation in recovery activities such as 12-step groups (BAM) Personal information de-identified, secured on encrypted database, and password protected	ESQYIR Intervention: Database with servers maintained in HIPAA-compliant data centers over secure channels. Theory- based Social Cognitive Theory (SCT). Online management portal with message creation feature, reporting tools (monitoring dashboards). SMS messages sent to participants Self-monitoring texts sent daily at 4 pm and inquired about low confidence, mood, stress, etc., and responses from participants were answered in 1–30 seconds with Feedback texts of positive messages, tips and advice from a pool of over 600 text messages, programmed not to repeat. Feedback text messages linked to severity of monitoring text responses Daily wellness text at noon of a recovery/wellness tip of the day Weekend text messages of substance use education topics or local resources adapted to specific substance of choice Two way communication with texts Intervention period 3 months	At the 90 day follow-up: ESQYIR participants were less likely to have a positive urinalysis (OR = 0.52, 95% CI 0.34–0.78, p = .002) ESQYIR participants reported significantly less substance use severity (β = -.46, p = .002) ESQYIR participants reported significantly more involvement in recovery activities (β = 1.63, p = .03) Younger participants had higher odds of relapsing compared to older participants (OR = 0.89; 95% CI 0.81–0.99, p = .03).	Novel theory based (SCT) mobile aftercare model (i.e., texting) engage youth in recovery by motivating them to engage in recovery behaviors. Self-monitoring feature of aftercare intervention encourages healthy behavior change in a variety of areas. Promotes self-regulation and control. Texting intervention served as a buffer towards youth relapse 3 months after treatment. Intervention was intensive, with several texts per day and repeated reminders to respond to SM texts, although future interventions can be automated Limitations included participants' self-selection, un-reported drop-out rates and how many texts were not responded to.

(*Continued*)

Table 1. (Continued)

Citation	Sample characteristics	Design	Intervention components	Results	Key findings
Gustafson et al. (2014)	Adults exiting residential alcohol treatment program Eligibility: At least 18 years old Smartphone with ACHESS system and data plan (provided) Screened: 380 Ineligible: 13 Declined: 18 Randomized: 349 Average age:38 Male 61% White: 80% Monetary incentives provided Phones: 56 did not work properly 19 were stolen 20 damaged 22 lost	Randomized Controlled Trial Groups ACHESS (n = 170) for 8 months, and then 4 months of treatment as usual (TAU; CBT and MET (individual and in groups) and/or weekly AA meetings. Control (n = 179): Received 12 months of TAU. Assessments Baseline 4 month 8 month 12 month (4 month postACHESS) Outcome variables Risky Drinking Days (4+ drinks for men, 3+ drinks for women)	ACHESS: Contained content (e.g., relaxation exercise) as well as GPS initiated alerts (e.g., if patient entered bar, would receive message inquiring about desire to be there). Participants completed weekly BAM Index and/or whether they had lapsed, and could give permission to share information with counselor. Self-Determination Theory is basis of A-CHESS, focusing on enhancing personal perceptions of competence, relating to others, and being intrinsically motivated rather than coerced. Two way communication with texts Intervention Period 8 months	Patients completed 3751 weekly BAMs and shared 93.5% with counselors, less than information about a lapse in abstinence (41.9%) At the 12-month follow-up, participants in the ACHESS group reported Lower risky drinking days ($t_{(757)} = 2.28$, $p = .023$) Greater abstinence rates in past 30 days (OR = 1.65, 95% CI = [1.05, 2.57], $p = .032$). Number of ACHESS pages viewed and days used were significantly associated with risky drinking days. Perceived competence reported at 4 month assessment-mediated intervention effects on number of risky drinking days at 8 months.	Well conducted study with high follow-up rates (78% at 12 months). 18 participants refused to participate because they did not like the GPS tracking system Patients' use of ACHESS declined over the course of the study, although a lower rates than observed in other studies (90% used at least once in months 1–4, 58% in last week prior to 8 month assessment). Theoretical indication of mechanisms of behavior change (perceived competence) Unclear which specific components of A-CHESS facilitated drinking reductions Costs of A-CHESS per patient ($597/patient) may limit generalizability and dissemination

