

EFFECTIVENESS OF MOBILE APPS AND TEXT MESSAGE TO MANAGE ALCOHOL CONSUMPTIONS: SYSTEMATIC REVIEW AND META-ANALYSIS

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Abstract

BACKGROUND: According to the practical guidelines adopted by many countries to manage alcohol-related problems, continuous monitoring, education and social support are effective strategies to prevent problematic behaviors caused by drinking.

OBJECTIVE: The purpose of this study is to do literature review and meta-analysis to find out the trend of related researches using smartphone applications developed to help alcoholics to manage their alcohol consumptions and alcohol-related problems.

METHODS: A systematic review and meta-analysis was conducted to evaluate the effectiveness of mobile interventions for individuals with problematic alcohol consumptions. Based on the inclusion criteria for literature review, a total of 18 articles were selected. Meta-analysis was done following PRISMA, and 6 electronic databases were searched systematically to identify relevant studies.

RESULTS: This study reviewed 18 mobile app-based intervention studies aiming to manage problematic alcohol consumption, using either mobile application or text messages. Meta-analysis was conducted on the outcomes in drinking days, excessive drinking and amount of drinking, and pooled analyses favored intervention. Of 18 studies reviewed, 7 used app and 11 used text message interventions. 5 studies reported reduction of drinking days and pooled analysis favoured the intervention (SMD= -0.207, 98% CI: -0.380 to -0.035). 11 studies reported reduction of excessive drinking, and pooled analysis showed statistically significant effectiveness of mobile interventions (SMD= -0.365, 98% CI: -0.559 to -0.170). 10 studies reported the outcome of alcohol consumption and the pooled analysis showed statistically significant reduction using mobile intervention (SMD= -0.232, 98% CI: -0.342 to -0.121). The additional subgroup analysis by dividing intervention types indicated that mobile applications showed greater effectiveness than text-based intervention.

CONCLUSION: Considering the importance of consistency in behavioral management intervention, this study is significant in that it testified the effectiveness of mobile approach that are available anytime and anywhere at users' convenience.

Keywords: Healthcare, Mobile Applications, Alcohol Drinking, Systematic Review, Meta-Analysis

1. INTRODUCTION

Alcohol is a dependence-causing material, and the overuse and excessive consumption of it leads to health problems, increasing social and medical costs. It is estimated that, globally, the harmful use of alcohol increases 5.1% of the medical cost. Alcohol is a leading factor risking life of young adults, causing one out of ten deaths in the age group from 15 to 49 years in the world, with about 3 million people dying annually from harmful use of alcohol [1].

Despite the fact the misuse of alcohol threatens the health of individuals vulnerable to alcohol, a large proportion of them are left alone or undermanaged, and, without little formal assistance, leading them not only to overdependence but to various health problems [2,3]. Given the significance of related problems, a number of countries have developed diverse strategies to tackle

the overuse of alcohol among people. There are many countries which have set national guidelines to control drinking related health problems. Those guidelines usually empathize the importance of continuous monitoring, education and social support as the keys to prevent and reduce harmful effects of drinking [4].

Mobile health (mHealth) is a term for health intervention provided via mobile devices such as mobile phones, smart phones and other internet-connected portable devices (e.g. iPad). mHealth has been identified as an effective solution to help those individuals vulnerable to alcohol to reduce or suppress problematic use of alcohol. Such devices can provide patients with timely service in their daily lives known as ecological momentary intervention. Mobile apps, in particular, provide

user-friendly interventions, such as personalized reminders, self-assessment, and access to online resources, etc.[5].

Those mobile devices can provide person-centered interventions, analyze personal data, recognize what the user needs, and even set action plans to change problematic behaviors [5]. In addition, advanced technology contained in such devices enables users to interact with health professionals, who can support and motivate them with constructive feedback [7]. Furthermore, those apps offer the data that health professional can follow to identify whether the users adhere to therapies [8], ensuring its effectiveness.

As of the fourth quarter of 2020 (fourth quarter), the number of healthcare apps available at Google Play was 49,890.

