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REMIT: Development of a mHealth theory-based intervention to decrease heavy episodic drinking among college students

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Abstract

mHealth apps are an effective means of delivering health interventions, and the college-age population is particularly proficient at using apps. Informed by current theories of Ecological Momentary Interventions (EMI), Motivational Interviewing (MI), and the Transtheoretical Model (TTM) of Change, investigators have developed a self-monitoring app—Reductions through Ecological Momentary/Motivational Intervention/Transtheoretical (REMIT)—with the aim of reducing hazardous drinking among college students. The app was developed using the Integrate, Design, Assess, and Share (IDEAS) framework. This step-by-step process for developing digital behavior change interventions was conducted in five phases to: (1) understand the users, (2) determine target behavior, (3) base the intervention in behavioral theory; (4) create delivery strategies, and (5) develop the REMIT prototype. REMIT uses assessments (informed by EMI) and components of MI and TTM to guide administration of nine modules designed to engage users in reducing alcohol use and related problems. REMIT users self-monitor their alcohol consumption and develop strategies to change drinking behaviors using a range of easy-to-use features, such as the Virtual Coach, automated text messages, interactive gaming mechanisms (gamification), drink consumption tracking, and Blood Alcohol Concentration (BAC) calculators. mHealth interventions have been shown to reduce alcohol use among college students when they are applied in real-life, real-time contexts. REMIT is a theory-based app that incorporates user-friendly features to reduce hazardous drinking among college students. The next step is to conduct a pilot trial to test the efficacy of the app and enhance the REMIT prototype.

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Keywords

Motivational interviewing; ecological momentary interventions; transtheoretical model; alcohol; App; mHealth; college students

Introduction

More than $250 billion is spent each year in the United States to address excessive alcohol use. The burden to society has been significant. Individuals under the influence of alcohol suffer unintentional injuries, physical and sexual assaults, and death (CDC 2015). College students are at risk. More than 80% of college students say they consume alcohol, and more than 40% report binge drinking, defined as five or more drinks on one occasion for men, four or more for women (USDHHS 2015). This level of use is associated with substantial morbidity and mortality in this vulnerable population (Hingson et al. 2011; Azofeifa et al. 2015). A 2016 national survey of 33,512 college students found that of those who drank in the previous 12 months, 13% were physically injured, 32% did something that they later regretted, 28% had memory loss, and 22% engaged in unprotected sex (ACHA-NCHA II 2016).

Substantial research has led to interventions aimed at reducing risky drinking among college students (Berman et al. 2016). Brief Motivational Interventions (BMIs) are empirically supported peer programs for college students ages 18–24 who experience alcohol-related problems (Carey et al. 2007; Ray et al. 2014; Carey et al. 2016). BMIs often incorporate Motivational Interviewing (MI) (Miller, 1996) and involve one to two individual and face-to-face meetings with clinicians (each session is approximately 50 minutes). Despite the evidence supporting BMI's success in facilitating change in alcohol consumption and associated problems among college students, many students continue to drink heavily and experience alcohol-related consequences. Furthermore, feasibility issues (e.g. staff training, face-to-face meetings with clinicians, and the costs of implementing and sustaining such an intervention) hinder widespread implementation (Cowell et al. 2012; Kazemi et al. 2014; Zarkin et al. 2015).

Could mobile technology deliver alcohol interventions in a more cost-effective and scalable manner? A systematic meta-analysis showed promising evidence that electronic screening and brief interventions (eSBIs) are effective in reducing alcohol consumption (Donoghue et al. 2014). Furthermore, recent reviews of technology-delivered adaptations of motivational interviewing (e.g. text, web-based) indicate preliminary and positive effects on health behaviors (Shingleton and Palfai 2016) and substance use (Jiang et al. 2017). The growing demand for mobile apps highlights their potential to reach a large number of individuals and disseminate information (Crane et al. 2015; Hall et al. 2015; Yasini and Marchand 2015; Quelly et al. 2016; Voth et al. 2016; White et al. 2016). Recent research highlights the popularity of mobile apps (Shrier et al. 2013) and the use of apps to deliver health information and interventions to college students (Patrick et al. 2008; Fjeldsoe et al. 2009), including alcohol abuse interventions (Shrier et al. 2013; Berman et al. 2016).

Most mobile health, or mHealth, interventions for college students are delivered via a smartphone app with a variety of features, including automated text messages, interactive gaming mechanisms (gamification), drink consumption tracking, and Blood Alcohol Concentration (BAC) calculators (Moore et al. 2013; Gajecki et al. 2014; Mason et al. 2014; Andersson 2015). To date, little research has tested interventions targeting risky drinking with mobile technologies and applications for college students (Witkiewitz et al. 2014; Berman et al. 2016). The few mobile-based apps for university students that have been tested in clinical trials have provided valuable information to users (Gajecki et al. 2014; Gajecki et al. 2013), but few of these apps have integrated evidence-based approaches from behavioral health change theories (Crane et al. 2015; Berman et al. 2016). Thus, little is known regarding its efficacy in regards to alcohol intervention using evidence-based strategies or theoretical grounding (Cohn et al. 2011; Weaver et al. 2013).

This study seeks to fill this gap in the literature by detailing our efforts to develop the REMIT app, grounded in the essential, evidence- and theory-based components of BMIs that facilitate change in drinking behaviors. Guided by components of the IDEAS framework (Mummah et al. 2016), we created a smartphone app that delivers an intervention in real time to reduce risky drinking among college students.