Lucht et al. (2014)	Patients being discharged from detox at psychiatric center in Germany. Eligibility: 18+ years old Alcohol detoxification and alcohol dependence Personal Phone with SMS Screened: 160 Recruited: 80	2 group, block-assigned Pilot Trail Pre/postdesign Groups Treatment at Usual (TAU; n = 38): Could access Inpatient/ Outpatient services in region SMS + TAU (n = 42) Assessments Baseline 30 days 60 days Outcome variables DD DDD Hard drinking days (HDD; 6 + drinks/day) Abstinent days (AD)	Interactive Short Message Service SMS system Hardware components included standard personal computer (PC) with internet and Global System for Mobile Communications (GSM) modem Linux operating system SMS sent via modem from the providers' PC to patients' mobile phones (cellular phone networks) 2 times per week (Monday, Thursday): *Dear Mr/Mrs X, did you drink alcohol or do you need help?* If YES, SMS system sent email to notify therapist to call patient within 24 hours If NO, one randomly chosen (of 40) responses sent (e.g., "Good job!"). Two way communication with texts Intervention period 8 weeks	Repeated measures MANOVA revealed no significant differences were found between the groups on DD, DDD, HDD, and AD (ps > .10) SMS patients reported more inpatient detox days, psychiatric hospital days, and abstinence clinic days than TAU (ps < .05) SMS group reported first relapse later than the control group. Participants replied 50% of the time to the text prompts with "NO", 38.8% with no response, 3.6% with other text, and 7.5% with 'YES'	In a high-risk population, SMS can facilitate access to counselors with low time commitment; the SMS system performed 3006 contacts, 20.5% of messages led to phone call by counselor (averaging 3–4 calls per day total). SMS good feasibility and acceptability of an 8 week interactive program. SMS-based approach not a complete replacement for treatment as indicated by significant treatment received by participants after detox Limitations include small sample size, block assignment procedure, lack of collateral verification, and group differences in pretreatment consumption variables

(*Continued*)

Table 1. (Continued)

Citation	Sample characteristics	Design	Intervention components	Results	Key findings
Shrier et al. (2014)	Primary Care patients in Northeast U.S. Marijuana use Personal digital assistant (PDA) provided Eligibility Use marijuana 3+ times per week Enrolled: 27 Initial screen: 22 Intervention: 16 Male: 30% Age: 19.2 (15–24) Remuneration of up to $280	Single group pilot trial Group Momentary Self-Monitoring and Feedback + Motivational Enhancement (MOMENT; n = 16) Assessments Baseline Intervention 3 Month Follow-up Outcome variables PDA POSIT	17 week program with 3 study phases (baseline, intervention, and follow-up) 6 study visits and 3 mobile momentary reports and daily diaries. Counselor conducted two 1-hour motivational enhancement therapy (MET) sessions identified top 3 trigger situations. After 2nd MET session, participants completed momentary self-monitoring using programmed PDA MOMENT messaging directly applied motivational intervention in context of daily life, supported self-efficacy and prompted coping strategies. Participants received coping strategies in a text message format when they reported being in a top-3trigger situation Two way communication with texts Intervention period 3 weeks	GEE models revealed no significant reductions in PDA and POSIT scores from baseline to 3 month follow-up ($ps > .10$) 377–677 momentary, 50–106 daily reports per study phase. Desire to use during a top-3 trigger exposure decreased significantly ($p < .0001$). Top triggers most frequently selected being at home, a friend's house or a relative's house (45%); being with friends (44%); hanging out or resting/about to sleep (45%); feeling stressed, frustrated, bored or anxious (86%).	MOMENT feasible, well-accepted and efficacious for extending clinic based motivational counseling for heavy marijuana use MOMENT holds promise for improving momentary, daily and individual-level marijuana-related outcomes as messages personally tailored relevant and timely immediate feedback messages. Participants reported reading the messages and finding them motivating, being comfortable and not burdened. Participants did not report concerns reported of privacy or confidentiality issues. Limitations included lack of control group, high pre-intervention attrition rate, small sample size