There are several reviews conducted examining effectiveness of mobile interventions in reducing alcohol overuse and drinking-related problems. Yet it remains unclear whether mobile intervention is effective in dealing with alcohol-related problems, because the number of previous reviews is not sufficient to be accepted enough to justify the findings. They did not conduct meta-analysis due to the insufficient number of case studies and inconsistency of outcome data [9-12]. Other reviews reported alcohol addiction was one of health issues [13] and mobile interventions were included as one that used technology [14]. Given the growing evidence on the effectiveness of such interventions on alcohol-related problems, it is time to have comprehensive understanding of functionality and contents that affect success of apps.

The purpose of this study is to review the related literature review, and conduct meta-analysis to find out the trend of intervention research using smartphone applications developed for managing alcohol assumptions.

2. Methods and Procedures

2.1 Study selection

A systematic review and meta-analysis was conducted to evaluate the effectiveness of mobile interventions on individuals with problematic alcohol consumptions. The Preferred Reporting Items for Systematic Reviews and Meta-analysis (PRISMA) was followed [15] to find out peer reviewed randomized controlled trials (RCTs) which used mobile intervention for individuals with problematic alcohol. Six electronic databases -- Pubmed, Embase, CINAHL, CENTRAL, PsychInfo and KoreaMed -- were searched systematically to identify relevant studies. The keywords used to find out related studies were mobile health, mhealth, mobile application, mobile phone, smart phone, mobile app, text message, SMS, alcohol, excessive alcohol, binge drinking and problematic drinking. Additional manual search was conducted using reference lists of relevant articles to find out articles meeting inclusion criteria.

2.2 Inclusion criteria

The studies meeting the PICO (population, intervention, control, and outcomes) criteria were included: (P) studies conducted on

individuals with alcohol-related problem (self-reported) and alcoholic individuals (diagnosed) + no other serious illness; (I) studies on mobile intervention on them (devices were identified); (O) reported outcomes of such interventions on such individuals (such as reduced amount of alcohol consumptions, drinking days, risky drinking days and behavior, and (SD) randomized controlled trials (RCTs).

SD: RCT and non-RCT(quasi experimental pre-post control group study)

Studies were excluded if they (a) were targeting individuals without alcohol problem, (b) did not use mobile devices to provide intervention, (c) were not written in English or Korean, or (d) did not report empirical data. Included studies were qualitative studies, review studies, protocols and conference presentations.

2.3 Data extraction

Data were extracted by the two main authors independently using a form developed by them. For the qualitative data, two authors (MH and WH) extracted data independently including characteristics of; study participants, contents of mobile intervention and duration. The numerical study outcomes were also extracted independently by two authors (SK and YH).

2.4 Quality assessment

Cochrane Collaboration provides the Risk of Bias (ROB) tool which is useful in evaluating quality of included studies. The ROB uses 6 criteria -- randomization, allocation concealment, blinding of participants, blinding of assessment, publication bias and other risks such as rating the risk of bias at the level of high, low and unclear risk.

2.5 Statistical analysis

The meta-analysis was conducted using Comprehensive Meta Analysis (CMA) software program (reference). To know the estimated effect size, standardized mean difference (SMD) and 95% confidence interval were calculated. The heterogeneity of studies was determined using I^2 and random effect size was used if I^2 was greater than 50%.

3. Results

3.1 Search Outcome

The systematic search retrieved a total of 5,834 records, and 4,779 remained after duplications were removed. 4,779 were screened for their title and abstract and full texts of 46 articles were reviewed in consideration of inclusion. Out of 46 studies, 28 were excluded for the following reasons: 12 studies did not use mobile devices for alcohol management intervention; 13 articles were not RCTs; three had study participants without alcohol problem and/or those with other mental illness (Fig. 1).