Methods

Over the course of nine months, investigators from multiple disciplines developed the REMIT app (e.g. nursing, computer science, mathematics) along with experts in product design and graphics. Five of the most relevant phases of the IDEAS framework were used to guide the integration of theory in the REMIT design (Mummah et al. 2016): (1) understand the users, (2) determine target behavior, (3) intervention based in behavioral theory, (4) create delivery strategies, and (5) develop the REMIT prototype. Following a review of the literature, investigators conducted focus groups to gain insight into the purpose of the interventions and potential outcomes (phases 1 & 2). The next step was to ground the intervention in the BMI behavioral theory (phase 3). To develop creative implementation strategies and the prototype (phases 4 & 5), the team conducted brainstorming sessions to discuss the conceptual design and how to incorporate BMI technical and relational components.

Phases 1 & 2. Understand the users to determine target behavior

The investigators reviewed the literature and conducted four focus groups with college students (n = 26) who reported engaging in risky drinking behavior and had completed an in-person intervention to address their heavy episodic drinking behaviors. (see Kazemi et al. 2014; 2017). These groups focused on the role of heavy episodic drinking in the students' lives and to determine their interest in interventions using mHealth technology. We also examined their views of the in-person intervention and thought on an alternative technology-based intervention app. Several themes emerged from these focus groups that later guided the development of REMIT features, such as automated text messages, interactive gaming mechanisms (gamification), drink consumption tracking, and BAC calculators. Insight gathered from the focus groups also helped investigators choose heavy episodic drinking as

the behavior that the intervention would aim to modify (Kazemi et al. 2014). The focus group participants reported Findings in phases 1 & 2 were consistent with two recent studies that examined engagement strategies for app users including feature and content preferences (Garnett et al. 2015; Milward et al. 2015). These studies found that desirable app features included self-monitoring tools, ease of use, goal setting, personalized feedback (PF), social support, and a plan to change drinking behaviors. Thus, the prototype was designed to change harmful drinking behaviors in at-risk students by motivating them to make a commitment to behavioral change.

Phase 3. Intervention based on behavioral theory

Ecological momentary interventions (EMIs), therapies provided to individuals during their daily lives in real time and real-world situations also informed development of the REMIT app (Heron and Smyth 2010). EMIs are often administered using mobile phones, personal digital assistants (PDAs), or handheld computers (see Heron and Smyth 2010, for a review), and have been well received by, and effective in, young adults (Cohn et al. 2011; Wray et al. 2014). Although ecological momentary assessment (EMA) is also used for real-time assessment of alcohol behaviors in real-life settings (Cohn et al. 2011; Wray et al. 2014), it is primarily intended to assess situational predictors of alcohol use and alcohol-related consequences with minimal impact on the behavior (Heron and Smyth 2010). In contrast, EMIs can combine the assessment of an EMA with the real-time delivery of the intervention to facilitate change.

Motivational Interviewing (MI) is an empirically supported, evidence-based approach to reducing alcohol use and problems among college students (Miller and Rollnick 2013). Often delivered in conjunction with PF, MI is a person-centered conversational-style intervention designed to strengthen motivation for change by using an individual's natural language to explore his or her unique reasons for and against making a behavioral change. To integrate MI into the app, we reviewed the literature in search of components linked with alcohol use reductions. We used MI theory to guide the clinical direction of the participants' engagement with the app, as well as the specific language the app would use. Then, we used EMI and TTM (Prochaska and DiClemente 1984; Heron and Smyth 2010) theories to provide structure and content of the alcohol-related PF.

Regarding the clinical direction of the app, MI theory proposes four sequential and recursive processes that describe what occurs during motivational interviewing: engaging, focusing, evoking, and planning (Miller and Rollnick 2013). Engaging is an essential element of building trust and rapport. Focusing allows the individual to concentrate on a specific change (e.g. drinking behavior). Evoking involves eliciting reasons for change and reactions from the individual. Planning includes developing a strategic and concrete plan for success (Miller and Rollnick 2013). An important component of MI is giving individuals opportunities to react to feedback and to reflect on strategies that might be useful for their success (Miller et al. 2000). To promote individual self-reflection on alcohol use and foster commitment to use intrinsically relevant strategies for change, developers linked each component of REMIT to each of the four processes of MI.

The REMIT intervention approach also incorporates technical components of MI. Current MI theory (Miller and Rose 2009; Arkowitz et al. 2015) posits that post-session behavioral change is directly related to in-session client language, specifically referred to as change talk or 'any self-expressed language that is an argument for change' (Miller and Rollnick 2013, p. 159). Therapists using MI-consistent (MICO) skills (also termed microskills) demonstrated the ability to evoke change language in college students (Apodaca and Longabaugh 2009; Apodaca et al. 2014; Borsari et al. 2015). This result was confirmed by three recent meta-analyses of MI sessions with other populations (Magill et al. 2014; Romano and Peters 2016; Magill et al. 2017). Thus, REMIT developers incorporated the evidence-based MICO language into the app. Table 1 provides a summary of REMIT components and their theoretical underpinnings.

TTM was incorporated into the app to provide a useful heuristic for the behavior change process (DiClemente et al. 2004). MI principles are compatible with the classical work of Prochaska and DiClemente (1984) Transtheoretical Model of change (TTM) and Roger's (1951) client-centered critical conditions for change (Rogers 1959; Prochaska and Norcross 2010). To change behavior, TTM contends that individuals must move through five stages: Precomtemplation (PC), Contemplation ©, Preparation (P), Action (A) and Maintenance (M). The model has been adapted to address heavy alcohol use in the college setting (Prochaska et al. 2004). Prochaska and colleagues' study found that students in the *precontemplation* stage are unaware of the risk of drinking behaviors and unlikely to change. In the *contemplation* stage, students are aware of the pros and cons of alcohol use, but ambivalent about reducing or stopping consumption. Students in the *action* stage have been engaged in modifying hazardous drinking behaviors within the previous six months. *Maintenance* is a stage where students have sustained positive changes (Prochaska and DiClemente 1984; Prochaska et al. 2004). The TTM is also used to personalize text messages from the Virtual Coach to correspond with the participant's current stage of change (Rollnick et al. 1992). Thus, language such as *'Consider thinking about…,' 'As you continue to think about…'* and *'As you continue to …'* are used for participants in the pre-contemplation, contemplation, and action stages (see Table 2).