Haug et al. (2015)	Swiss adults completing outpatient treatment Alcohol Personal mobile phone with text messaging Eligibility Outpatient treatment was completed, no cognitive impairment or language barrier. Enrolled: n/a Randomized: 50 Male: 72% Age: 50.4	Two-group randomized pilot trial Pre/Postdesign Single-blind (Counselors) Groups Intervention (n = 25): Six months of receiving individually tailored text messages weekly (wks 1–8) or bi-weekly (wks. 10–26). Assessment Only Control (n = 25) Assessments Baseline 6 months Outcome variables AUDIT-C Treatment Utilization	Interactive Short Message Service SMS system Hardware components included standard personal computer (PC) with internet and Global System for Mobile Communications (GSM) modem Linux operating system Monitoring of self-selected drinking goals (abstinence, controlled drinking) sent Mondays at 6 pm Motivational text messages to support self-selected goals. Telephone calls from counselor when participants reported need of support on nonadherence to drinking goals Control group received total of 421 text message prompts. Theory based on behavioral self-control techniques and social support. Two way communication with texts Intervention Period 6 months	No group differences emerged in: Rates of risky alcohol use (AUDIT-C score of 4+; OR = 0.56, 95% CI: 0.16–1.95, p = .36) Engagement in alcohol treatment (OR = 1.50, 95% CI: 0.45–5.03, p = .51) 421 text messages prompted a total of 371 (88.1%) replies within 48 h. 11 (44%) intervention group participants sent at least one call for help reply.	Interactive low-intensive aftercare program was well accepted by all participants. Ability to receive support from counselors rated as helpful by all participants. Generalizability of approach limited by lack of assessment of the time period or number of phone calls needed to reach the participants in case of a call for help email. Limitations include small sample size, possible recruitment bias (counselor concerns regarding no treatment control condition), lack of assessment of drinking cues, cravings, more detailed drinking measures, and participants could not change goals over the 6 months.

(*Continued*)

Table 1. (Continued)

Citation	Sample characteristics	Design	Intervention components	Results	Key findings
Gonzalez et al. (2015)	Individuals with alcohol use disorder & minimally motivated Eligibility: 18–45 years old Experiencing problems with alcohol Smartphones and laptops provided Screened: 228 Unable to text or use email: 18 Consented: 99 Randomized: 60 Received Intervention: 54 Completed: 48 Monetary incentives provided	Randomized Pilot Trial Pre/Postdesign Groups Location-Based Monitoring and Intervention for Alcohol Use Disorders (LBMI-A; *n* = 28) Web-based & Drinker's Check-up (DCU) supplemented by bibliotherapy (DCU + bib; *n* = 26) Assessments Baseline Weekly for 6 weeks Outcome variables Percent days abstinent (PDA) Percent heavy drinking days (PHDD) Drinks per week (DPW) The Short Inventory of Problems for alcohol-related problems (SIP) Severity of alcohol dependence (SADQ) The Structured Clinical Interview for *DSM-IV* (SCID) The URICA alcohol version for motivation to change	LBMI-A (smartphone): Seven psychoeducation modules (steps) Assessment and weekly feedback, tracker capabilities. High-risk locations for drinking. Selecting and using support people for change. Cravings and their management. Problem-solving skills Communication and drink refusal skills. Pleasurable nondrinking. DCU ± bib (laptop) 56 minute Web based BMI Assessment of drinking and problems, objective and norms-based feedback 2. Decisional balance exercise to resolve ambivalence about change. 3. Goal selection/Change plan. 4. Link to online resources. 5. Provided 16 page *Rethinking your Dinking* booklet (50% read entire booklet) One way communication Intervention period 6 week	Drinking outcomes PDA: Significantly differed in change over the course of study. LBMI-A group experienced an increase in PDA ($p < 0.001$) over the course of the study. The DCU +bid group did not experience significant change (*p*s>0.3). The LBMI-A group demonstrated large effect sizes for change from baseline for week 2 to 6 by Cohen's d. PHDD: There was a greater diminishment of change in PHDD in the LBMI-A group ($p = .001$) compared with the DCU+bid group ($p = .013$). The LBMI-A group demonstrate large effect sizes than DCU+bid group at each time point using Cohen's d (0.83, 0.85, 1.01, 1.09, 0.89, and 0.94 vs. 0.57, 0.65, 0.69, 0.57, 0.77, and 1.10 at week 1, 2, 3, 4, 5, and 6) DPW: DPW decreases over time for both groups ($p < .001$ for LBMI-A and $p = .003$ for DCU = bid). DCU+bib group showed medium within group change and the LBMI-A group demonstrated medium to large effect sizes.	LBMI-A resulted in a significant increase in PDA over the course of the study, but not DCU+bib; Within group effect size for change from baseline are large in the LBMI-A group and moderate in the DCU+bib group. Both interventions resulted in significant decreases in PHDD and DPW. Cost-effective and accessible. Limitations included small sample size, sequential delivery of interventions due to limited resources, and compensation was different based on group