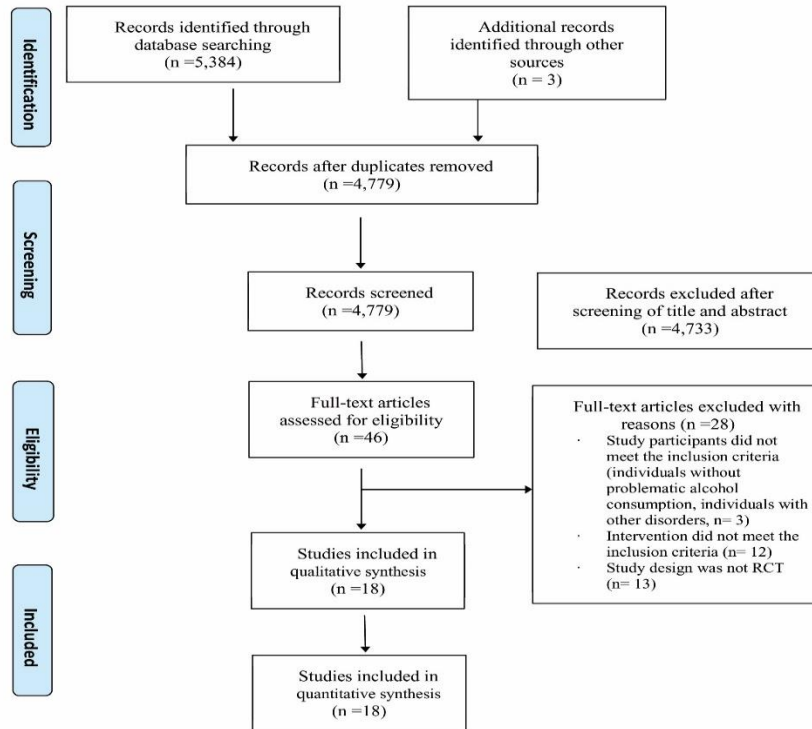


Figure 1. Study flow diagram

The characteristics of study and participants were summarised in Table 1. Of 18 studies reviewed, 7 used app [16-22] and 11 used text message intervention [23-33]. A total of 6,226 participants were included; those who were diagnosed and screened to have risky drinking using measurement such as Alcohol Use Disorders Identification Test (AUDIT). The study participants' ages ranged from as early as teenagers to those in their 40's and the intervention periods were from 1 week to 8 months.

Comparative meta-analysis

The results of primary analysis of included studies are displayed in figure 2. Five studies [16, 19-21, 26] reported outcome of drinking days and pooled analysis favoured the intervention (SMD= -0.207, 98% CI: -0.380 to -0.035). 11 studies [16-21, 26-29, 33] reported the excessive drinking outcomes and pooled results showed statistically significant effectiveness of mobile interventions (SMD= -0.365, 98% CI: -0.559 to -0.170). Ten studies [20-23, 25, 27, 29, 30, 32, 33] reported the outcome of alcohol consumption and the pooled analysis showed statistically significant reduction using mobile intervention (SMD= -0.232, 98% CI: -0.342 to -0.121).