Phases 4 & 5. Create delivery strategies & develop the prototype

The multidisciplinary team conducted iterative brainstorming sessions to identify creative ways to deliver BMI components in real-time via REMIT (phases 4 & 5). BMIs cover a wide variety of topics (more than 30) ranging from quantity and frequency of alcohol use to personal genetic risk of alcoholism. We examined the research to determine how many topics to address in the different modules. First, Ray and colleagues (2014) found that more highly personalized topics (15–20 personal alcohol-related consequences) or fewer less-personalized topics (6–10 general risks of alcohol use) were related to reductions in alcohol use and related problems. However, these topics were delivered in individual or group BMI sessions often lasting 60 minutes or more. As REMIT users would access the app in briefer but more frequent instances, we felt that nine topics would be ideal. Second, we sought to include topics that would be of interest to the student. This decision was informed by research with high-risk college drinkers (heavy episodic drinking at least once a week) who rated 14 topics on relevance (personally relevant to me) and motivation (would motivate me

to cut back on my drinking) (Miller and Leffingwell 2013). We chose our nine topics from those viewed as both relevant and motivating: genetic risks, family history, tolerance, history of alcohol problems, social drinking motives, alcohol consumption patterns, practical costs of drinking, readiness to change drinking behaviors and alcohol-related consequences, and didactic information about alcohol. Furthermore, these nine topics have also been included (alone or together) in 65% or more of the BMIs in 31 different trials (Ray et al. 2014).

REMIT modules

The research team designed the REMIT app to be delivered over the course of two weeks, consistent with the delivery of a two-session BMI. The modules are activated when they are downloaded to the participants' smartphones. Users can then navigate the nine modules of the app with user-friendly directions.

Module 1. Introductory video

To facilitate navigation and engagement with REMIT, we developed an introductory video that provides directions and emphasizes personal choice and control. The video assures participants that they are the experts on themselves and that REMIT can help them gain a clear view of their drinking behaviors, needs, and goals. It also introduces and demonstrates the app's various features.

Module 2. Assessment

Baseline—The baseline survey is the only module that users are required to complete. The data is used to develop a user profile and alcohol history in preparation to track use. Additional surveys require participants to complete a Daily Drinking Questionnaire (DDQ) (Collins et al. 1985), a brief questionnaire that takes about five minutes and measures quantity and frequency of consumption on peak occasions within the past month. The participant is also asked about his or her reasons for wanting/not wanting to reduce drinking, triggers and barriers to change, injunctive and descriptive norms, percentage of income spent on alcohol, and personal risk factors (e.g. genetic risk information, family history, tolerance, history of alcohol problems, social drinking motives).

Module 3. Virtual coach

The MI process is facilitated by establishing a trusting and respectful relationship with the individual (Miller and Rollnick 2013). Participants choose from a diverse selection of cartoon-like coaches: male and female gender expressions as well as a variety of physical attributes representative of various racial or ethnic identities. This Virtual Coach, whose communication is scripted to embody aspects of MI, guides participants through an exercise in which they explore the pros and cons of making a change in personal alcohol use vs. maintaining the status quo. This process promotes appropriate strategies to assist students in changing their drinking behaviors. The Virtual Coach, through daily text messages and alerts, encourages participants to develop personalized plans to change their drinking behaviors. For example, the Virtual Coach engages participants by asking them to provide reasons for wanting (or not wanting) to reduce drinking, by facilitating goal setting, offering harm reduction strategies, and reminding students to complete their daily drink logs. The

Virtual Coach emphasizes personal responsibility and choice and encourages reflection and action.

Module 4. Text messages

Alcohol use, motivation to change, and perceived behavioral control naturally fluctuate on a daily basis. Using EMI daily self-monitoring and real-time self-assessment of alcohol use has been linked to successful behavioral change (Cohn et al. 2011; Wray et al. 2014). The Virtual Coach provides static and dynamic text messages.

Static—Several daily messages do not directly ask participants to reply to questions or take any action. These texts were adapted from another trial that conducted focus groups with college student drinkers and created a library of more than 100 text messages (Bock et al. 2016). The messages include motivational quotes, myths, facts about drinking, and other 'Did You Know?' tips. These texts are consistent with the MICO microskill of giving information.

Dynamic—The dynamic text messages provided by the Virtual Coach are scripted and prompt the participant to provide information or complete a task. For example, such messages might ask about alcohol consumption the previous day. If the participant responds in the affirmative, the Virtual Coach encourages the participant to post the alcoholic beverages in his or her drink log. The app then engages in a 'conversation' with the participant to elicit information and facilitate thought about topics such as BAC (e.g. *'Would you like to calculate your Blood Alcohol Concentration [BAC] from yesterday?'*). The app might use the perceived effectiveness of harm-reduction strategies selected by the participant at baseline to frame additional questions for thought and reflection. For example, *'When we first met, you identified some harm-reduction strategies that you thought might be helpful when you drink. Which of those strategies did you use when drinking yesterday?'* The Virtual Coach then asks if the participant would like to compare their pros and cons from the previous week. Asking permission is consistent with the MICO microskill of providing advice with permission. The respondent can answer 'no' and discontinue the conversation without consequence.

Module 5. Personalized feedback (PF)

Delivery—PF is based on assessment data provided by the students (Miller et al. 2013; Patrick et al. 2014). REMIT collects the data in surveys which are sent to students securely via the network. The surveys are then analyzed to compare drinking trends over multiple days. This information is stored in user profiles on a secured server. The PF is delivered to the students in text and graphics that help students understand their drinking patterns and allow them to compare their alcohol intake to typical students on campus. Data from the National College Health Assessment (ACHA-NCHA II) annual survey is used to provide normative personalized feedback to the students regarding their drinking behavior compared to the general university population. For example, a PF normative statement might be, *'You typically drink alcohol on three days per month, which puts you in the 56th percentile. That means that you drink as much as or more frequently than 56% of university students.'* By comparing the participant's data with data from the ACHA-NCHA II, the app provides

normative strategies to the students on how to reduce their drinking (ACHA-NCHA II 2016; Davis et al. 2016).