Note. A-CHESS = Addiction: Comprehensive Health Enhancement Support System; AUDIT = Alcohol Use Disorders Identification Test; BAM = Brief Alcohol Measure; BPD = Borderline Personality Disorder; DPDD = Drinks per Drinking Day; DPW = Drinks per week; eBAC = Estimated Blood Alcohol Content; GAIN = Global Appraisal Inventory of Needs; GEE = Generalized Estimated Equation; HED = Heavy episodic drinking; LANPP = Linux, Apche server, MySQL database; MET = motivational enhancement therapy; OPW = drinking occasions per week; pBAC = Peak Blood Alcohol Content; PHP-programming language; SMS = Short Message Service; SMS = Secure Messaging System; T-ASI = Teen Addiction Severity Index; US = United States.

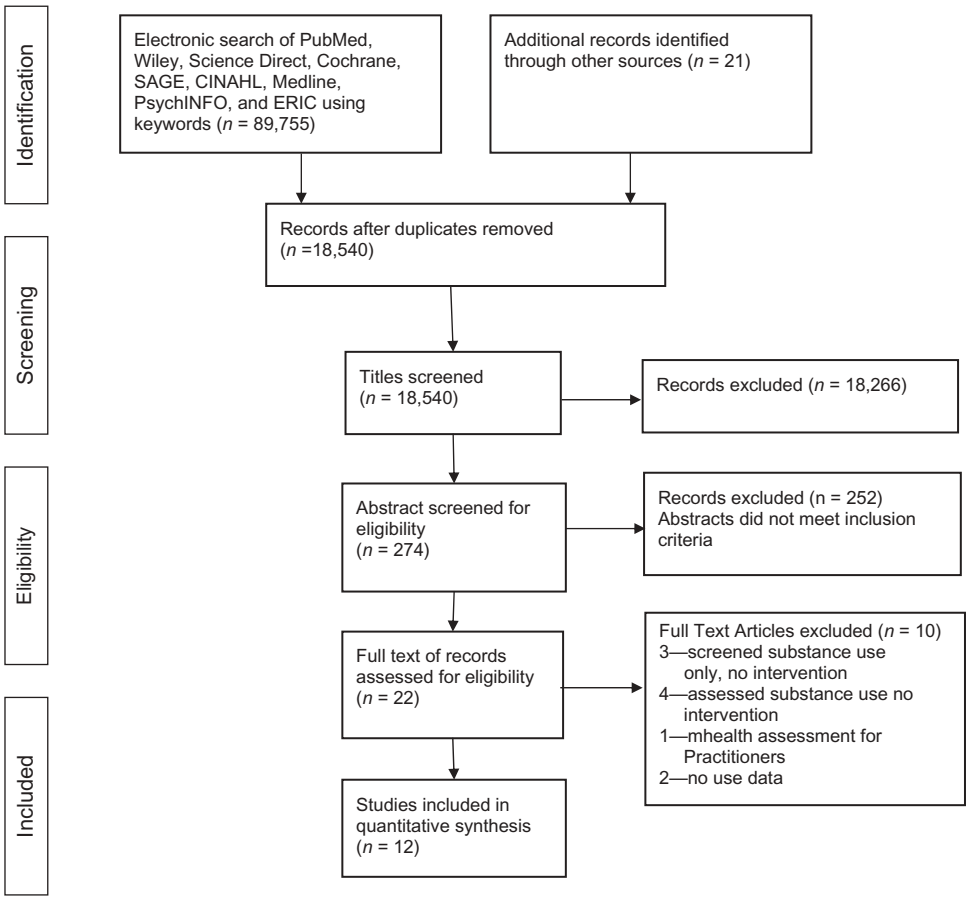

Fig. 1. Search process for the study.

Lucht et al., 2014; Shrier et al., 2014; Suffoletto et al., 2014). Ten out of the twelve studies used text messaging-based interventions (Agyapong et al., 2012; Gajecki et al., 2014; Gonzales et al., 2014; Haug et al., 2013, 2015; Lucht et al., 2014; Shrier et al., 2014; Suffoletto, Callaway, Kristan, Kraemer, & Clark, 2012; Suffoletto et al., 2014; Weitzel et al., 2007). Five of those ten studies used one-way communication, in which the participant was not able to respond with current use or questions (Agyapong et al., 2012; Haug et al., 2013; Gajecki et al., 2014; Gonzalez & Dulin, 2015; Weitzel et al., 2007), whereas the other five permitted participants to respond to texts and received feedback (Haug et al., 2015; Lucht et al., 2014; Shrier et al., 2014; Suffoletto et al., 2012, 2014), often tailored to the content of the response. Three studies (Gustafson et al., 2014; Haug et al., 2015; Lucht et al., 2014) had therapist contact facilitated by high-risk responses to responses provided by the participants.