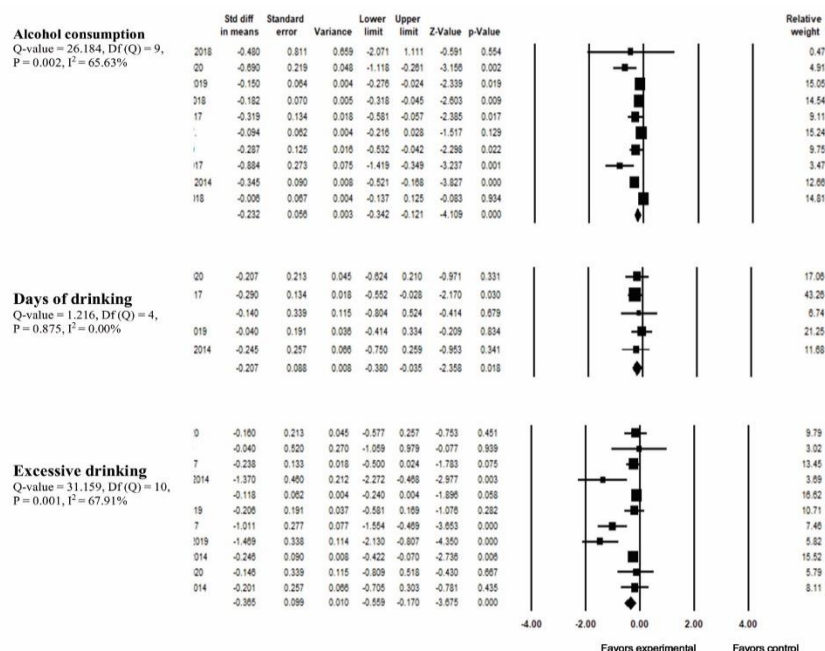


Figure 2. Forest plot of study outcomes

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Table 1. presents the summary of mobile interventions designed to manage alcohol consumption. There were largely two types of interventions: app based and text message based ones. Of studies included, 28 % of them used participants diagnosed as those with alcohol dependence, while 10 studies used self-reporting measurement including Alcohol Use Disorders Identification Test (AUDIT), and Heavy-Episodic Drinking (HED), etc.. Four studies used smartphone applications which included monitoring, and feedback features (n=4, 23%). Eleven

studies used text messages, and messages were in a range from daily to weekly base. The contents of message covered diverse domain including real time feedback on queries to supportive motivations. Thirteen mobile interventions were developed based on social cognitive theory, social norms theory, ecological momentary assessment (EMA), behavioral change theory, and cognitive behavioral therapy (CBT). Eight interventions involved expertise in healthcare (n=4) or psychology (n=4).

Table 1 Summary of the included studies in the meta-analysis

Source /Country /Methods	Participants / Eligibility criteria	Control	Intervention	Theoretical framework	Provider (App developer)	Outcome	Duration
16 Mellentin et al., 2019 /Denmark	Intervention n =54(46±14) Control n = 56(45±12) Females: I=28% C=23% Participants were recruited at the outpatient clinic	Aftercare as Usual	Cue Exposure Therapy app -Alcohol exposure session (with therapist): 1) watching one of eight alcohol videos on the mobile phone; to select their preferred beverage as the exposure material. 2) Session to induce cue-controlled cravings. 3) A direct phone number to a CET therapist in case of uncontrollable cravings Notification: A reminder every week. *App was only accessible during the opening hours of the clinic	Cue Exposure Therapy	Therapists (nurses and social workers trained for the purpose) have completed primary treatment	Drinking days Days with excessive drinking in the past 30 days	Individuals could practice exposure once a day, four times a week (a maximum of 32 sessions of approximately 15 minutes each)
17 Gustafson et al., 2014 /USA	Intervention n=170(38.3±9.5) Control n = 179(38.7±11.2) Females: I=39.4% C=39.1% Mean HED past/per week: Severity of AUD was not collected Criteria for DSM-IV alcohol dependence	Treatment asusual	Addiction– Comprehensive Health Enhancement Support System (A-CHESS) 1) Monitoring: weekly, using the Brief Addiction Monitor (BAM) 2) Information, 3) Communication, 4) Support services to patients: ways for patients and counselors to stay in contact	Self-determination theory	Counselors none	Risky drinking days Abstinence Negative Consequences of Drinking	8 months

			Notifications: automatically sent to counselors when a BAM score exceeded a preset threshold or the BAM was not completed.				
18 O'Donnell et al., 2019 / Australia	Intervention n=25(21.36±4.15) Control n =20 (22.75±4.41) Females: I=72 % C=90% Mean AUDIT-mean (SD): I=11.48(3.55) C=14.10(6.30) Problematic alcohol use by AUDIT		Ecological momentary intervention (EMI) which can deliver information in a timely manner close to the target behavior App to deliver a range of PBS (protective behavioral strategies) considering 1) the user's drinking goal 2) momentary affective state (i.e., negative or positive), 3) social, interpersonal context (i.e., who they are with).	Ecological momentary assessment (EMA)	Psychologist none	Amount of alcohol consumption Risky single occasion drinking (RSOD)	28 days
19 Witkiewitz et al., 2014 /USA	Intervention n = 32 Control n = 29 Mean age: 20.5 (1.7) Females: 27.7 % Mean HED past/per week: the average drinks per drinking day was 6.16 (SD = 3.01) with an average of 4.05 (SD = 1.62) drinking days per week Episode of heavy-episodic drinking (HED)		Brief Alcohol Screening and Intervention for College Students (BASICS) Empirically-supported intervention for college student heavy episodic drinking 1)Cognitive behavioral treatment 2)Personalized feedback about drinking behavior 3)Intervention module after completing each obile assessment (up to 31 different modules)	Ecological momentary assessment (EMA)	Psychologist none	Daily Drinking Questionnaire (DDQ) Young Adult Alcohol Problems Screening Test (YAAPST)	14-day
20 Berman et al., 2020 /Sweden	Intervention n=42 (48.38±12.70) Control n = 47 (49.43±11.20) Mean age: 48.93(11.88)	App contains information on hazardous	TeleCoach Three major components 1.Self-monitoring: reporting of daily drinking	Albert Bandura's Social Cognitive Theory	Psychologist none	Standard drinks per week The Daily Drinking Questionnaire (DDQ)	7 days