Participant's response to feedback from the virtual coach—As participants receive PF, REMIT prompts them to reflect on their behavior. Participants might be asked how they feel about the negative consequences of their drinking, their genetic risk, or what they think about the amount or frequency of their drinking. Other prompts encourage them to reflect on their readiness to change or how they feel when they see how their drinking compares to that of their peers. By eliciting emotional and cognitive reactions, the Virtual Coach prompts participants to use their language to begin identifying motivations for change. Consistent with MI, this increased change talk and evocation of personal reasons for change may increase the efficacy of REMIT for long-term behavioral change.

Behavior tracking—Participants complete daily drinking logs. Their logs provide the data, which is then analyzed on the server to provide personalized Virtual Coach text messages regarding their drinking. REMIT prompts participants to reflect on their drinking and respond with text messages to the Virtual.

Module 6. BAC calculators

Blood Alcohol Calculator (BAC) apps are commonly used among youth (Weaver et al. 2013), and college student drinkers consider BAC information relevant and motivating (Miller and Leffingwell 2013). Our app's BAC calculator allows participants to track their drinking habits by recording the number and types of drinks consumed in a day. The BAC calculator enables them to identify alcohol concentrations and corresponding blood alcohol levels in alcoholic drinks. Based on the data entered, the calculator provides immediate results delivered via text message. The Virtual Coach gives the individual information regarding the degree of intoxication and offers them an opportunity to adjust their drinking.

Module 7. Gaming feature

Use of games in health and fitness apps has become immensely popular (Lister et al. 2014). Consistent with the TTM, students in precontemplation or contemplation stages may benefit from more information to facilitate movement to the action stage (Prochaska et al. 2004). Therefore, we developed interactive educational games with rewards to engage participants in changing drinking behaviors and preventing alcohol-related consequences. We developed a trivia game to deliver important concepts via responses to multiple-choice and true/false questions on the following topics: Alcohol & The Body, Drinking/Sobering Up Myths, BAC, Social/Physical Tolerance, Gender Differences, Alcohol & Pregnancy, and Healthy Behaviors Alternatives. Participants accumulate points, and high scores earn prizes. The trivia game is interactive with anonymous connections to other users (all are given fictitious names). This allows the users to play the trivia game in competition with each other. The more participants play, the more information they about the harmful effects of drinking.

Module 8. Behavioral goals & strategies

In MI, the planning process occurs when the student is prepared to develop a specific plan for changing hazardous drinking behavior (Miller and Rollnick 2013). In REMIT,

participants are offered the opportunity to create a specific action plan. They receive text messages that guide them in establishing realistic goals. They are given reasons for these goals and strategies to reduce hazardous drinking. Participants personalize these efforts by examining and identifying their strengths, coping skills, and potential barriers and facilitators to success. Participants receive a menu of empirically supported strategies that can limit risk (e.g. stay away from drinking in rounds or large groups), and they are encouraged to identify high-risk situations during which they can employ their selected strategies. Finally, participants establish signs/cues that the plan is working, and options to consider if it is not working. Table 3 provides examples of the Virtual Coach's responses to a selection of behavioral goals and strategies.

Module 9. Resource feature

The REMIT app provides a feature that identifies and provides immediate access to resources. An Uber search function provides phone numbers for taxis near the user's geolocation. Alternative activities such as alcohol-free events offered on campus are promoted. The app provides a list of pleasurable nondrinking activities. This is also consistent with MI, as providing a menu of options is akin to the microskill of giving information, and the information is provided in a way that emphasizes personal autonomy and responsibility in selecting alternatives to drinking.

Discussion

This study aimed to integrate theory and current research into a mHealth intervention. We created the REMIT app with automated mobile features to deliver BMI in real time to college students with heavy episodic drinking behaviors. REMIT merges a variety of interactive features that provide encouragement, advice, tips, and strategies to change drinking behaviors. The app components are designed to enhance motivation to change through assessment and feedback and provide real-time access to empirically supported strategies and techniques for managing high-risk situations. Also, the components offer immediate access to resources, provide a list of pleasurable nondrinking activities, monitor drinking, and provide personal feedback on drinking. The next step is to evaluate the REMIT intervention for efficacy and acceptability by conducting a pilot trial. We will compare REMIT with BMI delivered face to face. The data collected will be used to continue to enhance the REMIT prototype.

There are limitations for the use of mobile devices including concerns regarding privacy (Proudfoot 2013). However, young adults reporting sensitive behaviors using mobile devices have few concerns about their privacy or the confidentiality of their data (Sunner et al. 2013; Black et al. 2014). Ethical issues related to privacy protection arise with the use of social networking features. For example, using competitive gaming features may raise the potential for personal data breaches. It is also important to note the digital divide that currently exists between racial/ethnic groups, rural/urban residence, age, and income, all of which are limitations to mHealth apps (Hong and Jinmyoung 2017). Research has shown that individuals most likely to have mHealth apps are better educated, have health insurance, and are confident in their abilities to care for themselves. Individuals who are less likely to use

mHealth apps are older or live in rural areas (Bhuyan et al. 2016). Another notable drawback to the mobile-based delivery of interventions is the lack of personal engagement with healthcare practitioners. However, empirical evidence supports the use of mobile-based interventions delivered as stand-alone interventions (Weitzel et al. 2007; Agyapong et al. 2012; Suffoletto et al. 2012) or as an integrated component of a treatment protocol (Gonzales et al. 2014; Gustafson et al. 2014; Lucht et al. 2014).