In the studies where the researchers used text messaging-based interventions as the main mHealth intervention, two did provide participants with phone calls from counselors in the event of any reported need for increased support or assistance (Huag et al., 2015; Lucht et al., 2014). In contrast, Shrier et al. (2014) provided two Motivational Enhancement Therapy (MET) sessions prior to participants completing mobile-based daily self-monitoring and receiving supportive feedback text messages. The text messaging consisted primarily of communication providing daily recovery and wellness help, social support resources, positive feedbacks, checks on medical adherence and clinical status and coping strategies to decrease use of substances.

Regarding dosage, participants in the study ranged from once or more a day (Agyapong et al., 2012; Gonzales et al., 2014; Shrier et al., 2014) to twice a week (Haug et al., 2015; Lucht et al., 2014; Suffoletto et al., 2014) to weekly or less (Haug et al., 2013; Suffoletto et al., 2012). The remaining interventions permitted the participants to access at their own pace. One study found that intervention access was highest in the first week of intervention and then tapered off significantly (Gonzalez & Dulin, 2015); another study found that the app was used on about 40% of days (Gustafson et al., 2014).

The structure and format of the mHealth interventions also varied widely. For example, Shrier et al. (2014) studied the effect of MOMENT intervention on youth who used marijuana frequently. Study duration was 17 weeks and included three study phases (baseline, intervention, and follow-up), six study visits and three periods of mobile momentary reports and daily diaries. In contrast, four studies featured smartphone and web-based applications (Gajecki et al., 2014; Gonzalez et al., 2015; Gustafson et al., 2014; Haug et al., 2015). Gajecki et al. (2014) compared three groups: Promillekoll (smartphone-based app),