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	Females: I=69.0% C=70.2% Total=69.7% AUDIT-mean (SD): 18.32(5.94) Self-reported hazardous alcohol use using AUDIT	drinking only	2.Relapse prevention “Saying no to alcohol” 3.Emotion regulation “Feel better without alcohol”			The Alcohol Abstinence Self-Efficacy Scale (AASE)	
21 Gajecki et al., 2017 /Sweden	Intervention n=93(25.66±5.99) Control n = 93 (24.67±6.42) Mean age: 25.41(6.45) Females: I=69.9 % C=72.0% Total=69.1% AUDIT-mean (SD): 13.46(4.69) Self-reported continued excessive consumption	A wait list group	TeleCoach™ app Two parts: 1. Self-monitoring of alcohol consumption: brief feedback and information on guidelines for hazardous drinking 2. A relapse prevention skills training: offering two options: “say no to alcohol” or “feel better without alcohol.”	-	Psychologist none	The Daily Drinking Questionnaire (DDQ) The number of days of drinking Average eBAC	12 weeks
22 Bertholet et al., 2019 /Canada and the US	Intervention n=461(34.2±9.8) Control n =516(34.3±9.8) Mean age: 34.2(9.8) Females: I=44.5% C=47.1% Total=45.9% AUDIT-mean (SD):18.3(7.1) Self-reported unhealthy alcohol use		Smartphone application Consists of five modules. 1) Personalized feedback 2) Self-monitoring tool 3) Tool to choose a designated driver 4) Blood alcohol content (BAC) calculator 5)Information on alcohol use and its consequences	Social norms theory	- none	Number of drinks per week	7 days
23 Iain K. Crombie et al., 2018 /Scotland	Intervention n = 411 Control n =414 Mean age: 34.6 Females: 0% Self-reported binge drinking using Scottish Index of Multiple Deprivation (SIMD)	89 text messages (general health) - did not mention alcohol-based on behavior change theories	A series of interactive text messages 21 text messages: designed to assess participants’ engagement with key components of the behavior change strategy.	Health Action Process Approach (HAPA)	- A multi-centre parallel group	Occasions of binge drinking	12 weeks
24 Sarah Sharpe et al., 2019 /New Zealand	Intervention n = 299 (34±13) Control n =299 (34±13) Females: I=85% C=86% AUDIT-mean (SD): AUDIT-C scores	Usual care	YourCall 16 text messages - the first week: welcomed the recipient, gave feedback about their drinking, linked them to	Behavioral change theory	Counselling, specialist evaluation and treatment.	alcohol consumption	4 weeks

	(control group: 6.82 [95% CI 6.62–7.03]; intervention group: 6.87 [95% CI 6.68–7.06]) Self-reported hazardous drinking patterns (medium-risk and above)		existing services (e.g. free phone alcohol helpline) and encouraged contemplation about their drinking -the second week: an empathetic yet clear recommendation to cut down on drinking -the second and third weeks: (by six messages) information and tips or strategies about reducing alcohol consumption -the fourth week: (three text message) supportive and encouraging content with the key messages reiterated		in 598 trauma inpatients		
25 Severin Haug et al., 2020 /Switzerl and	Intervention n = 66 (16.9 ±1.0) Control n=70 (17.2±1.3) Mean age: 17.1(1.3) Females: I=47.0% C=50.0% Total=48.5% Self-reported binge drinking	-	MobileCoach Alcohol Text messages to address binge drinking (1) Motivation to drink within low-risk limits (2) Strategy development to resist alcohol *Individual data were collected and analyzed	-	Prevention specialist centers none	Number of alcoholic drinks Binge drinking	3 months
26 Suzette Glasner et al., 2020 /USA	Intervention n = 17(47.6± 11.5) Control n =18(52.7± 6.1) Mean age: 50.2(10.2) Females: 14.3% Criteria for DSM-V diagnosis of alcohol use disorder	An informational pamphlet concerning HIV and alcohol use (INFO)	ALC-TXT-CBT intervention Individualized text message: (1) the top 3 barriers to ART adherence, with corresponding plans for coping in a manner that would facilitate taking medications as prescribed, (2) the specific times of day at which to deliver medication reminders, and (3) motives for stopping or maintaining	text messaging to deliver cognitive behavioral therapy (CBT)	A master's-level clinician Tarzana Treatment Center	The Addiction Severity Index (ASI) ART adherence	12 weeks