Despite these limitations, this study provides valuable information for health practitioners looking for alternatives to costly BMIs that require resources many institutions do not have (Cowell et al. 2012; Kazemi et al. 2014). College students are comfortable with the use of mobile apps, and thus may be responsive to REMIT's daily self-monitoring and real-time assessment of alcohol use. REMIT EMI features PF with statistics and graphics and a BAC app that allows students to compare their drinking trends, as well as their drinking vs. that of their peers. Daily self-monitoring and real-time self-assessment of alcohol use promote positive behavioral change. The gaming feature delivered in real time offers knowledge and connections to other users, along with resources for additional support.mHealth app interventions can reach a large number of individuals. Consistent with the principles of open science that encourage collaboration and sharing of knowledge, data, and resources to produce valid and replicable findings, there are several promising avenues of research we hope to pursue and facilitate (González 2005). First and foremost, we plan to examine the efficacy of mobile technology as an alcohol intervention for college students who are exhibiting heavy episodic drinking. Following the IDEAS framework, we will conduct a pilot study to compare REMIT with face-to-face interventions delivered by counselors. We will use data collected during the pilot project to continue to enhance the REMIT prototype. The smartphone app approach also has potential in addressing other important health issues, such as risky sexual behavior, HIV risk reduction, smoking cessation, and obesity. There is a need for randomized longitudinal studies to test the efficacy of mHealth app interventions for use in combating all of these behaviors. Larger sample sizes and multiple sites would increase generalizability, and longitudinal studies would help researchers understand the long-term effects of the interventions. Also, further investigation is needed to evaluate the efficacy of the app's features and delivery as a stand-alone tool or in combination with other alcohol-focused interventions.

Conclusion

Delivering BMI interventions in the traditional way from clinicians to patients is expensive and often not easily accessible. While effective at reducing alcohol use, BMI interventions are simply unavailable to a vast number of individuals that mobile-based interventions can reach (Milward et al. 2015). mHealth interventions have shown promise in reducing alcohol use among college students when they are applied in real-life, real-time contexts. Guided by the IDEAS framework, we provided details on the step-by-step integration of EMI, MI, and TTM into the development of REMIT, an app for college students with risky alcohol behaviors. App features are delivered as stand-alone components (e.g. text messages) or in combination (e.g. BAC, Games, text). This innovative modality represents a shift in the current BMI clinical implementation paradigm by combining a proven intervention with

enhanced mHealth technology for delivery. Future research will ultimately determine the app's efficacy at reducing risky drinking among college students.

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References

Agyapong VI, Ahern S, McLoughlin DM, Farren CK. 2012 Supportive text messaging for depression and comorbid alcohol use disorder: single-blind randomized trial. J Affect Disord. 141:168–176. [PubMed: 22464008]

American College Health Association (ACHA-NCHA II). 2016 American College Health Association-National College Health Assessment II: reference group executive summary. Linthicum (MD): Author.

Andersson C. 2015 Comparison of WEB and Interactive Voice Response (IVR) methods for delivering brief alcohol interventions to hazardous-drinking university students: a randomized controlled trial. Eur Addict Res. 21:240–252. [PubMed: 25967070]

Apodaca TR, Borsari B, Jackson KM, Magill M, Longabaugh R, Mastroleo NR, Barnett NP. 2014 Sustain talk predicts poorer outcomes among mandated college student drinkers receiving a brief motivational intervention. Psychol Addict Behav. 28:631–638. [PubMed: 25222170]

Apodaca TR, Longabaugh R. 2009 Mechanisms of change in motivational interviewing: a review and preliminary evaluation of the evidence. Addiction. 104:705–715. [PubMed: 19413785]

Arkowitz H, Miller WR, Rollnick S. 2015 Motivational interviewing in the treatment of psychological problems. 2nd ed. New York (NY): Guilford Press.

Azofeifa A, Mattson ME, Lyerla R. 2015 Driving under the influence of alcohol, marijuana, and alcohol and marijuana combined among persons aged 16-25 years: United States, 2002–2014. MMWR Morb Mortal Wkly Rep. 64:1325–1329. [PubMed: 26655490]

Berman AH, Gajecki M, Sinadinovic K, Andersson C. 2016 Mobile interventions targeting risky drinking among university students: a review. Curr Addict Rep. 3:166–174. [PubMed: 27226948]

Black SK, de Moor C, Kendall AD, Shrier LA. 2014 Feasibility of momentary sampling assessment of cannabis use in adolescents and young adults. J Child Adolesc Subst Abuse. 23:177–184.

Bock BC, Barnett NP, Thind H, Rosen R, Walaska K, Traficante R, Foster R, Deutsch C, Fava JL, Scott-Sheldon LAJ. 2016 A text message intervention for alcohol risk reduction among community college students: TMAP. Addict Behav. 63:107–113. [PubMed: 27450909]

Borsari B, Apodaca TR, Jackson KM, Mastroleo NR, Magill M, Barnett NP, Carey KB. 2015 In-session processes of brief motivational interventions in two trials with mandated college students. J Consult Clin Psychol. 83:56–67. [PubMed: 25111429]

Bhuyan SS, Lu N, Chandak A, Kim H, Wyant D, Bhatt J, Kedia S, Chang CF. 2016 Use of mobile health applications for health-seeking behavior among US adults. J Med Syst. 40:1–8. [PubMed: 26573639]

Carey KB, Scott-Sheldon LJ, Garey L, Elliott JC, Carey MP. 2016 Alcohol interventions for mandated college students: a meta-analytic review. J Consult Clin Psychol. 84:619–632. [PubMed: 27100126]

Carey KB, Scott-Sheldon LJ, Carey MP, DeMartini KS. 2007 Individual-level interventions to reduce college student drinking: a meta-analytic review. Addict Behav. 32:2469–2494. [PubMed: 17590277]

Centers for Disease Control and Prevention (CDC). 2015 Excessive drinking costs US. Available from: https://www.cdc.gov/features/alcoholconsumption

Cohn AM, Hunter-Reel D, Hagman BT, Mitchell J. 2011 Promoting behavior change from alcohol use through mobile technology: the future of ecological momentary assessment. Alcohol Clin Exp Res. 35:2209–2215. [PubMed: 21689119]

Collins RL, Parks GA, Marlatt GA. 1985 Social determinants of alcohol consumption: the effects of social interaction and model status on the self-administration of alcohol. J Consult Clin Psychol. 53:1890200.