Party Planner (web-based app), and control (baseline assessment and follow-up only). The Promillekoll app registered alcohol consumption with a visual blood alcohol concentration (BAC) and provided a warning if alcohol consumption could result in a BAC over 0.06. The Party Planner app offered pre-party planning simulations. Specifically, it provided examples of events where alcohol may be used, and color-coding features organized events based on an individual's likelihood of displaying risky drinking behaviors. After the drinking occasion, individuals could use the app to compare the pre-party plan developed with what occurred in real-time. Similarly, Gonzalez and Dulin (2015) also used a smartphone app and Internet-based interventions. Two parallel intervention groups received baseline assessment plus a six-week follow-up either as a smartphone Location-Based Monitoring and Intervention for Alcohol (LBMI-A) group or as an Internet-based Drinker's Check-up (DCU) supplemented by bibliotherapy (bib) group. The LBMI-A group participated in seven psychoeducation modules related to high-risk drinking behaviors. Alternatively, the DCU +bib group completed a brief motivational intervention that lasted 1 hour each week for the six-week period (Gonzalez & Dulin, 2015). Also, the participants rated the smartphone app higher on ease of use compared to the internet-based intervention +bib (score 4.0 vs. 3.2). Because this was a pilot study, further replication of these findings is recommended to strengthen the argument of the effectiveness of smartphone app interventions in decreasing problematic alcohol use.

Theoretical Constructs

The interventions used in studies were based on diverse theoretical frameworks and included Theory of Planned Behavior (TPD), Social Cognitive Theory (SCT), Self-Determination Theory, Motivational Enhancement Therapy, Elaboration Likelihood Model (ELM), behavioral self-control and social support, and Dialectical Behavioral Therapy (DBT). Gajecki et al. (2014) delivered text messages formulated from Ajzen's Theory of Planned Behavior (TPB), which states that an individual's intentions determine action (Ajzen, 1985). Similarly Gustafson et al. (2014) developed A-CHESS based on the Self-Determination Theory focusing on enhancing the individual's perceptions of competence by promoting intrinsic motivation. Informational texts were designed to deliver both behavioral and cognitive strategies. In contrast, Gonzales et al. (2014) delivered texts based on SCT, which highlights the importance of the interaction between personal factors and environmental influences on behavior (Bandura, 1986). In this study, texts had messages to support behavioral change within the context of the individual's phenomenal and personal experiences. The texts provided monitoring, daily wellness recovery support, weekend social support resources, and motivational messages designed to encourage behavioral change. Similarly, Shrier et al. (2014) used a motivational enhancement therapy approach using messages tailored to enhance behavioral change. Finally, Haug et al. (2013) designed messages based on the ELM which posits that individuals' level of cognition determines their ability to process persuasive messages.

Major Findings

All 12 studies indicated feasibility/accessibility of the interventions, except Suffoletto et al. (2012) mentioned a relatively high "not responding" rate at 11th week (20%). Overall, participants found the messages motivating and interesting, and there were no obvious iatrogenic effects of aspects that the participants disliked. Instead, it appears that mHealth interventions are used less and less as time passes unless there is regular contact and prompts with the participant, if the information is static, or relies on the participants' initiative to access, use declines within a week or two (e.g., Gonazales et al., 2015).

In terms of efficacy, mixed results were reported. Although various primary outcomes were studied, most of these papers got at least partial positives results. In some studies, even though significant difference between groups/before-after interventions was not observed in all variables, evidence of efficiency was found in some alcohol-related outcomes. Weitzel et al. (2007) reported fewer drinks per drinking day in the intervention group (handheld computer+messaging); however, no other group difference on alcohol variables was observed.