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			changes in substance use.				
27 Brian Suffoletto, et al., 2014 /USA	Intervention n=I(SA+F)=384(22.0±2.0) Control n=I(SA)=196(22.0±2.0) =185(21.8±2.1) Females: I(SA+F)=65.4% I(SA)=63.8% C=67.0% AUDIT-mean (SD):6.3(2.2) 6.3(2.2) 6.2(2.1) ED (emergency department) who screened positive for past hazardous alcohol use		SMS assessment + feedback (SA+F) asked to respond to drinking-related queries and received real-time feedback through SMS each Thursday and Sunday for 12 weeks	Health Belief Model, the Information Motivation Behavior model, and the Theory of Reasoned Action	Physicians Four urban teaching hospitals	Binge drinking days Amount of drinks per drinking day	12 weeks
28 Kate B. Carey et al., 2020 /the US	Intervention n = 61(18±0.36) Control n = 60(18±0.30) Mean age: 18(0.33) Females: I=50.0% C=50% Total=50.4% first-semester students at a residential 4-year university NIAAA (National Institute on Alcohol Abuse and Alcoholism) criteria for risky drinking	Historical facts	Daily text messages: containing accurate drinking norms (new information) Text Messages by Domain -Drinking Levels -Intoxicated Behaviors -Protective Behavioral Strategies -Campus Alcohol Culture -Consequences	The theory of normative social behavior	- none	Daily Drinking Questionnaire Brief Young Adult Alcohol Consequence Questionnaire (B-YAACQ)	10 weeks
29 Severin Haug et al., 2017 /Switzerland and	Intervention n=547(16.9±1.6) Control n=494(16.8±1.4) Mean age: 16.8(1.6) Females: I=51.7% C=53.4% Total=52.6% vocational and upper secondary school students (alcohol consumption is considerably higher in this age group)		MobileCoach Alcohol Web-and text message-based intervention: Individually tailored text messages addressing social norms, outcome expectations, motivation, self-efficacy, and planning processes Tailoring was according to data gathered at baseline and during repeated text message assessments	Social-cognitive theory)	Psychology master's degree students or graduates none	RSOD (risky single-occasion drinking)	3 months
30 Vincent I.O. Agyapon	Intervention n=29(39.4±10.6) Control n = 30(41.8±10.0)		Supportive text messages :Twice daily, automated,	Text messages were formulate	a psychiatrist, an addiction counsellor	CAD (Cumulative	3 months