Cowell AJ, Brown JM, Mills MJ, Bender RH, Wedehase BJ. 2012 Cost-effectiveness analysis of motivational interviewing with feedback to reduce drinking among a sample of college students. J Stud Alcohol Drugs. 73:226–237. [PubMed: 22333330]

Crane D, Garnett C, Brown J, West R, Michie S. 2015 Behavior change techniques in popular alcohol reduction apps: content analysis. J Med Internet Res. 17:e118. [PubMed: 25977135]

Davis JP, Houck JM, Rowell LN, Benson JG, Smith DC. 2016 Brief motivational interviewing and normative feedback for adolescents: change language and alcohol use outcomes. J Subst Abuse Treat. 65:66–73. [PubMed: 26710670]

DiClemente CC, Schlundt D, Gemmell L. 2004 Readiness and stages of change in addiction treatment. Am J Addict. 13:103–119. [PubMed: 15204662]

Donoghue K, Patton R, Phillips T, Deluca P, Drummond C. 2014 The effectiveness of electronic screening and brief intervention for reducing levels of alcohol consumption: a systematic review and meta-analysis. J Med Internet Res. 16:e142. [PubMed: 24892426]

Fjeldsoe BS, Marshall AL, Miller YD. 2009 Behavior change intervenetions delivered by mobile telephone short-message service. Am J Prevent Med. 36:165–173.

Gajecki M, Berman AH, Sinadinovic K, Rosendahl I, Andersson C. 2014 Mobile phone brief intervention applications for risky alcohol use among university students: a randomized controlled study. Addict Sci Clin Pract. 9:11. [PubMed: 24985342]

Gajecki M, Andersson C, Sinadinovic K, Berman AH. 2013 Interactive Voice Response (IVR) for problematic alcohol use: a three-armed randomized controlled trial. Paper presented at Society of Behavioral Medicine (SBM), 34th Annual Meeting and Scientific Sessions; March 20–23; San Francisco.

Garnett C, Crane D, West R, Brown J, Michie S. 2015 Identification of behavior change techniques and engagement strategies to design a smartphone app to reduce alcohol consumption using a formal consensus method. JMIR mHealth Uhealth. 3:e73. [PubMed: 26123578]

González AG. 2005 Open science: open source licenses in scientific research. NCJL Tech. 7:321.

Gonzales R, Ang A, Murphy DA, Glik DC, Anglin MD. 2014 Substance use recovery outcomes among a cohort of youth participating in a mobile-based texting aftercare pilot program. J Subst Abuse Treat. 47:20–26. [PubMed: 24629885]

Gustafson DH, McTavish FM, Chih M-Y, Atwood AK, Johnson RA, Boyle MG, Levy MS, Driscoll H, Chisholm SM, Dillenburg L, et al. 2014 A smartphone application to support recovery from alcoholism. A randomized clinical trial. JAMA Psychiatry. 71:566–572. [PubMed: 24671165]

Hall AK, Cole-Lewis H, Bernhardt JM. 2015 Mobile text messaging for health: a systematic review of reviews. Annu Rev Public Health. 36:393–415. [PubMed: 25785892]

Heron KE, Smyth JM. 2010 Ecological momentary interventions: incorporating mobile technology into psychosocial and health behaviour treatments. Br J Health Psychol. 15:1–39. [PubMed: 19646331]

Hingson R, Heeren T, Winter M, Wechsler H. 2011 Alcohol-related vehicular death rates for college students in the Commonwealth of Virginia. J Am Coll Health. 59:678–679. [PubMed: 21823966]

Hong YA, Jinmyoung C. 2017 Has the digital health divide widened? Trends of health-related internet use among older adults from 2003 to 2011. J Gerontol Ser B: Psychol Sci Social Sci. 72:856–863.

Jiang S, Wu L, Gao X. 2017 Beyond face-to-face individual counseling: a systematic review on alternative modes of motivational interviewing in substance abuse treatment and prevention. Addict Behav. 73:216–235. [PubMed: 28554033]

Kazemi DM, Cochran AR, Kelly JF, Cornelius JB, Belk C. 2014 Integrating mHealth mobile applications to reduce high risk drinking among underage students. Health Educ J. 73:262–273.

Kazemi DM, Borsari B, Levine MJ, Li S, Lamberson KA, Matta LA. 2017 A systematic review mhealth mobile interventions for alcohol and substance use. J Health Commun. 22:413–432. [PubMed: 28394729]

Lister C, West JH, Cannon B, Sax T, Brodegard D. 2014 Just a Fad? Gamification in Health and Fitness Apps. JMIR Serious Games. 2:e9. [PubMed: 25654660]

Lucht MJ, Hoffman L, Haug S, Meyer C, Pussehl D, Quellmalz A, Klauer T, Grabe HJ, Freyberger HJ, John U, Schomerus G. 2014 A surveillance tool using mobile phone short message service to reduce alcohol consumption among alcohol-dependent patients. Alcohol Clin Exp Res. 38:1728–1736. [PubMed: 24730528]