Suffoletto et al. (2012) found that participants in the intervention group had significant greater change in number of heavy drinking days (HDDs) and number of drinks per drinking day (DPDD). Haug et al. (2013) conducted a single group study and found significant decrease from baseline to follow-up on risky single-occasion drinking (RSOD). Suffoletto et al. (2014) observed decreased number of binge drinking days from baseline to 3 months in the group of participants receiving SMS assessment and feedback (SA+F). The number of binge drinking days in the SMS assessment only (SA) group increased significantly. The number of drinks per drinking day decreased in the SA+F group and increased in the control group, significantly. In Gonzales et al. (2014) a study about the efficacy of mobile-based aftercare intervention on substance use, youth who participated in the texting mobile pilot intervention were significantly less likely to relapse to their primary compared to the aftercare as usual control condition (OR = 0.52, p = .002) over time (from baseline throughout the 12-week aftercare pilot program to a 90-day follow-up). Participants in the texting aftercare pilot program also reported significantly less substance use problem severity and were more likely to participate in extracurricular recovery behaviors compared to participants in the standard aftercare group. A study on ACHESS (Gustafson et al., 2014) reported lower risky drinking days (t = 2.28, p = .023) and greater abstinence rates in past 30 days (p = .032) in the intervention group. No significant between group difference was found for primary alcohol variables by Lucht et al. (2014). However, the intervention group reported more inpatient detox days, psychiatric hospital days and abstinence clinic days than the control group. Likewise, male participants in the Promillekoll group increased the frequency of their drinking although they did not consume more alcohol compared to the control (Gajecki et al., 2014).

Shrier et al. (2014) investigated the effect of Momentary Self-Monitoring and Feedback + Motivational Enhancement (MOMENT) on marijuana use. No statistically significant reductions were observed in PDA and POSIT scores from baseline to 3-month follow-up. But desire to use during a top-3 trigger exposure decreased significantly. Gonzalez and Dulin (2015) found that percent of days abstinent (PDA) significantly differed in change

over the course of study. The LBMI-A group experienced an increase in PDA over the course of the study. The DCU+bid group did not experience significant change drinks per week (DPW) with decreases over time for both groups. However, Agyapong et al. (2012) observed no significant group differences in Cumulative Abstinence Duration (CAD) (p value = 0.08) and Haug et al. (2015) did not find significant group difference either. Gajecki et al. (2014) even found that Promillekoll (smartphone app) showed a negative effect on men. Greater HED per week than control at 7-week assessment was observed. Same results for the other intervention in the study, Party Planner, with no significant difference from control in drinking variables.

Follow-up Periods

The majority of the studies (9/12) incorporated a pre/postdesign, which conducted assessments at the conclusion of the intervention. The remaining three studies had a wide range of follow-up periods, ranging from two weeks (Shrier et al., 2014) to three (Gonzales et al., 2014) to 4 months (Gustafson et al., 2014).

Limitations

The authors of the reviewed studies identified several overarching limitations of their own work, including small sample sizes and more comparison groups with lower attrition rates are needed to further assess the impacts of specific mHealth features. Authors also acknowledged a lack of long-term follow-ups with which to examine whether any reductions in substance use were maintained. Furthermore, the features of many mHealth interventions were in early stage of development, and many of the earlier ones are likely outdated or incompatible with current technology.

Discussion

mHealth interventions have shown promise as a viable resource in the prevention, treatment, and aftercare of substance use (Gonzales et al., 2014; Haug et al., 2013; Lucht et al., 2014). Mobile technology is currently the most accepted and effective communication mode of connecting with both youth and adult populations, highlighting its utility as an effective intervention for high-risk behaviors including substance use. Phones with at least SMS capabilities appear to be ubiquitous; in the current review, very few participants (typically 1–3%) screened were not able to participate due to not having a phone, an event that was increasingly rare in the more recent studies. However, the saturation of our society with mobile technology poses a significant challenge for rigorous scientific investigations of mHealth to keep up with the ever-changing technology in this age (Rizvi, Dimeff, Skutch, Carroll, & Linehan, 2011). We also discuss other challenges indicated by the reviewed research.

Adaptation of mHealth Intervention to Recipient Needs

In addition to group differences, future investigations may focus on individual differences and needs. The participants ranged from light to moderate alcohol use (e.g., Haug et al., 2013; Suffoletto et al., 2012) to adults leaving inpatient treatment for alcohol use (e.g., Agyapong et al., 2012). Future research can examine how mHealth interventions can best be adapted to match the severity of the recipient. For example, brief intervention may be most appropriate with light drinkers as a preventative effort. Haug et al. (2013) had a targeted intervention that was designed for three risk levels, for example, high, low and nonrisk groups. Since there was evidence that this approach was effective, it would be efficacious to continue exploring interventions based on the degree of risk. In contrast, more in-depth automated interventions may be required to help participants exhibiting more severe alcohol use (Gajecki et al., 2014).