g, et al., 2018 /Canada	Mean age: Females: I=24.1% C=26.7%		AUD(alcohol use disorder)-related supportive text message	d based on addiction treatment principles	and a social worker Addiction Rehabilitation Centre	Abstinence Duration)	
31 Bock et al., 2016 /US	Intervention n = 31(22.0±3.2) Control n =29(21.5±2.8) Mean age: 21.8(3.0) Females: I=61.3% C=62.1% Total=61.7%	General motivational (not alcohol related) text messages	Text Message Alcohol Program (TMAP) Texts were written in three broad domains: 1) Facts about alcohol, 2) Strategies to limit alcohol use and alcohol-related risks, 3) Motivational messages.	-	-	Number of alcohol use Number of heavy drinking episodes (HDE) Peak eBAC(estimate blood alcohol concentration)	6week
32 Thomas et al., 2018 /Sweden	Intervention n=460(25.3±6.7) Control n =436(25.6±6.8) Females: I=57.6% C=56.0% HED Approximately 1 time a week: I=52.4% C=50.0%	Usual care	Automated text message-based program Twenty-three behavior change techniques : Aimed to motivate students to reduce their alcohol consumption, address self-regulation, increase self-efficacy, and increase students' awareness of social and professional support.	A theory-based intervention	An expert panel Health care center.	Amount of alcohol consumption Frequency of heavy episodic drinking Highest estimated blood alcohol concentration	6-week
33 Muench et al., 2017 /USA	Total n = 172 Mean age: 43.2(11.1) Females: 74.9%		Messaging interventions Weekly drink self-tracking mobile assessment texts (MA), loss-framed texts (LF), gain-framed texts (GF), static tailored texts (ST), and adaptive tailored texts (TA).	Social learning theory, NIAAA (National Institute on Alcohol Abuse and Alcoholism) guidelines	- none	Number of drinks Number of heavy drinking days	12week

Subgroup comparison of App VS Text message
Compared with text message based mobile intervention, mobile app was found to be more effective in reducing days of drinking

(SMD= -0.212, 98% CI: -0.391 to -0.034), excessive drinking (SMD= -0.486, 98% CI: -0.844 to -0.128) and amount of alcohol consumption (SMD= -0.322, 98% CI: -0.583 to -0.061).

Table 2. Results of subgroup analysis

Variables	Subgroups	No. of studies	SMD (95%CI)	Heterogeneity
Amount of alcohol consumption	App	3	-0.322 (-0.583 to -0.061)	Q-value = 6.344, Df (Q) = 2, P = 0.042, I ² = 68.47%
	Text	7	-0.209 (-0.345 to -0.073)	Q-value = 18.941, Df (Q) = 6, P = 0.004, I ² = 68.32%
Days of drinking	App	4	-0.212 (-0.391 to -0.034)	Q-value = 1.173, Df (Q) = 3, P = 0.759, I ² = 0.00%
	Text	1	-0.140 (-0.804 to 0.524)	Q-value = 0.000, Df (Q) = 0, P = 1.000, I ² = 0.00%
Excessive drinking	App	6	-0.486 (-0.844 to -0.128)	Q-value = 18.266, Df (Q) = 5, P = 0.003, I ² = 72.63%
	Text	5	-0.275 (-0.506 to -0.044)	Q-value = 10.629, Df (Q) = 4, P = 0.031, I ² = 62.37%

4. Discussions

This study attempted to objectively verify effects of mobile interventions by comprehensively analyzing mobile-based intervention studies conducted to manage alcohol consumption, to organize the characteristics of study subjects and interventions. 18 articles including 6,226 participants were synthesized using a comprehensive and systematic literature review and meta-analysis to verify the intervention effect of alcohol management for individuals with problems. The overall effect of mobile text-based and apps-based interventions used in behavior change interventions for alcohol management was reviewed and the effects of apps were analyzed. To the researchers' knowledge, this study is the first meta-analysis to evaluate the effects of mobile interventions on individuals with problematic alcohol consumption. Those papers and articles finally used in this study were 18 articles, and, among them, 14 articles (77.8%) were published between 2017 and 2020, indicating more active researches on the problem in recent years. The intervention types of the drinking management programs applied to subjects were programs that focused on the subjects' cognitive behavior change, and were performed in various types to prevent drinking-related problems and guide them to abstain from alcohol consumption. The results of comparative meta-analysis in this study were as follows: Five studies reported changes of drinking days and pooled analysis favored mobile interventions; Ten studies showed statistically significant effects of mobile interventions in reducing excessive drinking; Nine studies reported reduction of alcohol consumption, and, specifically, the use of mobile interventions resulted in statistically significant reductions in alcohol consumption. As the main result of this study, comparison of the mobile-based intervention subgroups of app versus text message showed that mobile app-based intervention had greater effects in reducing the number of drinking days, excessive drinking, and alcohol consumption than text message-based mobile intervention did. The results of this study support a previous study [34] that such interventions helped those alcoholic patients to gain more control in managing their underlying alcohol problems. Knowledge of the risks associated with alcohol consumption can prompt the willingness of such patients to seek help from mobile apps [35]. Excessive drinking has been associated with increased morbidity and mortality from disorders such as liver disease, high blood pressure and violent death. An important problem is that, as reported in the existing literature, the majority of alcohol management applications do not support the effectiveness of alcohol management, and some applications are reported to promote drinking [34].