Mason M, Benotsch EG, Way T, Kim H, Snipes D. 2014 Text messaging to increase readiness to change alcohol use in college students. J Prim Prev. 35:47–52. [PubMed: 24114551]

Magill M, Gaume J, Apodaca TR, Walthers J, Mastroleo NR, Borsari B, Longabaugh R. 2014 The technical hypothesis of motivational interviewing: a meta-analysis of MI's key causal model. J Consult Clin Psychol. 82:973. [PubMed: 24841862]

Magill M, Apodaca TR, Borsari B, Gaume J, Hoadley A, Gordon RF, Tonigan JS, Moyers T. 2017 A meta-analysis of motivational interviewing process: technical, relational, and conditional process models of change. J Consult ClinPsychol. doi:10.1037/ccp0000250

Miller WR. 1996 Motivational interviewing: research, practice, and puzzles. Addict Behav. 21:835–842. [PubMed: 8904947]

Miller MB, Leffingwell TR. 2013 What do college student drinkers want to know? Student perceptions of alcohol-related feedback. Psychol Addict Behav. 27:214. [PubMed: 23506366]

Miller MB, Leffingwell T, Claborn K, Meier E, Walters S, Neighbors C. 2013 Personalized feedback interventions for college alcohol misuse: an update of Walters & Neighbors (2005). Psychol Addict Behav. 27:909. [PubMed: 23276309]

Miller WR, Rollnick S. 2013 Motivational interviewing: Helping people change. 3rd ed New York (NY): Guilford Press.

Miller WR, Rose GS. 2009 Toward a theory of motivational interviewing. Am Psychol. 64:527–537. [PubMed: 19739882]

Miller WR, Toscova RT, Miller JH, Sanchez V. 2000 A theory-based motivational approach for reducing alcohol/drug problems in college. Health Educ Behav. 27:744–759. [PubMed: 11104373]

Milward J, Day E, Wadsworth E, Strang J, Lynskey M. 2015 Mobile phone ownership, usage and readiness to use by patients in drug treatment. Drug Alcohol Depend. 146:111–115. [PubMed: 25468818]

Moore SC, Crompton K, Van Goozen S, Van Den Bree M, Bunney J, Lydall E. 2013 A feasibility study of short message service text messaging as a surveillance tool for alcohol consumption and vehicle for interventions in university students. BMC Public Health. 13:1011. [PubMed: 24160674]

Mummah SA, Robinson TN, King AC, Gardner CD, Sutton S, Eysenbach G. 2016 IDEAS (Integrate, Design, Assess, and Share): a framework and toolkit of strategies for the development of more effective digital interventions to change health behavior. J Med Internet Res. 18:e317. [PubMed: 27986647]

Patrick K, Griswold W, Raab F, Intille S, Patrick K, Griswold WG, Intille SS. 2008 Health and the mobile phone. Am J Prev Med. 35:177–181. [PubMed: 18550322]

Patrick ME, Lee CM, Neighbors C. 2014 Web-based intervention to change perceived norms of college student alcohol use and sexual behavior on spring break. Addict Behav. 39:600–606. [PubMed: 24333038]

Prochaska JO, DiClemente CC. 1984 Self change processes, self efficacy and decisional balance across five stages of smoking cessation. Prog Clin Biol Res. 156:131–140. [PubMed: 6473420]

Prochaska JO, Norcross JC. 2010 Systems of psychotherapy: a transteorctical analysis. 7th ed California: Brooks & Cole.

Prochaska JM, Prochaska JO, Cohen FC, Gomes SO. 2004 The transtheoretical model of change for multi-level interventions for alcohol abuse on campus. J Alcohol Drug Educ. 47:34.

Proudfoot J. 2013 The future is in our hands: the role of mobile phones in the prevention and management of mental disorders. Aust N Z J Psychiatry. 47:111–113. [PubMed: 23382507]

Quelly SB, Norris AE, DiPietro JL. 2016 Impact of mobile apps to combat obesity in children and adolescents: a systematic literature review. J Spec Pediatr Nurs. 21:5–17. [PubMed: 26494019]

Ray AE, Kim S-Y, White HR, Larimer ME, Mun E-Y, Clarke N, Jiao Y, Atkins DC, Huh D. 2014 When less is more and more is less in brief motivational interventions: characteristics of intervention content and their associations with drinking outcomes. Psychol Addict Behav. 28:1026. [PubMed: 24841183]

Rogers C. 1959 A theory of therapy, personality relationships as developed in the client-centered framework In: Koch S, editor. Psychology: a study of a science. Vol. 3: formulations of the person and the social context. New York: McGraw Hill.

Rollnick S, Heather N, Gold R, Hall W. 1992 Development of a short readiness to change questionnaire for use in brief, opportunistic interventions among excessive drinkers. J Addict. 87:743–754.

Romano M, Peters L. 2016 Understanding the process of motivational interviewing: a review of the relational and technical hypotheses. Psychother Res. 26:220–240. [PubMed: 25204407]

Shingleton RM, Palfai TP. 2016 Technology-delivered adaptations of motivational interviewing for health-related behaviors: a systematic review of the current research. Patient Educ Counsel. 99:17–35.

Shrier LA, Rhoads AM, Fredette ME, Burke PJ. 2013 Counselor in your pocket: youth and provider perspectives on a mobile motivational intervention for marijuana use. Subst Use Misuse. 49:134–144. [PubMed: 24000892]

Suffoletto B, Callaway C, Kristan J, Kraemer K, Clark DB. 2012 Text-message-based drinking assessments and brief interventions for young adults discharged from the emergency department. Alcohol Clin Exp Res. 36:552–560. [PubMed: 22168137]

Sunner LE, Walls C, Blood EA, Mehta CM, Shrier LA. 2013 Feasibility and utility of momentary sampling of sex events in young couples. J Sex Res. 50:688–696. [PubMed: 22823546]

U.S. Department of Health and Human Services (USDHHS). 2015 National survey on drug use and health: 2-year R-DAS (2002 to 2003, 2004 to 2005, 2006 to 2007, 2008 to 2009, 2010 to 2011, and 2012 to 2013), ICPSR34482-v3. Ann Arbor (MI): Inter-University Consortium for Political and Social Research.