Additionally, gender differences deserve further examination, as negative and positive effects of the interventions can have different implications between genders. Similarly, the use of more diverse samples (e.g., high school and college students, young adults, and older adults) should be included in future approaches to increase knowledge of potential differences in age and environment. Understanding these differences can help create more effective interventions based on specific group needs. For instance, early intervention for substance use is critical for high school students to prevent the further risky behavior. Also, use of alcohol on college campuses may vary by season or event, which may impact the effectiveness of the intervention. Further, results of this systematic review indicated that eBAC calculations had an adverse effect on college students' alcohol consumption, suggesting that it may be important to identify factors that may have a positive effect on college students' alcohol consumption and tailor apps to include those factors (Gajecki et al., 2014).

Enhancing Use of Mobile Interventions

Another limitation noted in the reviewed articles related to attrition. Attrition rates were high in several studies between baseline and follow-ups, and there tended to be a pattern of high rates of initial use followed by decreases in participant engagement with the mobile intervention. Another limitation among the studies was the nonresponse to text which may in part be attributed to the depersonalized messages (Haug et al., 2013; Suffoletto et al., 2012) This attrition and lack of response to prompts are of particular concern as 9 of 12 studies had relatively brief intervention periods ranging from 2 weeks to 3 months. Few studies have evaluated whether intervention effects last after the end of the intervention, and/or whether participants continue to use texts once the intervention period ends.

Therefore, a clear gap exists in the literature with a need for longer follow-up to examine the mHealth intervention effect on substance use behavior, refining study procedures to identify and address barriers to engagement and use of mobile interventions.

It may be valuable to increase the frequency and personal relevance of contact. The provision of didactic information was not utilized by the study participants whether it was a booklet (Suffoletto et al., 2012), online bibliotherapy (Gonzalez & Dulin, 2015) or web content (Gustafson et al., 2014). One recommendation to address retention barriers is to increase response rates to text messages and continue to explore varying designs to address a wide range of potential dual diagnoses and substances (Gonzales et al., 2014; Shrier et al., 2014). Differing feature designs would allow targeted effects based on individual needs. Another important issue is the degree to which mobile

intervention can facilitate lasting changes in behavior; many of the studies conducted the intervention until the final follow-up, resulting in a lack of a no-treatment (or "wash-out") period during which the participant did not have access to the mobile intervention. As a result, it is difficult to determine whether observed changes in behavior persist or dissipate once access to the mobile intervention is removed.

The current systemic review highlighted the strengths and limitations of the few studies that have examined the effectiveness of mHealth interventions with substance use. For example, although mHealth interventions can reach a large number of individuals and promote self-regulation, there is a need for larger sample sizes and longitudinal studies in future investigations of mHealth interventions for substance use, as larger sample sizes would help increase generalizability, and longitudinal studies would help researchers understand the long-term effects of the interventions. Also, a majority of the researchers utilized self-report data to obtain their results, which may have impacted the accuracy of the reported effectiveness of the interventions due to potential socially desirable responding of participants. Therefore, future research using collateral informants or drug screens would enhance confidence in the observed outcomes.

Conclusions

The current review supports the mounting evidence that mHealth technology is a promising means to address substance use and warrants further development and study. In person interventions, while effective at reducing substance use, are simply unable to reach a vast number of people that technology-based interventions can reach (Milward et al., 2015). mHealth interventions have been shown to reduce substance use among vulnerable individuals when they are applied in real-life, real-time contexts. Given the familiarity and comfort that young adults have with mobile phones and their willingness to adopt new trends, we see an exciting opportunity to use mHealth interventions to reduce substance use either by themselves or through enhancing traditional intervention techniques by increasing access to real-life contexts within one's natural environments.

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