Many systematic reviews of mHealth studies have demonstrated their effectiveness in solving a wide range of health behaviors

and outcomes [36-39]. The ubiquity of mobile phones has paved the way for innovative solutions to tackle healthcare problems, including the prevention and treatment of chronic diseases [39]. Through the meta-analysis, this study found out that mobile interventions used (1) cognitive, (2) supportive, (3) monitoring strategies, and that mobile apps produced greater effectiveness than text based mobile interventions in managing alcohol consumption. Possible reasons for greater effectiveness of mobile app-based intervention could be that (1) apps could provide comprehensive multidimensional approaches, (2) apps are available when individuals actually needed; apps could be more interactive while text-based interventions would be likely one-way, (3) apps are optimized and individualized in that the data accumulated and acquired via apps could be analyzed and utilized and so on.

Mobile health (mHealth) can provide individualized interventions, analyze personal data, recognize one's needs, and create action plans to change problem behaviors [6]. The advanced technology of information and communication enables users to experience interactions with health professionals with supporting and motivating constructive feedback [8]. In addition, the innovative approach of smartphone apps using personalized messaging and interactive features could be a means to provide effective health promotion programs to improve problem behaviors for geographically dispersed people [6]. This is consistent with the results of previous studies [6-8], which indicated that mobile app-based intervention actually provide data that allows medical professionals to track treatment adherence and actually increase the number of drinks in alcoholic patients [7].

The additional subgroup analysis by dividing intervention types indicated that mobile applications showed greater effectiveness than text message-based intervention. The results of this meta-analysis suggest that app-based behavior change interventions have a positive impact on health outcomes. Despite the recognition that excessive alcohol use has physical and psychological problems, many people still continue to drink excessively, and there is no official support or management for this, causing various health problems along with excessive dependence on alcohol [2]. According to the practical guidelines for alcohol withdrawal management, continuous monitoring, education, and social support are effective strategies to prevent harmful drinking [4]. In this respect, this study is meaningful in that it attempted to verify the effectiveness of mobile-based alcohol management interventions.

Previous meta-analysis studies of smartphone apps for health behavior changes have revealed similarly promising results to

those of this study on self-management [40-42] and weight loss [43]. Meanwhile, other meta-analysis studies have revealed that even simple text-message interventions could help people to do smoking cessation, weight loss, and escape from drug addiction [36,44-46], and that behavioral changes may persist after the intervention was discontinued [47]. In other words, although the effect of mHealth is being accepted in the healthcare environment, related studies are still insufficient to have a scientific systematic basis.

Therefore, continuous research should be conducted to secure more quantitative evidence based on the exploratory results of this study. This study also suggests that the use of many common BCTs needs to be optimized for better outcomes, similar to other reviews finding mixed effectiveness of utilizing mHealth [39,40,45,48].

The results of this study presented the scientific basis for mobile interventions for alcohol management and are expected to provide basic data for evidence-based practice. This study verified the latest trend of related researches and integrated effects of literature on the effects of drinking management using mobile apps. This study is meaningful in that it can serve as basic data for the development of effective interventions in the future. And it verified effectiveness of mobile app-based intervention developed for alcoholic patients.

5. Conclusions

This study reviewed 18 mobile app-based intervention studies designed to manage problematic alcohol consumption, using either mobile application or text messages. Meta-analysis was conducted on the outcomes of such interventions in drinking days, excessive drinking and amount of drinking, and pooled analyses favored intervention. The additional subgroup analysis by dividing intervention types indicated that mobile applications showed greater effectiveness than text message-based intervention. Considering the importance of consistency in behavioral management intervention, the current study is significant in approving the effectiveness of mobile approach that are available anytime and anywhere at users' convenience. Future studies using mobile apps integrating essential features for cognitive and behavioral change would further ensure the effectiveness of mobile interventions on alcohol consumption management.

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Conflict of interest

The authors declare that they have no conflict of interest.

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