Voth EC, Oelke ND, Jung ME. 2016 A theory-based exercise app to enhance exercise adherence: a pilot study. JMIR Mhealth Uhealth. 4:e62. [PubMed: 27307134]

Weaver ER, Horyniak DR, Jenkinson R, Dietze P, Lim MS. 2013 Let's get wasted! and other apps: characteristics, acceptability, and use of alcohol-related smartphone applications. JMIR Mhealth Uhealth. 1:e9. [PubMed: 25100681]

Weitzel JA, Bernhardt JM, Usdan S, Mays D, Glanz K. 2007 Using wireless handheld computers and tailored text messaging to reduce negative consequences of drinking alcohol. J Stud Alcohol Drugs. 68:534–537. [PubMed: 17568957]

White BK, Martin A, White JA, Burns SK, Maycock BR, Giglia RC, Scott JA. 2016 Theory-based design and development of a socially connected, gamified mobile app for men about breastfeeding (Milk Man). JMIR Mhealth Uhealth. 4:e81. [PubMed: 27349756]

Witkiewitz K, Desai SA, Bowen S, Leigh BC, Kirouac M, Larimer ME. 2014 Development and evaluation of a mobile intervention for heavy drinking and smoking among college students. Psychol Addict Behav. 28:639–650. [PubMed: 25000269]

Wray TB, Merrill JE, Monti PM. 2014 Using ecological momentary assessment (EMA) to assess situation-level predictors of alcohol use and alcohol-related consequences. Alcohol Res Curr Rev. 36:19–27.

Yasini M, Marchand G. 2015 Mobile health applications, in the absence of an authentic regulation, does the usability score correlate with a better medical reliability? Stud Health Technol Inform. 216:127–131. [PubMed: 26262024]

Zarkin G, Bray J, Hinde J, Saitz R. 2015 Costs of screening and brief intervention for illicit drug use in primary care settings. J Stud Alcohol Drugs. 76:222–228. [PubMed: 25785797]

Table 1.

REMIT theoretical components.

Feature	MI Components	MI Process	EMI	TTM
Introduction	MICO skills	Engaging		
Video	Relational			
Baseline assessment		Focusing		Assign stage of change
Personalized Feedback	MICO skills	Focusing Evoking	Self-Reported genetic risks, descriptive norms, consequence, didactic information	Provides user's readiness to change
Response to Feedback	MICO skills	Evoking		
Behavior tracking	MICO skills	Focusing	Self-Reported Data	
Virtual coaching	MICO Skills	Focusing, Evoking	Algorithm-based automated text prompted by user responses	MICO Language consistent with stage of change
	Relational			
Static texts	MICO skills	Evoking		
Dynamic texts	MICO skills	Focusing, Evoking	Algorithm-based automated text prompted by user responses	MICO Language consistent with stage of change
BAC	MICO skills	Focusing	Self-Reported Data	
Calculators			Personalized Feedback	
Educational games		Engaging		
Behavioral Strategies	MICO skills	Planning	Algorithm-based automated text prompted by user responses	MICO Language consistent with stage of change
Resources		Planning		

BAC: Blood Alcohol Concentration; MICO: Motivational Interviewing-Consistent.

Table 2.

Example virtual coach language consistent with transtheoretical model stage of change.

	Precontemplation	Contemplation	Action
Virtual Coach: 'Do you think that you might drink tomorrow?' Response: Yes	'Thanks for sharing that information. In order to make smarter and safer choices around alcohol use if you choose to drink, planning ahead can be very important. If you do choose to drink tomorrow, you can consider using at least one of the harm reduction strategies that you've already selected and make plans to follow through. For example, if one of your strategies was to use a designated driver to get home after drinking, you might talk to a friend ahead of time about being your designated driver or make sure that you have the number of a taxi or other safe ride programed in your phone. Good luck and I'll check back with you tomorrow to see how it went if you drank!'	'Thanks for sharing that information. As you continue thinking about making safer choices about your drinking if you choose to drink, you can make plans to use two or more of the harm reduction strategies that you've already selected. So for example, if one of your strategies was to use a designated driver to get home after drinking, you could talk to a friend ahead of time about being your designated driver or make sure that you have the number of a taxi or other safe ride programed in your phone. Good luck and I'll check back with you tomorrow to see how it went if you drank!'	'Thanks for sharing that information. As you continue to take actions to help make safer choices around drinking, you can make definite plans to use all of the harm reduction strategies that you've already selected. So for example, if one of your strategies was to use a designated driver to get home after drinking, you could talk to a friend ahead of time about being your designated driver or make sure that you have the number of a taxi or other safe ride programed in your phone. Good luck and I'll check back with you tomorrow to see how it went if you drank!'

Table 3.

Example virtual coach response to selection of behavioral goals and strategies.

Prompt for each student-checked strategy: 'That's great that you used this strategy. How effective was this harm reduction strategy for you?'	
If 'Not Effective'	'I'm sorry to hear that this strategy didn't help you. Why do you think this strategy didn't work? [TEXT BOX] If you like, you can remove this strategy from "My Strategies" and select another.'
If 'Somewhat Effective'	'It's good that you found at least some success with this strategy. Is there anything you think that you can do to make this strategy more helpful in the future when drinking? [TEXT BOX] If you like, you can remove this strategy from "My Strategies" and select another.'
If 'Very Effective'	'That's great! You found something that worked well for you. This strategy will likely assist you the next time that you choose to drink. If you ever need to, though, you can always change this strategy at "My Strategies," and select another. Or add to the list!'.

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